Biotechnology: solutions for our alimentation

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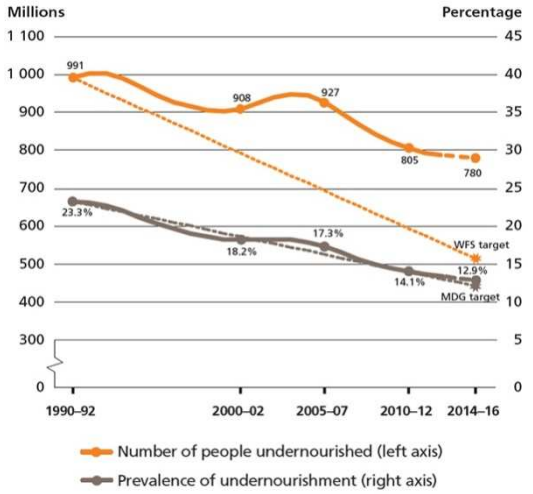
UEAA. AAF. Paris, October 12, 2016

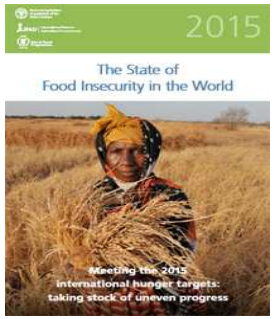
Introduction

Human populations have always sought to ensure their survival through food security. The goal is to enhance yields and prevent attacks of pests and diseases in order to feed a growing population.

Today, about 793 million of people are globally undernourished.

http://www.fao.org/





One of the major issues in the 21st century is to feed 10 billion people avoiding waste,
respecting the environment,
and in a context of climate change.

The common white button mushroom, potato and apple have been modified to resist browning with new breeding techniques.

Drought-resistant maize

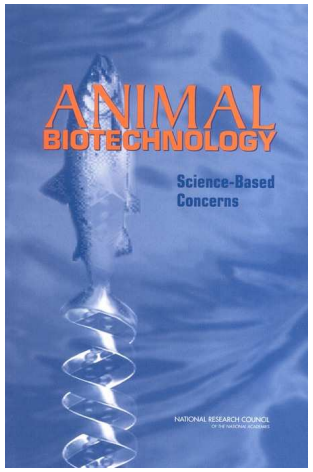
We propose to show how

life sciences and **biotechnology**

have contributed to this challenge

through key examples

in **animals** and **plants**.

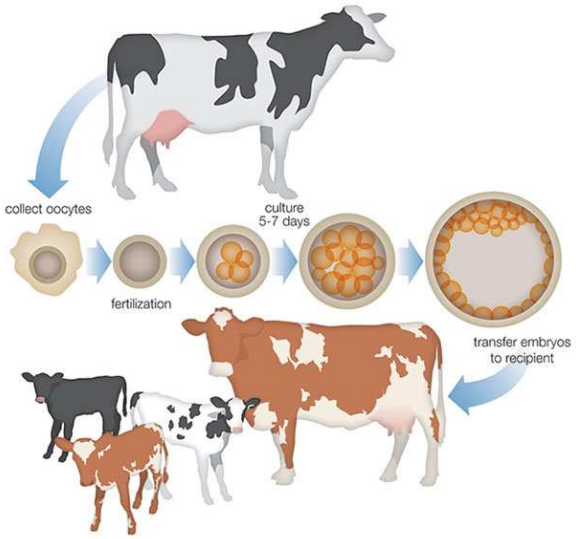


Major progress in animal production

Control of reproduction

(1940)

- Artificial insemination (AI)
- Embryo transfer
- Cloning *(JP Renard's talk)*



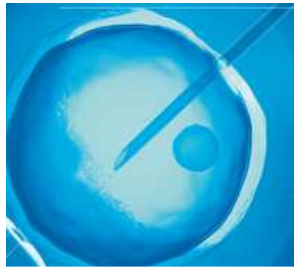
http://www.progressivedairy.com/topics/a-i-breeding/utilize-embryo-transfer-for-higher-conception-rates-during-heat-stress

→ Increase of milk **yield** and **quality**
(in cow, goat, sheep).

