

# **Geneticky modifikované organizmy**

(Nielen v potravinách)

Mgr. Peter Lenárt

# Geneticky modifikovaný organizmus

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- Organizmus, ktorého genetický materiál bol upravený pomocou metód génového inžinierstva

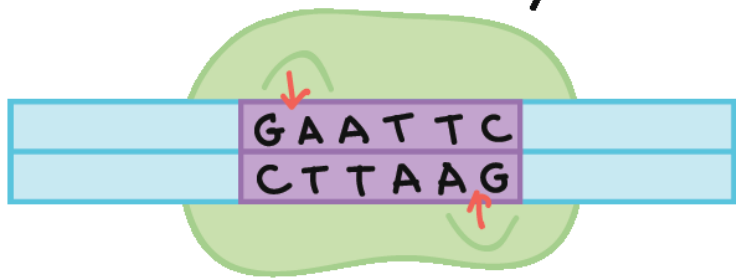
Niekedy sa vyčleňujú takzvané transgénne organizmy :

- Organizmy, do ktorých bola vložená genetická informácia nepríbuzného organizmu

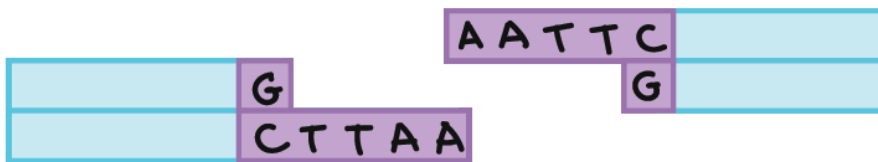
# História a využitie

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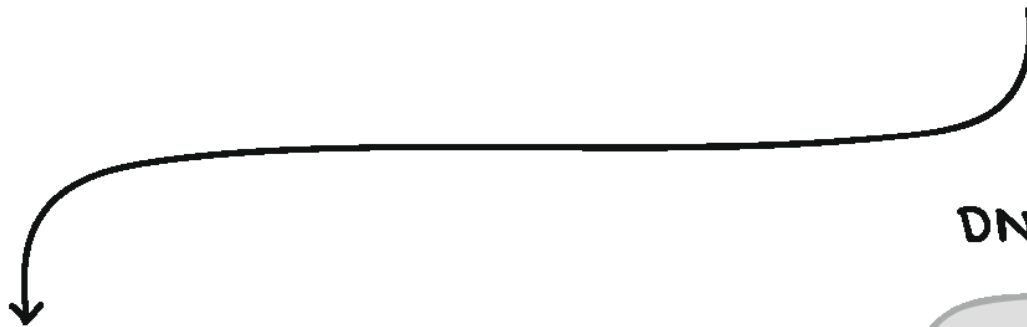
Restriction enzyme



Enzyme cuts DNA

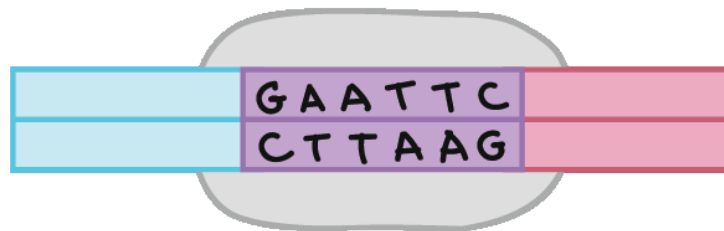


Fragments have single-stranded overhangs



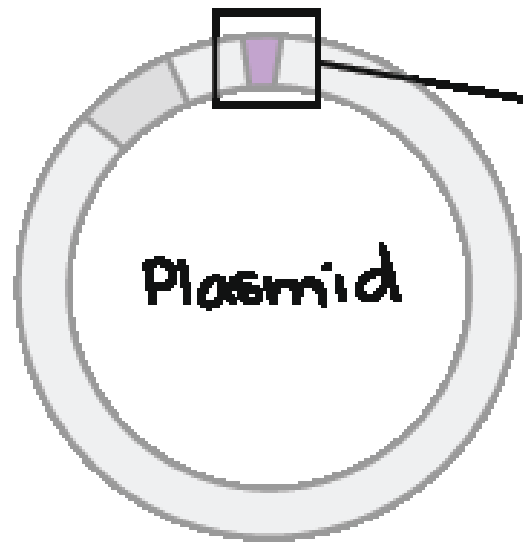
Fragments with matching overhangs base-pair and stick together

DNA ligase



DNA ligase seals the gaps

Target gene



Plasmid



# Prvé aplikácie

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- Ľudský inzulín bol prvým liečivom vyrábaným pomocou genetického inžinierstva
  - Úspešná výroba od roku 1978 (FDA schválila v 1982)
- Nasledovala rada ďalších medicínskych aplikácií ako napr. výroba rekombinantného ľudského rastového hormónu (1981) či príprava prvých rekombinantných zvieracích vakcín (1982)



**1951:  
10,000 POUNDS OF PIG  
PANCREASES MAKE  
1 POUND OF INSULIN**



**TODAY:  
GENETICALLY  
ENGINEERED  
BACTERIA PRODUCE  
ANIMAL-FREE INSULIN**



# Ojedinelé aplikácie?

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- V roku 2015 bolo okolo 400 liečiv vyrábaných pomocou DNA rekombinantných technológií



# GMO baktérie neprodukujú len lieky

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- Medzi ďalšie využitia patrí produkcia:
  - syrov
  - pracích prostriedkov
  - biosenzorov
  - papiera
  - textilu
  - piva
  - a ďalších

# Geneticky modifikované potraviny

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# Flavr Savr Rajče

- Prvá geneticky modifikovaná potravina schválená FDA (1994)
- Rajčata s predĺženým dozrievaním – dlhšie prežijú skladovanie a uchovávajú si prirodzenú chuť a farbu
- S počiatku veľký komerčný záujem, ale pre vysoké náklady na produkciu nikdy nešlo o ziskový produkt
- V roku 1997 bola v USA výroba zastavená

