# Increased Mycotoxins in Organic Produce?

*Prof. Joe Cummins exposes the propaganda campaign against organic food that has little or no scientific basis; and genetic modification is not the answer to reducing aflatoxin contamination*

**Corporate propaganda against organic produce**

Mycotoxins are toxic metabolites produced by fungi. Mycotoxin poisoning has been known since the beginning of agriculture and has taken a large toll on humans and farm animals consuming contaminated crops. Mycotoxins cause immunological effects, specific organ damage, cancer, and in some cases, death. Agricultural workers may also suffer from skin and respiratory exposure during crop harvest and storage. Mycotoxin poisoning is a worldwide problem associated with maize, rice, tree nuts and peanuts along with fresh fruits and vegetables.

Many countries regulate specific mycotoxins and most countries try to limit exposure to the toxins. Poor rural populations suffer greater impacts from mycotoxin exposure than urban dwellers because the urban food supplies have begun to be more strictly regulated.

Recently, pro-GM scientists in academia and biotech corporations have been claiming that organic food and feed is more heavily contaminated with mycotoxins than conventional and genetically modified foods, on grounds that organic production does not use chemical fungicides, and are hence more likely to be infected. But the United Nations Food and Agriculture Organization (FAO) states that, "studies have not shown that consuming organic products leads to a greater risk of mycotoxin contamination."

In fact, numerous publications support the comment of FAO; furthermore, there is no evidence that organic foods are more contaminated than conventional foods.

The fungal species of *Fusarium*, *Penicillium*, *Aspergillus* and *Stachybotrys* are the main producers of mycotoxins. The genes for the biosynthetic pathways for mycotoxin production are extensive and tend to cluster on a few chromosomes, which are passed on through vertical or horizontal gene transfer; in fungi, horizontal gene transfer is most effective. The structure, synthesis and biosynthesis of mycotoxins such as fumonisin have been extensively analyzed.

**Scientific studies refute corporate smear**

The exaggerated claims about greatly elevated levels of mycotoxin in organic foods on the internet or in news media have not been borne out by the peer-reviewed scientific literature.

Ochratoxin, a toxin produced in *Penicillium* and *Aspergillus*, is mainly found in grain, nuts and dried fruits and usually associated with storage of such foods. The toxin damages the kidney, causes cancer and immune suppression. Conventional and organic cereals on the Italian market were compared and no differences were found between the two agricultural practices. Ochratoxin was evaluated in cereal baby foods on the Italian market derived from integrated pest management, organic and conventional farms. Cereals from integrated pest management had no detectable toxin; those from conventional practices had elevated toxin levels in multigrain and seminola-based cereal while only organic rice-based cereal contained the toxin. The study concludes, however, that there is no significant risk to children who occasionally consume toxin contaminated at the observed levels.

Ochratoxin has also been found in the milk of cows consuming contaminated grain. Norwegian milk and baby formula from organic and conventional production was therefore compared. No toxin was found in any of the infant formulae. But the toxin was detected in 6 out of 40

conventional milk samples and 5 out of 47 organic milk samples, the highest level detected in conventional milk was twice the highest level detected in organic milk.

Conventional and organic Italian foodstuffs made up of maize, wheat, rice or mixed products were compared for the *Fusarium* toxins fumonisin and deoxynivalenol. Fumonisin causes cancers of liver or kidney along with blood disorders and pulmonary edema in farm and experimental animals. Deoxynivalenol (vomitoxin) causes anorexia at low levels and vomiting at higher levels, and also damages the immune system. Both organic and conventional foods contained the toxins, but more of the conventional foods were contaminated than organic foods. The highest deoxynivalenol levels were found in conventional rice-based foodstuffs while the highest level of fumonisin was found in conventional maize-based foodstuffs. Organic foodstuffs contained consistently lower contamination than conventional foodstuffs.

A broad study including heavy metals, nitrates and mycotoxins in a range organic and conventional foods in France found no significant differences between organic and conventional foods in a number of mycotoxins. One high level of patulin was observed in a sample of organic apples but no values for patulin content in conventional apples were reported in the study.

Patulin is produced by *Penicillium* and *Aspergillus*, and is known to damage genes, cause birth defects, immune and neurological dysfunction. No significant difference in patulin levels was found between organic and conventional apple products. Nevertheless, a report from *Science in Africa* indicated that patulin was present in commercial apple products and claimed that a study on organically produced apple cider has found "levels up to 40,000 micrograms per liter". It used that finding to make general claims about the unsafe practices in organic agriculture. Despite extensive and repeated literature searches, I have been unable to locate a single peer-reviewed report documenting such a huge level of toxin contamination. But that value has been promulgated through a number of news media and web reports.

Genetic modification (GM) has been promoted as a means of preventing mycotoxin contamination, particularly in maize. Several strategies have been proposed but the only one deployed is to incorporate *Bacillus thuringiensis* (Bt) toxin to prevent corn borer tunneling which encourages fungal growth in maize [13]. Bt and conventional isogenic maize was studied in France and Spain. Moderate to low levels of mycotoxins were found on both GM and conventional maize but significant differences were found in some areas. The presence of mycotoxins in Bt and conventional maize tested in central Europe concluded that under European conditions the use of Bt maize will only slightly reduce contamination of maize with mycotoxins produced by *Fusarium* fungi.