→ Increase of breeder **comfort** by synchronizing fertilization, calving and milking.

Advantages of AI far outweigh disadvantages

1. Semen from **elite sires** increases the accuracy and and intensity of selection (decreasing consanguinity).
2. Control of veneral and other **diseases**.
3. Improve **economical** records keeping on farms.
4. **Safer** by the elimination of dangerous bulls on the farm.

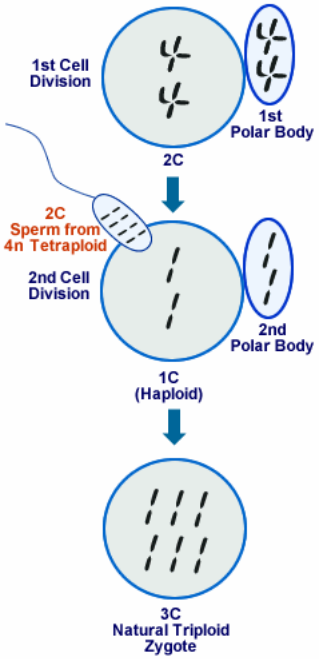


Possibility of eating oysters during the reproduction period

Industry request to have a good quality oyster throughout the year to extend the marketing season (1993)

Embryo + hyperbar treatment → tetraploids

tetraploids X diploids → triploids not milky and sterile



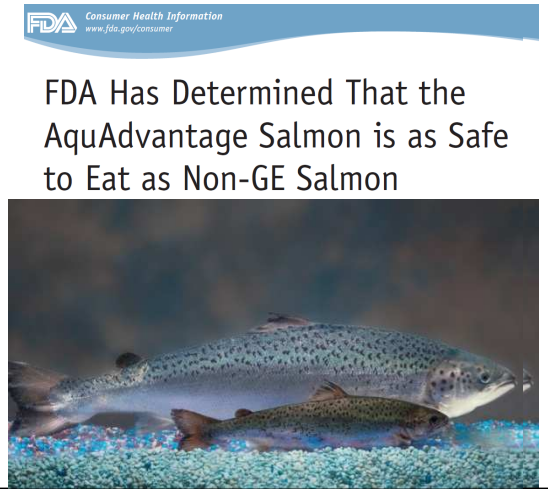
Other example of triploidy: GM animals

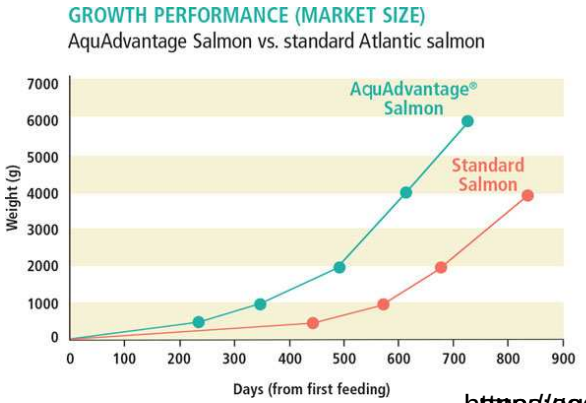
By 2020, the global demand for animal protein is projected to be 20 million tonnes per year: need for healthy protein by producing more fish in less time compared to current salmon farming techniques.

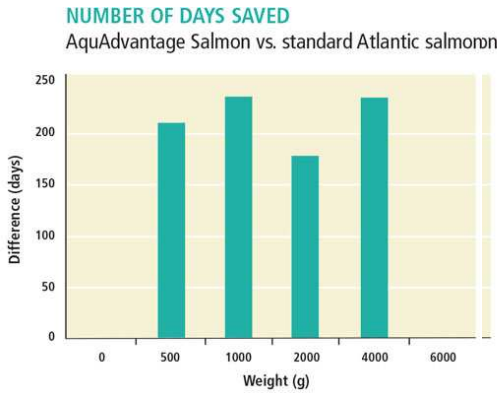
The only GM As on the market (USA and Canada, 2015) are salmons having an accelerated growth thanks to the addition of a growth hormone gene from salmon.

