Is the *Bacillus thuringiensis* toxin more dangerous to human health than pesticides?

Unlike pesticide-treated crops, plants that are genetically modified to express the *Bacillus thuriengsis* (Bt) toxin are safe for human consumption without any negative consequences. Current research indicates that the human body does not provide a suitable environment for the Bt toxin to be effective (Kuiper *et al.* 2001), the Bt toxin exists in scarce amounts within food (Kuiper *et al.* 2001), and pesticides are highly toxic to humans and are easily dispersed (Gilden *et al.* 2009). The Bt toxin produces several crystalline (Cry) proteins that attack and destroy target cells by creating a pore in the cell membrane, disrupting the ion concentration and molecular transport regulation across the cell bilayer (Kwak *et al.* 1995). Consequently, water can freely and rapidly enter the target cell, causing osmotic lysis (Kwak *et al.* 1995).

Currently, there have been no observable toxic or allergenic effects on humans due to the consumption of crops expressing the Bt toxin. In order for the Bt toxin to be effective, Cry proteins must be solubilised and activated by enzymes in pH 10 environments (Betz *et al.* 2000). However, the human gastric system is highly acidic, which deactivates the enzymes that activate Cry proteins by cleaving their C-terminals (Haider and Ellar 1989). Consequently, Cry proteins cannot achieve the crucial structures that will enable them properly bind to the target cell's receptors. Another prerequisite for Bt toxin effectiveness is the presence of specific receptors for the Cry proteins (Kwak *et al.* 1995). Such specificity is proven through an experiment that removed a single alanine from a Cry protein, resulting in the protein being unable to bind to the specific receptors (Kwak *et al.* 1995). Although the Bt toxin affects some non-target species - close relatives of the target species -, immunocytochemical analysis of Cry proteins report that humans lack the

specific receptors entirely (Betz *et al.* 2000). Despite the fact that Cry proteins possess some allergenic qualities such as the tendency to induce an IgE immune response in rats, they do not pose a risk as an allergen because they are rapidly degraded by pepsin present in the human gastric system (Kuiper *et al*. 2001). In addition, Cry proteins are determined to possess an amino sequence that is drastically different from all known allergens (Kuiper *et al*. 2001).

Not only are Cry proteins unable to bind to specific receptors within the human body, but also they are found in very small amounts in genetically modified foods (Kuiper *et al*. 2001). In particular, after genetically modified maize crops underwent dry milling and alkaline cooking, only 0.1-0.2% of the original Cry proteins survived (Kuiper *et al*. 2001). Admittedly, some other Bt crops could retain more Cry proteins, even after extensive processing. However, an experiment was conducted to test effects of feeding rats Cry proteins with dosage levels of 10,000 times the amount typically produced by genetically modified crops (Kuiper *et al*. 2001). Resulting histopathograms indicated that Cry proteins did not bind to the rat cells, and thereby failing to induce any toxic effects (Kuiper *et al*. 2001). In order for the Bt toxin to be effective, a single Cry protein must bind to a receptor on the cell membrane, and then other Cry proteins bind to the first protein (Gill 1995). The quaternary protein complex eventually extends through membrane and forms a pore, stabilised by hydrogen bonding, disulphide bridges, and hydrophobic interactions (Gill *et al.* 1992). Thus, without an appreciable number of Cry proteins, pore formation does not occur effectively.

Unlike the Bt toxin, pesticides are proven to have acute and chronic toxic effects on humans (World Resources Institute 1999). Most pesticide poisonings are related to

organophosphates and carbamates, which negatively impact humans by rendering specific enzymes in the nervous system dysfunctional (World Resources Institute 1999). In a 1991 survey, 60% of Ecuador farmers reported to suffer from acute toxic effects such as headaches, skin rashes, flu-like symptoms, difficulty walking, and brain disorders because they were constantly exposed to pesticides (World Resources Institute 1999). Chronic toxic effects include neurological damage, immune system suppression, male sterility, and cancer (City of Toronto 2009). Unfortunately, farmers are especially vulnerable to pesticide toxins because the heat generated by the sun deters them from wearing proper protective equipment (World Resources Institute 1999). As a result, farmers inhale and ingest pesticides more frequently, in addition to exposing skin for pesticide contact (Gilden *et al.* 2009). While the Bt toxin is contained within the plant, pesticides can spread by wind travel and spill contamination (World Resources Institute 1999). Therefore, even non-farming citizens are susceptible to pesticide poisoning (World Resources Institute 1999). In addition, pesticides extend their damage to human health by affecting foetuses via the placenta (Gilden *et al.* 2009). Prenatal exposure to pesticides has been linked to the development of asthma and birth defects (Gilden *et al.* 2009). In contrast to pesticides, the Bt toxin protects human health as it reduces 93% of fungal toxins in corn, which are linked to esophageal and liver cancer (Betz *et al*. 2000). Also, Cry proteins do not accumulate in the body while pesticides can be found intact in bloodstream (Betz *et al*. 2000).

Evidently, genetically modified plants expressing the Bt toxin are significantly safer than crops treated with pesticides. Due to the acidity of the human gastric system, Cry proteins, which are responsible for inducing toxic effects, are unable to become activated and functional (Haider and Ellar 1989). Moreover, humans simply lack the specific

receptors that Cry proteins require to form a pore in the cell membrane (Haider and Ellar 1989). Accordingly, even high doses of Bt microbial preparations have no effect on humans when ingested (Kuiper *et al*. 2001). Conversely, pesticides are observed to have negative impacts on humans such as increasing the risk of cancer and birth defects (City of Toronto 2009). Unlike the Bt toxin, pesticides are especially dangerous because they can spread and poison people, even those who are not farmers (World Resources Institute 1999).