**Aflatoxin is a mycotoxin of global significance**

Aflatoxin is a naturally occurring mycotoxin that has attracted worldwide attention because it is a powerful toxin that damages genes. Two types pf mould - *Aspergillus flavus* and *Aspergillus parasiticus* - can produce the toxin. *Aspergillus flavus* is widespread in soil, and mouldy grains and nuts are commonly contaminated with the fungus. Aflatoxin production is favoured by moisture and high temperature. At least 13 different types of aflatoxin are produced and the most potent of these is aflatoxin B1. Grain testing for aflatoxin is provided by the Grain Inspection Packers and stockyard administration of USDA at a cost of $25 per test.

Liver cancer is the fifth most prevalent cancer in the world; and 80% of the cases are in the developing world. The primary causes of liver cancer in the developing world are the hepatitis B virus and aflatoxin, and most ferociously, the two combined. Limiting the contamination of foodstuffs by aflatoxin is a particularly important target for public health. However, aflatoxin contamination of food is also a major problem in the developed world.

The biological strategies explored to reduce or eliminate aflatoxin in food and feed include inoculating seeds with *Aspergillus* strains unable to produce aflatoxin, to replace toxin-producing strains in the soil. Crops resistant to *Aspergillus* are selected using traditional genetic methods with molecular marker-assisted selection or by direct genetic modification.

A workshop on aflatoxin elimination and fungal genomics provided an overview on ecological and genetic approaches to controlling aflatoxin. Cotton seed is an important crop for oil and feed. Strains of *Aspergillus flavus* without toxins were made to colonize sterile seed, a treatment that reduced the proportion of toxin-contaminated seed by over 50% the first year, and more in later years, providing an economic benefit to the producer. Non-toxin strains of *Aspergillus flavus* and *Aspergillus parasiticus* alone or in combination significantly reduced aflatoxin content of peanuts, a mixture of the two types of fungus being the most effective. Intra-specific competition is the basis of the biological control of aflatoxin. Sexually compatible strains fuse to form mycelia that produce aflatoxin, while vegetative incompatibility reactions result in the death of the fused mycelia resulting in reduced aflatoxin production. The strain of *Aspergillus flavus* used to reduced aflatoxin in cotton has been found to be defective in aflatoxin synthesis. Growth and mycotoxin production of *Aspergillus flavus* and *Aspergillus parasiticus* were inhibited by extracts of *Agave cactus* (the cactus used in tequila). Scaling up production of such natural inhibitors may be worthwhile.

Conventional plant breeding and conventional breeding using molecular markers are being used to select for genes conferring resistance to *Aspergillus* infection. Genetic resistance to *Aspergillus* and to aflatoxin production have been identified in maize but more work is needed to produce commercial varieties. It is becoming clear that traits for low aflatoxin production are quantitative trait loci (QTL) involving the additive effects of many genes, rather than a qualitative effect of one or a few genes. Such quantitative loci are the most important kind of genes in plant breeding, governing plant size, yield of grain, disease resistance, etc. QTL for low aflatoxin have been identified in maize. QTL have been pyramided (pyramiding is combining genes from many strains into a single strain by crossing) in maize combining resistance to *Aspergillus* with resistance to ear feeding insects, which wound the maize and allow fungal infection to take place. QTL provide the most promising long term protection against aflatoxin crop pollution.

Genetic engineering has focused on *Bacillus thuringiensis* (Bt) toxin to reduce wounding of the crop to allow fungal infestation or on more direct methods to limit fungal infestation. Maize was inoculated with *Aspergillus flavus* and infested with corn borers, Bt strains produced grain with less aflatoxin than isogenic lines lacking Bt. The experiment was interesting but employed artificial conditions, with neither natural fungal infection nor borer infestation. Peanuts modified with a Bt cry 1Ac gene were found to contain reduced levels of aflatoxin. Peanuts were also modified with a bacterial chloroperoxidase gene that resisted *Aspergillus* infection and showed promise in producing peanuts with reduced aflatoxin. The bacterial chloroperoxidase gene and several other candidate genes have been used to transform cotton but data on their effectiveness in reducing aflatoxin has not yet been obtained. A gene for a ribosomal inhibiting protein (RIP) was isolated from maize and used to transform peanut, RIP blocked fungal ribosomes without inhibiting the ribosomes of maize, and the effectiveness of the modified peanut has not yet been tested. In general the GM crops are not yet fully tested for their ability to reduce aflatoxin pollution of maize, peanut and cottonseed.

**Conclusion**

In conclusion, peer-reviewed publications indicate that organic foods are *not* more hazardous sources of mycotoxins than conventional foods. On the contrary, organic foods tend to be less contaminated, and may provide protection from the toxins. The use of GM maize has not provided major protection from mycotoxins in comparison to conventional maize.

There is a growing sense that the world of public relations has unleashed a propaganda campaign against organic food that has little or no scientific basis.

As far as aflatoxin is concerned, biological control using fungi unable to make the toxin to control those that produce it has proved effective in cotton, and conventional breeding using QTL to produce strains resistant to fungal infestation has proved useful in maize. Genetic modification has had preliminary success using Bt genes to prevent insect wounding followed by fungal infestation, though the toxicity of Bt genes and proteins is still untested and

unknown. Thus, the biological control and conventional breeding methods are the most immediately useful in reducing aflatoxin contamination of food and feed.

*ISIS Press Release 23/11/04*