- Breeding time: 16-18 months (vs. 36 months for conventional farmed salmon)
- Using 25% less feed than conventional salmon on the market today

Sterility by triploidy to prevent dissemination of GM salmons in oceans.







https://aquabounty.com/our-salmon/

As a result of progress in basic research on plant and algal lipid metabolism, in combination with advances in **synthetic biology**, we can now tailor plant lipids for desirable properties:

production of polyunsaturated fatty acids

Soybean
or
GM *Camelina sativa*
could feed salmon
as a source of heart-healthy
omega-3 fatty acids.

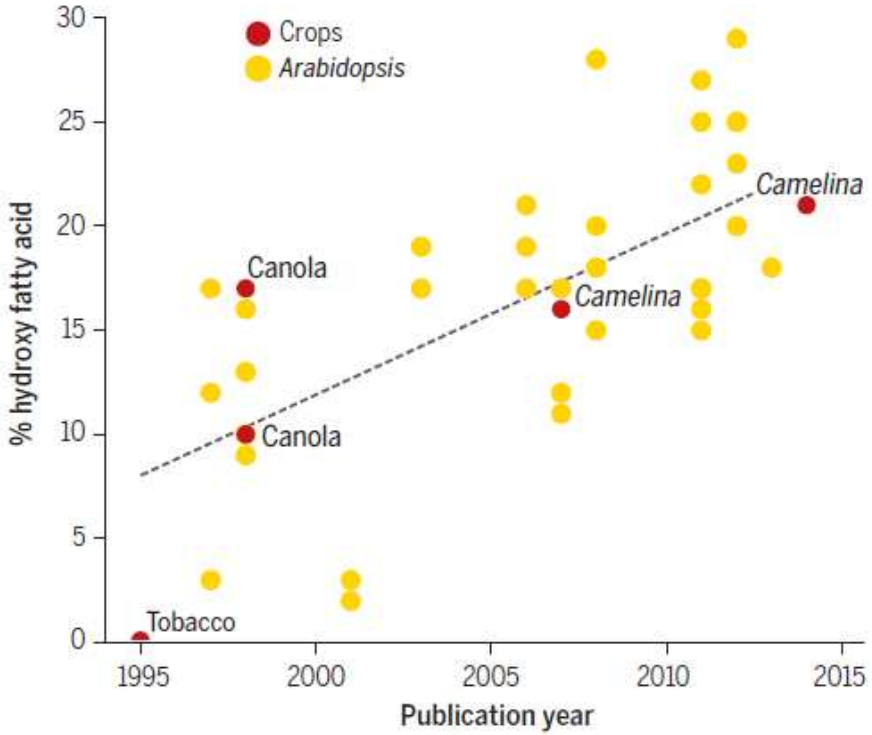


Fig. 2. Twenty years of engineering hydroxy fatty acids in oilseeds. Data points represent individual reports of GM crops or *Arabidopsis* accumulating hydroxy fatty acids. Data are adapted from Horn *et al.* 2013, 2016

