Alternative Proteins
Present State and Future Outlook

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Discussion Topics

• Meat and dietary contributions of animal-derived foods

• Meat protein alternatives
  • Size of market and future projections
  • Discussion of specific alternative proteins

• Key long-term success factors
What is MEAT?

• USDA definition (9 CFR § 301.2)
  • “The part of the muscle of any cattle, sheep, swine, or goats which is skeletal or which is found in the tongue, diaphragm, heart, or esophagus, with or without the accompanying and overlying fat, . . .”

• Practical definition (Kauffman, 2001):
  • “the edible postmortem component originating from live animals,” particularly “domesticated cattle, hogs, sheep, goats and poultry, as well as wildlife such as deer, rabbit and fish.”
Dietary Contributions of Animal-Derived Foods

- 24% of energy
- 48% of protein
- 34–67% of essential amino acids
- 23–100% of essential fatty acids
- >50% of each of
  - Calcium
  - Vitamins A, B$_{12}$, D, riboflavin
  - Choline

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Meat Protein Alternatives

• Protein sources that attempt to replicate the experience of eating meat in its various forms, but without the use of animals
Meat Proteins Alternatives

• Driven by various factors:
  • Animal welfare/rights
  • Health and wellness
  • Vegetarianism/veganism
  • Environmental concerns
  • Profit

• Various products currently delivering on these to various degrees
## Alternative Protein Sources

<table>
<thead>
<tr>
<th>Origin</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant</td>
<td>Soy and other pulses, wheat, gluten</td>
</tr>
<tr>
<td>Fungi</td>
<td>Mycoprotein</td>
</tr>
<tr>
<td>Animal</td>
<td>Cell-cultured meat</td>
</tr>
<tr>
<td></td>
<td>Insect (crickets, ants, etc.)</td>
</tr>
<tr>
<td>Other</td>
<td>Macroalgae (seaweed)</td>
</tr>
<tr>
<td></td>
<td>Microalgae (unicellular eukaryotes or prokaryotes)</td>
</tr>
</tbody>
</table>
Market Size and Future Projections

• Meat Substitutes Market
  • Global:
    • US$3.71B (2016)$\textsuperscript{1}
      • Estimated CAGR 7.5% from 2016–2022
      • Most growth coming from wheat-based, mycoprotein, soy-based
    • US$7.5B by 2020$\textsuperscript{2}
  • United States
    • USD 553MM in revenue (2013)$\textsuperscript{1}$
    • Still small BUT growing steadily

$\textsuperscript{1}$ Grand View Research; $\textsuperscript{2}$ Allied Market Research
Plant Protein

- Most mature sub-segment of alternative protein segment
- Mostly soy-based products but also wheat, gluten, pea
- Recent developments aim to simulate meat more closely than mature products
  - Placement in refrigerated case, next to meat
  - Making product red and “bleed” like meat
    - Leghemoglobin (Impossible Burger) → GMO
    - Beet juice (Beyond Meat)
Meet the IMPOSSIBLE BURGER!*  

Main ingredients:  
Wheat protein  
Leghemoglobin  
Coconut  

*Made entirely of plants!
Available at participating St. Louis restaurants. Patty made from plants.

Impossible is a trademark of Impossible Foods Inc. Used under license.
Mycoprotein

• Quorn™
  • Made from soil mold *Fusarium venenatum* PTA-2684
  • Grown in large (50-m high) aerobic culture vessels
  • Some concern regarding sensitivity by some consumers
Insect Protein

• Protein – primary nutritional component
• Estimated ≈2,000 edible species
  • Beetles, caterpillars, wasps, ants, bees, locusts, grasshoppers, crickets, cicadas, leafhoppers, plant-hoppers, termites, dragonflies, flies
• Challenge
  • Americans and Europeans react negatively to entomophagy (yuck! factor)
  • Insects are animals (must be killed; not vegetarian)
• Much potential to meet protein needs in developing countries
Iowa State University
Cell-Cultured Meat

• Idea first conceived by Willem van Eelen – late 1940s
• First cell-cultured hamburger revealed Aug 2013
  • 5 oz. Patty; cost: $325,000 ($104 MM per cwt.)
Cell-Cultured Meat

• Process
  • Harvesting, proliferation and differentiation of muscle satellite cells in culture medium
  • Satellite cells $\rightarrow$ myoblasts $\rightarrow$ myocytes $\rightarrow$ myotubes $\rightarrow$ muscle cells
Cell-Cultured Meat, cont.

- Technical Challenges
  - Need for fetal calf serum to provide growth factors
  - Ways to control culture contamination without antibiotics
  - Can it be made to truly mimic natural muscle tissue?
    - Structure/texture (3D structure)
    - Fat (adipose tissue)
    - Color (myoglobin)
    - Flavor (flavor precursor molecules)
Cell-Cultured Meat, cont.

- Potential Benefits
  - Environmental
    - Reduced greenhouse gas emissions (GHG)
    - Reduced water, land use
    - Lower environmental impact
  - Product tailoring
    - Nutritional profile
    - Eating quality
  - Food safety
    - No animal pathogens (?)
Cell-Cultured Meat, cont.

- Potential Benefits, cont.
  - Fewer or no animals
    - Reduced numbers
    - No need to kill animals
  - Appeal to vegans, vegetarians or those opposed to animal use for food production
  - Moral/ethical implications
  - Provision of desired raw materials without undesirable/underutilized parts
    - e.g., lean only, fat only
    - No need to dispose of unwanted animal parts
Cell-Cultured Meat, cont.

- Regulatory Framework
  - Issue with in vitro meat
  - What can it be called?
  - How will it be labeled?
    - Can it be called “meat”
  - Who has oversight?
    - USHHS-FDA & USDA formal agreement signed March 7, 2019
Cell-Cultured Meat, cont.

- HHS/USDA Agreement of 03/07/19
  - FDA:
    - Tissue collection, cell lines/banks, components & inputs
    - Initial cell collection & development/maintenance of cell banks
    - Proliferation & differentiation through time of harvest
  - USDA:
    - Inspection in establishments that harvest, process, package or label cells, to ensure products are safe, unadulterated, wholesome and properly labeled
    - Pre-approval of labels of human food products derived from cultured cells
Cell-Cultured Meat, cont.

- Consumer Acceptance
  - Would it run counter to current or future consumer trends?
    - e.g., natural, fresh, less processed, GMO-free, chemical-free, etc.
  - Will “yuck” factor come into play?
  - Can it be priced competitively with other proteins?
Numerous Start-Ups

San Francisco, CA
Maastricht, Netherlands
Israel

San Francisco, CA
Rehovot, Israel
Emeryville, CA
San Francisco, CA
Advocacy and Funding Groups

NEW HARVEST

THE GOOD FOOD INSTITUTE
Investors

Tyson

Cargill

MAPLE LEAF

PHW

IOWA STATE UNIVERSITY

NIAA National Conference – 10 April 2019
Key Long-Term Success Factors*

• Financial viability (price v. cost)
• Delivery of meat-like eating experience
  • Appearance, color, texture, mouthfeel, flavor
  • Ground meat not the same as intact
    • i.e., burger ≠ steak
• Delivery of nutritional attributes similar to meat
  • Protein, Fe, Vit B_{12}, Se, Zn, P, CLA
• Delivery on ethical/moral promises
  • Animal-free, non-GMO, healthier
Key Long-Term Success Factors*

• Demonstrated lower environmental impact
  • Life-cycle assessments

• Consumer acceptance likely to be niche-based