Soy Protein
Applications in Nutrition & Food Technology

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National Soybean Research Laboratory
University of Illinois at Urbana-Champaign
National Soybean Research Laboratory (NSRL) Vision

• University of Illinois

• Research Facility for the Industry

• Public and Private Partnerships
  – Managed Research Areas (MRAs)
  – Education and Training

• International Outreach
  – Fulfilling the service mission of the University
  – Research-based outreach when international is the unit of analysis
  – Malnutrition, economic development, and sustainable value chains
Training and Education

Soy Processing
Soy Dairy
Entrepreneurship
Nutrition Education

Soy in Meat Applications
Soy in Baking Applications
Biodiesel
Soy in Local Cuisine
Soybean Processing and Utilization Training

- University of Illinois
- Soybean Processing
- Soy in Meat, Dairy,
- Baking Applications
- Extrusion Technology
- Consumer Marketing

Email: nscates2@illinois.edu  Web: www.nsrl.uiuc.edu
WISHH and NSRL

• Technical Resource for WISHH

• Provide training in processing, nutrition education, and develop culturally-appropriate soy applications for human nutrition

• Support for sustainable solutions

• Support for microenterprise development
Protein GAP Across Countries

The Largest "Protein GAP" Countries in 2003

Sources: FAO, UN
What Is the Forecast for 2025?

Projected Protein GAP in 2025

Sources: FAO, UN
The Importance of Protein

• Maintenance of Body Functions
• Growth, Development at Crucial Points (Pregnancy and Lactation and the First Year of Life)
• Source of Essential Amino Acids
  – Change in Amino Acid Profile Affects Effectiveness of Dietary Protein Intake to Maintain Nitrogen Balance
• Health Maintenance and Disease Management
• RDI is Established Using Highly Digestible and High Quality Protein
  – Lower Quality Protein Means Higher Protein Requirements
Health Benefits of Soy Protein
Chronic Disease Prevention

• Cholesterol – Heart Disease
• Hypertension
• Certain cancer
• Diabetes
• Menopause
• Osteoporosis
• Weight Loss
Soy Health Claims

• Heart Health (October 1999)
  – Diets low in saturated fat and cholesterol that include 25 grams of soy protein a day may reduce the risk of heart disease.
    • A serving of soy milk has 7 grams of soy protein
    • A serving of textured soy protein has 12 grams of protein
    • A serving of soy flour in a muffin has 15 grams of protein
Soybean Composition

15% Soluble Carbohydrates (sucrose, stachyose, raffinose, others)

18% Oil

14% Moisture, ash, other

38% Protein

15% Insoluble Carbohydrates (dietary fiber)
Why Soy

Complete Vegetable Protein

Contains all Three of the Macro Nutrients Required for Good Nutrition

Adaptable and Economical

Multiple Product Options
  - Soy Flour
  - Textured Soy Protein
  - Soy Milk
  - Whole Soy
  - Soy Protein Concentrate
  - Soy Protein Isolate
Why Consume Soy Foods

• Health
  – Nutrition and growth
  – Disease prevention

• Functional properties
  – Water absorption
  – Emulsification
  – Texture
Soy Improves Functional Properties of Foods

- Bland
- Absorbs Flavor
- Conditions Dough
- Emulsifies
- Increases Whiteness
- Improves Texture
- Retains Moisture
- Absorbs Fat
- Keeps Product Fresh for a Longer Time
Soy Protein Products

- Soy Flour
- Textured Soy Protein
- Soy Protein Concentrate
- Soy Protein Isolate
- Soy Milk
Soy Protein Products

- Soybean
- Flour TVP
- Conc
- Isolate

- Oil
- Carbohydrate & Minerals
- Protein
Soy Protein Products

- Soy Flour: 50% Protein
- Soy Protein Concentrate: 70% Protein
- Isolated Soy Protein: 90% Protein

Protein (moisture free basis)
Carbohydrate, lipid, vitamins, minerals
American Baked Products

Soy Protein Ingredient:
• Soy flour

Functional Properties:
• Improves whiteness
• Dough conditioner
Defatted Soy Flour

• **Applications:**
  - Weaning Foods - Porridge and Gruel
  - Cookies - Crackers
  - Muffins - Breads
  - Cereals - Cakes
  - Doughnuts - Pastas
  - Dry mixes - Tortillas
  - Nan and Flat Breads - Soups and Sauces
  - Ground Meat

