Application of high-pressure and ultrasound technologies for legume proteins as wall material in microencapsulation

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ORCID

Introduction

- ✓ Legume proteins are important in today's Europe for food & feed production
- ✓ Major European strength
- ✓ Encouraging European Union (EU) policies for the production of protein and leguminous plants in the EU's agriculture sector.

- ✓ Legume proteins: sustainable and economic resources to address the challenge of providing healthy, sustainable, and affordable nutritional needs to the growing global population

Introduction

Legume protein functional properties

- ✓ Recently, legume proteins are highly focused for their easy availability, hypo-allergenicity, excellent techno-functional properties, and emulsifying ability (wall forming and gelling),
- ✓ Green trend to replace animal-derived proteins (e.g., whey protein, gelatin, and casein) in encapsulation process

Introduction

Problems associated with legume proteins

- ✓ Poor solubility
- ✓ Lower functionality
- ✓ Less viscosity
- ✓ Unpleasant grassy and beany flavor, compared to animal-derived proteins, limiting their use as biopolymers for the encapsulation processes

- ✓ Transformation of legume protein functionality is an important phenomenon for a wide range of scientific and industrial applications used in encapsulation.

Legume protein modification approaches

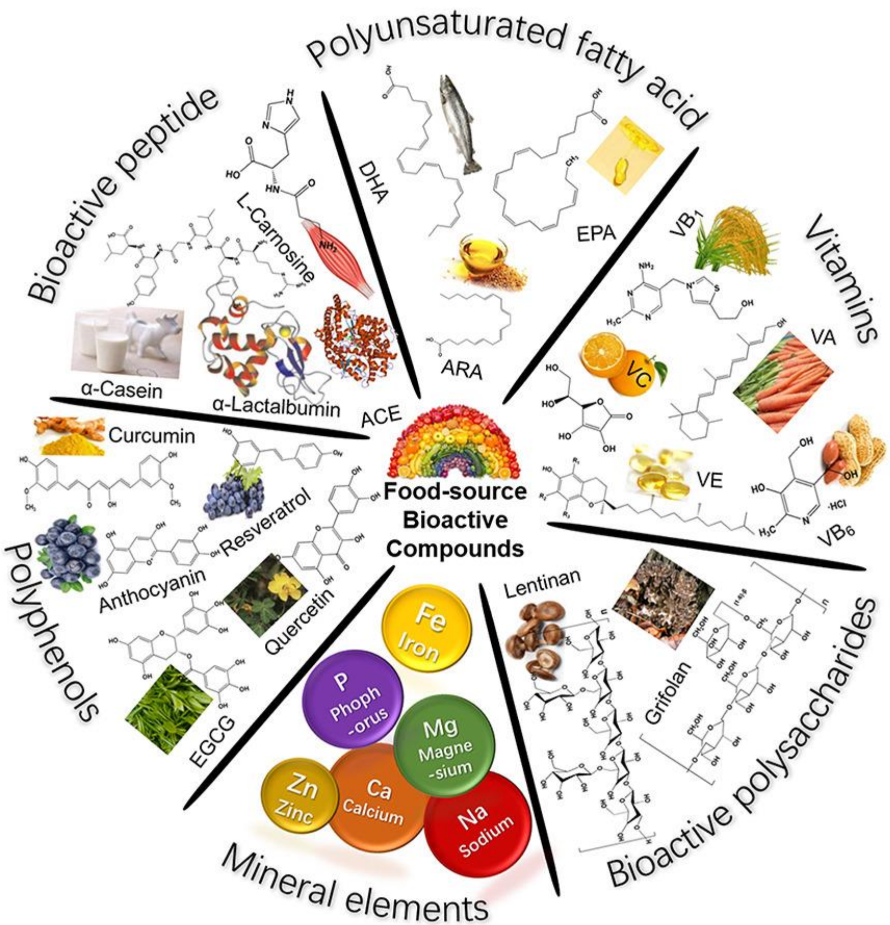
- ✓ Various emerging technologies have therefore attracted in modification of legume protein functionality with favorable emulsification and encapsulation properties
- ✓ food industries can accept them as a low-cost, sustainable, and
- ✓ Nature-inspired biopolymers.
- ✓ Biopolymers could potentially be used to encapsulate a wide variety of bioactive compounds and control their triggered release, which further increase the nutritional value of food through fortification/enrichment.