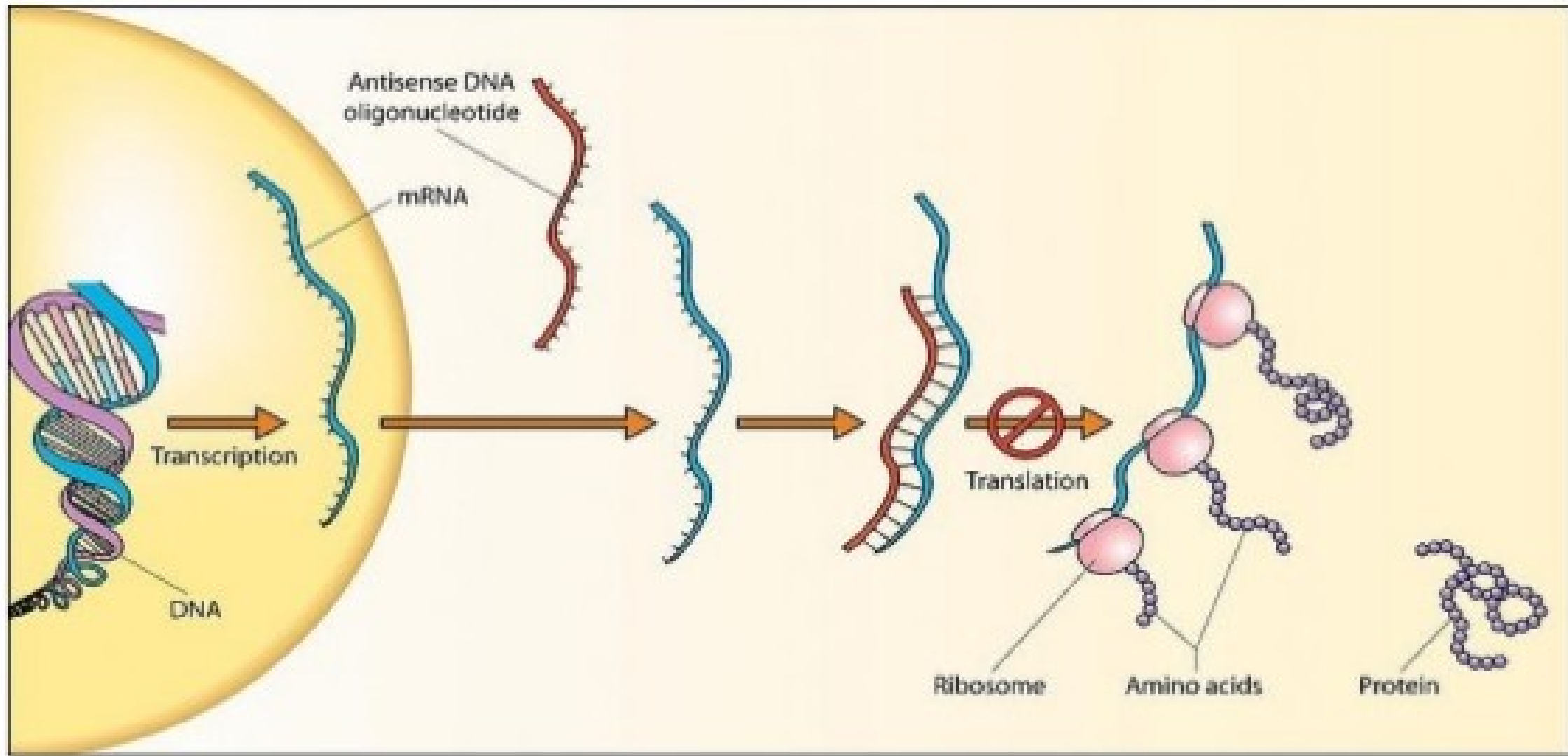


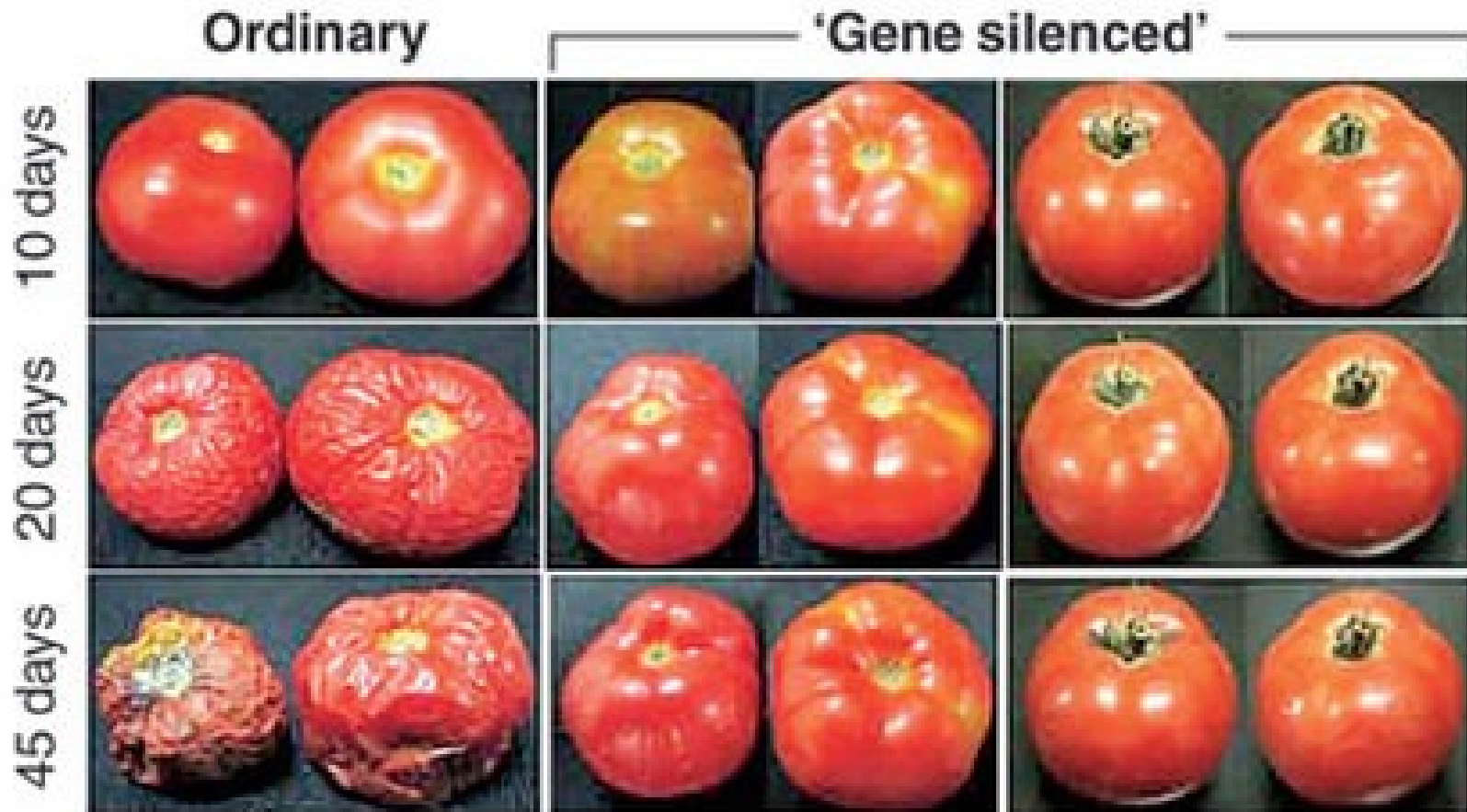
# Flavr Savr Rajče

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- Rajčata produkujú enzým polygalakturonidáza, ktorý rozkladá pektín v bunecnej stene a tým spôsobuje „mäknutie rajčat“.
- Do rajčat sa vložila druhá kópia génu kódujúceho polygalakturonidázu, avšak sekvencia génu bola „otočená naopak“







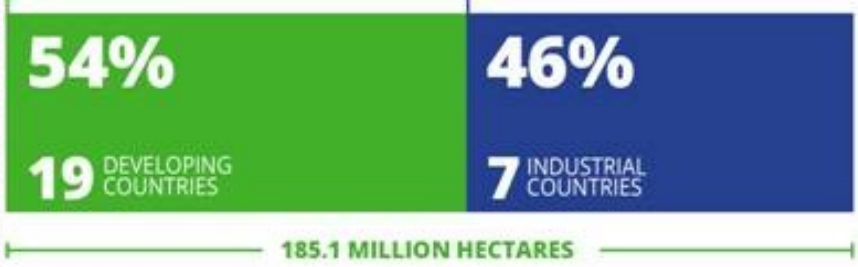
**Image shows three sets of tomatoes. The ordinary control tomatoes (extreme left) soften and shrivel up, while texture of gene-silenced tomatoes remains intact for up to 45 days.**

*Photo credit: Asis Datta, Subhra Chakraborty, National Institute of Plant Genome Research, New Delhi*

Miera využívania GMO  
plodín v poľnohospodárstve

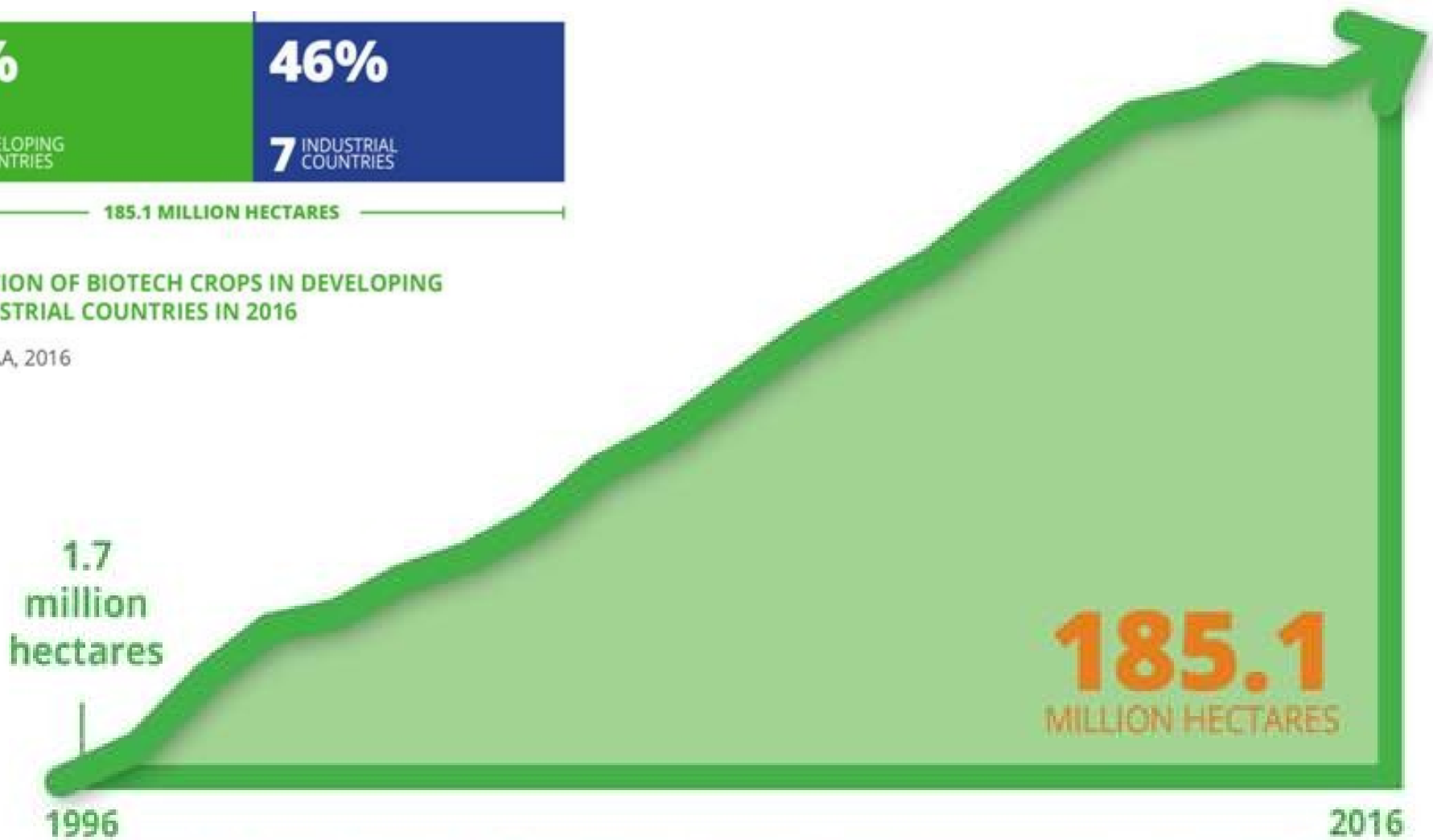
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**FIGURE 2.**  
**DISTRIBUTION OF BIOTECH CROPS IN DEVELOPING**  
**AND INDUSTRIAL COUNTRIES IN 2016**

