Safer plants for a safer food

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Maize is the world's third major cereal crop with production reaching nearly 700 million tonnes in 2005 and the first one in Italy with 10,6 million tonnes of maize produced annually. Maize is the primary source of food for pigs and poultry, but it is also important for ruminants. For example, in Italy 82% of maize is used in animal food industry, 12% in starch industry, 4% for direct human consumption and 2% for other industrial applications, such as the production of paper, biodegradable plastics, solvents and biofuels. Thus, a large proportion of maize enters directly or indirectly the human food chain.

One of the major problems for maize cultivation is the occurrence of fungal infections, which lead to loss of yield and contamination of grains with mycotoxins, in particular aflatoxins and fumonisins. Fusarium fungi are responsible for the most abundant fungal infections in several wet zones such as northern Italy, causing contaminations of maize kernels with fumonisin B2, B3 and most frequently B1.

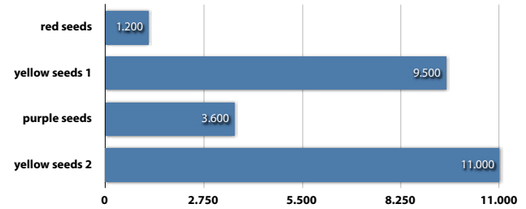
Grains and food contaminated with fumonisins are toxic to animals and result in hepatic and renal injury for most species, in addition to serious animal diseases in horses (leukoencephalomachia) and pigs (porcine pulmonary edema). Since 1993 the International Agency for Research on Cancer has classified fumonisin B1 as "possible carcinogenic to humans".

In 2006, the European Union established severe maximum levels for Fusarium toxins in maize and maize products. However, since the foreseen levels were not achievable for maize under certain weather conditions, they were recently increased to avoid a disruption of the market whilst maintaining a high level of public health protection (table 1).

Good agricultural and manufacturing practices, such as early planting and harvesting, moderate irrigation, moderate nitrogen fertilization and appropriate storage, can prevent to a certain degree the contamination by Fusarium fungi. However, climatic conditions during the growth of maize, in particular at flowering, have a major influence on the Fusarium toxin content. Another major risk factor is the attack of insects, especially corn borer, which transport fungal infection into seeds, leading to 15-80% loss of yield depending on the season. Bt transgenic maize, which is resistant to corn borer, can be a solution to lower fumonisins in maize, but legal restrictions do not allow cultivation of transgenic maize. In addition, Bt maize does not guarantee that the fumonisin level will be kept to a concentration not dangerous for human consumption, if the season is favourable to the invasion of pests. To eliminate fumonisin contaminations, it is therefore crucial to develop new maize hybrids more tolerant or resistant to fungal infections.

We have developed, by traditional breeding, different corn hybrids accumulating high content of flavonoids and/or anthocyanins not only in seeds, but also in stems and leaves. Flavonoids and anthocyanins are one of the most important classes of bioactives, giving the red and blue pigments widely present in fruits and vegetables. These compounds resulted to be a natural powerful defense system against fumonisin contamination during seed development, since flavonoid- and anthocyanin-rich seeds obtained from plants grown in northern Italy, during an unfavourable season such as 2006, showed up to 87% lower fumonisin content compared to yellow control seeds traditionally cultivated (fig. 1). Our plants can therefore limit the loss of yield due to fungal infestations and offer a safer source of food not only for animal feeding, but also for direct human consumption. In addition, using plant material not genetically modified, will overcome difficulties and limitations due to legal restrictions or consumer bias for ogm-free food.

Fig. 1: Fumonisin content in maize seeds in parts per billion (Field 2006)



On the other hand, several studies indicate the importance of anthocyanins also as antioxidant compounds, giving them a further added value as protective compounds against age-related diseases, such as cardiovascular disease and cancer. In a multidisciplinary collaboration within the European consortium FLORA, we have recently found that the amount of cardiac tissue that was damaged by ischemia was reduced by approximately 30% in rats fed our anthocyanin-rich maize (Toufekistan et al., 2008). Thus, the health promoting-effect of our anthocyanin-maize plants, together with the lower fumonisin content, represents an attractive combination to use this maize as functional food to improve health both in animals and in humans. A third advantage of these plants is that they represent a rich and economic source of anthocyanins, which can be used both as natural red colorants and functional ingredients. There is in fact a considerable demand for food colorants from natural sources as an alternative to synthetic colorants, since 25% of consumers perceive foods without artificial ingredients as desirable. Anthocyanin-enriched extracts are currently obtained from grape, specifically from the skin wastes of wine production. Other plant species having potential for a supply of anthocyanins are blueberry (900-4500 mg/Kg), blackberry and blackcurrant (600-3500 mg/Kg), but industrial extraction from these fruits is expensive due to a low yield of cultivation. With respect to this, our anthocyanin-rich plants can be an economic alternative, since anthocyanins are produced at much higher levels (17800 mg/Kg) in seeds and all other plant tissues. Furthermore, very high yields of maize production can be achieved.

The anthocyanins of purple corn have a long history as colorants, since they have been used for centuries in South America in the preparation drinks and desserts.

Table 1: Maximum levels of fumonisins B1+B2 in maize (Rule EU 1126/2007)

	ppb
Maize seeds	4000
Maize flours	
Particle size < 500 µm	2000
Particle size > 500 µm	1400
Maize products	
For direct human consumption	1000
Breakfast flakes and snacks	800

References:
Toufektsian et al., 2008 Chronic dietary intake of plant-derived anthocyanins protects the rat heart against ischemia-reperfusion injury. Journal of Nutrition 138: 747-752.

Patent PCT/EP2008/003253 (Corn having high pigment levels and reduced mycotoxin content, preparation and use thereof "- C. Tonelli, R. Pilu, K. Petroni)

On the web:

http://www.flora-flavonoids.eu