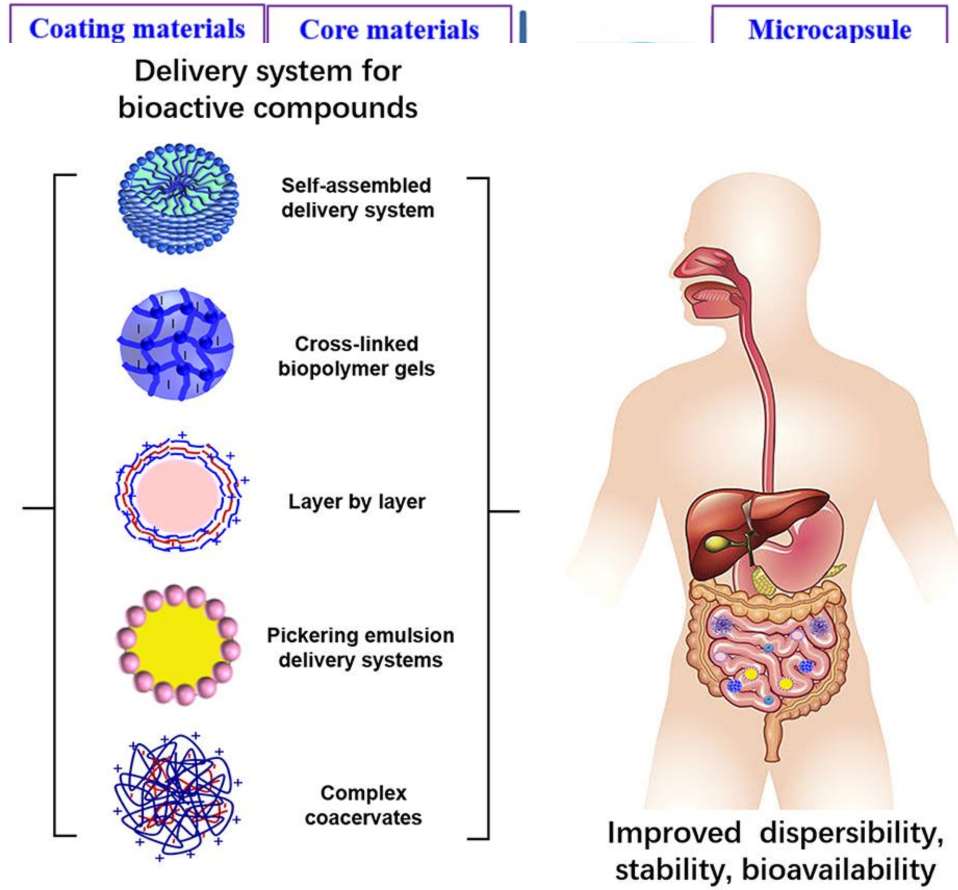
Problems associated with bioactive compounds

Extracted bioactive compounds and their protection from....

- Light
- Temperature
- different pH
- Poor solubility
- High water solubility
- Less bioavailability

Microencapsulation





in ethylacetate

phase (water and PVA) while stirring to form an emulsion

Filtration

Washing → Drying → Sieving → Packaging

Research Project

Microencapsulation properties of legume proteins: An integrated valorization towards sustainable plant-based functional food systems in Europe

Specific objectives

- To understand the potential of legume proteins (lupine and pea) as wall materials in microencapsulation applications (WP1)
- To modify and optimize functional properties of legume proteins for microencapsulation process (WP2)
- To study the applicability of microcapsules with modified legume proteins in fortification using functional pancake as a model food: *In vitro* digestion and release kinetics (WP3)

