But What Did They Really Eat?

A Critical Analysis of

Three Sisters’ Food Value

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Three Sisters Cropping System

“…symbiotic plant complex of North America without an equal elsewhere.” C. Sauer 1962

“...foundation of (Iroquois) subsistence” .. enabled them to “develop institutions of sedentary life.” W. Fenton 1978
Iroquoia before Colonization
Three Sisters in Iroquoia

* Central to cultural identity (*Creation Story, Words that Come Before All Else*), social-political power, subsistence.

* Women controlled most aspects of agricultural production.
Agronomic Characteristics

* Typically planted on mounds.
* Usually crops planted as polyculture, but not always.
* No plows- hand tools only.
* Continuously cropped- not shifting cultivation.
* Fertile, productive soils.
Agricultural Productivity

- Historic records provide first-hand observations: highly productive agriculture, but no yields.
- Field experiments (Mt. Pleasant and Burt 2010)
  - Two sites 1993 to 1997
    - Musgrave Research Farm, Cayuga County
    - Private farm, Tompkins County
- Crop varieties and agronomic practices similar to what Iroquois would have used in 17th and 18th centuries.
Field Research Sites
Crop Yields: Three Sisters and Monocultures Tompkins County 1993-1994

![Bar chart showing crop yields for Three Sisters and Monocultures.](image-url)
Crop Yields:
Three Sisters and Monocultures
Cayuga County 1997

[Bar graph showing crop yields per acre for Three Sisters, Corn Mono, Bean Mono, and Pumpkin Mono.]
Determining Food Values

★ Focus on energy and protein
★ Subsistence farmers first ensure they can supply sufficient energy (kcal).
★ Next priority is protein.
★ Most subsistence farmers plant
  ★ grain (wheat, maize, rice) for energy
  ★ legume (bean, pea, lentil) protein
But What Did They Really Eat?
Corn
Beans
Nutritional Content Depends on Time of Harvest

<table>
<thead>
<tr>
<th>Crop</th>
<th>Food</th>
<th>Water g/100g</th>
<th>Energy Kcal/kg</th>
<th>Protein g/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Sweet corn</td>
<td>76</td>
<td>86</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Corn grain</td>
<td>10</td>
<td>3650</td>
<td>9</td>
</tr>
<tr>
<td>Bean</td>
<td>Green bean</td>
<td>90</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Kidney bean</td>
<td>12</td>
<td>3370</td>
<td>30</td>
</tr>
</tbody>
</table>
Crop Yields To Food Yields?

Crop Weights at Harvest
Averaged over sites and years

Water %
Maize 10
Bean  12
Pumpkin flesh 90
Pumpkin seed 5
Convert Harvest Weight to Energy and Protein

<table>
<thead>
<tr>
<th></th>
<th>Energy kcal/kg</th>
<th>Protein g/kg</th>
<th>Water g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>3650</td>
<td>94</td>
<td>100</td>
</tr>
<tr>
<td>Bean</td>
<td>3370</td>
<td>225</td>
<td>120</td>
</tr>
<tr>
<td>Pumpkin Flesh</td>
<td>260</td>
<td>10</td>
<td>916</td>
</tr>
<tr>
<td>Pumpkin Seed</td>
<td>5590</td>
<td>302</td>
<td>5</td>
</tr>
</tbody>
</table>

All values from [http://ndb.nal.usda](http://ndb.nal.usda)
Energy
Three Sisters vs. Monocultures

![Bar chart showing energy output per hectare in kcal/ha (x 10^6) for Three sisters, Maize mono, Bean mono, and Pumpkin mono crops. The chart compares the energy output of Pumpkin Seed, Pumpkin flesh, Bean, and Maize in each crop system.]
Protein
Three Sisters vs. Monocultures

![Graph showing protein (Kg/ha) for Three Sisters, Maize Mono, Bean Mono, and Pumpkin Mono. The graph compares Pumpkin Seed, Pumpkin Flesh, Bean, and Maize.]
Plant Proteins Incomplete, But Complementary

