Viewpoint: There’s no such thing as a ‘GMO,’ and the history of potatoes illustrates why the term is ‘nonsensical’

The expression “genetically modified organisms” (“GMOs”) is not only void of scientific value, but has negative effects on agricultural progress and food policy.

The history of crop domestication offers many examples of failed experiments: each unlucky outcome, considered on the merit of its individual pros and cons, was discarded if unsatisfactory, whether it was created using recombinant DNA or other biotech methods.

“Anti-GMOers” show a peculiar, recurrent absence of logic when they demonize “GMOs” as a supposed whole, on the basis of alleged dangers related to this or that single DNA-spliced variety. It is an illicit pluralization.

The detrimental consequences of applying the nonsensical “GMO” pseudo-category in the agri-food biotech area is shown through several examples taken from the world of potatoes, with different stories and trajectories of recombinant DNA, mutagenized and traditionally bred varieties.

Scholars and science communicators should abandon the use of the misleading “GMO” term and of the related warped meme.

1.“GMO(S)” are an epistemological and empirical fallacy

The expression “genetically modified organisms” is scientifically meaningless and semantically dubious.

“GMOs” are currently defined, in short, as “organisms obtained via recombinant DNA techniques”; such description is very problematic, for two main reasons.

1. The boundary which should distinguish these biotech methods and their outcomes from other, similar agri-food products (e.g. those deriving from traditional hybridizations, physical/chemical mutagenesis or several methods used in labs) is foggy and shifting: “Emerging genetic technologies have blurred the distinction between genetic engineering and conventional plant breeding” (National Academy of Sciences 2016, xviii).

2. If we stick to the core of the pseudo-concept, “GMO” is equated to “transgenic”, i.e. organisms whose genetic make-up has been modified in one or a few tiny spots, inserting some DNA sequences taken from other species (placed close or far on the tree of life) in order to have the modified bacterium or plant or animal express new traits (e.g. resistance to pests, tolerance to herbicides, enhanced level of nutrients, capacity to produce useful substances, improved ability to stand abiotic stresses such as drought or flood, etc.): even if we adopt such a narrow approach, no common denominator can be found among these diverse products, nothing that can allow us to give coherence to this extremely heterogeneous bunch.

nongmofb large

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There is no such thing as “GMOity” or “GMOness”.

The “GMO” blunder is falsely based on a “genomic misconception” (Ammann 2014), i.e. the wrong idea that certain biotech processes should be singled out (and subject to sectarian regulation). Not a single reliable, peer-reviewed paper has ever been published which tries to give scientific justifications for considering the direct DNA-tinkering (as part of “green” biotechnologies) with plants, animals or microorganisms as *inherently* dangerous – or indeed safe. A sound block of studies, funded by the European Union, confirms that scientific assumption: “The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are not *per se* more risky than e.g. conventional plant breeding technologies” (European Commission 2010, 16).

As an immediate consequence of this impossible categorization, the question whether “GMOs”, taken as a supposed ensemble, are healthy or noxious does not make sense: wouldn’t it be silly to ask whether mushrooms are safe? (Note that “mushrooms” is a category with taxonomic value; “GMO(s)” is not.)

To be clear, a negative impact on health can derive from *any* agri-food product, *"GMO" or otherwise*; yet, accurate examination of the results from each individual experiment does work: we got rid of ill-fated recombinant DNA varieties of barley, canola, maize, rice, wheat, potato, etc. and traditionally bredvarieties of squash, celery and potato (Haslberger 2003, 739-740; Kuiper et al. 2001, 516). Beforeentering the market, each agri-food product must be singularly evaluated: one by one, case by case."GMO" or otherwise should make no difference at all. Unsatisfactory outcomes just end up in the wastebin. Using the former analogy, we may say that we separate the good mushrooms from the bad ones.

> In summary, the overwhelming scientific consensus has a double basis (Tagliabue 2016): from a theoretical point of view, the distinction between "GMOs" and the rest of the agri-food world is groundless and misleading; from a practical point of view, the safety of the currently commercialized products which were produced with recombinant DNA has been confirmed by many hundreds of studies (Nicolia et al. 2012. See also http://gmopundit.blogspot.it/p/450-published-safety-assessments.html) and from their use in real life, for instance as feed for billions of animals (see Van Eenennaam and Young 2014). The EU alone imports around 40 Mt each year of soybeans or products thereof to satisfy the need for proteins in feed, most of which is transgenic. Such conclusions are no surprise: genetically engineered crops which did not pass muster never entered the market.

