The Science Behind Plant-based Proteins

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The Good Food Institute
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The Good Food Institute

Accelerating the shift to a sustainable, healthy, and just food system through four key areas of work:

Science and Technology
Advancing and open-sourcing the foundational science of plant-based and cell-based meat

Innovation
Helping innovators build successful companies and steering private sector funding toward a sustainable and just food system

Corporate Engagement
Consulting with the world’s biggest food companies to help them capitalize on opportunities in the rapidly growing plant-based market

Policy
Advocating for fair regulation of plant-based and cell-based meat and lobbying for governmental investment in sustainable protein R&D

We work as a force multiplier, bringing the expertise of our departments to the rest of the world.

UNITED STATES
EUROPE
BRAZIL
ASIA PACIFIC
INDIA
ISRAEL
How do we feed 10 billion people by 2050?

Adapted from OurWorldInData.org and based on UN FAO statistics.
Animals are inefficient processors

9 ENERGY CALORIES = 1 FOOD CALORIE

11% CONVERTED
Global Demand for Meat
2005 vs. 2050 (in tonnes)

Source: Food and Agriculture organization of the United Nations, ESA Working Paper No. 12-03, p. 131
Plant proteins are far more sustainable

Source: WRI
This is a consumer shift, not a fad

Meat substitutes accounted for 14% of global meat launches in the first nine months of 2018, up from 6% in 2013.
Taste still a barrier to mass adoption

Top reasons for **not wanting** to eat plant foods

- Don’t taste good: 34%
- Not necessary: 35%
- Expensive: 31%
- Won’t keep me full: 28%
- Have less protein: 24%
- No product info available: 20%
- Lack essential nutrients: 19%

Believe plant-based **can taste just as good as the real thing**

- Dairy: 16%
- Burgers: 14%
- Hot dogs/sausages: 11%
- Ground meat: 10%
- Jerky: 10%
- Raw fish: 9%
- Shellfish: 9%
- Cold cuts: 9%
- Bacon: 8%
- Fish files: 8%
- Steak: 8%

Source: Adapted from Datassential, PLANT + CELLULAR 2017 Report
The top taste barriers are focused on moisture, flavor, and texture

- **Moisture**
  - Dry
  - Lack of moisture/juiciness

- **Flavor**
  - Too strong
  - Off flavor
  - Unpleasant aftertaste

- **Texture**
  - Too uniform
  - Too compact
  - Too soft or “mushy”

Source: Food Systems Innovations, “Chicken and Burger Alternatives: Taste Test Results” (December 2018)
From source material to final product: How to achieve sensory experience that mimics meat?
Protein alternatives fit into four categories from a production/cost/infrastructure perspective.
Plant-based Meat Production

**SOURCE**
The best source material for the end product is selected.

**OPTIMIZE**
The source material is optimized via breeding or engineering.

**RAW MATERIAL OPTIMIZATION**
Raw materials are isolated and functionalized by mechanical and chemical processes to create optimal ingredients for the end product.

**END PRODUCT COMPOSITION AND PROCESS OPTIMIZATION**
The correct mix of ingredients and processes are established to create the desired taste, texture, smell, and structure.

**Final Product**
How to achieve tastes and textures that mimic meat?
Plant-Based Meat Technology Mind Map
Crop Analysis and Optimization

Plants provide all the raw materials (proteins, carbohydrates, fats, flavors) for plant-based meats.
Most plant-based proteins on the market are soy-based

Source: GFI Supplier Database
Crops have not traditionally been optimized for protein applications

- Soy: Soybean oil
- Wheat: Wheat gluten, Pea starch
- Pea: Soybean meal

Nahashon et al. 2011
Optimize the Crop with the End Product in Mind
Optimizing Crops to Improve Raw Materials

PRECISION BREEDING

GENE EDITING

NUTRITION
FUNCTIONALITY
PERFORMANCE
COST
Methods to isolate and functionize raw materials for plant-based meats
Optimizing raw materials to improve the final product

Native tertiary protein

Cross-linking and texturization

MECHANICAL

ENZYMATIC
Extrusion is currently the primary method for creating textured plant proteins

Low-moisture
• Ideal for restructured meat products (patties, sausages, cakes, etc.)

High-moisture
• Ideal for whole cut meat products (filets, strips, etc.)
Shear cell technology

Applying shear forces to create fibrous plant-based meat
Extrusion-based bioprinting

Flexible and tunable assembly of structured meat from a wide variety of ingredients
End Product Composition and Process Optimization

Establishing the correct mix of ingredients and processes to create the desired taste, texture, smell, and structure.
Ingredient Optimization Enhances the Final Product

Biochemistry is transforming plant-based meats

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<th>RECAPITULATING THE CONSUMER EXPERIENCE OF COOKING</th>
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OPTIMIZING FLAVOR AND FUNCTIONALITY

IMPROVING TASTE AND TEXTURE THROUGH FAT ENCAPSULATION

RECAPITULATING THE CONSUMER EXPERIENCE OF COOKING

DIGITAL TASTE BUDS TO OPTIMIZE FORMULATIONS
Optimizing plant-based foods with fermentation technology

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Recombinant protein production can be used for high-value ingredients and enzymatic functionalization.
Non-animal cell culture to produce novel ingredients

Mushroom Fermentation

CO$_2$-based Hydrogenotroph Fermentation

Extremophile Fermentation
Four categories of alternative proteins to supply the global demand for meat, eggs, and dairy

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The new “feed” industry

- High molecular-weight proteins
  - High utility for plant-based meat, egg, and dairy products

- Amino acids, small peptides
  - High utility for cell-based meat production; may need to supplement with fermented amino acids

- Simple sugars and longer polysaccharides
  - High utility for microbial fermentation (production of ingredients, enzymes, growth factors, fungal protein) or scaffolding for cell-based meat
THE GOOD FOOD INSTITUTE

THE GOOD FOOD CONFERENCE

The Future of Meat
Accelerating the Plant-Based & Cell-Based Meat Industries

The Palace Hotel – San Francisco, CA
September 4 - 6, 2019

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