Source: ISAAA, 2016



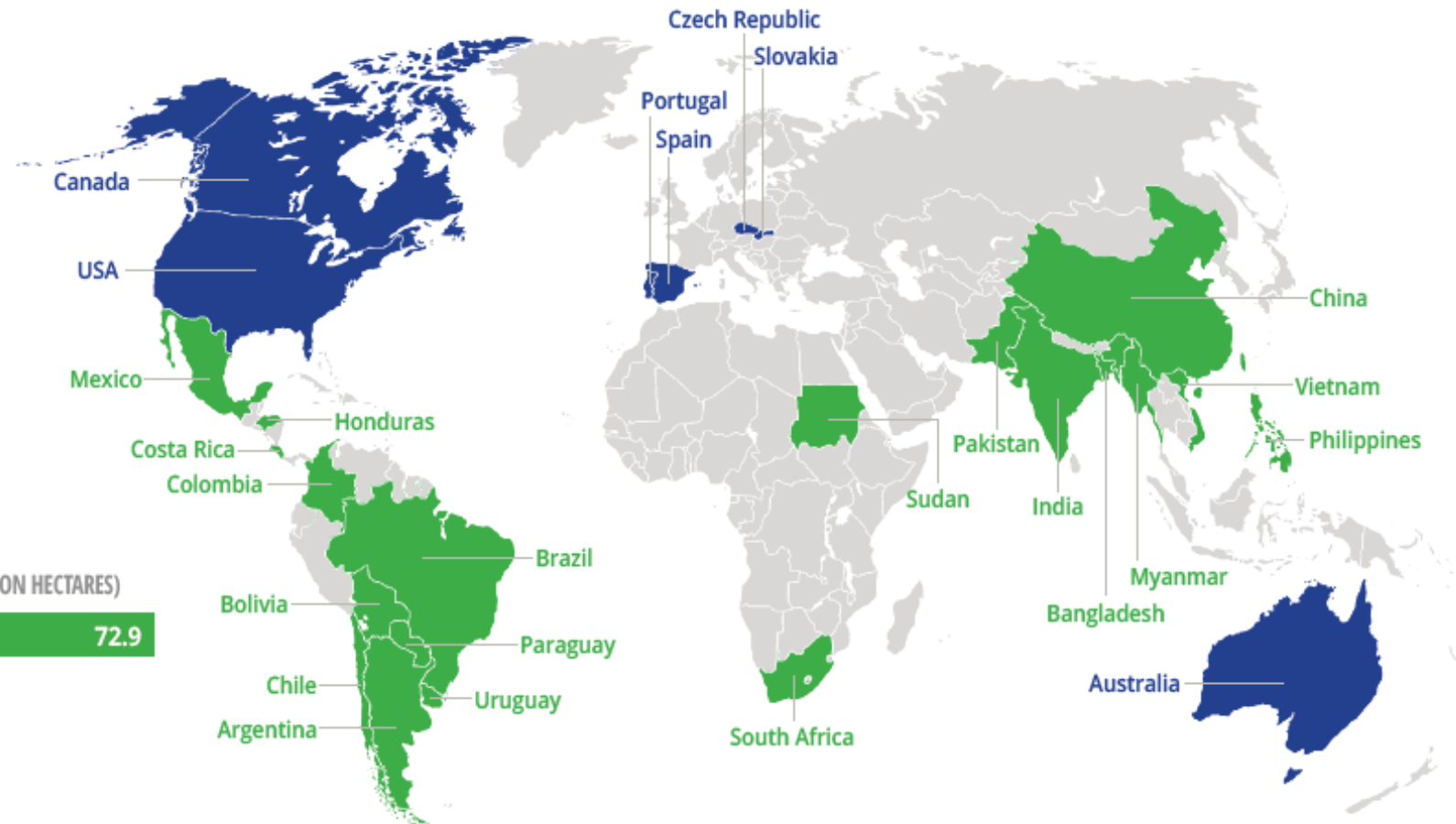
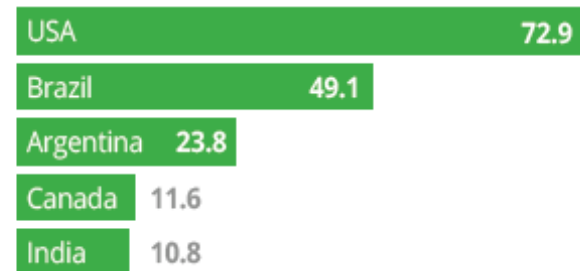
**FIGURE 1. GLOBAL AREA OF BIOTECH CROPS, 1996 TO 2016 (MILLION HECTARES).**

Source: ISAAA, 2016

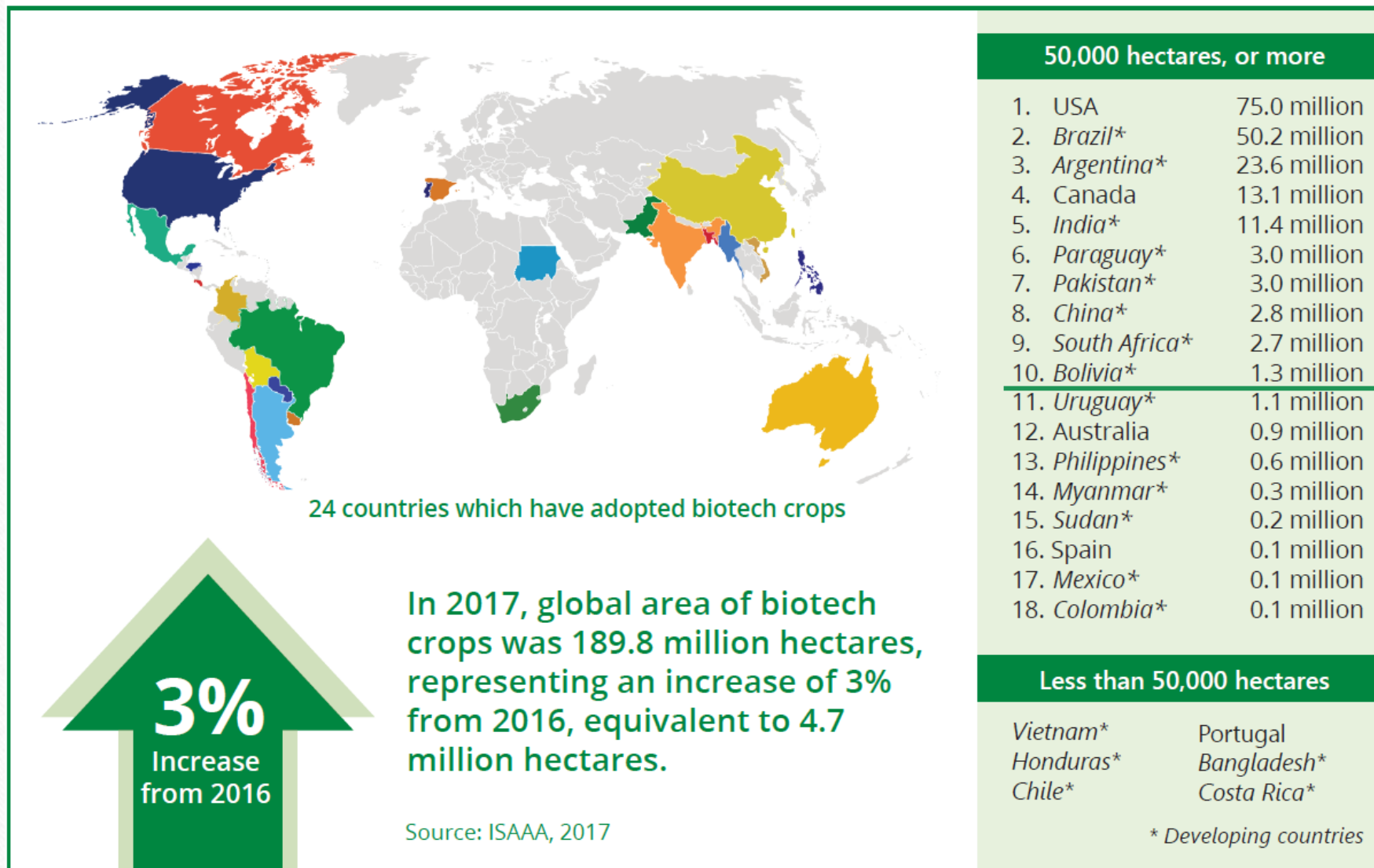
26 countries planted 185.1 million hectares (457.4 million acres) of biotech crops in 2016, the 21<sup>st</sup> year of global commercialization of biotech crops



TOP 5 COUNTRIES GROWING  
BIOTECH CROPS IN 2016 (MILLION HECTARES)



**Figure 2. Global Area (Million Hectares) of Biotech Crops, 1996 to 2017, by Country, Mega-Countries, and for the Top Ten Countries**



**3%**  
Increase  
from 2016

Poradie	Krajina	2016 (miliónov hektárov)	2017 (miliónov hektárov)
1	USA	72.9	75.0
2	Brazília	49.1	50.2
3	Argentina	23.8	23.6
4	Canada	11.1	13.1
5	India	10.8	11.4
6	Paraguay	3.6	3.0
7	Pakistan	2.9	3.0
8	China	2.8	2.8
9	South Africa	2.7	2.7
10	Bolívia	1.2	1.3

