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Canadian Biotechnology Action Network

FACTSHEET
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Genetically engineered Bt insect-resistant corn poses human health risks

Research continues to find indicators of potential harm to humans from eating genetically engineered (genetically modified or GM) Bt insect-resistant corn.

Bt in GM crops is not equivalent to natural Bt.

Insect resistant corn plants are genetically engineered (genetically modified) to express a toxin from the soil bacteria *Bacillus thuringiensis* (Bt) which is known to harm the guts of particular types (orders) of insects but supposedly not others. The Bt (Cry) proteins bind to specific receptors on the membranes of mid-gut cells in certain pests, resulting in their rupture. Other insects, animals, and humans do not have those receptors and it is assumed that the Bt proteins are degraded in the gut and are not harmful to them. For example, in its most recent Bt corn approval summary (in 2021, for MON95379 from Bayer), Health Canada states that, "There are no known equivalent receptor sites for Cry proteins in mammalian species and the more acidic environment of the mammalian gut leads to degradation of Cry proteins; therefore, this toxic mode of action is not considered relevant to humans."[1] However, studies continue to undermine this assertion (see below).

Genetically modified (GM) Bt crops are also promoted as safe to non-target organisms on the basis that organic and conventional farmers have long used Bt as an insecticide spray that is benign to non-target organisms. However, the Bt toxins in GM crops are different from natural Bt in structure, function, and biological effects.[2]

Bt is shown to harm non-target insects.

Bt toxin proteins in genetically modified plants have been shown to impact insects that are not the intended targets. For example, spiders, wasps, ladybugs, and lacewings, which are predators that eat Bt-targeted insects, were negatively affected by ingesting prey that had consumed GM Bt toxins.[3] Additionally, a study published in 2023, funded by the French government, found that Bt Cry1A toxins disrupt normal growth and functioning of gut cells in fruit flies.[4] The editor's evaluation published with that study is that these findings raise the possibility of Bt toxins altering the intestinal lining of non-targeted animal species.

Bt is shown in animal feeding tests to harm mammals.

GM Bt toxins and GM Bt crops have also been found to have toxic effects on mammals in controlled animal feeding studies. Toxic effects and indications of toxicity have variously been observed in the blood, stomach, small intestine, liver, kidney, spleen, and pancreas, as well as immune responses, though the mechanism is not clear from these studies.[5] At least one study on mice shows Bt toxins binding to the guts.[6]

Health Canada does not undertake or require animal feeding studies in order to assess the safety of GM foods, and very few such tests appear to have been provided to Health Canada by companies for GM food safety assessments.[7] In at least four cases, long-term, peer-reviewed animal safety tests on GM corn were conducted years after Health Canada had approved these products as safe.[8] For example, Monsanto's corn NK603 was approved in 2001, four years before Monsanto published its own peer-reviewed 90-day animal feeding trial.[9] Further, Health Canada's approval was granted a full decade before the first-ever independent, long-term feeding study.[10] That much-debated study (Seralini et al, republished 2014) observed mammary tumours, and kidney and liver damage, leading to premature death.[11]

Interpreting the results of animal feeding studies is often controversial, with contested results. Many industry funded studies have observed statistically significant effects in GM-fed animals that the authors have, however, dismissed as not biologically relevant or not adverse.[12] In 2007, independent scientists analyzed data from Monsanto's 90-day animal feeding test on the GM corn MON863 (data that was released as a result of a court case) and published their argument that the data could not lead to a conclusion of safety.[13] In 2009, some of these same scientists examined data from tests on three commercialized GM corn - NK603, MON810, and MON863 – and argued that they show side-effects.[14]

Bt has allergenicity potential.

The Cry1Ab endotoxin, which is expressed in the most widely planted Bt corn varieties, exhibits three properties of food allergens: resistance to digestion in simulated gastric fluid, heat stability, and amino acid homology to a known allergen.[15]

The allergenic potential of Cry proteins was shown in the case of "StarLink" corn which was approved for animal feed use but not human consumption because of its suspected allergenic potential. The company's initial studies found that the Cry9c protein of StarLink was stable, and the US Environmental Protection Agency (EPA) concluded that it was therefore likely to survive processing and digestion, to possibly interact with the human immune system.[16] (Starlink corn widely contaminated the North American food system in 2000.[17])

Stacking Bt corn traits is not assessed for safety.

