GMOs: What's all the fuss?

Alan McHughen
University of California
Riverside, CA
alanmc@ucr.edu

FPI Survey (2004)

- Are GM foods in US supermarkets?
- Do ordinary tomatoes contain genes?
- Would a tomato with a fish gene taste "fishy"?
- If you ate a GM fruit, might it alter your genes?
- Can animal genes be inserted into a plant?
- Give an example of GM food on the market

What is GM/GE/Biotechnology ?

- Any of several techniques used to add, delete or amend genetic information in a plant, animal or microbe

- Used to make pharmaceuticals (insulin, dornase alpha, etc.), crops (Bt corn, disease resistant papaya, etc.) and industrial compounds (specialty oils, etc.)

History of genetic engineering

- rDNA began in 1973, with GE bacteria
- First commercial product- insulin- in 1982
- First food- cheese – 1988 (UK), 1990 (US)
- First food crop, FlavrSavr™ tomatoes, in 1994
- So far, there have been no documented cases of harm from GMOs.

Who uses Biotech products ?

- Consumers: diabetics, victims of CF, cancer, etc.
- Farmers in US (USDA data, 2005):
  - Soybean: 87% of acreage
  - Cotton: 79% of acreage
  - Corn: 52% of acreage
  - Others: papaya, canola, squash, etc.
- Farmers in developing countries (ISAAA data)
  - 90% of GE crop farmers are poor, subsistence

World GE crops 2005*

- **21 countries grew GE crops commercially**:
  US, Argentina, Brazil, Canada, China, India.
- **New countries:**
  Portugal, France, Czech Republic, Iran
- **New crops:**
  Bt Rice (Iran); stacked traits (e.g. Bt +HR)

**ISAAA data, 2006*

Economics of GE crops

In the USA, six GE crops— soybeans, corn, cotton, papaya, squash and canola — provide:

- Over 5 billion additional pounds of food and fiber on the same acreage,
- improved farm income by $1.9 billion, and
- reduced pesticide use by 46 million pounds.

National Center for Food and Agricultural Policy (NCFAP), 2004

Documented benefits of biotech crops

- Farmers
  - Increased yields (especially in developing countries)
  - Decreased chemical input costs
  - Cleaner fields, less dockage
  - Less fuel used
  - Less tillage
  - Fewer adverse health effects (esp. China).

Documented benefits of biotech crops

- Consumers
  - Safer food (less mycotoxin in maize, esp Africa/Asia)
  - Safer food (greater regulatory scrutiny)
  - Less pesticide
  - Environmental benefits.

Documented benefits of biotech crops

- Environment
  - Less pesticide burden
  - Safer pesticides
  - Improved soil from less tillage
  - Less fuel usage
  - Increased biodiversity

- Sources: NCFAP, Plant Biotechnology, June 2002; November 2004
- Canola Council of Canada, An agronomic and economic assessment of transgenic canola, 2001
- Munkvold, G.P., Hellmich, R.L., and Rice, L.G. 1999. Comparison of fumonisin concentrations in kernels of transgenic Bt maize hybrids and non-transgenic hybrids. Plant Dis. 83:130-138.

So, What's the fuss?

- GE is unnatural, 'crossing the species barrier'
- GE food contains bacterial genes
- GE plants spread uncontrollably
- GE is unethical
- GE is 'risky'
- GE is controlled by corporate interests
- GE crops are unregulated; no prior scrutiny

Concerns with GMOs

- **Scientific**
  - Environment
  - Health safety
- **Non-scientific**
  - Ethical
  - Socio-economic
  - Political
    - Covert Trade
    - Covert Technological
  - FEAR!

Problem of context

- "Fear subverts rational and critical thinking"
  - E.g. use of pesticides in agriculture
    - "Natural" products are invariably safe
      - Synthetic chemicals are invariably hazardous
    - Toxicology doesn't matter:
      - **all** chemicals are equally hazardous
    - Amount doesn't matter:
      - **any** amount is too much.

Fear and loathing: the context of risk

- Roanoke (Va) *Times (9/20/2004)*: "Mellisa Williamson, 35… worries about the effect on her unborn child from the sound of jackhammers.'
  - Is Ms Williamson (or other similarly concerned parent) likely to feed GMO babyfood to her child?