Zdroj: ISAAA

# CROP TRAITS UNDER VARIOUS STAGES OF RESEARCH IN AFRICA IN 2017

## Kenya



**Maize** ..... Drought tolerance: Water Efficient Maize for Africa (WEMA)  
WEMA Insect resistance ( Bt maize)  
Stacked maize event for Bt and Drought



**Cotton** ..... Insect resistance



**Gypsophila flower** ..... Pink Colouration of Petals



**Cassava** ..... Cassava Brown Streak Disease (CBSD)  
Cassava Mosaic Disease (CMD)



**Sweet potato** ..... Resistance to Sweet potato virus disease









**Banana** ..... Banana bacterial -Xanthomonas Wilt (BXW) resistance



**Sorghum (ABS)** ..... Biofortification



### Nigeria

-  **Cowpea** ..... Insect resistant to Maruca pest
-  **Sorghum (ABS)** ..... Biofortification
-  **Rice** ..... Nitrogen use, Water efficiency and salt tolerant (NUWEST) Rice
-  **Maize** ..... Insect resistance Bt + Herbicide tolerant Ht corn
-  **Cotton** ..... Insect resistance
-  **Cassava** ..... Delayed postharvest starch deterioration






### Ethiopia

-  **Cotton** ..... Insect resistance

### Sudan

-  **Cotton** ..... Insect resistance

### Uganda

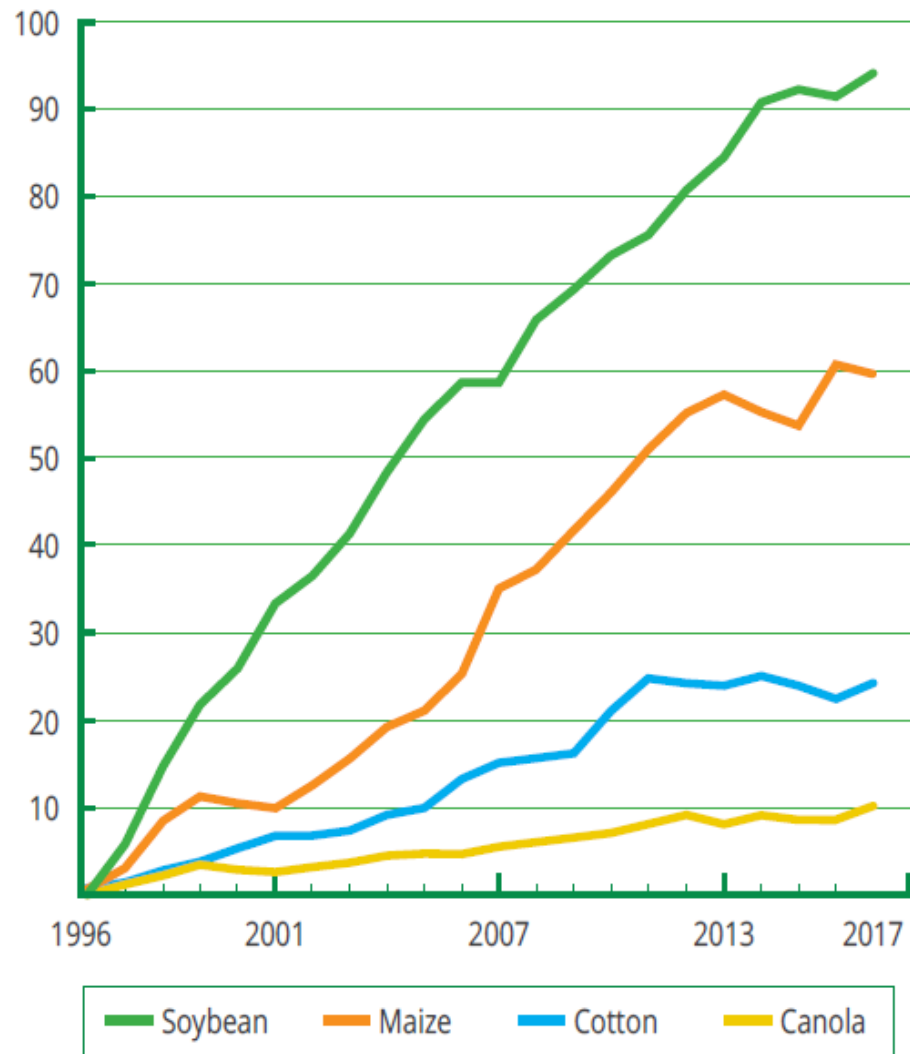
-  **Maize** ..... Drought tolerance and Insect resistance stacked events (WEMA)
-  **Banana** ..... Banana bacterial -Xanthomonas Wilt (BXW) resistance  
Banana parasitic nematode resistance  
Biofortification
-  **Cassava** ..... Cassava brown streak Disease (CBSV) resistance  
Cassava Mosaic Disease
-  **Rice** ..... Nitrogen Use/Water Efficiency and salt tolerant
-  **Potato** ..... Late blight Disease resistance

### Tanzania

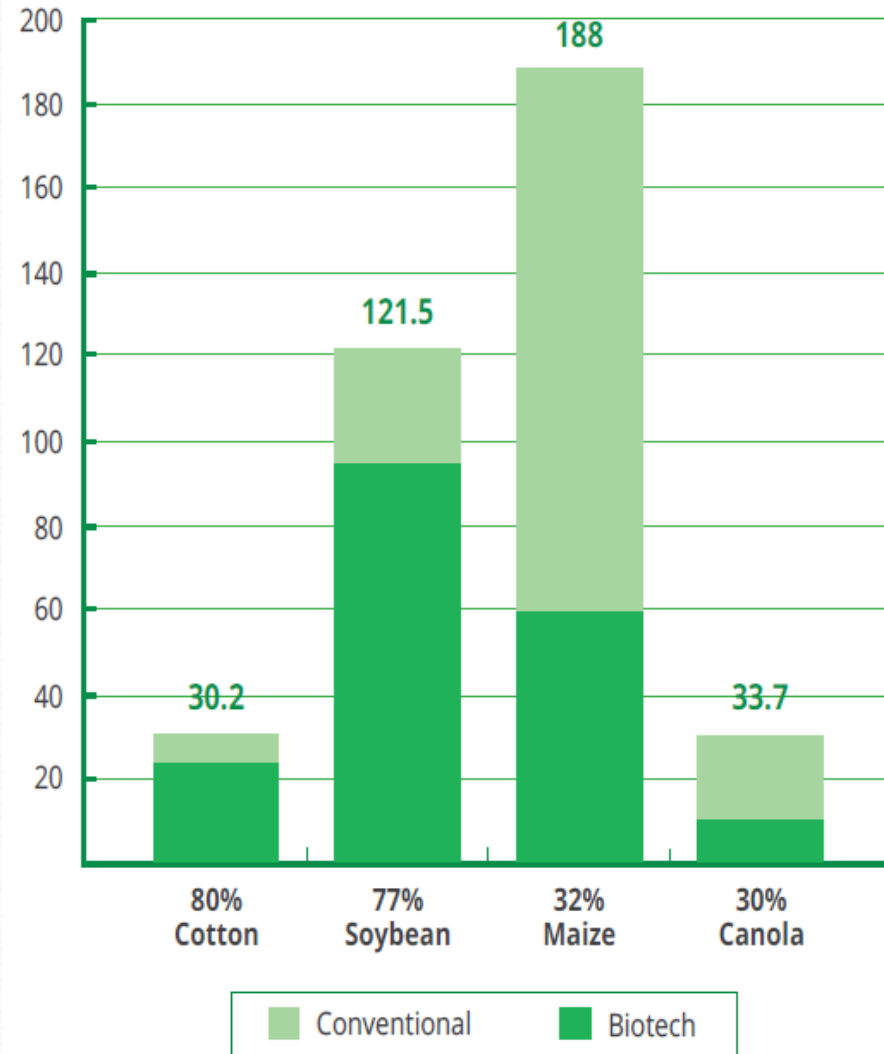
-  **Maize** ..... Drought tolerance; Stacked – Bt/DT (WEMA)

### Malawi

-  **Cotton** ..... Insect resistance
-  **Banana** ..... Bunchytop virus resistance
-  **Cowpea** ..... Insect resistance
-  **Banana plantain** ..... Bunchytop virus resistance



**Figure 16. Global Area of Biotech Crops, 1996 to 2017: by Crop (Million Hectares)**



**Figure 17. Global Adoption Rates (%) for Principal Biotech Crops, 2017 (Million Hectares)**



# Efektívnosť GMO plodín

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(a)