Most GM corn varieties on the market in Canada and the US are "stacked" with more than one Bt trait:

- Of the 26 Bt corn products on the market in Canada in 2023, 24 had more than one insect-resistant trait, and all were tolerant to one or more herbicides. Eighteen of the 26 products expressed more than two Bt toxins.[18]
- Of the GM corn varieties sold in the United States in 2023, on average each expressed 3.6 Bt/VIP traits for insect resistance (and 2.5 herbicide tolerant traits). Fifteen expressed five to seven Bt/VIP toxins.[19]

However, Health Canada does not assess the environmental or food safety of plants with stacked GM traits: if each of the individual GM traits (events or lines) has been approved, companies are free to stack these traits together without a government risk assessment. This means that there has been no investigation of possible combinatorial effects. For example, in 2010, Monsanto commercialized its first "Smartstax" corn that had eight different GM traits – six insect-resistant traits and two herbicide-tolerance traits – without a safety assessment by Canadian government regulators.[20]

Bt protein content is not carefully quantified and varies between tissues within plants and between plants growing under different environmental conditions.[21] There are no government maximum residue limits for Bt toxins in plants,[22] and the levels of these toxins exceed maximum tolerances for widely used corn insecticides.[23]

There is no monitoring to track potential harm.

In challenging the Mexican government's decision to restrict food uses of GM corn, the Government of Canada wrote (2024) that, "To date, Canada is not aware of any credible evidence of adverse health effects directly attributable to GM technology, or from GM derived foods, including corn."[24] However, there is no monitoring of GM foods or active, dedicated research. There have been no post-market studies on human populations to determine if there have been adverse health effects and, without tracing or labelling of GM foods, such studies are not possible.[25] In 2003, for example, the United States Society of Toxicology stated that, "verified records of adverse health effects are absent, although the current passive reporting system would probably not detect minor or rare adverse effects, nor can it detect a moderate increase in common effects such as diarrhea."[26]

The US government has only recently (2019) implemented a disclosure standard that requires a form of labelling for some GM foods. In Canada, there is no mandatory labelling of GM foods and the Canadian government does not monitor which GM foods are on the market.

There are risks of unintended changes in GMOs.

Tracking GM foods is necessary because unintended and unpredicted changes in genetically modified organisms (GMOs) can remain undetected for years. There is a high level of unintended traits observed, even in highly-selected commercialized genetically engineered plants, that suggests product developers and government regulators are not fully controlling for unintended effects.[27] Unintended effects, and mistakes, can be missed.

For example, in 2003, the structure of the transgene in Monsanto's GM corn MON810 was found to be different from the description provided to regulators by Monsanto,[28] in a discovery that suggests a genomic rearrangement involving the transgene insertion site. In 2013, European regulators also discovered a "hidden" gene present in many commercialized GM crops,[29] and, in 2019, foreign DNA was unexpectedly found in genome-edited hornless cows that were claimed to be free of foreign DNA.[30]

Dietary exposure is not carefully accounted for.

Canadian's exposure to GM corn has changed significantly, in both volume and form, since the first Bt plants were approved. Dietary exposure to GM corn and GM traits has increased significantly as more GM corn was planted, more corn ingredients have been incorporated into processed foods,[31] more Bt traits have been stacked together, and as GM traits were introduced to sweetcorn.

Health Canada maintains that its GM food safety evaluations include the most conservative estimates of dietary exposure and that, in corn for example, "dietary exposure is calculated taking into account every use of corn that exists, which would include whole kernel consumption."[32] And yet, for example, Health Canada's summary of its 2001 decision to approve the GM corn NK603 mentions dietary

exposure via animal feed and processed corn ingredients and explicitly stated that, "The 603 line of transgenic corn is not a sweet corn,"[33] and that, "Consequently, the dietary exposure of Canadians to this product is anticipated to be the same as for other lines of commercially available field corn."[34] However, ten years later, without any new government assessment, Monsanto introduced NK603 into sweet corn varieties in Canada.[35]

In Monsanto's response to a 2011 study (Aris et al.[36]), the company referred to dietary exposure saying, "Cry1Ab is present in GM maize intended primarily for animal feed and processing to food ingredients (corn syrup, starch, etc.), and human consumption is expected to be quite low."[37] However, independent scientists and the public have no access to the information behind Monsanto's stated expectation. Cry1Ab is now in 15 of the 19 GM Bt corn products that were on the market in Canada in 2023, including some sweet corn.[38]

The Canadian government does not have information about the dietary exposure of Canadians to GM foods beyond knowing that 88% of the corn grown for grain in Canada is GM and 81% of soy.[39] The government does not know, for example, how much GM sweet corn is grown, sold, and eaten in Canada.