2. EXEMPLARY POTATOES

The most beloved tuber on this planet will help us to show the foolishness of the bogus "GMO" category, and consequently, how counterproductive its effects are.

2.1 USA

Potato tissues contains solanine, a substance which is toxic over certain levels, as has been known for decades (Hansen 1925), and it is particularly dangerous because not even cooking neutralizes it. At the end of the 60s, in the USA, a new variety, named Lenape, was created through traditional breeding: from the organoleptic point of view, it was fantastic for French fries, something most people love; too bad this new cultivar showed exceptionally high levels of solanine, as it was soon discovered. (Zitnak, Johnston 1970. Popular article: Koerth-Baker 2013. Similar case: a variety of Swedish origin: Hellenäs et al. 2005). Obviously, the unfortunate new cultivar never reached the supermarket shelves.

Several years later, in the mid 90s, the US-based agribusiness giant Monsanto was authorized to sell a recombinant DNA variety called NewLeaf: it was a Bt crop, i.e. it contained a gene from *Bacillus thuringiensis*, whose product has insecticidal properties, thereby protecting spuds against the terrible potato-beetle; its immediate success soon led to the creation of another two varieties, whose genome was manipulated to combat two viruses. As a result, the producer was not able to keep up with the orders coming in from farms: but the perspective suddenly changed in 1999, when the "anti-GMO" wave gained increasing influence in the public opinion; while sales of the NewLeaf cultivars turned out to be not very profitable, big potato buyers, like the fast-food chain McDonald's, refused to purchase a raw material which was blamed by a significant part of its clients.

In order to use the new potato varieties, agricultural businesses would have had to sustain the cost of segregation, i.e. the requested separation of “GMO” tubers from the “normal” ones: the production of recombinant DNA potatoes became unremunerative for farms and therefore the sales of seed potatoes dropped to such a low that Monsanto chose to discontinue the offer. Big distributing chains were still in need of large amounts of potatoes though, as long as they did not carry the “GMO” stigma: thus, farmers went back to traditional varieties, spraying them with millions of tons of pesticides. (For a detailed account, see Kaniewski and Thomas 2002; Thornton 2004).

Anti-corporate groups fight “GMOs” in order to hit industries and capitalism: it is a questionable socio-economic struggle, perfectly legitimate though. Yet, if these self-proclaimed “environmentalists” think they have obtained a victory in the case of NewLeaf potatoes, they’d better think again: “It is ironic that those activists who list reduction in use of pesticides as a major goal are those that have effectively blocked the most successful scientific approach to that end.” (Kaniewski and Thomas 2002, 45) The environment and the old-fangled chemical pesticide industries sincerely thank the “anti-GMO” brigade. (Well beyond these spuddy anecdotes, the blanket “anti-GMO” opposition seems to go against the interest of the poor: see Paarlberg 2014.)

To summarize, Lenape (a variety which was obtained through traditional crosses) was toxic, while NewLeaf (transgenic) was safe. The first one disappeared for obvious reasons, the second one (also) due to the “anti-GMO” scaremongering.

What is particularly interesting in this dual episode is a refrain that occurred many times. Genetically enhanced varieties were rejected by anti-biotech groups because they were “GMOs”, and to justify this approach an illogical gambit is very frequently used: the alleged danger of a certain DNA-spliced crop is taken as proof that all the items of such ill-defined kind are harmful. Now, suppose that, considering the Lenape failure, somebody had commented, in alarmistic tones: “That toxic potato was obtained through hybridization! This biotechnology is inherently unsafe: it has to be banned!”. Everybody would see there is no logic in that illicit pluralization. But a similar gross mistake is made by those who, any time a problem *seems* to appear with a single recombinant DNA veg, hysterically attack "GMOs" (pluralized).

I use the verb "seem" because, over more than twenty years of widespread consumption, only the few cases we have already described have been reported: those unlucky "GMO" outcomes were abandoned before they could be marketed. Other failed recombinant DNA experiments were also discarded, which were not noxious but showed undesired effects (unbalanced protein content, problems with growth, poor yields). The same happened who knows how many times, in the history of agriculture, with traditionally bred experimental crops, without creating pointless societal dread.

