Formulation and processing consideration in development of products with alternative/emerging protein ingredients

Mario Ferruzzi, Ph.D.
Arkansas Children's Nutrition Center
University of Arkansas for Medical Sciences

Food Forum Alternative Protein Sources
Day 2 roundtable The Role of Processing in Creating Healthy and Sustainable Alternative Protein Products

August 17, 2022

Disclosure: Mario Ferruzzi (Past 12 months)

Financial Relationship (prior 12 months)	**Commercial Interest**
Grant/Research Support	USDA-ARS; USDA-NIFA; NIH-NCCIH/ODS/NIA; USAID; PepsiCo
Scientific Advisory Board/ Consultant/Board of Directors	Florida Department of Citrus; Sensient Technologies; Institute for the Advancement of Food and Nutrition Sciences; International Food Information Council
Speakers Bureau	US Tea Association;
Stock Shareholder	Sensient Technologies
Employee	University of Arkansas for Medical Sciences
Other	

Proteins as food ingredients: What do they provide beyond nutrition?

Proteins are components of food structure and provide multiple functionalities in a diverse array of finished products

Water Binding
Viscosity Building
Gel formation
Emulsification
Foaming
Texture agent
Dough Forming
Fiber Forming
Flavor Binding
Nutrient Binding
Color Formation

Product Category	Common functionality requirements of protein ingredients
Beverages	Solubility, colloidal stability, acid stability, water binding, emulsifying
Bakery	Solubility, emulsifying, gelation, foaming, foam stability, water binding, gluten like structure, color formation
Confectionary	Foaming, solubility, gelation, emulsifying
Frozen Deserts	Emulsifying, colloidal stability, solubility, water binding, fat mimic
Dairy alternatives	Emulsifying, colloidal stability, solubility, foaming, foam stability
Infant Formula	Nutritional, solubility, emulsification, colloidal stability to heat
Alternative Meats	Structure, texture, emulsification, water binding, salt solubility, gelation, fat mimic, color formation

Alternative protein product landscape continues to evolve

Animal Protein Analogues

Dairy Alternatives

Cereals/Snacks

Alternative protein sources in this space are combined with processes to mimic the profiles and quality of animal protein products

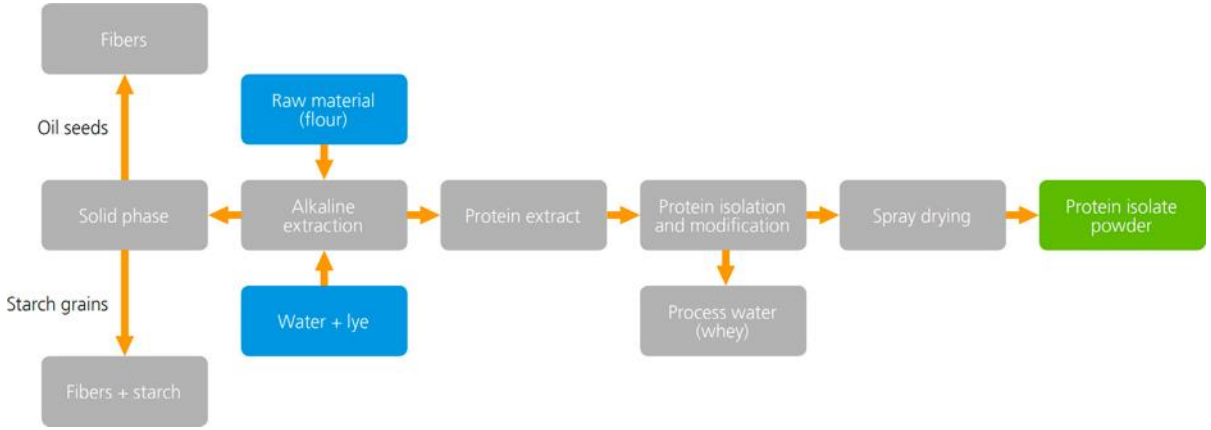
Animal Proteins Targets

Milk, Muscle, Egg & Blood

Common Plant-Protein Sources used in mimic animal products

Cereals: Wheat, Corn, Barley, Oats & Rice
Pseudocereals and seeds: Quinoa, Amaranth, Chia & Buckwheat
Legumes: Soybeans, Pea, Lupins, Lentils & Chickpea
Tubers: Potato
Oilseeds: Canola, Cottonseed, peanut, Sunflower & Hemp

