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Are Transgenic Food Crops Safe For Human Consumption?

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The current controversy about genetically modified crops should be appreciated by Community Medicine specialists. GM crops are plants used in agriculture, the DNA of which has been modified using genetic engineering techniques. This is usually done to introduce a new trait to the plant which does not occur naturally in the species, like resistance to certain pests, or diseases, or environmental conditions, reduction of spoilage, or resistance to chemical treatments or improving the nutrient profile of the crop.[1]

Farmers in the world have largely adopted GM technology at present.In 2012, GM crops were planted in 28 countriesof which20 were developing countries. It was also the first year in which developing countries grew 52% of the total GM harvest. Approximately 17.3 million farmers grew GM crops; and 90% of them were small-land holding farmers in developing countries. Farmers grew 11 different transgenic crops commercially on 160 million hectares of land.[2]

Scientists say that food derived from GM crops poses no greater risk to human health than conventional food. GM crops also provide a number of ecological benefits. However, opponents have objected to GM crops per se on several grounds, including environmental

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concerns, whether food produced from GM crops is safe, whether GM crops are needed to address the world's food needs, and economic concerns raised by the fact these organisms are subject to intellectual property law.[3]

We know that Food biotechnology is that branch of food science in which modern biotechnological techniques are applied to improve food production or food itself. Different biotechnological processes have been used throughout the ages to create and improve new food products and beverages,like industrial fermentation, plant cultures, and genetic engineering.The use of food biotechnology dates back to thousands of years ago to the time of the Sumerians and Babylonians. These groups of people used yeast to make fermented beverages such as beer. Plant enzymes such as malts was also used thousands of years ago, before there was even an understanding about enzymes. Invention of the microscope by Anton van Leeuwenhoek allowed humans to discover microorganisms which could then be used in food production. Food biotechnology took a giant leap in1871 when Louis Pasteur discovered that heating juices to a certain temperature would kill off bad bacteria which would affect wine and fermentation. This process was then applied to milk production, heating milk to a certain temperature to improve food hygiene.[4]

Then came the discovery of enzymes and their role in fermentation and digestion of foods. Typical industrial enzymes used plant and animal extracts, but this was later substituted by microbial enzymes like chymosin in the production of cheese. The enzyme rennet was extracted from the stomach lining of the cow. Scientists later started using a recombinant chymosin in order for milk clotting, resulting in cheese curds. Food enzyme production using microbial enzymes was the first application of Genetically modified organisms. [5]

Scientists first discovered that DNA can transfer between organisms in 1946.[6] The first genetically modified plant was produced in 1983, using an antibiotic-resistant tobacco plant.[7] In 1994, the transgenic FlavrSavr tomato was approved by the FDA for marketing in the US - the modification allowed the tomato to delay ripening after picking. In the early 1990s, recombinant chymosin was approved for use in several countries, replacing rennet in cheese-making.[8] In 1995 US gave approval to transgenic crops like canola with modified oil composition (Calgene), *Bacillus thuringiensis* (Bt) corn/maize (Ciba-Geigy), cotton resistant to the herbicide bromoxynil (Calgene), Bt cotton(Monsanto), Bt potatoes (Monsanto), soybeans resistant to the herbicide glyphosate (Monsanto), virus-resistant squash (Monsanto-Asgrow), and additional delayed ripening tomatoes (DNAP, Zeneca/Peto, and Monsanto).In 2000, with the creation of golden rice, scientists genetically modified food to increase its nutrient value for the first time. In 2013, roughly 85% of corn, 91% of soybeans, and 88% of cotton produced in the United States were genetically modified.[9]

Genetically engineered plants are generated in a laboratory by altering their genetic makeup and are tested in the laboratory for desired qualities. This is usually done by adding one or more genes to a plant's genome using genetic engineering techniques. Most genetically modified plants can be modified in a directed way by gene addition (cloning) or gene subtraction (genes are removed or inactivated). Plants are now engineered for insect resistance, fungal resistance, viral resistance, herbicide resistance, changed nutritional content, improved taste, and improved storage.[10]

Once satisfactory plants are produced, sufficient seeds are gathered, and the companies producing the seed need to apply for regulatory approval to field-test the seeds. If these field tests are successful, the company must seek regulatory approval for the crop to be marketed. Once that approval is obtained, the seeds are mass-produced, and sold to farmers. The farmers produce genetically modified crops, which also contain the inserted gene and its protein product. The farmers then sell their crops as commodities into the food supply market, in countries where such sales are permitted.

