

# Alternative food production systems: Consumer concerns

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Consumer Reports

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# 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



mixture for burgers is prepared at an Impossible Foods facility in California. PHOTO: JANE LANHEE S

<http://www.nationalcompass.net/2017/09/23/impossible-burger-animal-meat-substitute/>

# Ingredients of various burgers

Characteristic	Ground Beef 80% Lean (USDA 23573) 1 patty (113 g)	Beyond Burger 1 patty (113 g)	Impossible Burger 1 patty (113 g)	Amy's Organic California Burger, Light in sodium 1 patty (71 g)
Ingredients	beef	Water, pea protein isolate, expeller pressed canola oil, refined coconut oil, rice protein, natural flavors, cocoa butter, mung bean protein, methylcellulose, potato starch, apple extract, salt, potassium chloride, vinegar, lemon juice concentrate, sunflower lecithin, pomegranate fruit powder, beet juice extract (for color)	Water, soy protein concentrate*, coconut oil, sunflower oil, natural flavors*, 2% or less of: potato protein, methylcellulose, yeast extract*, cultured dextrose*, food starch modified, soy leghemoglobin*, salt, soy protein isolate*, vitamin E*, zinc gluconate, Vitamin B1*, Vitamin C*, niacin, Vitamin B6*, Vitamin B2*, Vitamin B12* *potentially GE	Organic mushrooms, organic bulgur wheat, organic onions, organic celery, organic carrots, organic walnuts, organic wheat gluten, organic potatoes, organic high oleic safflower and/or sunflower oil, sea salt, organic garlic
No GMOs	Can be	Yes- Non GMO Project Verified	No	Yes Prohibited in USDA organic
USDA Organic	Can be	No	No	Yes

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

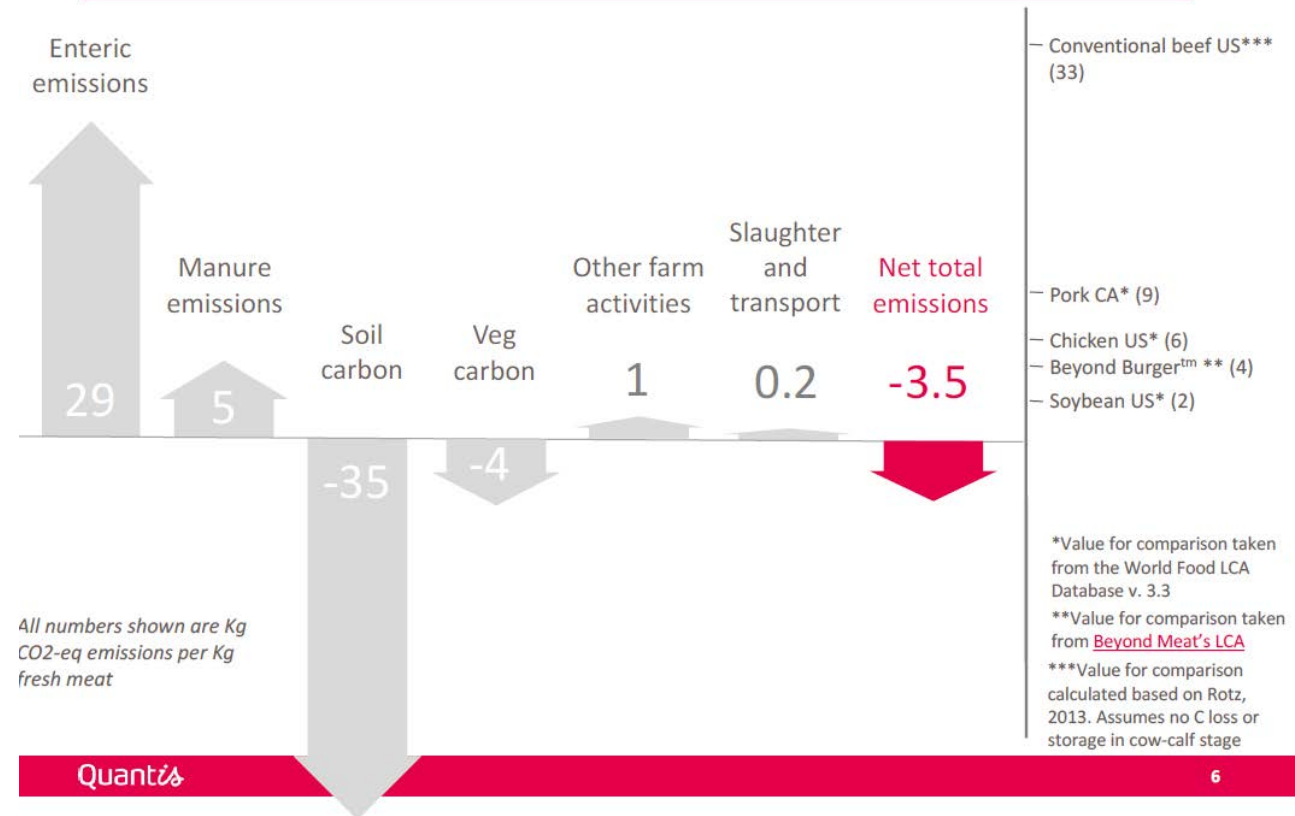
Nutritional Characteristic	Ground Beef 80% Lean (USDA 23573) 1 patty (113 g)	Beyond Burger 1 patty (113 g)	Impossible Burger 1 patty (113 g)	Amy's Organic California Burger, Light in sodium 1 patty (71 g)
Calories	306	250	240	150
Total Fat (g)	20	18	14	5
Sat Fat (g)	7.5	6	8	0.5
Cholesterol (mg)	100	0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