Resources

Comments submitted to the USMCA Secretariat by Center for Food Safety, Bill Freese, March 15, 2024. https://www.centerforfoodsafety.org/files/usmca-ge-corn-comments--cfs-final-3-15-24_44453.pdf

GMO Myths and Truths (updated fourth Edition), John Fagan, Michael Antoniou, and Claire Robinson, Earth Open Source, 2018.

Are GM Foods Better for Consumers?, Canadian Biotechnology Action Network, 2015. www.gmoinquiry.ca/consumers

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The Canadian Biotechnology Action Network (CBAN) brings together 16 groups to research, monitor and raise awareness about issues relating to genetic engineering in food and farming. CBAN members include farmer associations, environmental and social justice organizations, and regional coalitions of grassroots groups. CBAN is a project of MakeWay's shared platform.

www.cban.ca/corn

Endnotes

1 Health Canada (2021) Lepidopteran Protected Corn – MON 95379. https://www.canada.ca/en/health-canada/services/food-nutrition/genetically-modified-foods-other-novel-foods/approved-products/lepidopteran-protected-corn/document.html

2 Latham J.R., Love M., Hilbeck A. (2017) The distinct properties of natural and GM cry insecticidal proteins. *Biotechnology and Genetic Engineering Reviews* 33(1), 62–96. https://www.tandfonline.com/doi/full/10.1080/02648725.2017.1357295

3 Examples include: He Y et al. (2024) Influence of Cry1Ab protein on growth and development of a predatory spider, Pardosa pseudoannulata, from protective perspectives. *Ecotoxicology and Environmental Safety*, 269, 115799 ; Liu W et al. (2023) Dietary exposure to Cry1Fa protein can lower microbiome biodiversity and induce shift in symbiotic microbial communities in wolf spider Pardosa astrigera. *Entomologia Generalis* 43(2): 471–479 ; Rolim G. et al. (2023) Effects of Bacillus thuringiensis on biological parameters of Tetrastichus howardi parasitizing Bt-resistant pupa of Spodoptera frugiperda, *Crop Protection* 172 ; Hilbeck A. et al. (2012) A controversy re-visited: Is the coccinellid Adalia bipunctata adversely affected by Bt toxins? *Environ Sci Eur* 24, 10 ; *Hilbeck A. et al (1998) Toxicity of Bacillus thuringiensis Cry1Ab toxin to the predator Chrysoperla carnea (Neuroptera: Chrysopidae). Environmental Entomology 27: 1255-1263.*

4 Jneid R. et al. (2023) Bacillus thuringiensis toxins divert progenitor cells toward enteroendocrine fate by decreasing cell adhesion with intestinal stem cells in Drosophila. *Elife*, Feb 27. https://doi.org/10.7554/eLife.80179

5 Examples include: Trabalza-Marinucci, Massimo et al. (2008) A three-year longitudinal study on the effects of a diet containing genetically modified Bt176 maize on the health status and performance of sheep, *Livestock Science* 113, 2–3; Séralini G.E. et al (2007) New analysis of a rat feeding study with a genetically modified maize reveals signs of hepatorenal toxicity. *Arch Environ Contam Toxicol* 52(4), 596-602; de Vendômois J.S. et al (2009) A comparison of the effects of three GM corn varieties on mammalian health. *Int J Biol Sci* 5(7): 706–726; Fares N.H., El-Sayed A.K. (1998). Fine structural changes in the ileum of mice fed on delta-endotoxin-treated potatoes and transgenic potatoes. Nat Toxins 6(6), 219-33; El-Shamei Z.S. et al (2012). Histopathological changes in some organs of male rats fed on genetically modified corn (Ajeeb YG), *Journal of American Science* 8(10), 684–696; Gab-Alla A.A. et al (2012). Morphological and biochemical changes in male rats fed on genetically modified corn (Ajeeb YG). Journal of American Science 8(9), 1117–1123.; Finamore A. et al (2008). Intestinal and peripheral immune response to MON810 maize ingestion in weaning and old mice. *J Agric Food Chem* 56(23), 11533-9.

