Soyfoods & Health: A Brief Discussion of Key Issues

Mark Messina

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markjohnmessina@gmail.com
Soyfoods & Health: A Brief Discussion of Key Issues

- Protein quality
- Cholesterol lowering
- Soy allergy
- “Anti-nutrients”
- Mineral absorption
- Soy infant formula
- Breast cancer prevention
Macronutrient (% calories) Composition of Soybeans in Comparison to Common Beans

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Soybeans</th>
<th>Common beans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate</td>
<td>27*</td>
<td>70</td>
</tr>
<tr>
<td>Fat</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>Protein</td>
<td>33</td>
<td>27</td>
</tr>
</tbody>
</table>

* Mostly oligosaccharides
Soyfoods: From East to West

Isolated soy protein

Soy protein concentrate

Soy flour
Protein Quality

1. Digestibility

2. Amino acid pattern
Protein Efficiency Ratio (PER) versus Protein Digestibility Corrected Amino Acid Score (PDCAAS)

Rat sulfur amino acid (limiting in beans) requirement is 50% higher than humans
# Digestibility & Protein Digestibility Corrected Amino Acid Scores for Soy Isolates & Soy Protein Concentrates

<table>
<thead>
<tr>
<th>Product</th>
<th>Digestibility (percent)</th>
<th>Truncated PDCAAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISP*</td>
<td>97.3</td>
<td>1.00</td>
</tr>
<tr>
<td>SPC</td>
<td>97.0</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*mean of 3 proteins

J Agric Food Chem 59:12707-12., 2011
Effect of Adding Full or Defatted Soy Flour to Cassava Complementary Porridges (35:65 w/w) on the PDCAAS

![Bar chart showing the effect of conventional and extrusion cooking methods with and without soy flour on PDCAAS values. The chart indicates a higher PDCAAS for extrusion cooking with defatted soy flour compared to conventional cooking with no soy flour.]
Effect of Adding Full or Defatted Soy Flour to Cassava Complementary Porridges (35:65 w/w) on the PDCAAS

Muoki J Sci Food Agric 2012
Effect of Adding Full or Defatted Soy Flour to Cassava Complementary Porridges (35:65 w/w) on the PDCAAS

Muoki J Sci Food Agric 2012
“25 grams of soy protein per day ... may reduce risk of heart disease”

Countries with approved health claims

- Brazil
- Indonesia
- Japan
- Korea
- Chile
- Turkey
- Malaysia
- Philippines
- United Kingdom*
- United States
- Columbia
- South Africa
Decrease in LDLC (%) in Response to Soy Protein: Results of Recently Published Meta-Analyses

<table>
<thead>
<tr>
<th>Reference</th>
<th>Studies</th>
<th>(N)</th>
<th>LDLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson</td>
<td>20</td>
<td>1946</td>
<td>5.5</td>
</tr>
<tr>
<td>Jenkins</td>
<td>22</td>
<td>757</td>
<td>4.3</td>
</tr>
<tr>
<td>Harland</td>
<td>10</td>
<td>2913</td>
<td>6.0</td>
</tr>
<tr>
<td>Reynolds</td>
<td>36</td>
<td>1387</td>
<td>4.0</td>
</tr>
<tr>
<td>Zhan</td>
<td>33</td>
<td>1749</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Effects of Soy Protein on LDLC in Hypercholesterolemic Children (N=16)

Baseline: 216 mg/dl

Low saturated fat
- Soy
+ Soy

Mean age, 8.8 y. Range, 4-18
Effects of Soy Protein on LDLC in Hypercholesterolemic Children (N=16)

Baseline    Phase I    Phase II

Low saturated fat

- Soy       + Soy

Soy protein, 0.5 g/kg bw.
Mean age, 8.8 y. Range, 4-18
Effects of Soy Protein on LDLC in Hypercholesterolemic Children (N=16)

Soy protein, 0.5 g/kg bw.
Mean age, 8.8 y. Range, 4-18
Prevalence of Soy Allergy among Adults