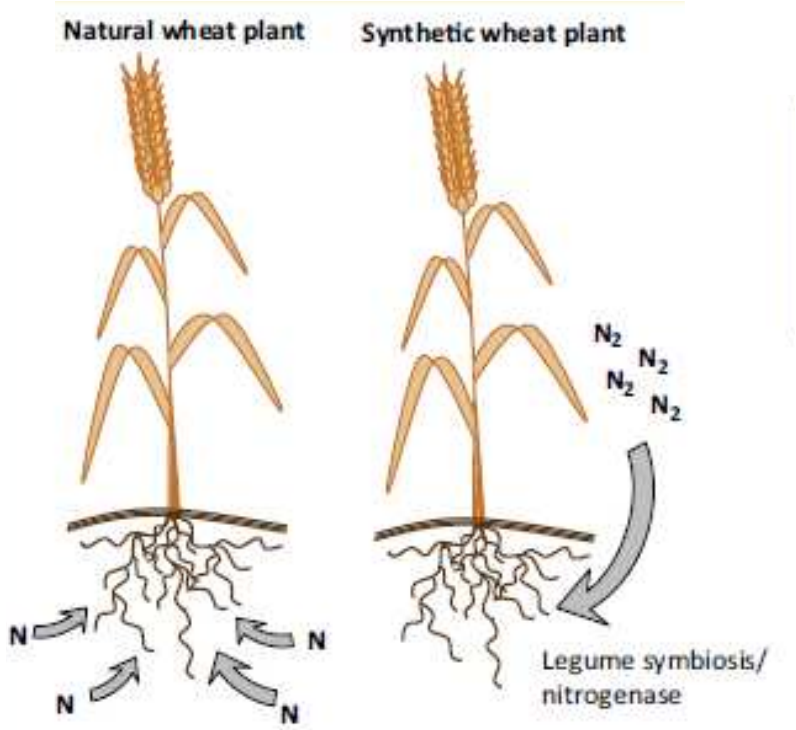
Plant production in EU

1. In EU: 1.24% of increased **yield** per year mainly due to plant breeding.
2. Since 2000, plant selection increased **gross domestic product** of 14 billion euros.
1. Plant breeding in EU prevented loss of **biodiversity** along with ecosystem management and Good Ag Practices.
2. During the last 15 years **CO2** production in UE was reduced by 3.4 billion tons.

http://hffa-research.com/recent-study-of-the-hffa-research-gmbh-stresses-the-socio-economic-and-ecological-value-of-plant-breeding/