• **Shelf Life (minimum) of One Year**
Textured Soy Protein

• Applications as an ingredient with:
  – Ground meat for patties
  – Sausage
  – Meat Loaf
  – in Vegetarian Foods
  – in Stews and Soups

• Shelf Life of One Year
Soy Protein Concentrate

Applications in:
- a Variety of Meat Systems
- Baked Goods
- and Specialty Items

Shelf Life of One Year
Soy Protein Isolate

• Applications as an Ingredient in High Protein Foods Including:
  – Dairy Foods
  – as a Milk Replacer
  – Nutritional Supplements
  – Meat Systems
  – Infant Formulas
  – Nutritional Beverages
  – Cream Soups and Sauces
  – Snacks

• Shelf Life of One Year
Soy Milk

- Applications:
  - Beverage
  - to Produce Yogurt
  - to Produce Ice Cream
  - to Produce Tofu
  - in Soups and Sauces
Benefits of Soy Milk

- No Lactose
- No Cholesterol
- Low in Saturated Fat
- Low in Sodium
## Composition of Soy Milk, Cow’s Milk and Mother’s Milk

<table>
<thead>
<tr>
<th>Item/100 g</th>
<th>Soymilk</th>
<th>Cow’s Milk</th>
<th>Mother’s Milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorie</td>
<td>44</td>
<td>59</td>
<td>62</td>
</tr>
<tr>
<td>Water (g)</td>
<td>90.8</td>
<td>88.6</td>
<td>88.2</td>
</tr>
<tr>
<td>Protein</td>
<td>3.6</td>
<td>2.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Fat</td>
<td>2.0</td>
<td>3.3</td>
<td>3.1</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>2.9</td>
<td>4.5</td>
<td>7.1</td>
</tr>
<tr>
<td>Ash</td>
<td>0.5</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Minerals (mg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>15</td>
<td>100</td>
<td>35</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>49</td>
<td>90</td>
<td>25</td>
</tr>
<tr>
<td>Sodium</td>
<td>2</td>
<td>36</td>
<td>15</td>
</tr>
<tr>
<td>Iron</td>
<td>1.2</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Vitamins (mg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiamine (B1)</td>
<td>0.03</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Riboflavin (B2)</td>
<td>0.02</td>
<td>0.15</td>
<td>0.03</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.50</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Saturated Fatty Acids (%)</td>
<td>40-48</td>
<td>60-70</td>
<td>55.3</td>
</tr>
<tr>
<td>Unsaturated fatty acid (%)</td>
<td>52-60</td>
<td>30-40</td>
<td>44.7</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0</td>
<td>9.24-9.9</td>
<td>9.3-18.6</td>
</tr>
</tbody>
</table>
# Quantity: Higher Protein

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Protein per 100 gms (in gms)</th>
<th>Calories per 100 gms (in Kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy Flour (defatted)</td>
<td>52</td>
<td>290</td>
</tr>
<tr>
<td>Textured Soy Protein</td>
<td>52</td>
<td>270</td>
</tr>
<tr>
<td>Wheat Flour</td>
<td>10</td>
<td>360</td>
</tr>
<tr>
<td>Corn meal</td>
<td>8</td>
<td>370</td>
</tr>
<tr>
<td>Rice</td>
<td>7</td>
<td>360</td>
</tr>
<tr>
<td>Wheat Soy Blend</td>
<td>22</td>
<td>360</td>
</tr>
<tr>
<td>Soy Bulgur</td>
<td>18</td>
<td>340</td>
</tr>
<tr>
<td>Corn Soy Blend</td>
<td>17</td>
<td>380</td>
</tr>
<tr>
<td>Lentils</td>
<td>28</td>
<td>340</td>
</tr>
<tr>
<td>Peas</td>
<td>25</td>
<td>340</td>
</tr>
</tbody>
</table>
## Protein Quality – Why Soy

<table>
<thead>
<tr>
<th>Product</th>
<th>PDCASS Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg White</td>
<td>1.00</td>
</tr>
<tr>
<td>Milk (Casein)</td>
<td>1.00</td>
</tr>
<tr>
<td>Beef</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Soybean</strong></td>
<td><strong>0.90 – 1.00</strong></td>
</tr>
<tr>
<td>Pea</td>
<td>0.73</td>
</tr>
<tr>
<td>Kidney Bean</td>
<td>0.68</td>
</tr>
<tr>
<td>Chickpea</td>
<td>0.66</td>
</tr>
<tr>
<td>Oats</td>
<td>0.57</td>
</tr>
<tr>
<td>Peanut Meal</td>
<td>0.52</td>
</tr>
<tr>
<td>Lentils</td>
<td>0.52</td>
</tr>
<tr>
<td>Rice</td>
<td>0.47</td>
</tr>
<tr>
<td>Corn</td>
<td>0.42</td>
</tr>
<tr>
<td><strong>Whole Wheat</strong></td>
<td><strong>0.40</strong></td>
</tr>
<tr>
<td>Wheat Gluten</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Soy Added to Cereal Grains Improves Growth