2.2 UK

Let's move to the UK, for another story of ominous potatoes. In 1998, esteemed researcher Árpád Pusztai , scientifically known for his competence, was conducting experiments: the aim was to test the safety, on guinea-pigs, of a variety of recombinant DNA potatoes: these tubers had been modified with the addition of a gene from the snowdrop, in order to improve their resistance to certain parasites. Unfortunately, the scientist was under the impression that a series of negative reactions were happening: before submitting his data and the relevant conclusions for publication through the correct procedure, i.e. submitting a manuscript to a scientific journal, he gave an interview to a TV channel. The backlash was immediate and overwhelming: the mass-media waged a frantic campaign against the dangers of "GMOs" – note the usual, senseless transformation of a singular into a plural.

The hapless researcher's house was besieged by journalists; public opinion, which was still shaken by the recent echoes of "mad cow" disease in the UK, became even more jittery (by the way, it should be remembered that "GMOs" had nothing to do with that). Pusztai was called to answer for his incautious declarations; the dubious data were re-examined by his superiors in the institute where he had been working for decades, the alarm was judged to be unjustifiable and the researcher was fired. However, he had the opportunity to publish his experiments and deductions, which were heavily criticized in terms of both merits and methods. To this day, the story of Pusztai and his martyrdom is told as a clear example of the toxicity of "GMOs": hidden powers conspired to deny their dangerousness.

Let's try to rationalize this episode. For argument's sake, let's assume that those potatoes were toxic; any such case – whether transgenic or otherwise, potato or whatever cultivar – should be treated like the unlucky Lenape variety (which was not transgenic: but this is irrelevant!): some decades before, that crop was simply discarded as a sad biotech fiasco, without creating any media frenzy. "Even if it were demonstrated that Pusztai's conclusions were correct, namely, that GM potatoes containing the gene for lectin have detrimental effects on the immune system, metabolism, and organ development of rats, this would not justify a general conclusion that all GM foods are dangerous to human health." (Krebs 2000) A micro-lesson in elementary logic. A simple way of reasoning that "anti-GMOers" seem to be incapable of.

2.3 European Union

Another case of problematic potatoes is the transgenic Amflora variety. A premise: a significant share

(25%) of the potatoes which are produced in the developed world are employed for industrial purposes; starch is extracted from the precious spuds and is used mostly in the textile, paper, mining and food sectors. But the starch comes in two different kinds (amylose and amylopectin), one of which has to be strongly reduced, through a costly process, to obtain a usable raw material for the industrial application. Which form of starch has to be reduced depends on the type of application; back in 1991, researchers in a private company managed to modify the tuber's DNA by "switching off" the gene which dictates the production of one type of starch (amylose), solving the problem at its source.

gmos in the eu

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The authorization request in the EU was made in 1996. Usual story: if such an excellent result had been obtained without creating "a GMO", everybody would have been happy, or at least the recombinant DNA deniers wouldn't have raised an eyebrow; instead, there was unsurprising fierce opposition, with a bizarre on-and-off push-and-pull between the EU Commission, the ministers of agriculture of the EU member states and the European Food Safety Authority; the EFSA was involved because the producer had requested authorization of the Amflora also as food, just in case some tubers ended up with other potato stocks.

Public scientists, after examining the dossier for two times (2005 and 2009), had given the green light on both occasions: they noted that the main reason for suspicion put forward by "anti-GMO" groups, i.e. an antibiotic-resistant gene which was inserted into the Amflora's DNA as a marker, did not imply any risk; but the politicians were still pussyfooting. The stalemate lasted almost fifteen years, until the authorization eventually arrived in 2010, only to be overruled at the end of 2013 by the EU Court for procedural errors; but in 2012 the producer, Germany's BASF, which was discouraged by the continuing unfavorable climate, had already thrown in the towel, withdrawing Amflora from the European market and even transferring its entire Plant Science sector to the USA.

Even if we maximize recycling, which is a commendable activity, paper and cardboard production will inevitably grow: we can predict that, despite an initial success of e-books and information websites, the traditional publishing area (books, magazines, newspapers) will hold out for years; paper requirements will also be increased by industrial and domestic use, with an obvious link to the enduring population growth. Therefore, the question "anti-GMOers" should answer are very simple. For excellent ecological reasons, why don't they want an engineered tuber to contribute to satisfying the demand for paper manufacturing? Using tubers instead of cellulose from trees could diminish the pressure on forests.