Papaya has been genetically modified to resist the ringspot virus. 'SunUp' is a transgenic red-fleshed Sunset cultivar that is homozygous for the coat protein gene of PRSV; 'Rainbow' is a yellow-fleshed F1 hybrid developed by crossing 'SunUp' and nontransgenic yellow-fleshed 'Kapoho'. In the early 1990s, Hawaii’s papaya industry was facing disaster because of the deadly papaya ringspot virus. Then the genetic modification was done and it saved the papaya industry. Today, 80% of Hawaiian papaya is genetically engineered.[11]

The New Leaf potato, brought to market by Monsanto in the late 1990s, was developed for the fast food market, but was withdrawn from the market in 2001 after fast food retailers did not pick it up and food processors ran into export problems. There are currently no transgenic potatoes marketed for human consumption. In October 2011 BASF requested cultivation and marketing approval as a feed and food from the EFSA for its Fortuna potato, which was made resistant to late blight by adding two resistance genes, blb1 and blb2, which originate from the Mexican wild potato Solanumbulbocastanum. However in February 2013 BASF withdrew its application. In May 2013, the J.R. Simplot Company sought approval for their "Innate" potatoes from USDepartment of Agriculture, which contain 10 genetic modifications that prevent bruising and produce less acrylamide when fried than conventional potatoes; the inserted genetic material comes from cultivated or wild potatoes, and leads to RNA interference, which prevents certain proteins from being formed.[12]

In 2012, an apple has been genetically modified to resist browning, known as the Nonbrowning Arctic apple produced by Okanagan Specialty Fruits, was awaiting regulatory approval in the US and Canada. A gene in the fruit has been modified such that the apple produces less polyphenol oxidase, a chemical that hastens the browning of apples. [13]

Corn used for food has been genetically modified to be resistant to various herbicides and to express a protein from Bacillus thuringiensis that kills certain insects. About 90% of the corn grown in the US has been genetically modified.[14]

Soybean seeds contain about 20% oil. To extract soybean oil from the seeds, the soybeans are cracked, adjusted for moisture content, rolled into flakes and solvent-extracted with commercial hexane. The remaining soybean meal has a 50% soy protein content. The meal is 'toasted' (a misnomer because the heat treatment is with moist steam) and ground in a hammer mill. Ninety-eight percent of the U.S. soybean crop is used for livestock feed. Part of the remaining 2% of soybean meal is processed further into high protein soy products that are used in a variety of foods, such as salad dressings, soups, meat analogues, beverage powders, cheeses, nondairy creamer, frozen desserts, whipped topping,infant formulas, breads, breakfast cereals, pastas, and pet foods. Processed soy protein appears in foods mainly in three forms: soy flour, soy protein isolates, and soy protein concentrates.[15]

Corn oil and soy oil, already free of protein and DNA, are sources of lecithin, which is widely used in processed food as anemulsifier. Lecithin is highly processed. Therefore, GM protein or DNA from the original GM crop from which it is derived is often undetectable with standard testing practices - in other words, it is not substantially different from lecithin derived from non-GM crops. Nonetheless, consumer concerns about genetically modified food have extended to highly purified derivatives from GM food, like lecithin.This concern led to policy and regulatory changes in Europe in 2000, when Regulation (EC) 50/2000 was passed which required labelling of food containing additives derived from GMOs, including lecithin. Because it is nearly impossible to detect the origin of derivatives like lecithin with current testing practices, the European regulations require those who wish to sell lecithin in Europe to use a meticulous system of Identity preservation (IP).[15]