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Maize</th>
<th>Bean</th>
<th>Pumpkin Seed</th>
<th>Pumpkin Flesh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/gram N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Histidine</td>
<td>0.17</td>
<td>0.17</td>
<td>0.23</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Isoleucine</strong></td>
<td><strong>.026</strong></td>
<td><strong>0.38</strong></td>
<td><strong>0.17</strong></td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td>Leucine</td>
<td>0.76</td>
<td>0.78</td>
<td>0.38</td>
<td>0.003</td>
</tr>
<tr>
<td><strong>Lysine</strong></td>
<td><strong>0.19</strong></td>
<td><strong>0.41</strong></td>
<td><strong>0.32</strong></td>
<td><strong>0.003</strong></td>
</tr>
<tr>
<td>Methionine</td>
<td>0.12</td>
<td>0.07</td>
<td>0.08</td>
<td>0.001</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>0.23</td>
<td>0.36</td>
<td>0.25</td>
<td>0.002</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.19</td>
<td>0.27</td>
<td>0.17</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Tryptophan</strong></td>
<td><strong>0.03</strong></td>
<td><strong>0.08</strong></td>
<td><strong>0.10</strong></td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td>Valine</td>
<td>0.28</td>
<td>0.28</td>
<td>0.21</td>
<td>0.002</td>
</tr>
</tbody>
</table>
### Calcium, Vitamins A and C, and Niacin

<table>
<thead>
<tr>
<th></th>
<th>Calcium mg/100g</th>
<th>Vitamin A IU/100g</th>
<th>Vitamin C mg/100g</th>
<th>Niacin mg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3.63</td>
</tr>
<tr>
<td>Bean</td>
<td>83</td>
<td>0</td>
<td>4.5</td>
<td>2.11</td>
</tr>
<tr>
<td>Pumpkin flesh</td>
<td>21</td>
<td>8513</td>
<td>9.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Pumpkin Seed</td>
<td>46</td>
<td>15</td>
<td>1.9</td>
<td>4.99</td>
</tr>
<tr>
<td>RDA</td>
<td>1000</td>
<td>5000</td>
<td>60</td>
<td>15</td>
</tr>
</tbody>
</table>
Nixtamalization

* Maize soaked and/or cooked in alkaline solution.
* Reduces cooking time.
* Increases calcium content 100 to 400%  
  * Calcium ions (from wood ash) attracted to maize starch grains.
* Improves protein quality  
  * Increases relative amounts lysine, tryptophan, histidine, methionine and threonine.
* Increases niacin (B vitamin), preventing pellagra  
  * Increased tryptophan, precursor to niacin, increases niacin
Three Sisters vs. Monocultures: Unrealistic Comparisons

![Bar graph showing energy in kcal/ha for Three sisters, Maize mono, Bean Mono, and Pumpkin mono. The graph compares the energy content of Pumpkin Seed, Pumpkin flesh, Bean, and Maize.]
Monoculture Mixtures

33-33-33  50-25-25  80-10-10
Monoculture Mixtures vs. Three Sisters

Energy

Kcal/ha (x 10^6)

33/33/33 50/25/25 80/10/10 100/0/0 Three Sisters

- Pumpkin
- Bean
- Maize
Monoculture Mixtures vs. Three Sisters

![Graph showing protein kg/ha for different mixtures and Three Sisters method. The x-axis represents different mixtures: 33/33/33, 50/25/25, 80/10/10, 100/0/0, and Three Sisters. The y-axis represents protein kg/ha ranging from 0 to 350. The chart includes labels for Pumpkin, Bean, and Maize.]
One Last Question:
How Many People/Hectare Could Three Sisters Support?

* First determine adult energy and protein requirements on daily and annual basis.
  * Daily:
    * 2500 kcal/day
    * 60 g protein/day
  * Yearly
    * 912,500 kcal
    * 22 kg protein

* Then use energy and protein produced by Three Sisters and monoculture mixtures.
People Supported
Monoculture Mixtures vs. Three Sisters

![Bar chart showing people supported per hectare for different monoculture mixtures and Three Sisters farming methods. The chart compares energy and protein production across various mixtures.](chart.png)
Conclusions

* Intercropped maize, bean, and pumpkin highly productive cropping system that largely satisfied Haudenosaunee dietary needs.

* Maize, anchor of the system, with its very high crop yields produces very large amounts energy and significant protein.

* Three Sisters provides more energy and protein than individual crop monocultures and more than monoculture mixtures of three crops.
Conclusions

* Bean and pumpkin seeds increase protein and improve protein quality.
* Pumpkin flesh provides lots of Vitamin A.
* Maize nixtamalization
  * Decreases cooking time
  * Increases calcium 100 to 400%
  * Improves protein quality
  * Increases niacin, preventing pellagra
* Three Sisters provides (based on yields from field experiments)
  * Energy for 13.4 people/ha/yr
  * Protein for 15.9 people/ha/yr