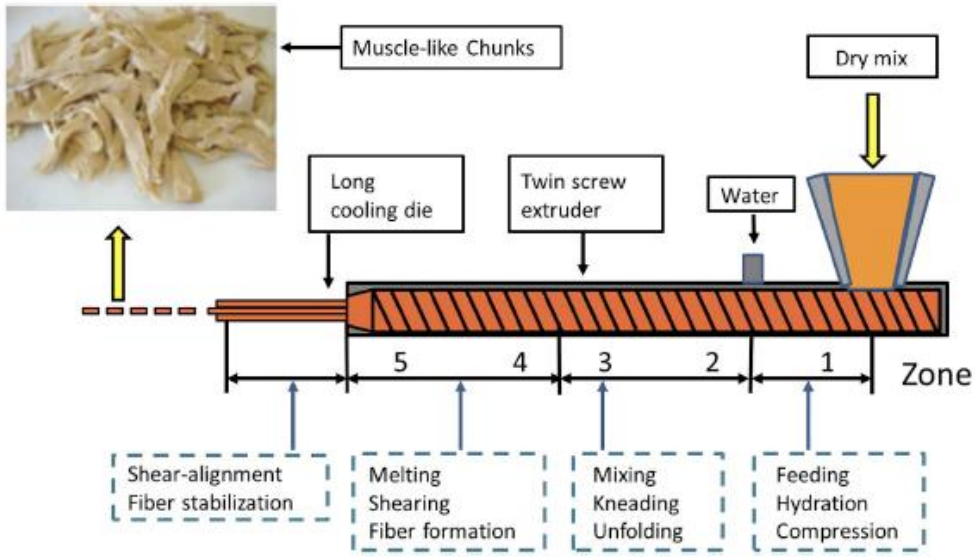
Typical Plant-Protein Ingredient Processing



Loveday SM, British Nutrition Foundation Nutrition Bulletin, 45, 321–327

Formulation and product strategies needed to manage the major gaps

Extrusion is a main technology for plant-based meat analogues



Sha & Xiong, Trends in Food Science & Technology 102 (2020) 51–61

- Color
  - Managing base color (raw and cooked)
  - White color challenge
  - Brown/grey color challenges
- Texture
  - Simulating muscle tissues
  - Milk viscosity and emulsification
- Flavor
  - Scalping of added flavor
  - Masking and matching
- Nutrition
  - Amino acid composition and protein digestibility
- Stability and Safety

Considering product forms: Ground Beef

What must they match by formulation?

Visual appearance

- Color (Raw and Cooked)
- Marbling/fat
- Texture of ground beef (raw and cooked)

Flavor

- Taste and aroma (Cooked)

Ingredients

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

Blue – Main protein ingredients
Red – Color ingredients
Green – Moisture Control

Arkansas Children's Research Institute | Nutrition Center
UAMS UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES

Considering product forms: Ground Beef

GROUND BEEF
80% LEAN / 20% FAT

Nutrition Facts
Serving Size 4oz (112g)
Servings Per Container varied

Amount Per Serving	
Calories 290	Calories from Fat 200
	% Daily Value
Total Fat 23g	**35%**
Saturated Fat 9g	**46%**
Trans Fat 0g	
Cholesterol 80mg	**27%**
Sodium 70mg	**3%**
Total Carbohydrate 0g	**0%**
Protein 20g	
Calcium 0% •	Iron 15%

Not a significant source of Dietary Fiber, Sugars, Vitamin A or Vitamin C.

*Percent Daily Values are based on a 2,000 calorie diet.

THE BEYOND BURGER
PLANT-BASED BURGER PATTIES

Nutrition Facts
Serving Size: 1 Patty, 4oz (113g)
Servings Per Container: 2

Amount Per Serving	
Calories 290	Calories from Fat 190
	% Daily Value*
Total Fat 22g	34%
Saturated Fat 5g	25%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 450mg	19%
Total Carbohydrate 6g	2%
Dietary Fiber 3g	12%
Sugars 0g	
Protein 20g	32%
Vitamin A 0% •	Vitamin C 90%
Calcium 2% •	Iron 25%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g
Protein		50g	65g

Calories per gram: Fat 9 • Carbohydrate 4 • Protein 4

Arkansas Children's Research Institute | Nutrition Center

UAMS
UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES

Considering product forms: Chicken Breast

Ingredients

Water, Chickpea Flour, Coconut Oil Pea Protein Isolate, Calcium Carbonate, Canola Oil, Citrus Fiber, Vinegar Yeast Extract, Dried Garlic, Salt Methylcellulose, Sodium Alginate Calcium Chloride, Gum Arabic, Carob Bean Gum, Xanthan Gum, Natural Flavor, Spice, Dried Onions, Vegetable Juice Color, Dried Yeast, Citric Acid, Sodium Carbonate.