Science vs. Non-science

- Non-scientific approach
  - Starts with conclusion, searches for evidence to support it (*cherry picking*)
  - Discredits alternative views
  - Often lacks **Context**
- Scientific approach (*n.b. not all scientists*)
  - Collects and analyses all available evidence before (perhaps) reaching conclusion
  - Actively seeks alternative interpretations
  - Is his/her own greatest critic
  - Applies **Critical thinking skills.**

Applying Context and Critical Thinking
Crops: traditional and modern

- All new crops (traditional or biotech) must be genetically altered and distinct

- DUS= *D*istinct, *U*niform, *S*table.

Variety release requirements: genetically engineered crops

- USDA (APHIS) - environmental issues
- HHS (FDA)- food and feed safety
- EPA- pesticide usage issues.

DUS, plus…

- Molecular characterization of inserted DNA,
- Southern and restriction analyses
- PCR for several fragments,
- Various enzyme assays (ALS, NOS, NPT-II)
- Copy number of inserts
- Size of each fragment,
- Source of each fragment
- Utility of each fragment
- How fragments were recombined
- How construct was delivered into flax
- Biological activity of inserted DNA (genes)
- Quantitative analyses of novel proteins (western analyses)
- Temporal activity of inserted genes
- spatial activity of inserted genes
- complete amino acid analysis
- detailed amino acid analysis for valine, leucine and isoleucine
- Toxicity (feeding trials were not warranted)
- Allergenicity (feeding trials were not warranted)
- Biological analysis:
- Pathogenicity to other organisms
- dormancy,
- outcrossing
- potential for horizontal gene transfer
- seed production
- flowering time,
- flower morphology
- analysis of relatives
- stability of inserted genes over seed generations
- survivability in natural environment
- survivability in agricultural environment in presence of herbicide
- survivability in agricultural environment in absence of herbicide
- Interaction with other organisms- alterations to traditional relationships
- Interactions with other organisms- novel species
- Changes to persistence or invasiveness
- Any selective advantage to the GMO
- Any selective advantage to sexually compatible species
- Plan for containment and eradication in the event of escape

Methods of Genetic Modification

- Recombinant DNA (rDNA)

- Mutagenesis
- Somaclonal variation
- Embryo rescue
- Crossing or selection within a population
- Introduction
- Succession/invasion.

Similar products, similar risks ?

HT Canola:	Group
Sulfonylurea	2. ALS/AHAS inhibitor
Trifluralin	3. Mitotic inhibitor
Bromoxynil	4. PGR
Triazine	5. Photosynthetic inhibitor
Glyphosate	9. EPSP Synthase inhibitor
Glufosinate	10. Glutamine Synth. Inhibitor

Different process, same product

- Rice: disease resistance (*Xa21* gene)
- Canola: herbicide tolerance (SuRs)

- Coffee: reduced caffeine
- Maize: enhanced tryptophan
- Flaxseed: reduced linolenic acid
- Soybean: increased oleic acid.

Changes in Genetically Modified Food:

- **DNA content:**
  - highly variable, depends on species
- GM additional DNA,
  - approx. 1 gene added to 25,000 genes.
- Or, approx. 0.000 000 7% new DNA.
- **Protein:**
  - highly variable, depends on food.
- GM protein, approx. 0.00004 % of total protein is novel.

NAS/IOM Conclusions

- Foods with a novel substance or altered levels of usual components should be scrutinized for safety, regardless of method of breeding
- A new modified food, whether GE or other, whose composition is similar to conventional version may warrant little or no safety evaluation.

Consensus of scientific societies

- The method of breeding is immaterial to the risk of hazard. All breeding involves changes to DNA and carries some (albeit small) risk
- There is no scientific justification to single out GE for 'special' regulatory or liability considerations.

Conclusion

- **When you encounter concerns with GMOs:**
  - Is it science or non-science?
    - Science is product oriented
    - Science is evidence based
  - If science, demand peer reviewed evidence
  - If peer reviewed data, ask how it compares to *Status Quo*
  - Apply critical thinking and context:
    - Evaluate all evidence, both pro and con.