MELON

Native legume proteins in microencapsulation

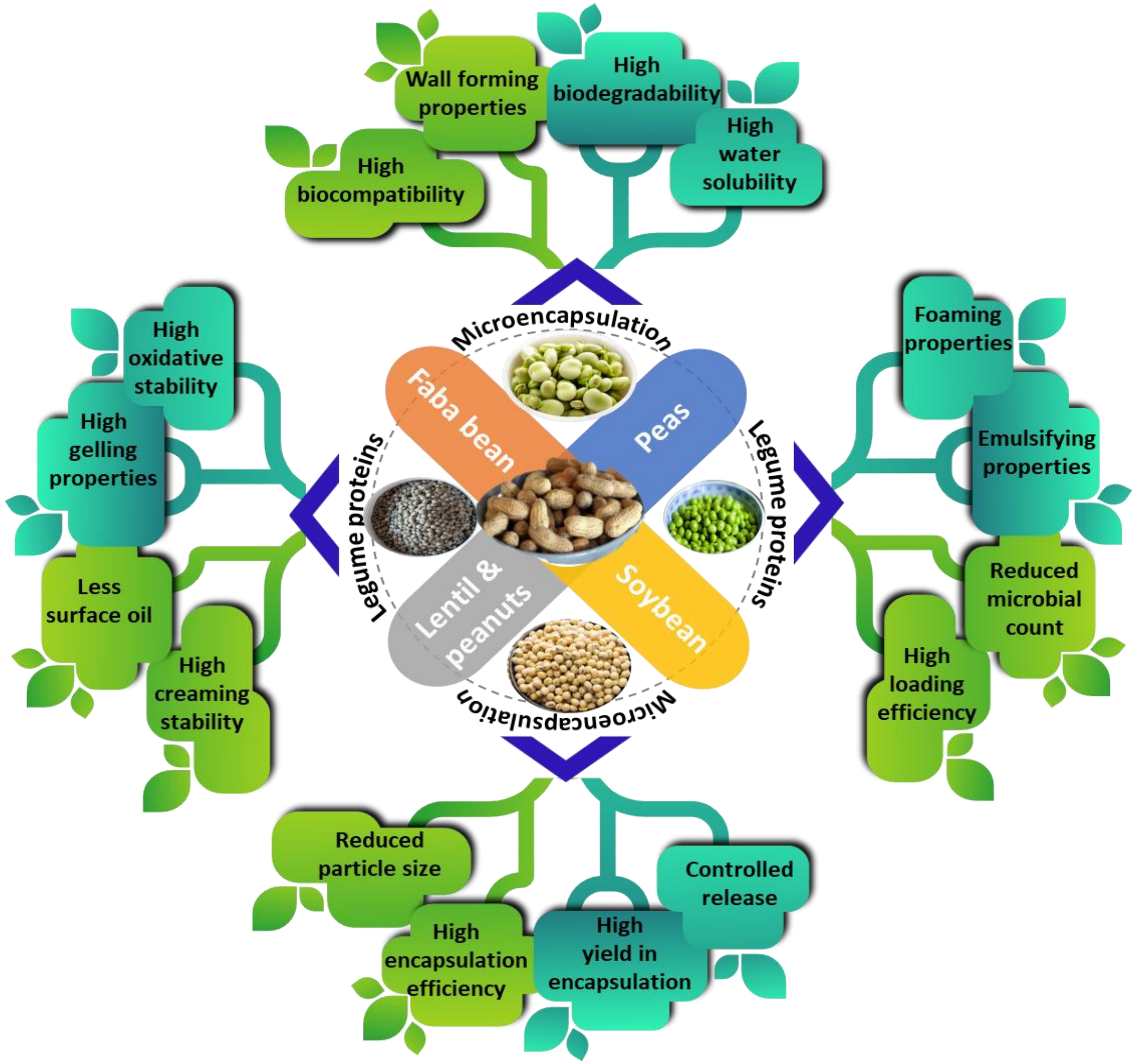


