Alternative food production systems: Consumer concerns

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Consumer Reports
NAS Food Forum on Alternative Food Production Systems
Washington, D.C.
August 7, 2019
Alternative (Animal Replacement) Food Products

• Plant-based
  • Tofu, tempeh, seitan, falafel, veggie burger, Beyond Burger

• Plant-based + GE inputs
  • Impossible Foods—Impossible burger (with GE SLH soy leghemoglobin)
  • Perfect Day—vegan milk (with GE casein and whey proteins)

• Animal cell culture products
  • Memphis Meats
  • JUST
  • Finless Foods
Outline

• A. Alternatives to beef: Beyond Burger, Impossible Burger, cell-cultured meat
• B. Ingredients
• C. Nutritional comparison
• D. Climate impact (greenhouse gas emissions) comparison
• E. Impossible burger safety issue
• F. Cell-cultured meat
Impossible Burger

the heme fermentation lab at Impossible Foods’ production facility in Redwood City, California

## Ingredients of various burgers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Ground Beef 80% Lean (USDA 23573) 1 patty (113 g)</th>
<th>Beyond Burger 1 patty (113 g)</th>
<th>Impossible Burger 1 patty (113 g)</th>
<th>Amy’s Organic California Burger, Light in sodium 1 patty (71 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No GMOs</td>
<td>Can be</td>
<td>Yes- Non GMO Project Verified</td>
<td>No</td>
<td>Yes Prohibited in USDA organic</td>
</tr>
<tr>
<td>USDA Organic</td>
<td>Can be</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Beyond Burger and Impossible Burger are ultra processed foods, ground beef and Amy’s Organic California Burger much less processed. Ultra processed foods have recently been linked to overeating and weight gain.
Nutritional characteristics of various burgers: Consumer Reports

<table>
<thead>
<tr>
<th>Nutritional Characteristic</th>
<th>Ground Beef 80% Lean (USDA 23573) 1 patty (113 g)</th>
<th>Beyond Burger 1 patty (113 g)</th>
<th>Impossible Burger 1 patty (113 g)</th>
<th>Amy’s Organic California Burger, Light in sodium 1 patty (71 g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>306</td>
<td>250</td>
<td>240</td>
<td>150</td>
</tr>
<tr>
<td>Total Fat (g)</td>
<td>20</td>
<td>18</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Sat Fat (g)</td>
<td>7.5</td>
<td>6</td>
<td>8</td>
<td>0.5</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>85</td>
<td>390</td>
<td>370</td>
<td>270</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>345</td>
<td>300</td>
<td>610</td>
<td>240</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>0</td>
<td>3</td>
<td>9</td>
<td>21</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>29</td>
<td>20</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td>Calcium (%DV)</td>
<td>2</td>
<td>8</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Iron (%DV)</td>
<td>15</td>
<td>25</td>
<td>25</td>
<td>8</td>
</tr>
</tbody>
</table>

Plant burgers not necessarily more nutritious than beef and have more sodium. Beyond Burger and Impossible burger have similar levels of calories, fat, and saturated fat, with significantly more sodium.
Climate change impacts of alternative foods compared to beef

<table>
<thead>
<tr>
<th>Impact</th>
<th>Conventional beef</th>
<th>Beyond Burger</th>
<th>Impossible Burger</th>
<th>White Oak Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global warming potential kg CO₂ eq per kg product</td>
<td>33</td>
<td>4.0</td>
<td>3.5</td>
<td>-3.5</td>
</tr>
</tbody>
</table>

Carbon footprint breakdown per kg of White Oak Pastures’ beef

<table>
<thead>
<tr>
<th>Source</th>
<th>Emissions (kg CO₂ eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional beef US***</td>
<td>(33)</td>
</tr>
<tr>
<td>Pork CA* (6)</td>
<td>9</td>
</tr>
<tr>
<td>Chicken US* (6)</td>
<td>1</td>
</tr>
<tr>
<td>Beyond Burger** ** (4)</td>
<td>0.2</td>
</tr>
<tr>
<td>Soybean US* (2)</td>
<td>-3.5</td>
</tr>
</tbody>
</table>

*Value for comparison taken from the World Food LCA Database v. 3.3
**Value for comparison taken from Beyond Meat’s LCA
***Value for comparison calculated based on Rott, 2013. Assumes no C loss or storage in cow-calf stage.
Impossible Burger