6 Roberto I. Vázquez-Padrón, Joel Gonzáles-Cabrera, Carlos García-Tovar, Leticia Neri-Bazan, Rubén Lopéz-Revilla, Manuel Hernández, Leticia Moreno-Fierro, Gustavo A. de la Riva (2000) Cry1Ac Protoxin from Bacillus thuringiensis sp. kurstaki HD73 Binds to Surface Proteins in the Mouse Small Intestine, Biochemical and Biophysical Research Communications, Volume 271, Issue 1, 2000, Pages 54-58, ISSN 0006-291X, https://doi.org/10.1006/bbrc.2000.2584.

7 E. Ann Clark (2000) Food Safety of GM Crops in Canada: toxicity and allergenicity. http://www.plant.uoguelph.ca/research/homepages/eclark/safety.htm

8 See Canadian Biotechnology Action Network (2015) Are GM Foods Better for Consumers? www.gmoinquiry.ca/consumers

9 Hammond et al. (2004) "Results of a 13 week safety assurance study with rats fed grain from glyphosate tolerant corn." Food Chem Toxicol 42:1003–1014.

10 Canadian Biotechnology Action Network (2012) Séralini, et al. GM corn safety study in context: Introduction and basic comparison, September 26. https://cban.ca/wp-content/uploads/CBAN-Factsheet-Seralini-Corn-Safety-Study-2013-3.pdf

11 Séralini, GE., Clair, E., Mesnage, R. *et al. (2014) Republished study: long-term toxicity of a Roundup herbicide and a Roundup-tolerantgenetically modified maize. Environ Sci Eur* 26, 14. https://doi.org/10.1186/s12302-014-0014-5

12 Fagan, John, Michael Antoniou, and Claire Robinson (2018) GMO Myths and Truths (updated fourth Edition) Earth Open Source. Page 97.

13 Séralini GE, D. Cellier and JS de Vendomois (2007) New analysis of a rat feeding study with a genetically modified maize reveals signs of hepatorenal toxicity. Arch Environ Contam Toxicol. 2007 May;52 (4):596-602. March 13.

14 de Vendômois, J.S., Roullier, F., Cellier, D., Séralini, G.E. (2009). A Comparison of the Effects of Three GM Corn Varieties on Mammalian Health. *International Journal of Biological Sciences*, 5(7), 706-726. https://doi.org/10.7150/ijbs.5.706.

15 Freese B. (2024) Comments submitted to the USMCA Secretariat by Center for Food Safety, March 15. https://www.centerforfoodsafety.org/files/usmca-ge-corn-comments--cfs-final-3-15-24_44453.pdf

16 Taylor, Michael R. and Tick, Jody S. (2001) The StarLink Case: Issues for the Future. Pew Initiative on Food and Biotechnology. October.

17 Canadian Biotechnology Action Network (2019) GM Contamination in Canada: The failure to contain living modified organisms – incidents and impacts. www.cban.ca/ContaminationReport2019

18 Canadian Corn Pest Coalition (2023) Bt Corn Products Available as of March 2023. https://cornpest.ca/wp-content/uploads/2023/03/Canadian-Bt-Traits-Table-March-2023-English-4.pdf

19 Benbrook CM and Klein K., (2024) Comments Submitted to the USMCA Genetically Engineered Corn Dispute Resolution Tribunal, Friends of the Earth, March 13. https://foe.org/wp-content/uploads/2024/03/Friends-of-the-Earth-USMCA-Mexico-Corn-comments.pdf

20 Minister of Health, Government of Canada (2009) letter to Canadian Biotechnology Action Network. October 7. Posted at https://cban.ca/wp-content/uploads/Minister-of-Health-SmartStax-response-to-CBAN-2009-Oct.pdf

21 Trtikova M, Wikmark OG, Zemp N, Widmer A, Hilbeck A. Transgene expression and Bt protein content in transgenic Bt maize (MON810) under optimal and stressful environmental conditions. PLoS One. 2015 Apr 8;10(4):e0123011. doi: 10.1371/journal.pone.0123011. PMID: 25853814; PMCID: PMC4390241.

