Safety of Genetically Modified Foods and Food Ingredients

Ruth S. MacDonald, RD PhD
Professor and Chair
GMO in US food system

- Corn-derived ingredients
  - Oil, starch, corn syrup, alcohol
- Soybean-derived ingredients
  - Oil, soy flour, soy proteins, lecithin
- Canola oil
- Sugar from sugar beets
- Papaya, squash, sweet corn
Indirect GMO foods

• Animals fed GMO grain
  • Meat - beef, chicken, pork
  • Milk, yogurt, cheese, butter
  • Eggs

• Foods made with any of the above
  • Prepared meals
  • Baked goods
  • Desserts
Timeline of GMO in US Foods

1992 – FDA policy
1994 – Tomato and squash
1996 – Corn, soybeans, canola
1998 – Papaya
2008 – Sugar beets
2011 – High-oleic soybeans

www.foodinsight.org
Total APHIS permits 2013

USDA ERS, 2014
FDA policy on GMO foods

- 1986 Coordinated Framework for the Regulation of Biotechnology (CFRB)
  - Product not process

- 1992 substantial equivalence to conventional foods

- Voluntary submission
Safety measures

- **Toxicity**
  - genes, proteins or altered expression

- **Adverse nutritional changes**
  - anti-nutrients, altered expression

- **Allergenicity**
  - novel proteins

- **Horizontal gene transfer**
  - mutations
Testing approaches

• **Bioinformatics**
  - database comparisons

• **Digestibility/degradation**
  - in vitro, pure compound

• **Metabolomics**
  - protein expression patterns

• **Feeding trials**
  - acute and chronic toxicity

• **Field trials**
  - environmental influences

Safety testing

Tier I: Potential Hazard Identification

- History of Safe Use
- Bioinformatics Analysis
- Mode of Action and Specificity
- *In Vitro* Digestibility and Lability
- Expression Level and Dietary Intake

Tier II: Hazard Characterization

Determined on a case-by-case basis and might include one or more of the following:

- Acute toxicology assessment of transgenic protein
- Repeated dose toxicology assessment of transgenic protein
- Hypothesis-based Studies

Delaney et al, Food and Chemical Tox 46:S71-S97, 2008
Newly expressed proteins

- Foods contain many proteins
- Limited number of natural protein toxins
- Limited number of natural protein allergens
- Denaturation and enzyme digestion occurs

Delaney et al, Food and Chemical Tox 46:S71-S97, 2008

No substantiated allergenicity in humans to GM food or food ingredient with over 20 years of exposure
Livestock data

- 100 billion animals fed GMO grain between 2000-2011
- No difference in health outcomes comparing before after GMO introduction
- No difference in nutrient or food composition

<table>
<thead>
<tr>
<th>Industry</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broilers</td>
<td>94,683,600,000</td>
</tr>
<tr>
<td>Layer Hens</td>
<td>3,722,708,000</td>
</tr>
<tr>
<td>Turkeys</td>
<td>2,733,500,000</td>
</tr>
<tr>
<td>Beef cattle</td>
<td>339,350,000</td>
</tr>
<tr>
<td>Dairy cows</td>
<td>33,550,000</td>
</tr>
<tr>
<td>Hogs</td>
<td>1,219,460,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>102,732,168,000</strong></td>
</tr>
</tbody>
</table>

Van Eenennaam and Young, J Ani Sci, 2014
Livestock health

Van Eenenmaan and Young, J Ani Sci, 2014
Safety studies in animals

• Native plant DNA-fragments may be absorbed with very low frequency
• Assume same for recombinant DNA
• No transfer of recombinant DNA from feed to animal tissues (eggs, meat or milk)

Gut microbiota

- Horizontal gene flow
- DNA rapidly degraded by digestion
- Limited amount may escape to colon
- Native and recombinant DNA similar

Transformation of gut microbiota highly unlikely

European Commission: A Decade of EU-funded GMO Research (2001-2010)
http://ec.europa.eu/research
Genome stability

“No evidence that a random genomic change in a crop has ever resulted in a novel safety issue, even when new alleles or genes were created”

http://www.plantphysiol.org/cgi/doi/10.1104/pp.112.204271
Human health

- Consumption began 20 years ago
- No documented evidence for health risks
- Exposure rate is low
  - Processing of grains
  - Extraction of ingredients
  - Heat treatment
  - Low relative component of food
Implied correlations

Prevalent health issues
- Obesity
- Cancer
- Food allergies
- Gluten insensitivity
- Autism
- ADHD
- Alzheimer’s disease
- Depression
- Heart disease

Complex etiologies
- Foods and food patterns
- Lifestyle
- Chemical exposures
  - Pollutants
  - Endocrine disruptors
- Genetics
- Epigenetics
Confounding issues

• GMO crops linked with pesticides, specifically glyphosate

• No scientific evidence linking glyphosate to disease

  • Review of literature found no plausible mechanism by which glyphosate would induce adverse developmental or reproductive outcomes
  • Animal studies found not risk for cardiovascular defects from glyphosate exposure during pregnancy
  • Meta-analysis found no relationship between cancer and glyphosate exposure
    • Mink et al. Reg Tox Pharm 63:440-452, 2012
Scientific review

• Center for Science in the Public Interest
  • “…there is strong international consensus from both scientific regulatory bodies…, as well as scientific societies…..that foods made from the current GE crops are safe to eat.”

  Gregory Jaffe

• American Association for the Advancement of Science
  • “The World Health Organization, the American Medical Association, the U.S. National Academy of Sciences, the British Royal Society, and every other respected organization that has examined the evidence has come to the same conclusion: consuming foods containing ingredients derived from GM crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques.”


Statement by the AAAS Board of Directors on Labeling of Genetically Modified Foods, 20 October 2012
Summary

- GMO technology
  - Provides important tools for modern food system
  - No scientific basis for risk to human or animal health
  - Should be continually monitored and evaluated
  - Safety assessment must be transparent