- Key ingredient: GE soy leghemoglobin (SLH) produced in *Pichia pastoris* + 46 proteins from *P. pastoris*
- September 2014—Impossible Foods submits GRN 0540 for SLH
- November 2015 IF withdraws GRN 540
- January 2016: “Impossible Foods intends to conduct a 90-day feed study in rats to assess the systemic toxicology of the soy leghemoglobin.”
- October 2017: IF resubmits GE SLH (GRN 747) “for use as a flavoring and iron in meat analogue products”
  - No 90-day study, only 14-day and 28-day study
- July 2018: IF gets “no questions letter” from FDA
- August 2019: Soy LegH Prep gets approval as color additive
Safety Issues with the Impossible Burger

• Soy leghemoglobin (SLH), from root nodules, has never been consumed by humans, so no history of safe use.

• Potential allergenicity of SLH


• 33% of ingredients in SLH product is unknown GE yeast proteins (~ 46 proteins), which need separate safety evaluation
Safety issues raised by 28-day rat feeding study


• 28-day rat feeding study, 3 doses, N = 10
• Statistically significant changes (p<.05, p<.01) seen in:
  • Unexplained transient decrease in body weight gain
  • Changes in blood chemistry
  • Decreased reticulocyte count (can be sign of anemia and/or damage to bone marrow)
  • Decreased clotting ability
  • Decreased blood levels of alkaline phosphatase (can indicate malnutrition and/or celiac disease)
  • Increased blood albumin (acute infection or damage to tissues) and potassium values (can indicate kidney disease)
  • Decreased blood glucose and chloride (can indicate kidney problems)
  • Increased blood globulin values (common in inflammatory disease and cancer)
• All significant results explained away as “minimal” change, “nondose-dependent,” “non-adverse,” “no toxicological relevance,” and “within expected biological variation”
Soy LegH Prep color additive approval

• August 1, 2019: FDA approves soy LegH Prep as a color additive in ground beef analogue products

• Agrees with Impossible Foods that feeding rats up to 1536 mg LegH Prep/kg bw/day through diet for 28 consecutive days did not produce any test article-related, toxicologically relevant effects.

• Statistically significant effects were explained away: “some incidental clinical observations that involved changes of small magnitude, and changes that did not show dose-response, did not occur in both sexes, and randomly occurred in some treatment group(s) were toxicologically not relevant.”
How does a company make meat in the laboratory?

- Biopsy (muscle tissue) or embryo from live animal
- Stem cells (muscle, fat, connective tissue),
- Appropriate culture medium: vitamins, lipids, amino acids, minerals
  - Fetal calf serum (growth and differentiation factors, hormones, albumins, globulins, cell adhesion factors, etc.)
  - Antimicrobials to deal with contaminants
- Bioreactor, scaffolding (collagen, chitin/chitosan, corn starch fibers, etc.)

Potential safety problems:

- Contamination (bacteria, viruses, fungi, yeast, mycoplasma)
- Appropriate growth medium (particularly growth, differentiation factors)
- Appropriate texture (physical, electrical, chemical)
Production of Animal cell culture products

Fig. 1. Scaffold-based cultured meat production

Fig. 2. Possible in vitro meat production scheme

Current regulatory framework

- Animal cell culture products: November 16, 2018 statement by USDA Secretary Perdue and FDA Commissioner Gottlieb
  - FDA oversees cell collection, cell banks, and cell growth and differentiation
  - FDA → USDA cell harvest
  - USDA oversees production and labeling of food products derived from cells of livestock and poultry
Consumer Reports survey on Lab-grown meat June 2018

• Labeling issues:
• Industry proposals:
  • “clean meat”
  • “cell cultured meat”
• CR proposals from survey on Lab-grown meat, June, 2018
  • “lab-grown meat”
  • “artificial/synthetic meat”
Conclusions

• Alternative meat products (Impossible Burger and lab-grown meat) raise safety issues

• Plant-based burgers are not necessarily more nutritious than beef

• Beyond Burger and Impossible Burger are ultra processed foods

• Plant-based burgers have significantly fewer greenhouse gas emissions than industrially raised beef but not necessarily more than regenerative ag raised beef

• US diets should consist of less meat and more grains, fruits and vegetables that are minimally processed

• Consumers think labels on cell-cultured meat should be “lab-grown meat” or “artificial/synthetic meat.”