We are afraid that the worst perspectives are likely: the Amflora is designed for industrial uses, but it was strongly opposed because, like recombinant DNA cotton, it is an agricultural product. Let's remember the asymmetric as well as weird distinctions shown by the short history of the "anti-GMO" hostility: almost no protest against transgenic biotechnologies of various colors ("red" medical-pharmaceutical, "white" industrial, "grey" for bioremediation, etc.); nothing is said regarding "green" applications for making food ingredients and additives in closed production cycles (e.g. chymosin for making cheese); but thumbs-down, and aggressive rejection, of transgenic crops in open fields, be they food (maize, soybeans, potatoes etc.) or non-food (cotton, other fibers, and the Amflora potato). Such twisty pigeon-holing has never been justified.

But a paradox occurred: while the Amflora producer was abandoning the EU market, another German seed company, using advanced methods of mutagenesis, was able to inactivate a gene involved in the synthesis of the undesired starch in conventional potatoes. Indeed the gene was the same that was switched off in Amflora, only the method to achieve the switching was different in molecular terms, but the result was one and the same. In other words, a mutagenizing technique allowed the same "silencing" effect of that targeted DNA sequence: the Amflora "is a GMO", while the mutagenized variety, called "Super potato", in the crooked mental maze of the "anti-GMO" brigade and EU decision makers, is not. Here's the absurd situation: the veto on the Amflora persists, while its «politically correct twin» encounters no obstacles. Antis and politicians show no minimal sign of rational consistency.

A "Natural GMO" potato

A very frequent slogan is used by opponents of advanced agri-food biotechnologies: transgenic crops are "unnatural", and therefore potentially noxious, and even unethical; copying a DNA sequence from a microbe to splice it into the genome of a crop is seen as a sort of violation to the natural order, an undue jump in the tree of life. Even common definitions of "GMOs" invoke nature, e.g. the European Union's relevant Directive: "an organism […] in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination" (European Union 2001, Art. 2).

Horizontal gene transfer is a phenomenon which is not frequent, but actually happens in nature, particularly in the area of plant-microbe interactions. It was recently discovered that a variety of sweet potatoes (taxonomically very different from the sort of potatoes we are accustomed to) contains fragments of bacterial DNA: ironically, such genetic material comes from *Agrobacterium tumefaciens*, the microorganism that is frequently used by biotechnologists to attempt the transfection of transgenes into the genome of the target plant. The authors' conclusion is quite optimistic: "given that this crop has been eaten for millennia, it may change the paradigm governing the "unnatural" status of transgenic crops." (Kyndt et al. 2015. For more than two hundred examples of "natural GMOs", see http://gmopundit.blogspot.it). Whatever the reactions of laypersons to this nice piece of biological/agronomic information will be, from a theoretical point of view the conclusion looks clear: exquisite sweet potatoes drive the final nail into the coffin of the warped "GMO" pseudo-concept.

Reasonable Hopes?

Many scientists believe, without prejudices, that recombinant DNA biotechnology may give us better potatoes, first of all providing direct benefits to consumers (Patil et al. 2016) and therefore encouraging the public's acceptance: for instance, a new variety containing a higher level of nutrients has been created and long tested by Indian scientists (Chakraborty et al. 2010. Popular article: MacKenzie 2010). Hope persists: "The advantages of GM technology to improve the potato crop, reduce pesticide use, increase yields, and lower production costs will continue to provide incentive for integration of this technology into potato breeding and commercial crop production." (Grafius, Douches 2008, 214) If only regulators and consumers could free themselves from the "GMO" bugbear…

> These stories have surely shown that "GMO(s)" is a misleading notion, a damaging meme that should dissolve: in time, it will be considered a subject as interesting as the sex of angels used to be.

REFERENCES

Ammann Klaus (2014) Genomic Misconception: a fresh look at the biosafety of transgenic and conventional crops. A plea for a process agnostic regulation. *New Biotechnology* 31(1), 1-17.

Chakraborty, Subhra et al. (2010) Next-generation protein-rich potato expressing the seed protein gene AmA1 is a result of proteome rebalancing in transgenic tuber, *Proceedings of the National Academy of Sciences* 107(41), p. 17533–17538.

