ABSTRACT: Mycotoxins in a southern African and global context

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Mycotoxins are toxic secondary metabolites produced by several species of fungi (moulds), e.g. *Fusarium, Aspergillus, Alternaria* and *Penicillium,* and cause toxic responses (mycotoxicoses) when ingested by animals and humans. The fungal contamination can occur in agricultural crops in the field, and at harvest (by preharvest fungi e.g. *Fusarium* spp.), in storage and during after–crop processing (by post-harvest fungi e.g. *Aspergillus* and *Penicillium* spp.)

The incidence and extent of mycotoxin contamination on grains, fruits, nuts and other agricultural commodities depend on several factors such as: geographical and seasonal factors, cultivation practices, harvesting practices, soil conditions, storage and transportation. Environmental factors such as temperature and humidity influence the level of mycotoxin production on these produce.

Research on mycotoxins, mainly since 1960 led to the discovery of more than 300 toxins, most of which are stable to food processing. These natural toxins display a diverse array of biological effects in humans and animals such as carcinogenicity, teratogenicity and mutagenicity. Some mycotoxins have been linked to human diseases such as ergotoxins linked to ergotism (*Claviceps purpurea*), called St Anthony's Fire in the Middle Ages in Europe; trichothecene toxins e.g.T_2-Toxin linked to Alimentary Toxic Aleukia in Russia in 1944, and the potent hepatocarcinogens, the aflatoxins *(Aspergillus flavus*) linked to the high incidence of Primary Liver Cancer amongst humans in parts of Mozambique, and to the acute aflatoxicosis in Kenya in April 2004 in which 125 people died. In South Africa, the occurrence of fumonisins (*Fusarium verticillioides*) in food is causally linked to the aetiology of oesophageal cancer in rural areas of the former Transkei. Several of the toxins cause diseases among animals and poultry, e.g. Ochratoxin A (nephrotoxin) linked to Danish Porcine Nephropathy; Fumonisins linked to leukoencephalomalacia in horses and pulmonary oedema in swine; T2 –toxin and vomitoxin linked to feed refusal and vomiting; Aflatoxin to death among chickens and turkeys (Turkey-X disease in the UK in 1960), and also to hepatitis in pigs, Zearalenone an estrogenic toxin to hyperestrogenism, vulvovaginitis and abortion in pigs; Phomopsin A to lupinosis in sheep; Sporidesmin produced on weeds (dubbeltjies) to facial eczema a phosensitization disease (Geeldikkopsiekte) occasionally affecting sheep in the Karroo. Outbreaks of diplodiosis amongst farm animals are linked to maize-derived feeds contaminated with *Diplodia maydis.*

Mycotoxins affect about 25% of the world's food crops, therefore, posing an enormous threat to the international trade in foods and feeds. In certain African countries, approximately 60% of the crops are lost due to fungal spoilage and mycotoxin contamination, thereby contributing to food insecurity. The economic losses affect the entire chain of food and feed production by the reduction of marketable grain, discounts for contaminated grain, increased cost of drying, decreased weight gain in animals (ill-thrift), fertility problems and increased costs of animal health. In the USA, it is estimated that the annual direct economic burden from aflatoxins, fumonisins and trichothecenes amounts to $ 1,5 bn to $ 2,5 bn.

Mycotoxins exhibit a wide range of different physicochemical properties in terms of pH stability, solubility, diversity of chemical structure and molecular weight (small /large molecules). Sophisticated analytical methods have been developed for the determination of mycotoxins in food including cereals and nuts, animal feed, dairy products and other contaminated materials. Analytical methods for mycotoxins such as TLC, ELISA (antibody-based screening techniques). capillary GC/MS, HPLC with fluorescence detection, and more recently HPLC-MS/MS have been reported. In South Africa about 30 laboratories undertake mycotoxin analyses, mainly on maize, meal/animal feeds, wheat, cereals and oats/grains. These analyses are mainly directed at aflatoxin B_1, B_2, G_1, G_2, ochratoxin A, fumonisin B_1, B_2, B_3, B_4, zearalenone and deoxynivalenol (DON).

The significant year to year fluctuations in mycotoxin levels as a result of adverse climatic conditions necessitate regular monitoring through a well coordinated national monitoring programme. The samples tested should also be representative of different seasons during each year. The maize industry focuses on aflatoxin, deoxynivalenol, zearalenone, fumonisins and ochratoxin A of which the fumonisins and zearalenone seem to be of highest importance.

Under the SA national regulations (Act no. 54 of 1972, as amended by government Notice No. R. 1145 of 8 October 2004), the only two mycotoxins considered are

- Aflatoxin in all foodstuffs, but specifically peanuts and dairy milk. The legal limit for aflatoxin B_1 is 5 ppb, with a total aflatoxin limit not exceeding 10 ppb. In milk the maximum limit of aflatoxin M_1 is 0.05 ppb.

- Patulin in apple juice and apple juice-based products is set at a legal limit of 50 ppb.

It is evident that deoxynivalenol, ochratoxin A and the fumonisins should be added to the South African regulations.

Future research programmes should be directed to a better understanding of factors contributing to mycotoxin formation and to the development of cereal cultivars resistant to fungal contamination and to mycotoxin formation. Notable progress is made internationally on modelling mycotoxin formation in relation to climatic conditions.

In South Africa, excellent mycotoxin research is carried out in the laboratories of the ARC, MRC, CSIR, SAGL, NMISA as well as at some tertiary institutions.