Projects to enhance yields

Generating nitrogen-fixing wheat

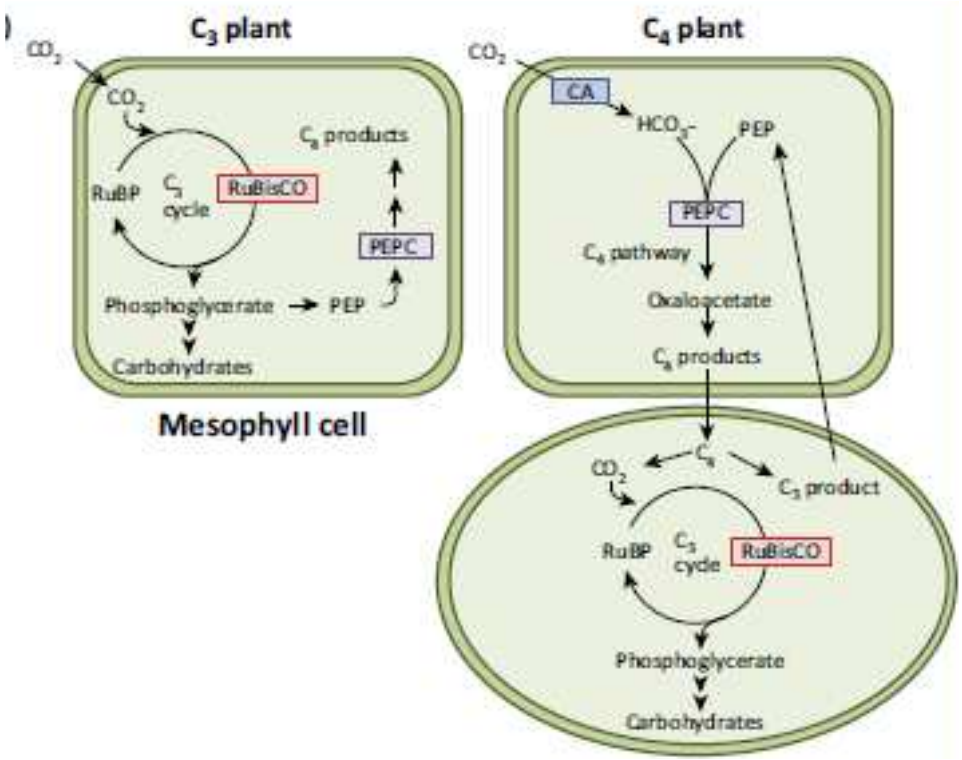


TIBTEC-1221; No. of Pages 12 ARTICLE IN PRESS
Review CellPress

Enabling plant synthetic biology through genome engineering

Nicholas J. Baltes and Daniel F. Voytas
Department of Genetics, Cell Biology, and Development, and Center for Genome