Grain yield

Grain yield-SS

Grain yield-DS

Grain yield-TS

Grain yield-QS

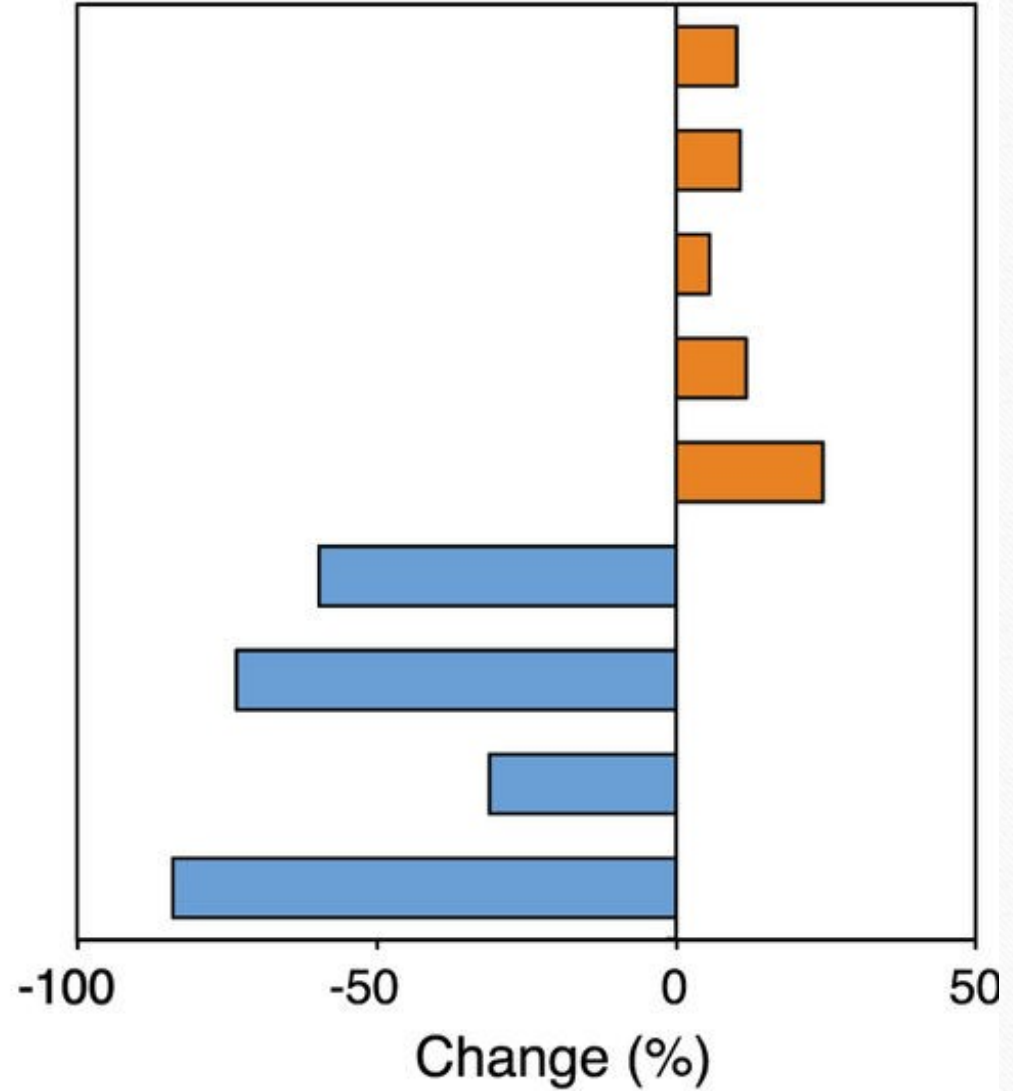


Damaged ears

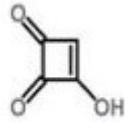
Damaged ears-DS

Damaged ears-TS

Damaged ears-QS



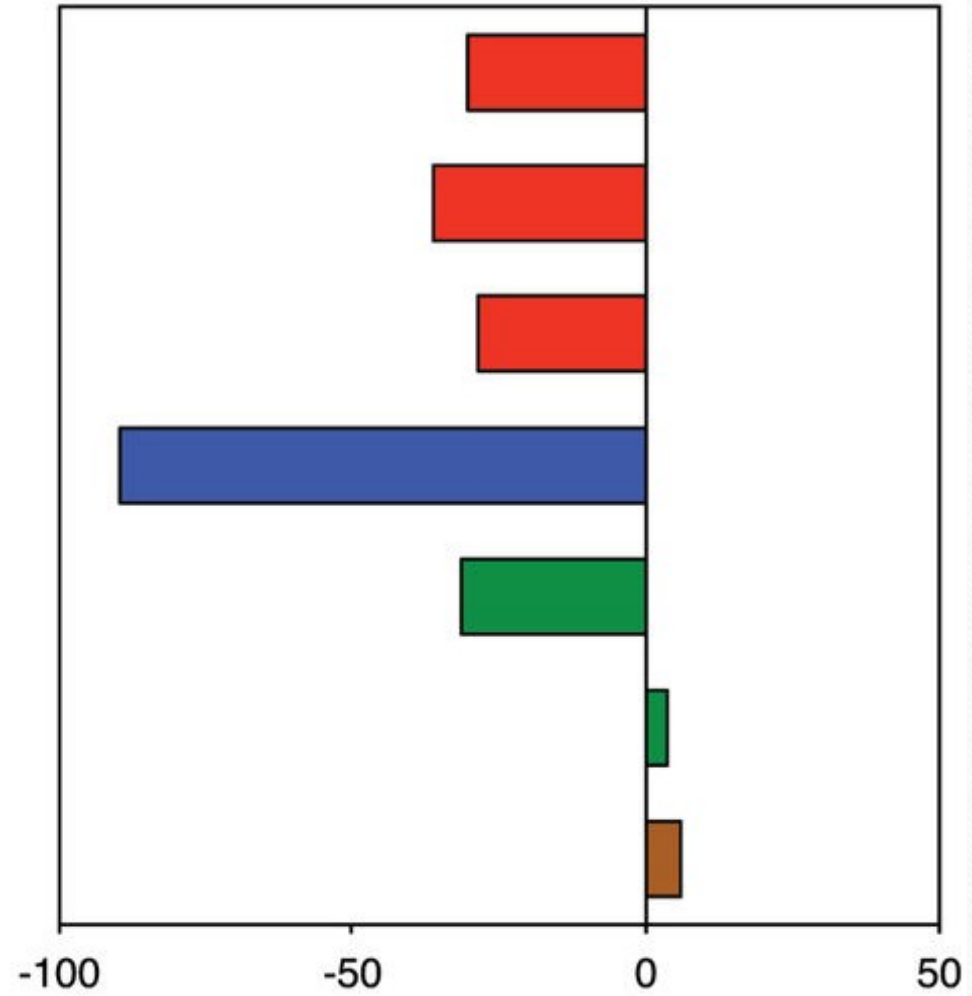
**(b)**



- Fumonisin
- Thricotecens
- Mycotoxins
- Diabrotica* spp.
- Braconidae*
- Cicadellidae*
- Residue mass loss



Change (%)



- Používanie geneticky modifikovanej ryže viedlo k redukcii používania herbicídov o 10.1% a insekticídov o 45.2%
- Používanie GMO rastlín tiež viedlo k výraznému zníženiu produkcie skleníkových plynov, ktoré bolo len v roku 2011 ekvivalentné odstráneniu viac ako 10 miliónov áut (Brookes and Barfoot 2011)
- Ekonomický prínos pestovania GMO bol len v roku 2012 18.8 miliardy dolárov
- GMO tiež výrazne zdvihli svetovú produkciu sóje a kukurice (Brookes and Barfoot 2012).

Bezpečnost'

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- GMO potraviny sú najprísnejšie regulovaným typom potraviny na svete
- Desiatky nezávislých vedeckých panelov vyhlásilo, že transgénne potraviny sú rovnako bezpečné, ako potraviny vyšľachtené iným spôsobom.
- K tomuto záveru dospela aj desaťročná štúdia financovaná európskou komisiou (voľne dostupné pod názvom „A decade of EU-funded GMO research - European Commission“)
- Patogény vyskytujúce sa v potravinách predstavujú neporovnateľne väčšie riziko ako GMO
  - V roku 2012 americké centrum pre kontrolu nemocí (CDC) v Atlante registrovalo vyše 128 000 prípadov hospitalizácie a 3 000 úmrtí v následku patogénov vyskytujúcich sa v potravinách. Na druhú stranu za vyše 20 rokov komerčného využitia GMO plodín v USA nebol zaregistrovaný jediný súvisiaci prípad úmrtia.

# Typy GM plodín

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# Ciele genetických modifikácií

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## 1. Generácia GM plodín

- a) Rezistencia k herbicídom
- b) Rezistencia voči vírusom, baktériám a hmyzím škodcom