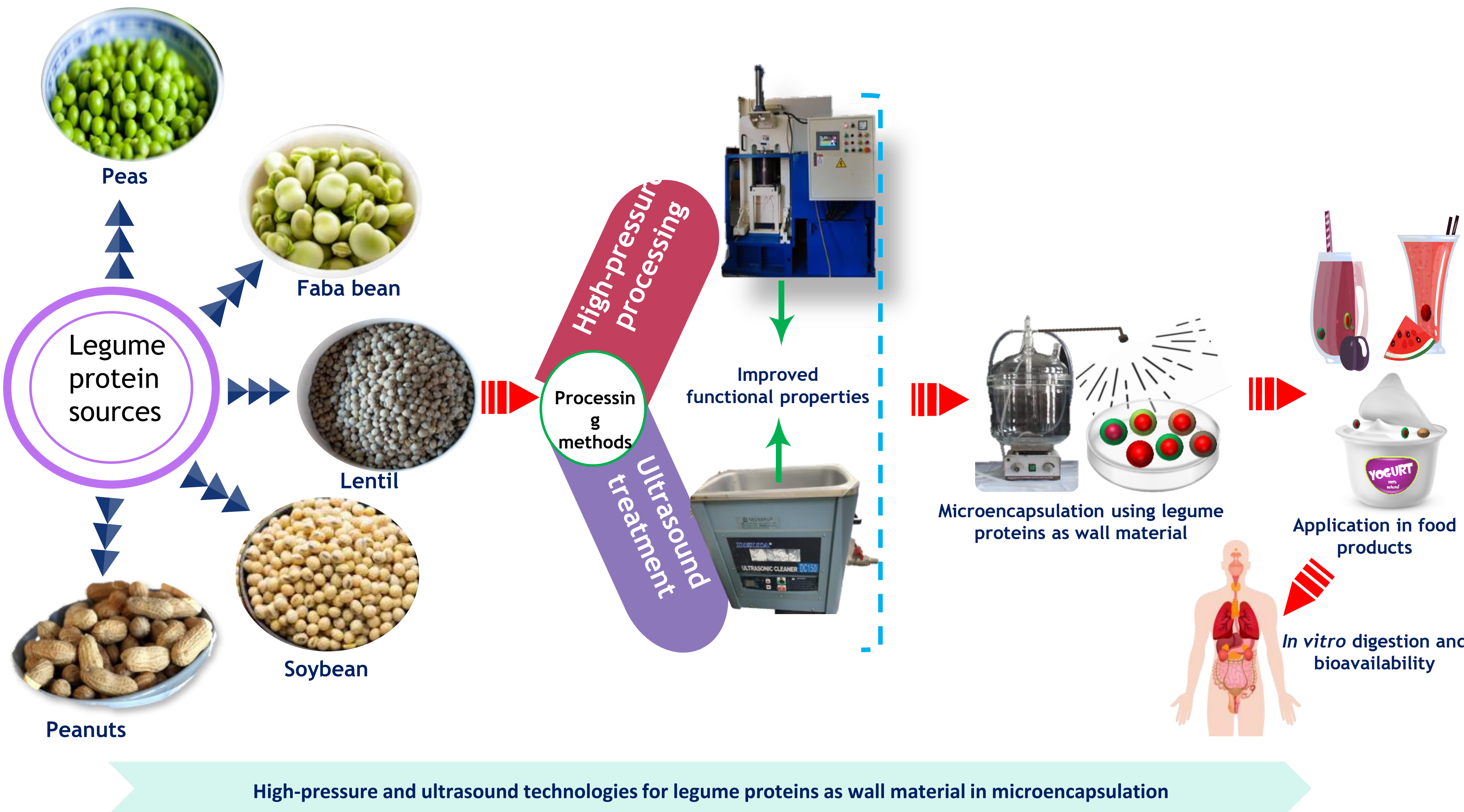
Figure 1. Properties of legume proteins (native) as carrier materials in microencapsulation