The “Big Eight”

Doctor-diagnosed: 0.04% (1/2500)
Self-diagnosed: 0.05% (1/2000)

Milk allergy 40x > soy

Soy Allergy and Children

- Incidence: 1/250 (0.4%)
- Percentage outgrowing soy allergy by:
  - Age 4, 25%
  - Age 6, 45%
  - Age 10, 69%

By age 10, 1.2/1000

Soybean “Anti-Nutrients”

• Phytate
  IP6, inositol hexaphosphate

• Protease inhibitors
  Bowman-Birk (BBI), Kunitz (KTI)

• Isoflavones
  Genistein, daidzein, glycine
Reduces absorption of minerals – calcium, iron, zinc, and magnesium

Phytate
(phytic acid)

• Naturally occurring compound
• Found in whole grains & beans
• Cell regulation
• Anti-oxidant
Ferritin: Iron Containing Protein

- Major form of legume iron
- Resistant to inhibitors of iron absorption?

Older research underestimated iron absorption

Publications
- J Nutr 2012 (Theil et al)
Absorption & Incorporation in Red Blood Cells of Iron from Soybean Ferritin and Ferrous Sulfate in 16 Nonanemic Women

AJCN 2006;83:103–7.
Fractional Calcium Absorption (%) by Healthy Women from Milk and Low- and High-Phytate Soybeans

Soybeans

Low phytate: 0.414
High phytate: 0.310

p<0.001

AJCN 53:745, 1991
Fractional Calcium Absorption (%) by Healthy Women from Milk and Low- and High-Phytate Soybeans

Soybeans

Low phytate: 0.414
High phytate: 0.310
2% milk: 0.377

p<0.001

AJCN 53:745, 1991
Calcium absorption in Australian osteopenic postmenopausal women: an acute comparative study of fortified soymilk to cow’s milk

Calcium bioavailability of calcium carbonate fortified soymilk is equivalent to cow’s milk in young women

Bioavailability of calcium from tofu as compared with milk in premenopausal women
Protease Inhibitors

• Ubiquitous in nature
• Phytoalexins (defensive molecules)
• Classified as antinutrients
• Inhibit protein digestion
• HIV/cancer drugs
• Chemopreventives?
“... protease inhibitors prevent conversion of normal cells to the malignant state ...”
# Trypsin Inhibitor Content of Soy Protein Products

<table>
<thead>
<tr>
<th>Product</th>
<th>% residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw soy flour</td>
<td>100</td>
</tr>
<tr>
<td>Toasted soy flour</td>
<td>6-15</td>
</tr>
<tr>
<td>Soybean concentrate</td>
<td>12-27</td>
</tr>
<tr>
<td>Isolated soy protein</td>
<td>19-21</td>
</tr>
<tr>
<td>Textured soy flour</td>
<td>10</td>
</tr>
</tbody>
</table>

Residual trypsin inhibitor content of soy infant formulas made with isolated soy protein ranges from 0.8 – 3.7 percent.
Benefits

Isoflavones (phytoestrogens)

Concerns
Soybean Isoflavone Aglycones

<table>
<thead>
<tr>
<th>Isoflavone</th>
<th>R₁</th>
<th>R₂</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genistein</td>
<td>H</td>
<td>OH</td>
<td>50</td>
</tr>
<tr>
<td>Daidzein</td>
<td>H</td>
<td>H</td>
<td>40</td>
</tr>
<tr>
<td>Glycitein</td>
<td>OCH₃</td>
<td>H</td>
<td>10</td>
</tr>
</tbody>
</table>
Isoflavones are Selective Estrogen Receptor Modulators

Tissue selective

mixed estrogen agonists/antagonists

Pharmaceutical examples of SERMs

• Tamoxifen
• Raloxifene

Isoflavones ≠ Estrogen
Comparison of the Clinical Effects of Soybean Isoflavones with Estrogen on Selected Endpoints

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Isoflavones</th>
<th>Estrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaginal tissue(^1)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Bone mineral density</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Breast tissue(^2)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Hot flashes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Endothelium(^3)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Skin health</td>
<td>Yes?</td>
<td>Yes?</td>
</tr>
</tbody>
</table>

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\(^1\) Vaginal maturation index  
\(^2\) Density & cell proliferation  
\(^3\) Flow mediated dilation
Clinical studies show no effects of soy protein or isoflavones on reproductive hormones in men: results of a meta-analysis.