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Without Soy</th>
<th>With Soy$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Rice</td>
<td>1.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Wheat Flour</td>
<td>0.7</td>
<td>2.0</td>
</tr>
<tr>
<td>Whole Wheat</td>
<td>1.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

$^1$Soy flour added to maize, rice, wheat flour, and whole wheat diets at a level of 8%, 8%, 10% and 8%, respectively.
## Soy Protein Products: Cost

<table>
<thead>
<tr>
<th>Product</th>
<th>Price (pound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy Flour (defatted)</td>
<td>$0.28</td>
</tr>
<tr>
<td>Textured soy protein</td>
<td>0.35</td>
</tr>
<tr>
<td>Soy protein concentrate</td>
<td>0.86</td>
</tr>
<tr>
<td>Soy protein isolate</td>
<td>2.00</td>
</tr>
</tbody>
</table>
## Price Ratio

<table>
<thead>
<tr>
<th>Product</th>
<th>Ratio (pound)</th>
<th>Ratio (pound protein)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soy Flour (defatted)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Textured Soy Protein</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Soy protein concentrate</td>
<td>3.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Soy protein isolate</td>
<td>7.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Product</td>
<td>Price (ton)</td>
<td>Price (pound protein)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Soy Flour (defatted)</td>
<td>$620</td>
<td>$0.54</td>
</tr>
<tr>
<td>Textured Soy Protein</td>
<td>$770</td>
<td>$0.67</td>
</tr>
<tr>
<td>Wheat Flour</td>
<td>$230</td>
<td>$1.02</td>
</tr>
<tr>
<td>Corn Meal</td>
<td>$173</td>
<td>$1.97</td>
</tr>
<tr>
<td>Rice</td>
<td>$560</td>
<td>$3.80</td>
</tr>
<tr>
<td>Soy Bulgur</td>
<td>$360</td>
<td>$0.90</td>
</tr>
<tr>
<td>Wheat Soy Blend</td>
<td>$360</td>
<td>$1.42</td>
</tr>
<tr>
<td>Peas</td>
<td>$240</td>
<td>$0.77</td>
</tr>
<tr>
<td>Lentils</td>
<td>$435</td>
<td>$1.16</td>
</tr>
</tbody>
</table>
Practical Applications of Soy Protein in WISHH Programs

• India
  – Textured Soy Protein in Rice Dishes
  – Soy Flour in Indian Breads and Sambar

• Mozambique
  – Textured Soy Protein as a Microenterprise Product

• Vietnam
  – Soy Milk and Tofu Production

• Tajikistan
  – Soy Flour in Flat Breads
Practical Applications of Soy Protein in WISHH Programs

Soy Flour with Micronutrients in FortiSoy™
Complementary Micronutrient Food for Infants and Children in Central America

Methods:

• Two products were developed containing calcium, iron, zinc, folate, vitamin C, and vitamin A.
• Soy flour was added to one of the products, while the other (the control) contained maltrin at similar caloric content.
• 2 scoops (26 grams) daily per child.
• Children aged 6 to 30 months were randomly assigned to the treatment group (n= 136) or control group (n=140).
Practical Applications of Soy Protein in WISHH Programs

Soy Flour with Micronutrients in FortiSoy™
Complementary Micronutrient Food for Infants and Children in Central America

Results:

- Both supplements were easily administered and acceptable to most participants.
- At one month, 87% of children on the control supplement and 88% of those on the soy supplement reported ongoing daily use.
- No allergic reactions were reported.
- Study to be completed this month and repeated in Summer of 2009.
Practical Applications of Soy Protein in WISHH Programs

- South Africa
  - Soy Protein Isolates in a Beverage
- Uganda
  - Soy Protein Concentrates in Baked Goods
- Haiti
  - Soy Milk and Mango Juice Beverages
- Ghana
  - Soy Milk in School Lunch Program
Thank You

National Soybean Research Laboratory

*Research, Outreach and Education supporting Soybean Production and Nutrition*

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