22 Freese B. (2024) Comments submitted to the USMCA Secretariat by Center for Food Safety, March 15. https://www.centerforfoodsafety.org/files/usmca-ge-corn-comments--cfs-final-3-15-24_44453.pdf

23 Benbrook CM and Klein K., (2024) Comments Submitted to the USMCA Genetically Engineered Corn Dispute Resolution Tribunal, Friends of the Earth, March 13. https://foe.org/wp-content/uploads/2024/03/Friends-of-the-Earth-USMCA-Mexico-Corn-comments.pdf ; Benbrook, C.M. (2012) Impacts of genetically engineered crops on pesticide use in the U.S. -- the first sixteen years. *Environ Sci Eur* **24, 24.**

24 Government of Canada (2024) Canada's Third Party Written Submission: Mexico – Measures Concerning Genetically Engineered Corn, Paragraph 8. March 15. Posted at www.cban.ca/Canadatradesubmission

25 Hilbeck et al. (2015) No scientific consensus on GMO safety. Environmental Sciences Europe 27:4. DOI 10.1186/s12302-014-0034-1

26 Society of Toxicology (2003). Position Paper: The Safety of Genetically Modified Foods Produced through Biotechnology. *Toxicological Sciences* 71(1), 2–8. https://doi.org/10.1093/toxsci/71.1.2

27 Wilson, A.K. (2021) Will gene-edited and other GM crops fail sustainable food systems? In A. Kassam and L. Kassam (Eds.) *Rethinking Food and Agriculture: New Ways Forward* (pp. 247-284). Woodhead Publishing.

28 Hernández M., M. Pla , T. Esteve, S.Prat, P. Puigdomènech and A. Ferrando. (2003) A specific real-time quantitative PCR detection system for event MON810 in maize YieldGard® based on the 3_-transgene integration sequence. *Transgenic Research* 12, 179–189. DOI: 10.1023/a:1022979624333

29 Podevin, N. and P. Du Jardin (2012) Possible consequences of the overlap between the CaMV 35S promoter regions in plant transformation vectors used and the viral gene VI in transgenic plants. *GM Crops & Food* 3(4):296-300. doi: 10.4161/gmcr.21406

30 Norris, A.L., Lee, S.S., Greenlees, K.J., Tadesse, D.A., Miller, M.F. & Lombardi, H.A. (2020) Template plasmid integration in germline genome-edited cattle. *Nature Biotechnology* 38: 163-164.

31 Sismondo, Christine (2006) Children of the Corn. Toronto Star. May 14. http://michaelpollan.com/reviews/children-of-the-corn/

32 Bourbonnière L., Section Head, Novel Foods Section, Health Canada (2011) to Lucy Sharratt, Coordinator, Canadian Biotechnology Action Network. July 28.

33 Health Canada (2001) Roundup Ready® Corn Line 603. April. http://www.hc-sc.gc.ca/fn-an/gmf-agm/appro/roundup_ready_corn_603-mais_603_roundup_ready-eng.php

34 Health Canada (2001) Health Canada, Decision Document 2002-35: Determination of the Safety of Monsanto Canada Inc.'s Roundup Ready™ Corn (Zea mays L.) Line 603. 2001. Roundup Ready® Corn Line 603. April. http://www.hc-sc.gc.ca/fn-an/gmf-agm/appro/roundup_ready_corn_603-mais_603_roundup_ready-eng.php

35 Bourbonnière, L, Section Head, Novel Foods Section, Health Canada email to Lucy Sharratt, Coordinator, Canadian Biotechnology Action Network. July 28, 2011.

36 Aris A, Leblanc S. (2011) Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada. Reprod Toxicol. 2011 May; 31(4):528-33. doi: 10.1016/j.reprotox.2011.02.004. Epub 2011 Feb 18. PMID: 21338670.

37 Goldstein, Daniel A., Samuel Dubelman, David Grothaus and Bruce G. Hammond (2012) Letter to the Editor, Comment: Aris and Leblanc "Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada", Reproductive Toxicology 33 (2012) 120– 121.

38 Canadian Corn Pest Coalition (2023) Bt Corn Products Available as of March 2023. https://cornpest.ca/wp-content/uploads/2023/03/Canadian-Bt-Traits-Table-March-2023-English-4.pdf

39 Statistics Canada (2023) Table 32-10-0042-01 Estimated areas, yield, production of corn for grain and soybeans, using genetically modified seed, in metric and imperial units. https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3210004201