## 2. Generácia GM plodín

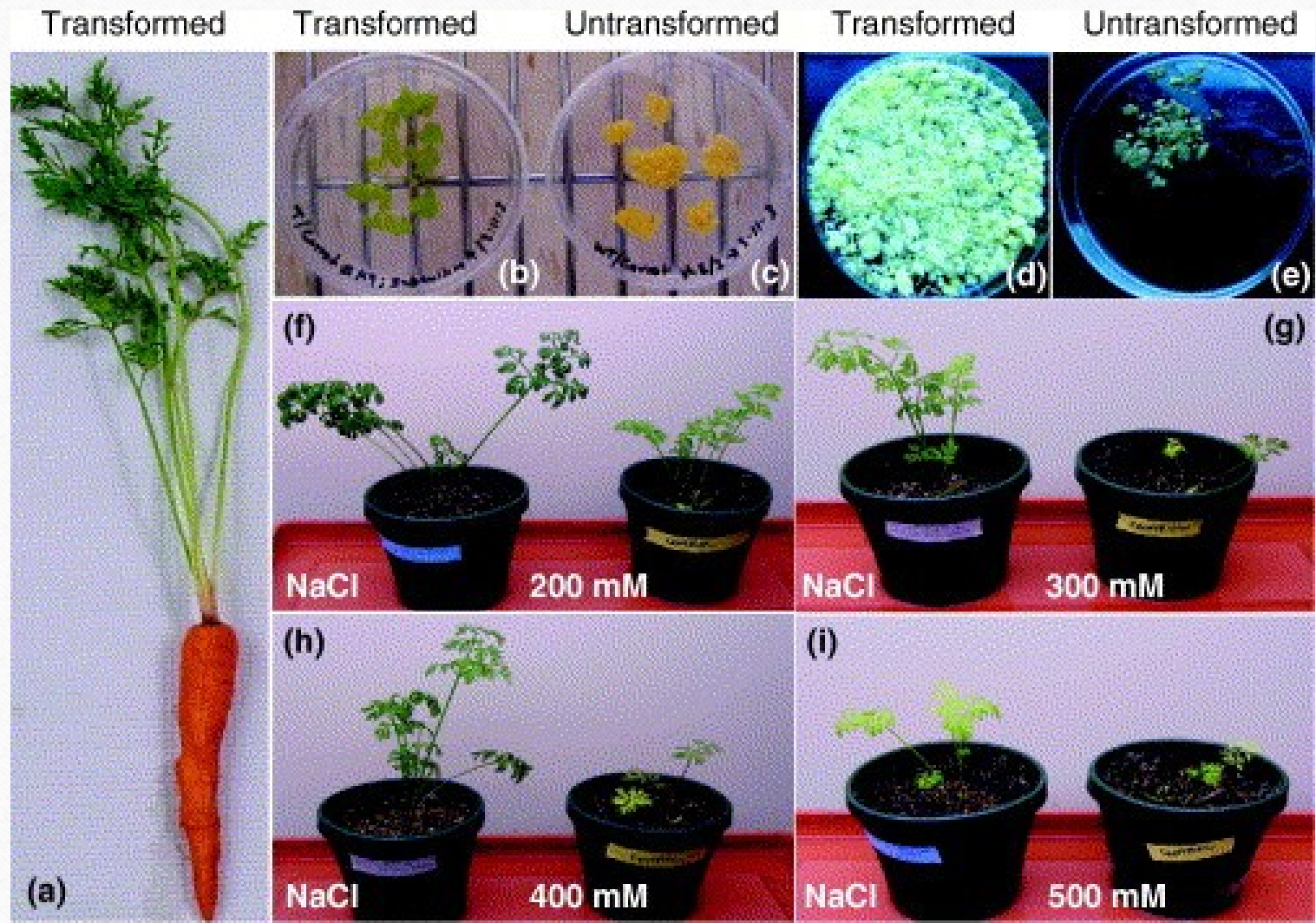
- a) Zvýšenie nutričnej hodnoty
- b) Zlepšenie chuti, kvality a trvanlivosti potravín
- c) Modifikácie organizmu pre prežitie v extrémnych podmienkach
- d) Získanie obnoviteľných a ekologických zdrojov pre chemickú výrobu
- e) Zvýšenie mechanickej stability proti škodám pri transporte a skladovaní

# Ciele genetických modifikácií

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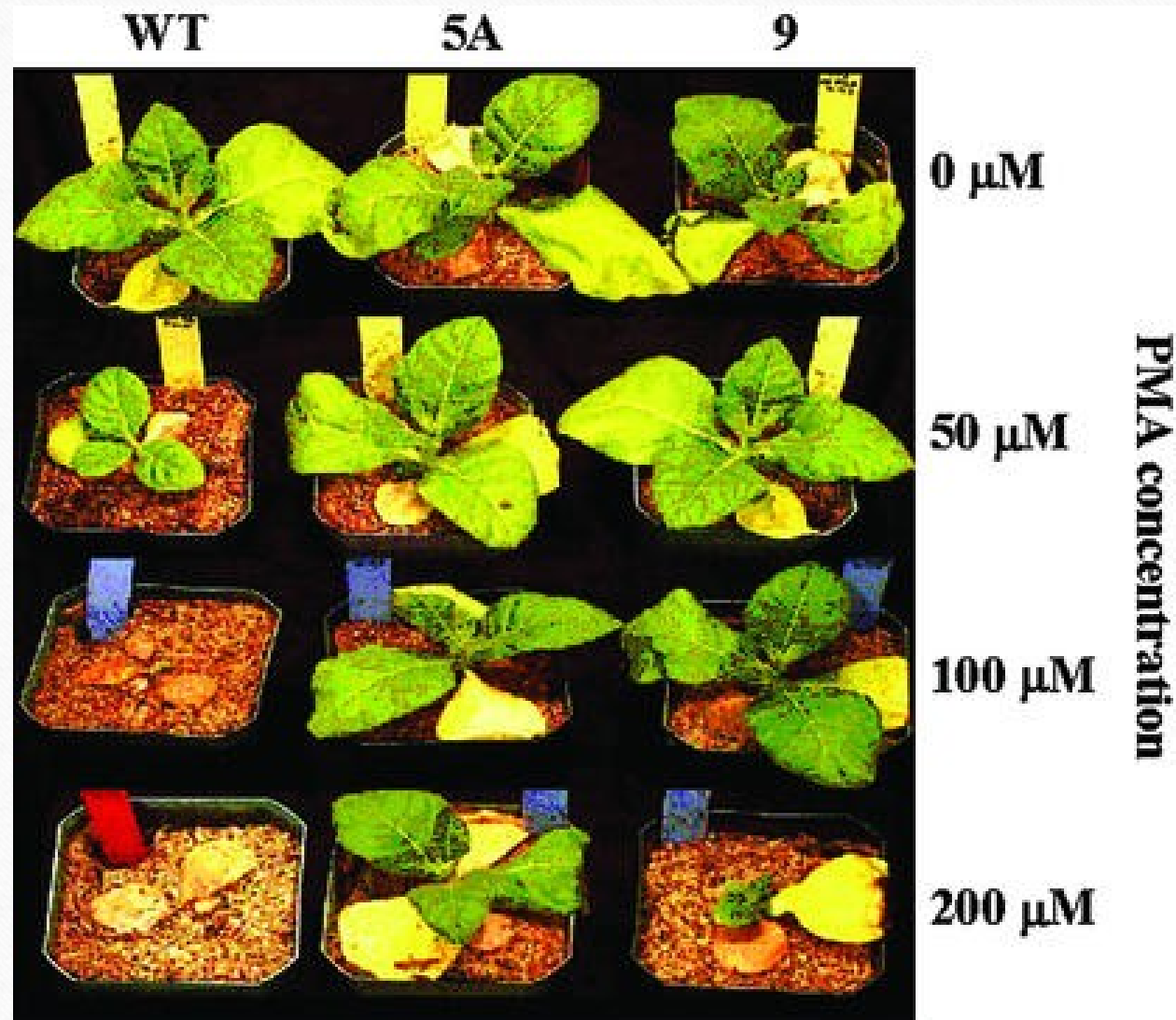
## 3. Generácia GM plodín

a) nové typy rastlín



(Daniell et al., 2005)

*TRENDS in Biotechnology*



(Ruiz et al., 2003)

PMA = phenylmercuric acetate

# Príklady GMO potravín

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# Bt-kukurica

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- *Bacillus thuringiensis* produkuje protein Cry ( $\delta$ -endotoxin), ktorý je selektívne škodlivý pre škodcov Lepidoptera, Diptera, Coleoptera.
- Bt-insekticídy sú obľúbené medzi organickými farmármi, pretože sú to „prírodne insekticídy“
- Bt-kukurica bola vyrobená inzerciou génu cry, vďaka čomu si rastlina sama vyrába Cry proteín, čo výrazne znižuje potrebu používania insekticídov