Engineering, University of Minnesota, Minneapolis, MN 55455, USA

Improving carbon-fixation, photosynthesis in rice

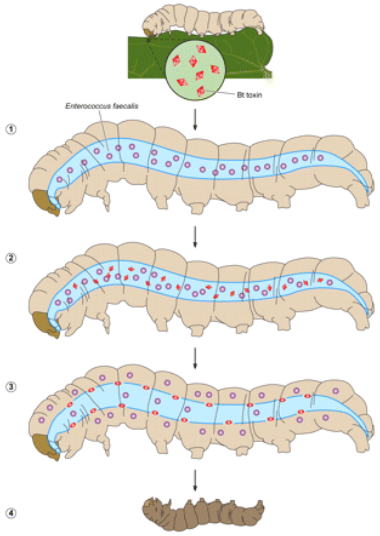


- Use of the hyper-active allele of a rubisco gene
- Use of the C4 in addition to the C3 metabolic pathway

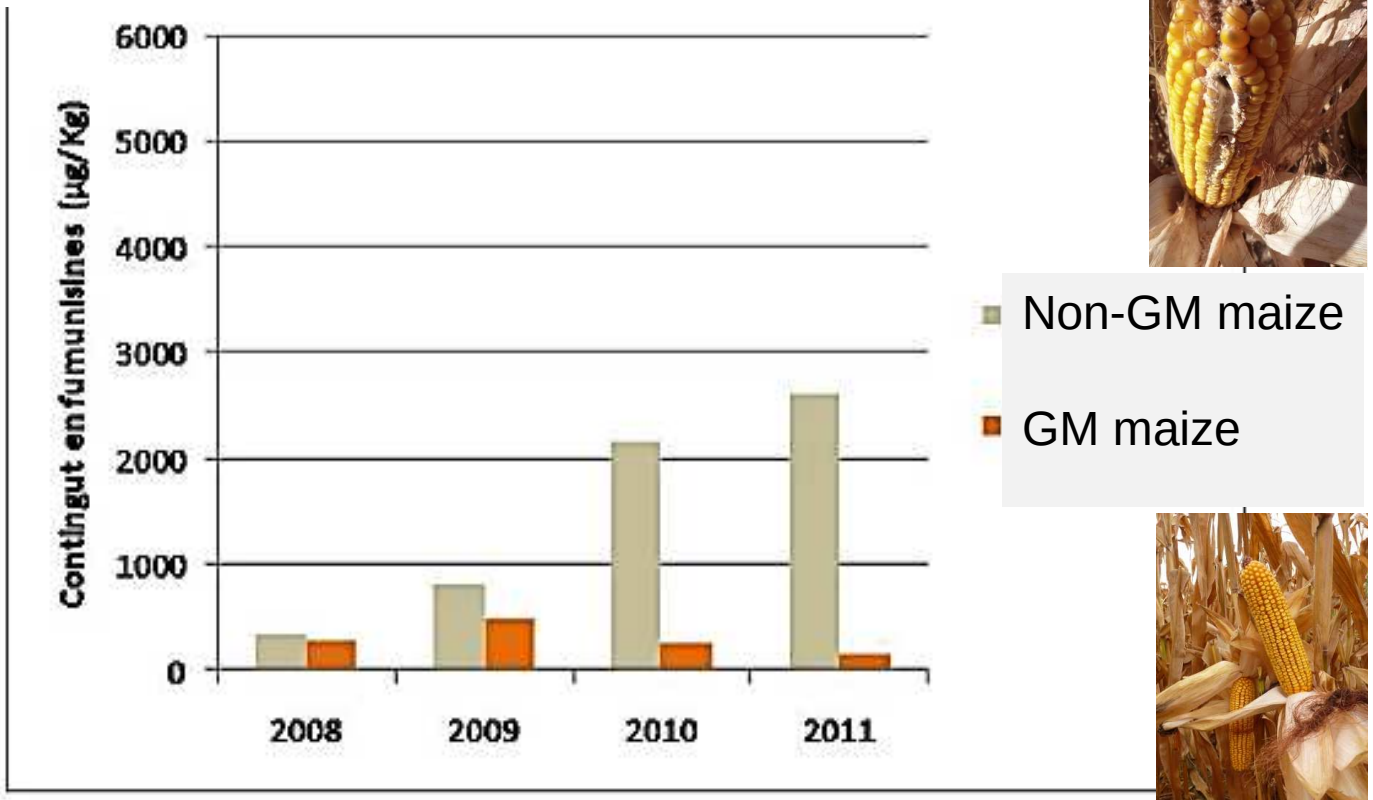
Increasing yields with high quality products