Most vegetable oil used in the US is produced from several crops, including the GM

crops canola, corn, cotton, andsoybeans Vegetable oil is sold directly to consumers as cooking oil, shortening, and margarine, and is used in prepared foods.[16]

There may be a very tiny amount of, protein or DNA from the original GM crop in vegetable oil. Vegetable oil is made of triglycerides extracted from plants or seeds and then refined, and may be further processed via hydrogenation to turn liquid oils into solids. The refining process removes all, or nearly all non-triglyceride ingredients.[17]

Starch or amylum is a carbohydrate consisting of a large number of glucose units joined by glycosidic bonds. This polysaccharide is produced by all green plants as an energy store. Pure starch is a white, tasteless and odourless powder that is insoluble in cold water or alcohol. It consists of two types of molecules: the linear and helical amylose and the branched amylopectin. Depending on the plant, starch generally contains 20 to 25% amylose and 75 to 80% amylopectin by weight.[18]

To make corn starch, corn is steeped for 30 to 48 hours, which ferments it slightly. The germ is separated from the endosperm and those two components are ground separately (still soaked). Next the starch is removed from each by washing. The starch is separated from the corn steep liquor, the cereal germ, the fibers and the corn gluten mostly in hydrocyclones and centrifuges, and then dried. This process is calledwet milling and results in pure starch. The products of that pure starch contain no GM DNA or protein.[19]

Starch can be further modified to create modified starch for specific purposes,including creation of many of the sugars in processed foods like

Maltodextrin, various glucose syrups,Dextrose, High fructose syrup,Sugar alcohols(such as maltitol, erythritol, sorbitol, mannitol).[19,20]

After deregulation in 2005, glyphosate-resistant sugar beet was extensively adopted in the United States. 95% of sugar beet acres in the US were planted with glyphosate-resistant seed in 2011.Sugar beets that are herbicide-tolerant have been approved in Australia, Canada, Colombia, EU, Japan, Korea, Mexico, New Zealand, Philippines, Russian Federation, Singapore, and USA.[21]

The food products of sugar beets are refined sugar and molasses. Pulp remaining from the refining process is used as animal feed. The sugar produced from GM sugarbeets is highly refined and contains no DNA or protein—it is just sucrose, the same as sugar produced from non-GM sugarbeets.[22]

Rennet is a mixture of enzymes used to coagulate cheese. Originally it was available only from the fourth stomach of calves, and was scarce and expensive, or was available from microbial sources, which often suffered from bad tastes. With the development of genetic engineering, it became possible to extract rennet-producing genes from animal stomach and insert them into certain bacteria, fungi or yeasts to make them produce chymosin, the key enzyme in rennet. The genetically modified microorganism is killed after fermentation and chymosin isolated from the fermentation broth, so that the Fermentation-Produced Chymosin (FPC) used by cheese producers is identical in amino acid sequence to the animal source. The majority of the applied chymosin is retained in the whey and some may remain in cheese in trace quantities and in ripe cheese, the type and provenance of chymosin used in production cannot be determined.[23]

FPC was the first artificially produced enzyme to be registered and allowed by the US Food and Drug Administration. FPC products have been on the market since 1990 and have been considered in the last 20 years the ideal milk-clotting enzyme. In 1999, about 60% of US hard cheese was made with FPC and it has up to 80% of the global market share for rennet.By 2008, approximately 80% to 90% of commercially made cheeses in the US and Britain were made using FPC. Today, the most widely used Fermentation-Produced Chymosin (FPC) is produced either by the fungus *Aspergillusniger* and commercialized under the trademark CHY-MAX® by the Danish company Chr.