High-pressure and ultrasound technologies for legume protein functionalities

Table 1. Recent studies dealing with high-pressure and ultrasound technologies for improvement of legume protein functionalities[1]

Method	Protein source	Treatment conditions	Findings	Reference
HPP	Red kidney bean	• Pressure of 200, 400, and 600 MPa for 15 min at 23°C • The average pressurization rate = 20 to 25 s per 100 MPa and de-pressurization time = <5 s	• Increased WHC, foaming, and emulsification properties at > 600 MPa • Changes in the secondary structure of β-sheets • Increased G' and G" with higher denaturation temperature of 105°C • Little changes were observed in protein structure at pressure of 200 and 400 MPa	Ahmed et al. (2018)
	Bambara bean	• Pressure of 200, 300, 400, 500, and 600 MPa at 22°C and pH of 4.50, 7, and 9	• Vicilin was the major protein • Structural changes were observed at different pH • Decreased the total number of hydrogen bonds • Exposure of tryptophan tyrosine residues • Stable protein structure was observed up to 600 MPa • Partial unfolding, dissociation of subunits, and protein aggregation were reported at different pH and HPP treatments	Mune Mune et al. (2020)
	Pea protein	• Pressure of 200, 400, and 600 MPa for 5 min at 23°C	• Formation of high molecular weight protein aggregates • High foaming capacity • Decreased intensity of the 11S protein band • Low particle size of 26-68 µm and foaming capacity of 81% with increased stability	Chao et al. (2018)
US	Pea and soy protein isolates	• Acoustic intensity of ~34 W cm^2 (20 kHz and an amplitude of 95%) for 2 min	• Reduced protein size of 187 to 298 nm and intrinsic viscosity of 0.31 dL/g with no change in the primary structure molecular weight profile of proteins	O'Sullivan et al. (2016a)
	Soy protein isolate	• Acoustic intensity of ~ 34 W cm^2 (20 kHz and an ultrasonic amplitude of 95%) for 2 min	• Reduced protein aggregate size of ~200 nm and intrinsic viscosity of 0.27 dL/g with no change in the primary structure molecular weight profile of proteins • Significant reduction in emulsion droplet size of 0.10 to 10 µm and lower interfacial tension of 12 to 0.20 mN/m with high stability at all concentrations over a 28-day storage at room temperature	O'Sullivan et al. (2016b)
	Soy protein isolate and pea protein concentrate	• 20 kHz with ultrasound power (562.50, 637.50, or 712.50 W) and exposure time (120, 360 or 600 s)	• Improved the OHC • Improved techno-functional properties with increase in dispersibility of protein materials	Omura et al. (2021)

[1]HPP = High pressure processing, US = ultrasonication.


Peas
Faba bean
Legume protein sources
Lentil
Soybean
Peanuts
High-pressure processing
Processing methods
Ultrasound treatment
Improved functional properties
Microencapsulation using legume proteins as wall material
Application in food products
In vitro digestion and bioavailability
High-pressure and ultrasound technologies for legume proteins as wall material in microencapsulation

Evolving consumer market and global legume market trends

- Growing demand for legume proteins (native and/or modified) due to consumer willingness towards a higher proportion of plant-based healthier foods and a further reduction in food loss and waste
- Development of consumer-oriented food product formulations, such as encapsulated licorice root extract beverage and yogurt

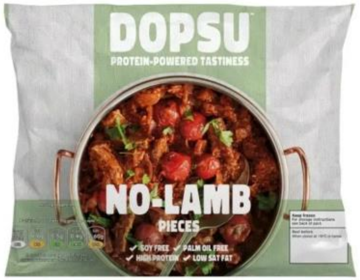
Nutralys® L85M: pea protein for meat-free products (Roquette)

Banza Pizza (Banza®)