Maize Bt MON 810 has a double advantage:
- struggle against insect pests and pathogenic fungi (no pesticide)
- increasing the crop sanitary status by reducing the presence of deleterious mycotoxins.
(transgenes

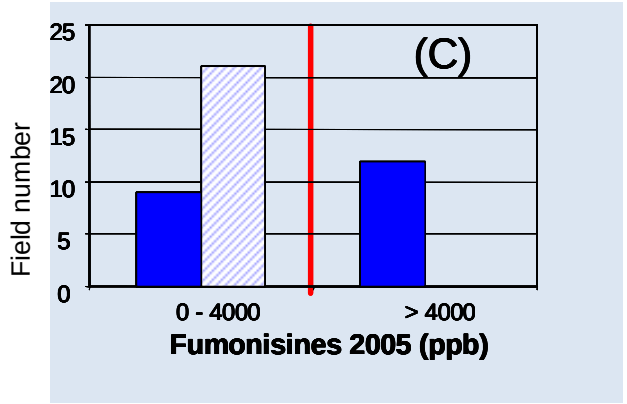
Bt: Bacillus thuringiensis
Natural pesticide used in organic culture

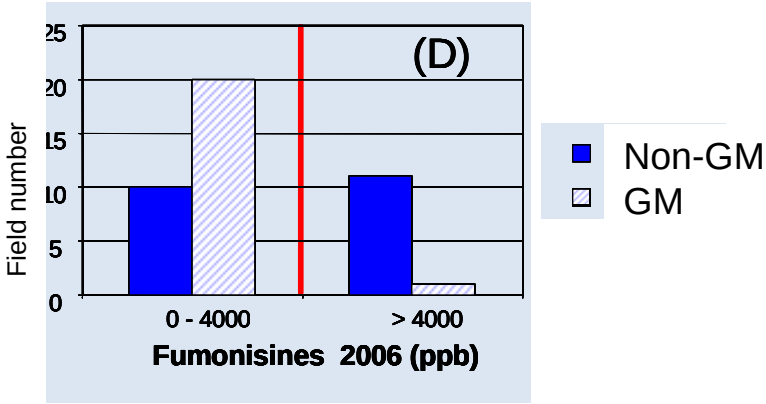


Fumonisine level in spanish fields



Fumonisine level in french fields





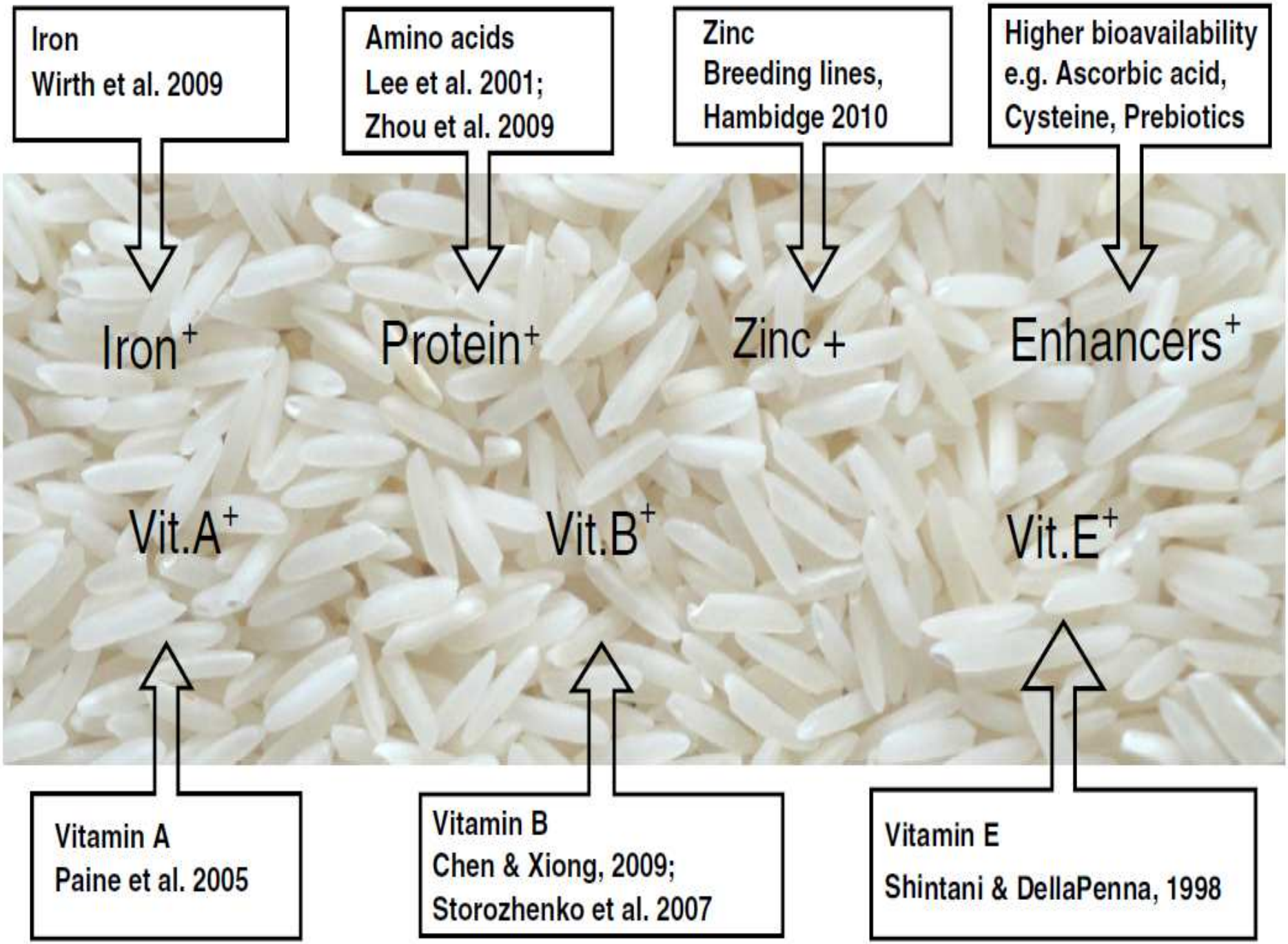
Folcher et al., 2010

Enhancing the content of some crops in vitamins and oligoelements: biofortification

By genetic selection or genetic modification.
(2000)

One example is **GM golden rice** containing provitamin A able to prevent children to become blind and prematurely die (with free licences).