Hansen, or produced by *Kluyveromyceslactis* and commercialized under the trademark MAXIREN® by the Dutch company DSM.[24]

Livestock and poultry are raised on animal feed, much of which is composed of the leftovers from processing crops, including GM crops. For example, approximately 43% of a canola seed is oil. What remains is a canola meal that is used as an ingredient in animal feed and contains protein from the canola. Likewise, the bulk of the soybean crop is grown for oil production and soy meal, with the high-protein defatted and toasted soy meal used as livestock feed and dog food. 98% of the U.S. soybean crop is used for livestock feed. As for corn, in 2011, 49% of the total maize harvest was used for livestock feed (including the percentage of waste from distillers grains). "Despite methods that are becoming more and more sensitive, tests have not yet been able to establish a difference in the meat, milk, or eggs of animals depending on the type of feed they are fed. It is impossible to tell if an animal was fed GM soy just by looking at the resulting meat, dairy, or egg products. The only way to verify the presence of GMOs in animal feed is to analyze the origin of the feed itself."[25]

In some countries, recombinant bovine somatotropin (also called rBST, or bovine growth hormone or BGH) is approved for administration to dairy cows in order to increase milk production. rBST may be present in milk from rBST treated cows, but it is destroyed in the digestive system and even if directly injected, has no direct effect on humans. TheFood and Drug Administration, World Health Organization, American Medical Association, American Dietetic Association, and the National Institute of Health have independently stated that dairy products and meat from BST treated cows are safe for human consumption. However, on 30 September 2010, the United States Court of Appeals, Sixth Circuit, analyzing evidence submitted in briefs, found that there is a "compositional difference" between milk from rBGH-treated cows and milk from untreated cows.The court stated that milk from rBGH-treated cows has: increased levels of the hormone Insulin-like growth factor 1 (IGF-1); higher fat content and lower protein content when produced at certain points in the cow's lactation cycle; and more somatic cell counts, which may "make the milk turn sour more quickly.”[26]

Thus the controversy goes on and researchers must give proper direction to public health specialists so that correct policy making will drive away the cobwebs in front of us. There is an immediate need for policy makers to do a brainstorming regarding the commercialisation of GM crops. Also the Public Health specialists should come up with clear directions for policy makers on the pros and cons of consumption of GM crops. And last but not least researchers should come up with meticulous research on this issue so that the results of such research can be directed towards correct decision making in this contentious issue.

References:

1. *A decade of EU-funded GMO research (2001-2010)* (PDF). Directorate-General for Research and Innovation. Biotechnologies, Agriculture, Food. European Union. 2010. doi:10.2777/97784. ISBN 978-92-79-16344-9
2. Hope, Alan (3 April 2013, News in brief: The Bio Safety Council..." Flanders Today, Page 2, Retrieved 27 April 2013
3. Ronald, Pamela (2011). "Plant Genetics, Sustainable Agriculture and Global Food Security". *Genetics* **188** (1): 11–20.
4. Bock, R. (2010). "The give-and-take of DNA: horizontal gene transfer in plants".*Trends in Plant Science* **15** (1): 11–22. doi:10.1016/j.tplants.2009.10.001.PMID 19910236.
5. Lederberg J, Tatum EL (1946). "Gene recombination in *E. coli*". *Nature* **158**(4016):58. Bibcode:1946Natur.158..558L. doi:10.1038/158558a0.
6. Morgante, M.; Brunner, S.; Pea, G.; Fengler, K.; Zuccolo, A.; Rafalski, A. (2005). "Gene duplication and exon shuffling by helitron-like transposons generate intraspecies diversity in maize". *Nature Genetics* **37** (9): 997–1002.doi:10.1038/ng1615. PMID 16056225. edit
7. Conner AJ, Glare TR, Nap JP. The release of genetically modified crops into the environment. Part II. Overview of ecological risk assessment Plant J. 2003 Jan;33(1):19-46
8. Bruening, G.; Lyons, J. M. (2000). "The case of the FLAVR SAVR tomato". *California Agriculture* **54** (4): 6–7. doi:10.3733/ca.v054n04p6.