Soybean isoflavone exposure does not have feminizing effects on men: a critical examination of the clinical evidence.

No clinical effects on:

- Sperm/semen (N=3)\(^1\)
- Testosterone (F & T) (N=36)
- Estrogen (N=9)
- Breast tissue\(^2\)
- Erectile function (animal studies)\(^3\)

\(^1\) Pilot epi study $\rightarrow \downarrow$ [sperm]; Hum Reprod 2008;23:2584.
\(^2\) Case report, gynecomastia, 360 mg/d isoflavones; Endocr Pract 2008;14:415.
\(^3\) Erectile dysfunction in vegan, 360 mg isoflavones/d; Siepmann, Nutrition 2011.
Soy Infant Formula

- In widespread use in since the 1960s
- >20 million Americans have used SIF
Mission:

To evaluate evidence of possible adverse developmental and reproductive effects caused by substances to which humans may be exposed.
Soy Infant Formula

“Minimal concern”*

“Negligible concern”*

*Negligible, minimal, some, concern, serious.

2009/2010

Current positions

*NTP Center for the Evaluation of Risks to Human Reproduction

CERHR

The American Academy of Pediatrics®
Breast cancer
Breast Cancer Incidence Rates (Age-adjusted per 100,000) in Selected Regions of the World

- N. America: 99.4
- N. Europe: 82.5
- S. America: 46.0
- Japan: 32.7
- N. Africa: 23.2
- China: 18.7
Age-Adjusted Breast Cancer Incidence Rates (/100,000) for Miyagi Prefecture, Japan, 1959-97

Westernization

Year of diagnosis

“There is growing evidence from epidemiologic studies that the consumption of traditional soy foods such as tofu may decrease the
risk of cancers of the breast, prostate, or endometrium, and there is selected evidence for a risk reduction of some other cancers.”
Hypothesis

Early Soy (Isoflavone) Intake Decreases Breast Cancer Risk
Early Soy (Isoflavone) Intake Decreases Breast Cancer Risk

- Animal studies supportive
- Several proposed mechanisms
- Epidemiologic studies supportive
# Early Soy Intake & Breast Cancer Risk: Epidemiologic Research

<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Location</th>
<th>(N)</th>
<th>% Risk ↓</th>
</tr>
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<tbody>
<tr>
<td>Shu, 2001</td>
<td>Shanghai</td>
<td>3015</td>
<td></td>
</tr>
<tr>
<td>Wu, 2009</td>
<td>USA</td>
<td>345</td>
<td></td>
</tr>
<tr>
<td>Korde, 2009</td>
<td>USA</td>
<td>255</td>
<td></td>
</tr>
<tr>
<td>Lee, 2009</td>
<td>Shanghai</td>
<td>305</td>
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*Premenopausal only CEBP;10:483, 2001; AJCN 89; 1145 2009;; 18: 1, 2009; AJCN 89:1920, 2009*
## Early Soy Intake & Breast Cancer Risk: Epidemiologic Research

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<td>60</td>
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<td>Lee, 2009</td>
<td>Shanghai</td>
<td>305</td>
<td>43*</td>
</tr>
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</table>

*Premenopausal only CEBP;10:483, 2001; AJCN 89; 1145 2009;; 18: 1, 2009; AJCN 89:1920, 2009
Young girls should be sure to eat $\geq 1$ serving per day.

- 1 oz (28 g)
- $\frac{1}{2}$ cup (100 g)
- 1 cup (240 ml)
- $\frac{1}{2}$ cup (100 g)
THANK YOU
markjohnmessina@gmail.com