Kontrola

Bt-kukurica



Bt-kukurica

Kontrola

Kontrola





# Zlatá rýža

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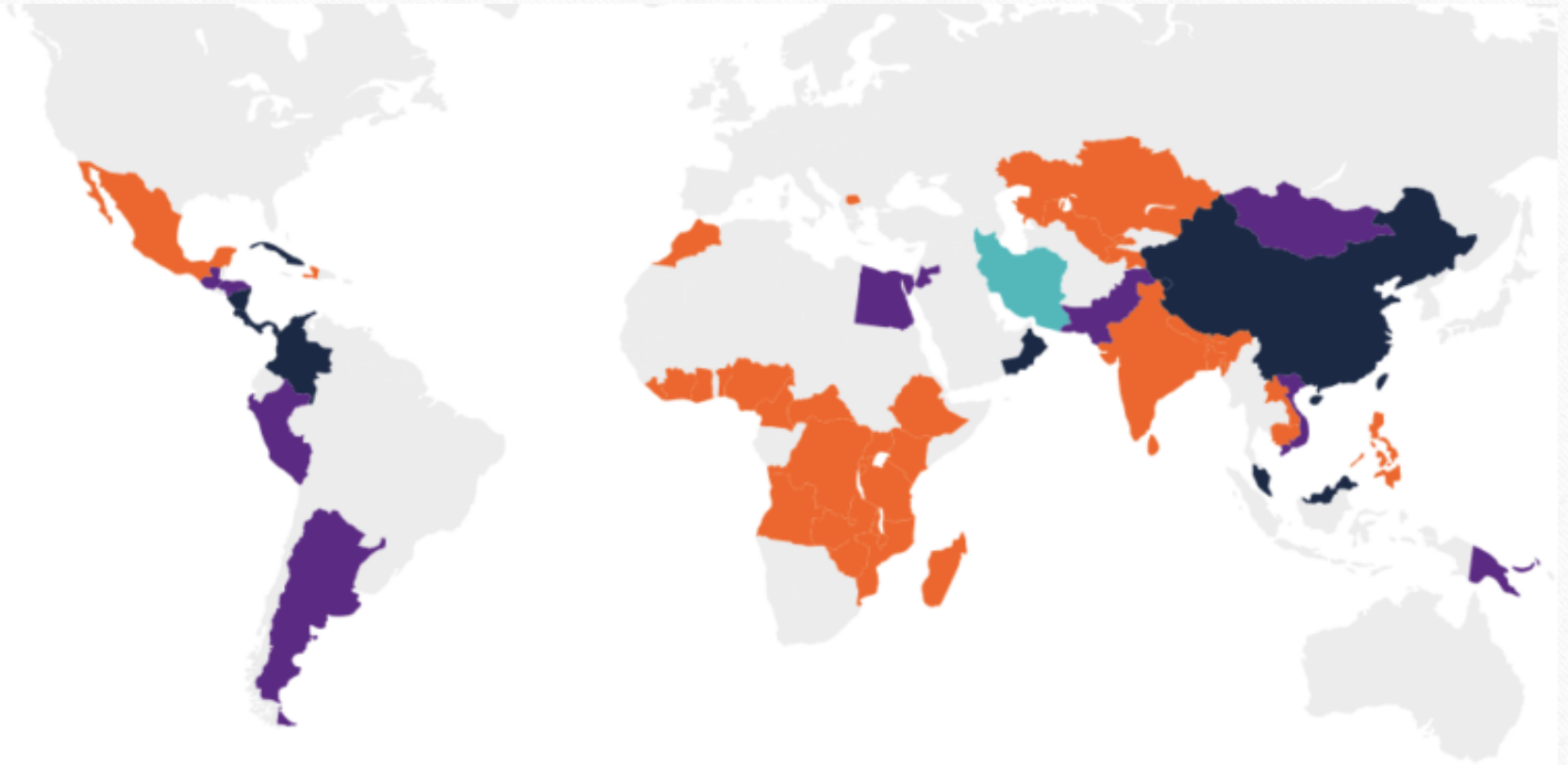
- Odroda ryže geneticky upravená tak, aby produkovala veľké množstvá  $\beta$ -karoténu (provitamín A)
- Bola vytvorená s humanitárnym zámerom:
  - Celosvetovo trpí ročne nedostatkom vitamínu A (VAD) 125 miliónov detí pod 5 rokov, pričom 250 – 500 tisíc detí ročne v jej následku oslepne. Viac ako polovica detí, ktoré oslepnú, do roka zomrie.
  - VAD tiež spôsobuje zhoršenú funkciu imunitného systému, anémiu a spomalený rast.
  - Zlatá ryža by dokázala tento problém vyriešiť, keďže už 60 g zlatej ryže denne (polka hrnčeka) obsahuje 60 % doporučenej dennej dávky (čínskej) pre deti vo veku 6-8 rokov. Čo je dostatočné množstvo na to, aby sa zabránilo VAD.

**Figure 1. Worldwide prevalence of vitamin A deficiency.**

*Map showing the prevalence of biochemical vitamin A deficiency in children under five, as indicated by a serum retinol concentration <math><0.70 \mu\text{mol/l}</math>. Based on data collected by WHO between 1995 and 2005 in populations at risk of vitamin A deficiency.*

**Level of vitamin A deficiency**

- Severe ( $\geq 20\%$ )
- Moderate ( $\geq 10\% - < 20\%$ )
- Mild ( $\geq 2\% - < 10\%$ )
- None ( $< 2\%$ )
- No data









JULY 31, 2000 \$3.50

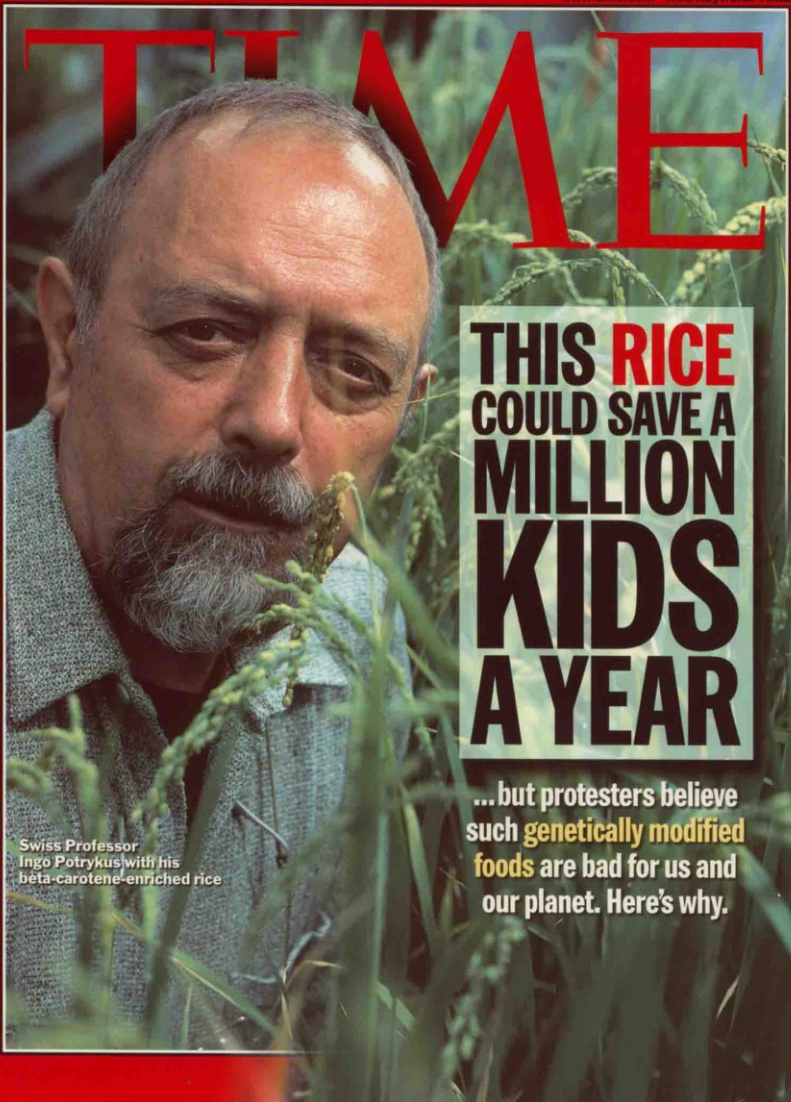
www.time.com AOL Keyword: TIME

# TIME

**THIS RICE  
COULD SAVE A  
MILLION  
KIDS  
A YEAR**

Swiss Professor  
Ingo Potrykus with his  
beta-carotene-enriched rice

... but protesters believe  
such **genetically modified**  
**foods** are bad for us and  
our planet. Here's why.





Environment Climate change Wildlife Energy Pollution

GM

## Nobel winners slam Greenpeace for anti GM campaign

About a third of living Nobel laureates sign an open letter saying Greenpeace has misrepresented the risks and benefits of genetically modified crops

most viewed



AI experts call for boycott over 'killer robots' project South Korea university



Salisbury attack: what UK said and what evidence



U.S.

## Stop Bashing G.M.O. Foods, More Than 100 Nobel Laureates Say

JUN 29, 2016 @ 03:41 PM 17,555

Speaking of Science

# 107 Nobel laureates sign letter blasting Greenpeace over GMOs

## More Than 100 Nobel Laureates Call Out Greenpeace For Anti-GMO Obstruction In Developing World

## Support Precision Agriculture

[Support GMOs and Golden Rice - Home](#)

[Laureates Letter Supporting Precision Agriculture \(GMOs\)](#)

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## 155 Laureates Supporting Precision Agriculture (GMOs)

Peter Agre	2003	Chemistry
Zhores I. Alferov *	2000	Physics
Sidney Altman	1989	Chemistry
Hiroshi Amano	2014	Physics
Werner Arber	1978	Medicine
Richard Axel	2004	Medicine
David Baltimore	1975	Medicine
Barry Clark Barish	2017	Physics
J. Georg Bednorz	1987	Physics
Paul Berg	1980	Chemistry
Bruce A. Beutler	2011	Medicine
Gerd Binnig	1986	Physics
J. Michael Bishop	1989	Medicine

Volume 19, Issue 6 December 2014 , pp. 724-742

Cited by 26

 Access  Open access

## The economic power of the Golden Rice opposition

Justus Wesseler <sup>(a1)</sup> and David Zilberman <sup>(a2)</sup> 

<https://doi.org/10.1017/S1355770X1300065X> Published online: 22 January 2014

### Abstract

Vitamin A enriched rice (Golden Rice) is a cost-efficient solution that can substantially reduce health costs. Despite Golden Rice being available since early 2000, this rice has not been introduced in any country. Governments must perceive additional costs that overcompensate the benefits of the technology to explain the delay in approval. We develop a real option model including irreversibility and uncertainty about perceived costs and arrival of new information to explain a delay in approval. The model has been applied to the case of India. Results show the annual perceived costs have to be at least US\$199 million per year approximately for the last decade to explain the delay in approval of the technology. This is an indicator of the economic power of the opposition towards Golden Rice resulting in about 1.4 million life years lost over the past decade in India.