Also in maize, tomato, sweet potato, banana, sorgho, chickpea cauliflower, …, staple crops.


Iron
Wirth et al. 2009
Amino acids
Lee et al. 2001;
Zhou et al. 2009
Zinc
Breeding lines,
Hambidge 2010
Higher bioavailability
e.g. Ascorbic acid,
Cysteine, Prebiotics
Iron+
Protein+
Zinc +
Enhancers+
Vit.A+
Vit.B+
Vit.E+
Vitamin A
Paine et al. 2005
Vitamin B
Chen & Xiong, 2009;
Storozhenko et al. 2007
Vitamin E
Shintani & DellaPenna, 1998

Perspectives (1)

To be able to provide enough food of high quality, conventional and new biotech techniques must be implemented.

The aims are:

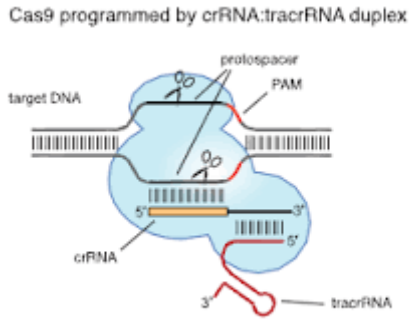
- creating **larger diversity** in less time
- producing more with **higher quality** food and **better yields**
- reducing the use of **intrants**
- decreasing the **greenhouse gaz emission**

Perspectives (2)

The new biotechnology allows:

- the **identifiation of new genes** of interest for food production
- targeted mutations using **new tools** such as CRISPR-cas9 for crop breeding and livestock domestication. (2012)

They are more precise, more flexible and cheap being thus more accessible to actors of small biotech companies and public labs.



The products obtained by these techniques must be evaluated on their quality and not on the techniques implemented to get them.

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Opinion on the Regulation of Targeted Mutagenesis in Plant Breeding

Opinion adopted by the Academy of Agriculture of France and the Academy of Technology on July 7, 2016

Since the early 1990s techniques of induced mutagenesis targeted by biotechnological processes have been developed.

Targeted mutations obtained are of great interest for plant breeding as they can accelerate the creation of varieties of interest and therefore reduce costs associated with it.

In a regulatory landscape still confused at the European level, and in the absence of hindsight on concrete data from the field, the two French Academies in their opinion voted on July 7, 2016 call public authorities permit the development of the experiments in progress, including field experiments, and to use their results in order to prepare a regulatory framework which incorporates both biomonitoring and technical advances that these new technologies may provide.

Appendix to the Opinion of the Academies of Agriculture and Technology on the Regulation of Targeted Mutagenesis by Editing the Genome in Plants

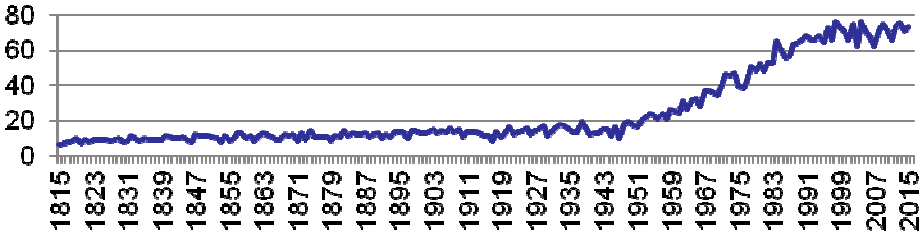
"….From the perspective of both these French Academies, techniques of targeted mutagenesis can, in principle, be excluded from the techniques regulated by the European Directive 2001/18/EC on the deliberate release of genetically modified organisms into the environment, according to its Annex 1B."

Conclusion

Living organisms are in a permanent evolution

→ research is needed to maintain and improve food production and biosafety.

Wheat Yield in France, 1815-2015 (qx/ha)



1 quintal= 3.674 bushels

Source: Eurostat

It is not only for what we do that we are held responsible, but also for what we do not do.

Thank you for your kind attention.