European Commission (2010) A decade of EU-funded GMO research (2001-2010). ftp.cordis.europa.eu/pub/fp7/kbbe/docs/a-decade-of-eu-funded-gmo-research_en.pdf

European Union (2001) Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC, *Official Journal of the European Communities* 2001, L106, p. 1–39, http://europa.eu/legislation_summaries/agriculture/food/l28130_en.htm

Grafius, Edward J.; Douches, David S. (2008) The Present and Future Role of Insect-Resistant Genetically Modified Potato Cultivars in IPM [Integrated Pest Management], Ch. 7 in Romeis, Jörg et al.(eds.), *Integration of Insect-Resistant Genetically Modified Crops within IPM Programs*, Dordrecht: Springer, p. 195-221

Hansen, A.A. (1925) Two fatal cases of potato poisoning, *Science* 61(1578): p. 340-341.

Haslberger AG (2003) Codex guidelines for GM food include the analysis of unintended effects. *Nature Biotechnology* 21(7), p. 739-741.

Hellenäs, Karl-Erik et al. (1995) High levels of glycoalkaloids in the established Swedish potato variety magnum bonum, *Journal of the Science of Food and Agriculture* 68(2), p. 249–255.

Kaniewski, Wojciech K.; Thomas, Peter E. (2004) The Potato Story, *AgBioForum* 7(1&2), p. 41-46, www.agbioforum.org/v7n12/v7n12a08-kaniewski.pdf

Koerth-Baker, Maggie (2013) The case of the poison potato, 25 March 2013, http://boingboing.net/2013/03/25/the-case-of-the-poison-potato.html

Krebs, John R. (2000) GM Foods in the UK between 1996 and 1999: Comments on “Genetically Modified Crops: Risks and Promise” by Gordon Conway, *Conservation Ecology* 4(1), p. 11, www.consecol.org/vol4/iss1/art11/

Kuiper H, Kleter GA, Noteborn HPJM, Kok EJ (2001) Assessment of the food safety issues related to genetically modified foods. *The Plant Journal* 27(6), p. 503–528.

Kyndt Tina, Quispe Dora, Zhai Hong, Jarret Robert, Ghislain Mark, Liu Qingchang, Gheysen Godelieve, Kreuze Jan F (2015) The genome of cultivated sweet potato contains Agrobacterium T-DNAs with expressed genes: an example of a naturally transgenic food crop. *Proc Natl Acad Sci USA* 112: 5844–5849.

MacKenzie, Debora (2010) Transgenic Indian superspuds pack more protein, *New Scientist*, 20 September 2010, www.newscientist.com/article/dn19473-transgenic-indian-superspuds-pack-more-protein/

National Academy of Sciences (2016) *Genetically Engineered Crops: Experiences and Prospects*, Washington (DC): The National Academies Press, 2016, www.nap.edu/catalog/23395/genetically-engineered-crops-experiences-and-prospects

Nicolia A, Manzo A, Veronesi F, Rosellini D (2012) An overview of the last 10 years of genetically engineered crop safety research. *Critical Reviews in Biotechnology* 34(1), 77-88.

Paarlberg, Robert (2014) A dubious success: The NGO campaign against GMOs. *GM Crops & Food* 5(3): 223-228.

Patil, Virupaksh U. et al. (2016) Genetic Engineering for Enhanced Nutritional Quality in Potato – a review, *Potato Journal* 43(1), p. 1-21

Tagliabue Giovanni (2016) The necessary "GMO" denialism and scientific consensus. *Journal of Science Communication* 15, 1-11. http://jcom.sissa.it/archive/15/04/JCOM_1504_2016_Y01

Thornton, Michael (2002) The Rise and Fall of NewLeaf Potatoes, in Eaglesham, Allan (ed.) [2004], *Biotechnology: Science and Society at a Crossroad*, 15th Annual Meeting of the National Agricultural Biotechnology Council, Pullmann (WA): Washington State University, 2004, p. 235-243, http://nabc.cals.cornell.edu/Publications/Reports/nabc_15/15_7_2_Thornton.pdf

Van Eenennaam, Alison L.; Young, Amy E. (2014) Prevalence and impacts of genetically engineered feedstuffs on livestock populations, *Journal of Animal Science*, September 2, 2014, 92: 4255–4278,

Zitnak, A.; Johnston, G. R. (1970) Glycoalkaloid content of B5141-6 potatoes, *American Potato Journal* 47(7), p. 256-260, http://link.springer.com/article/10.1007%2FBF02864825

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