9. Catchpole, G. S. (2005). "Hierarchical metabolomics demonstrates substantial compositional similarity between genetically modified and conventional potato crops". *Proceedings of the National Academy of Sciences* **102** (40): 14458.Bibcode:2005PNAS..10214458C. doi:10.1073/pnas.0503955102
10. Ronald, Pamela and McWilliams, James Genetically Engineered DistortionsThe New York Times, 14 May 2010, Retrieved 26 July 2010.
11. Ronald, Pamela and McWilliams, James Genetically Engineered DistortionsThe New York Times, 14 May 2010, Mentions that "in the early 1990s, Retrieved 26 July 2010
12. MacKenzie, Deborah (2 August 2008). "How the humble potato could feed the world" (cover story) *New Scientist* No 2667 pp.30–33.
13. Alexander J. Stein and Emilio Rodríguez-Cerezo (2009) The global pipeline of new GM crops, Implications of asynchronous approval for international trade. Institute for Prospective Technological Studies of the European Commission Joint Research Centre. Retrieved 18 January 2011
14. James, Clive (2010) Global Status of Commercialized Biotech/GM Crops: 2010 ISAAA Brief No. 42. ISAAA: Ithaca, NY. Retrieved 10 October 2011
15. Haroldsen, Victor M.; Paulino, Gabriel; Chi-ham, Cecilia; Bennett, Alan B. (2012). "Research and adoption of biotechnology strategies could improve California fruit and nut crops". *California Agriculture* **66** (2): 62–69.doi:10.3733/ca.v066n02p62.
16. Carpenter J. &Gianessi L. (1999). Herbicide tolerant soybeans: Why growers are adopting Roundup Ready varieties. AgBioForum, 2(2), 65-72.
17. Rennie, Rob and Heffer, Patrick Anticipated Impact of Modern Biotechnology on Nutrient Use Efficiency TFI/FIRT Fertilizer Outlook and Technology Conference 16–18 November 2010, Savannah (GA), Web page. Retrieved 25 April 2011
18. Michael Eisenstein Plant breeding: Discovery in a dry spell Nature 501, S7–S9 (26 September 2013) Published online 25 September 2013

19. Carpenter J. &Gianessi L. (1999). Herbicide tolerant soybeans: Why growers are adopting Roundup Ready varieties. AgBioForum, 2(2), 65-72.
20. L. P. Gianessi, C. S. Silvers, S. Sankula and J. E. Carpenter. Plant Biotechnology: Current and Potential Impact for Improving Pest management in US Agriculture, An Analysis of 40 Case Studies (Washington, D.C.: National Center for Food and Agricultural Policy, 2002), 5–6
21. Carpenter J. &Gianessi L. (1999). Herbicide tolerant soybeans: Why growers are adopting Roundup Ready varieties. AgBioForum, 2(2), 65-72.
22. L. P. Gianessi, C. S. Silvers, S. Sankula and J. E. Carpenter. Plant Biotechnology: Current and Potential Impact for Improving Pest management in US Agriculture, An Analysis of 40 Case Studies (Washington, D.C.: National Center for Food and Agricultural Policy, 2002), 5–6
23. Lemaux, Peggy (19 February 2008). "Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I)". *Annual Review of Plant Biology* **59**: 771–812. doi:10.1146/annurev.arplant.58.032806.103840.PMID 18284373. Retrieved 9 May 2009.
24. Wright, Brierley How Healthy Is Canola Oil Really? "Eating Well", March/April 2010 edition, Mentions 93% of rapeseed in the US is GM. Retrieved 26 July 2010
25. Johnson, Stanley R. et al Quantification of the Impacts on US Agriculture of Biotechnology-Derived Crops Planted in 2006 National Center for Food and Agricultural Policy, Washington DC, February 2008. Retrieved 12 August 2010.
26. Beckmann, V., C. Soregaroli, J. Wesseler (2011): Coexistence of genetically modified (GM) and non-modified (non GM) crops: Are the two main property rights regimes equivalent with respect to the coexistence value? In "Genetically modified food and global welfare" edited by Colin Carter, GianCarloMoschini and Ian Sheldon, pp 201-224. Volume 10 in Frontiers of Economics and Globalization Series. Bingley, UK: Emerald Group Publishing