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

Impact	Conventional beef	Beyond Burger	Impossible Burger	White Oak Pastures
Global warming potential kg CO <sub>2</sub> eq per kg product	33	4.0	3.5	-3.5

Carbon footprint breakdown per kg of White Oak Pastures' beef



# 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
- Heme iron itself may pose safety issue-risk of colorectal, esophageal and stomach cancer effect of red meat Bastide NM, Pierre FHF and DE Corpet. 2011. Heme Iron from Meat and Risk of Colorectal Cancer: A Meta-analysis and a Review of the Mechanisms Involved. *Cancer Prevention Research* <http://cancerpreventionresearch.aacrjournals.org/content/4/2/177#> and Ward et al. 2012. Heme iron from meat and risk of adenocarcinoma of the esophagus and stomach. *Eur J Cancer Prev* 21(2): 134-138. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3261306/>
- 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

Fraser RZ et al. 2018. Safety Evaluation of soy leghemoglobin protein preparation derived from *Pichia pastoris*, intended for use as a flavor catalyst in plant-based meat. *Int. J of Toxicology* 37(3):241-262. At: [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5956568/pdf/10.1177\\_1091581818766318.pdf](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5956568/pdf/10.1177_1091581818766318.pdf)

- 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.”

# Animal cell culture foods

- 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

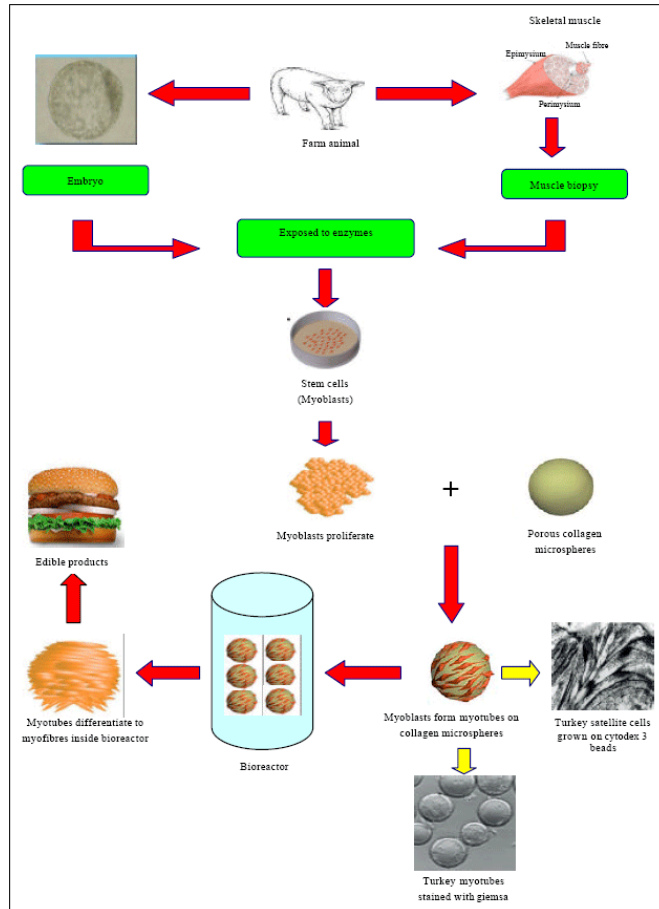


Fig. 1. Scaffold-based cultured meat production

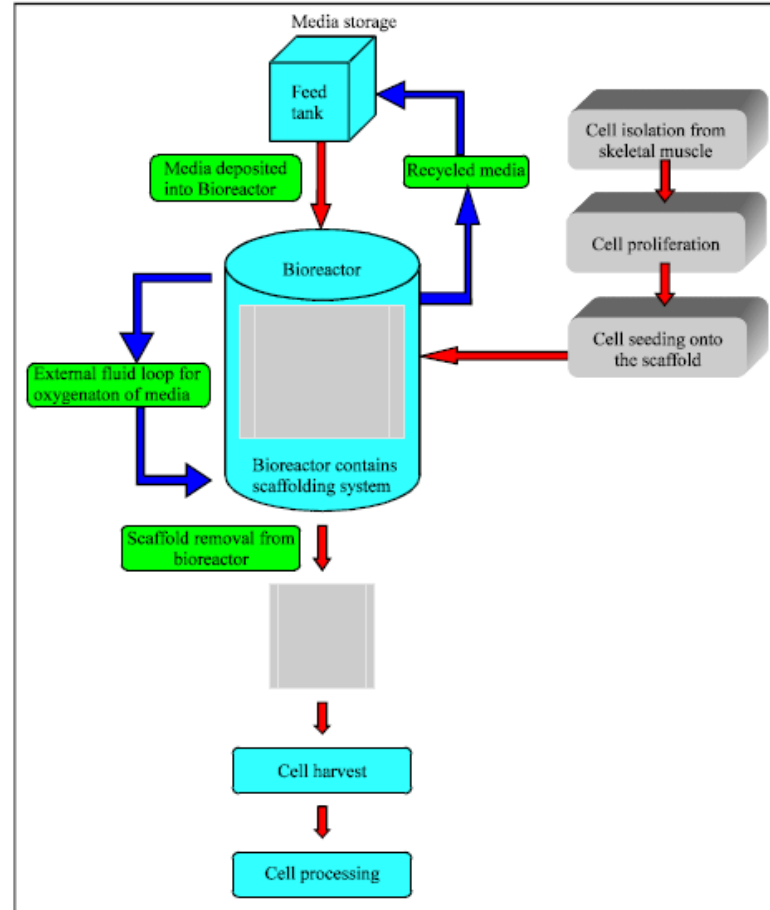


Fig. 2. Possible in vitro meat production scheme

From: Bhat ZF and H Bhat.  
 2011. Animal-free meat  
 biofabrication. *Am J of Food  
 Tech*, 6(6): 441-459. At:  
<http://docsdrive.com/pdfs/academicjournals/ajft/2011/441-459.pdf>

# Current regulatory framework

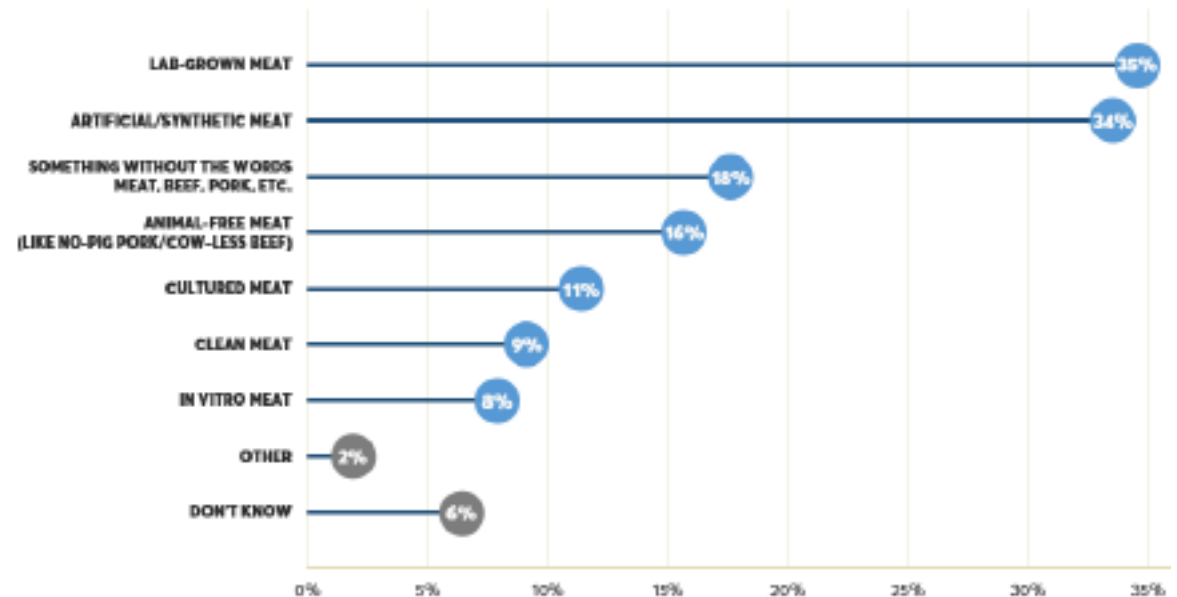
- Animal cell culture products: November 16, 2018 statement by USDA Secretary Perdue and FDA Commissioner Gottlieb
  - FDA oversees cell collection, cell banks, and cell growth and differentiation
  - FDA → USDA cell harvest
  - USDA oversees production and labeling of food products derived from cells 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”

## AMERICANS VIEWS ON PACKAGING OPTIONS

Which, if any, of the following do you believe would be an accurate way to identify this food product on its packaging?



\*Respondents were able to select up to three responses. Answer choices were presented in a randomized order. (If 'Don't know' was chosen, respondents were not able to select additional options)

Base: All respondents, n = 1,018

# 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.”