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# AquAdvantage® salmon

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- Vyvinutý v roku 1989 vložení jedné kópy *opAFP-GHc2* konstruktu, který obsahuje promotor zo Slimule americké (*Zoarcis americanus*), za kterým je umístěný rastový hormón z Lososa čavyča (*Oncorhynchus tshawytscha*)
- Narastie do požadovanej veľkosti na predaj za 16-18 mesiacov v porovnaní s 3 rokmi, ktoré to trvá nemodifikovaným lososom
- Na chov sa používajú triploidné sterilné samičky, ktoré majú navyše kvalitnejšie mäso, pretože nemusia investovať energiu na reprodukciu.
- Fertilný samčekovia a samičky sú skladované v nádržiach, ktoré niesu v žiadnom kontakte s oceánom





nature

MEDICAL & BIOTECH

# First Genetically Engineered Salmon Sold in Canada

US firm AquaBounty Technologies says that its transgenic fish has hit the market after a 25-year wait

By Emily Waltz, Nature on August 7, 2017

# Zhrnutie GMO

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## **pozitíva**

- Principiálne rýchlejšie ako klasické metódy šľachtenia
- Vieme presne, aké genetické zmeny nastali v modifikovanom organizme
- Majú veľký potenciál byť ekonomickejšie, ekologickejšie a zdravšie ako alternatívy
- Je nimi možné dosiahnuť aj zmeny, ktoré nie je možné vyšľachtit' „klasickými“ metódami

## **negatíva**

- Často negatívny postoj verejnosti
- Vyžadujú dobrú znalosť genetiky daného znaku
- Pre neistotu úspešného zavedenia na trh sa často jedná o rizikovú investíciu

# *In vitro* mäso

(nie je GMO)

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# FROM PIG TO PLATE

Researchers are adapting tissue engineering techniques to grow edible meat, *in vitro*.



1 Take a small biopsy



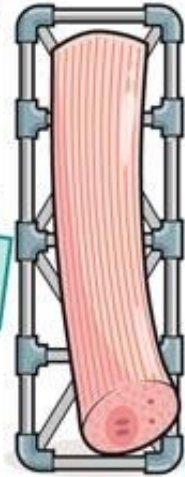
2 Extract myosatellite cells



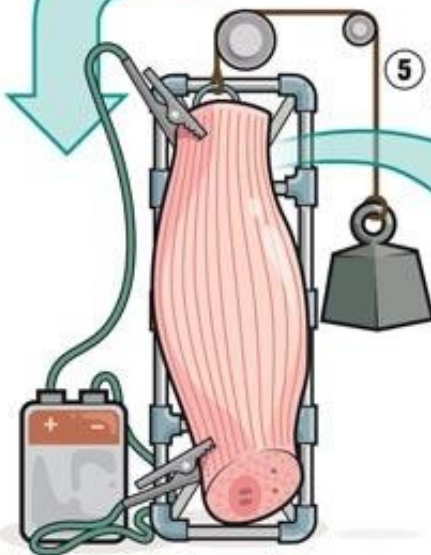
3 Add animal-free growth serum to multiply cells



4 Grow cells on scaffold to form myofibres, which bind together to form muscle.



5 Exercise muscle to boost protein



6 Grind up thousands of muscle strips



7 Add flavour, iron and vitamins



8 Cook. EAT!



# Cena?

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- Prvé pokusy s tvorbou *in vitro* mäsa začali približne v roku 2000
- Prvý v laboratóriu vypestovaný hamburger bol verejne zjedený (počas nahrávania televíziou) v roku 2013 a jeho vypestovanie stálo 250 000 dolárov
- Ceny výroby *in vitro* mäsa však prudko klesajú a je možné, že prvé komerčne predávané *in vitro* mäso sa na trhu v USA objaví už v blízkej dobe



News > Science

# Lab-grown 'clean' meat could be on sale by end of 2018, says producer

Cultured tissue, harvested without killing any animals, could allow scientists to grow meals' worth of products with just a handful of starter cells

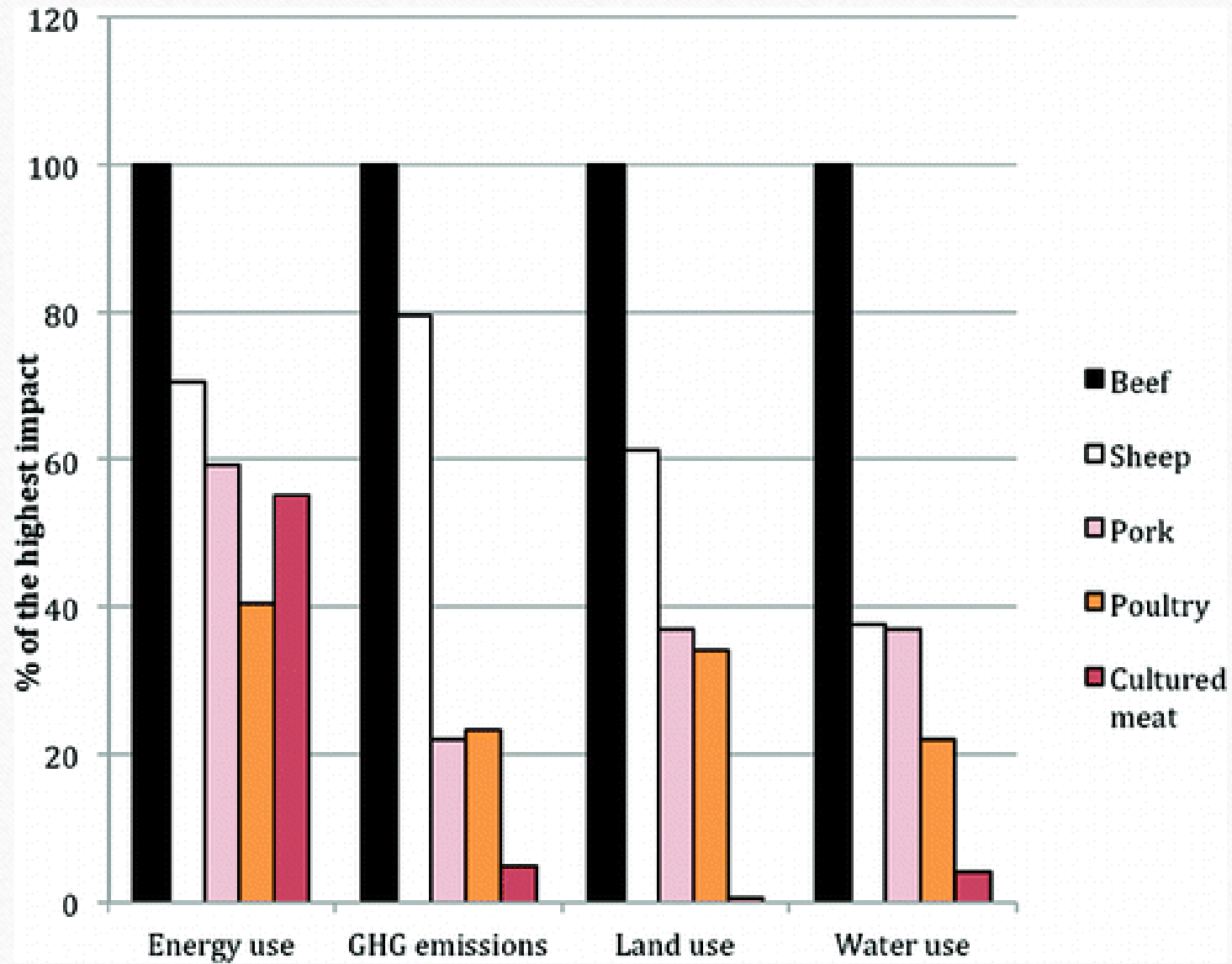


## How close are we to a hamburger grown in a lab?

By Charlotte Hawks, CNN

🕒 Updated 1923 GMT (0323 HKT) March 8, 2018





(Tuomisto and Mattos, 2011)





## DODO NUGGETS

★★★★

ADD TO MENU

CHOOSE ANOTHER STARTER

The dodo is back on the menu. Thanks to a dried specimen of a dodo in the Oxford University Natural History Museum it is possible to taste what the first sailors ate when they visited Mauritius in 1598. Tissue engineering and advanced genetic sequencing have allowed food scientists to reanimate this long-extinct species. Children love the taste of cutting-edge science, especially served with our sweet honey and mustard dipping sauce.



BISTRO IN VITRO MENU CHEFS REVIEWS RESERVATION

## WELCOME TO BISTRO IN VITRO

Hello meat eaters, hello vegetarians. Welcome to Bistro In Vitro, the restaurant for trailblazers, world changers and nature lovers. We cook to a high standard using the latest culinary techniques and a revolutionary new ingredient: in vitro meat. Welcome to the restaurant of the future!



## WHY IN VITRO MEAT?

Now that the world population is heading for 9 billion in 2050, our current way of producing and consuming meat is fast becoming unsustainable. Global warming, energy consumption, animal diseases and the anticipated worldwide food shortage are just some of the pressing food related issues we will need to address, and that is before we have even considered the much debated issue of animal cruelty and factory farming.



## PIG IN THE GARDEN

★★★

ADD TO MENU

CHOOSE ANOTHER MAIN COURSE

Meat comes from living animals, and that goes for the stem cells needed for in vitro meat as well. The pig in the restaurant's garden is a living repository of stem cells for the pork shoulder on our menu. Interested in meeting the pig with your dinner companions? Ask your waitress, and she will happily escort you.



## A FICTITIOUS RESTAURANT

**Bistro In Vitro** is a fictitious restaurant with a menu of in vitro dishes that may one day end up on your plate. We prepare exclusive cuts of meat, cultured and prepared with surprising flavours and textures that you would never encounter in the wild. By exploring and pushing the boundaries of our food culture we want to do away with the idea that cultured meat is an inferior meat substitute. That is why we serve you a digital selection of sustainable, animal friendly, exciting and delicious dishes that will prompt thought and discussion on in vitro meat.