Nutrition Facts

2 servings per container

Serving size	**1 breast(113g)**
Amount Per Serving	
Calories	**220**
	% Daily Value*
Total Fat 12g	**15%**
Saturated Fat 7g	**34%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 1050mg	**46%**
Total Carbohydrates 18g	**7%**
Dietary Fiber 5g	**17%**
Total Sugars <1g	
Includes 0g Added Sugars	**0%**
Protein 9g	
Calcium 2370mg	180%
Iron 4.7mg	25%
Potassium 450mg	10%
Vitamin D 0IU	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2000 calories a day is used for general nutrition advice.

Nutrition Facts

Serving Size 4oz (112g)
Servings Per Container about 4

Amount Per Serving	
Calories 120	Calories from Fat 10
	% Daily Value*
Total Fat 1.5g	**2%**
Trans Fat 0g	
Cholesterol 70mg	**23%**
Sodium 50mg	**2%**
Total Carbohydrate 0g	**0%**
Protein 26g	
Iron 4%	

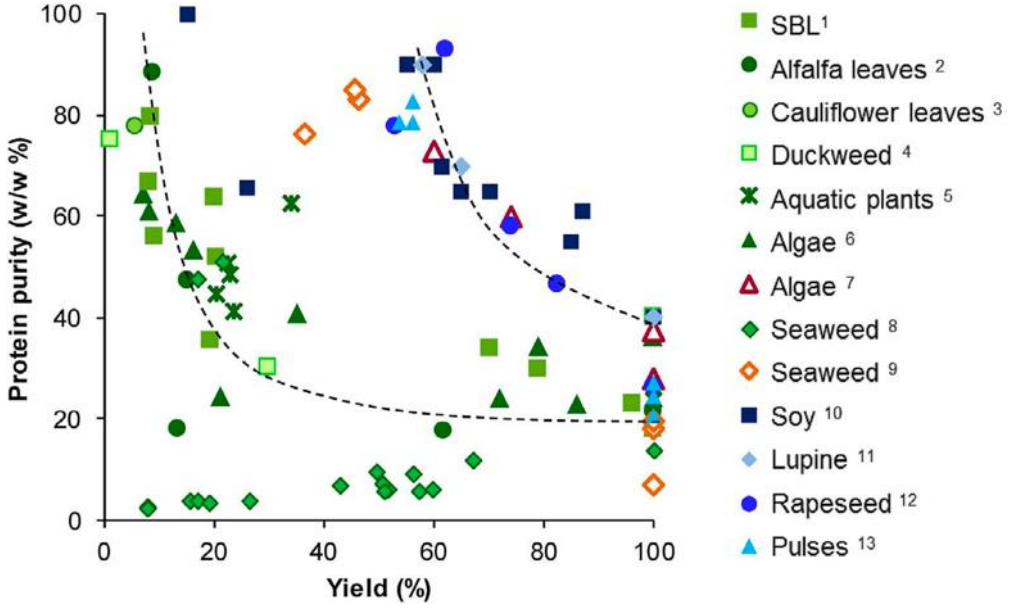
Not a significant source of saturated fat, dietary fiber, sugars, vitamin A, vitamin C and calcium.

*Percent Daily Values are based on a 2,000 calorie diet.

Arkansas Children's Research Institute | Nutrition Center

UAMS UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES

Other components come along with plant protein ingredients



Loveday SM, British Nutrition Foundation Nutrition Bulletin, 45, 321–327

Plant ingredients are processed extracts containing:

Things we like	Things we don't
Plant Micronutrients	Phytate/Phenolics
Unique Peptides	Heavy Metals
Plant Bioactives	Pesticide residues
Phenolics	Bacterial toxins
Carotenoids	
Tocochromanols	
Alkaloids	

Other questions to ponder in terms of formulation with alternative or emerging protein ingredients

- Should products match nutritional values of the product they mimic?
- What are potential unintended consequences in formulation that impact nutrition or safety?
- Presence of other components from plants (Risk/Benefit)
  - Adjustment for higher exposure to novel proteins and critical ingredients
  - Can they be leveraged to provide more benefits of “plants” in these products?
  - How do we manage risk of plant ingredients transferred to the analogue products?

Arkansas Children's Research Institute | Nutrition Center

USDA ARS Agricultural Research Service

UAMS University of Arkansas for Medical Sciences