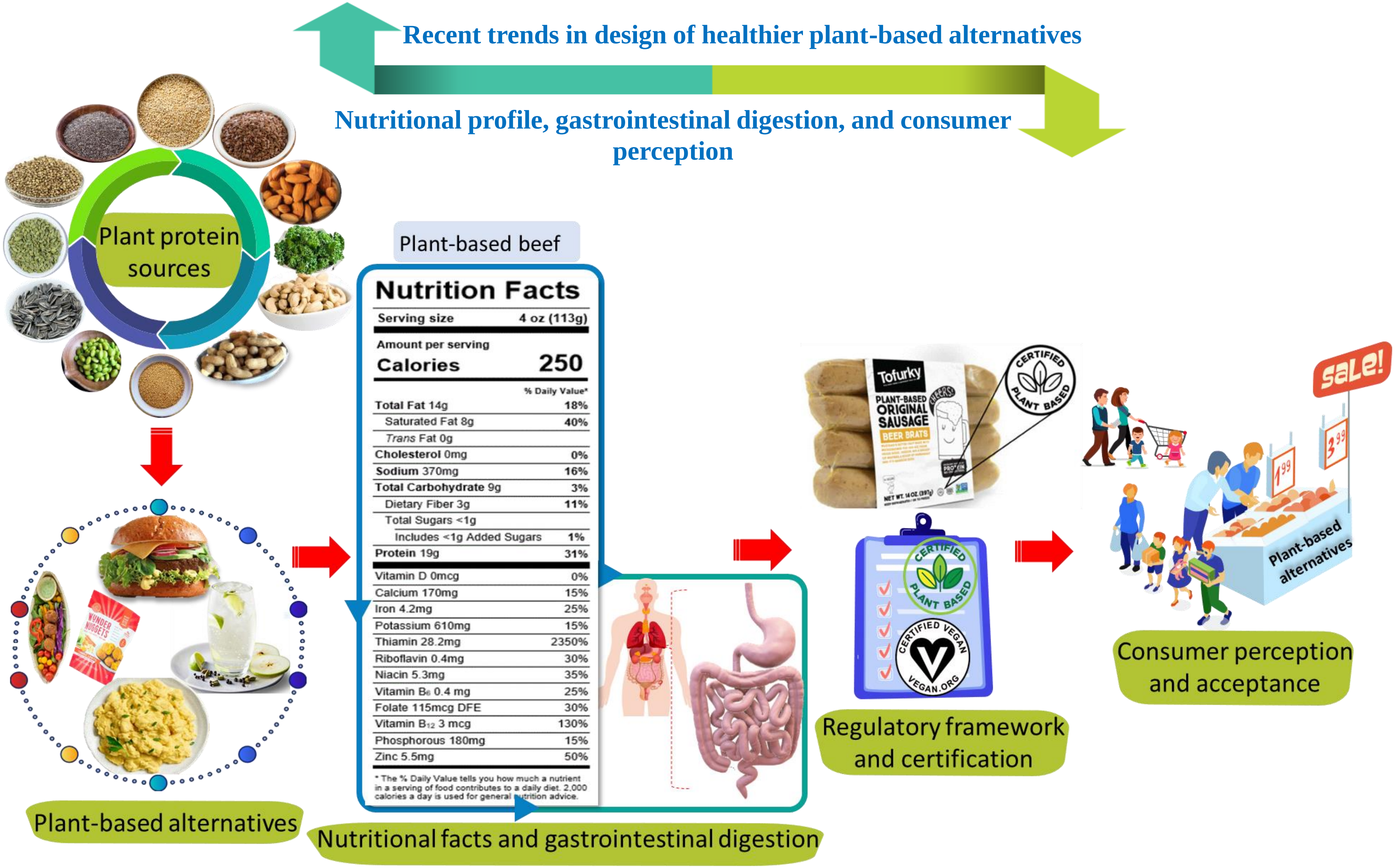
Plant-based pork (OmniFoods®)

Plant-based egg substitute (Nabati®)

Plant-based nuggets, bites, and strips (Tyson Foods®)



Dopsu™ (Plant-based duck, lamb, pork, and beef) (ABP Food Group®)


Recent trends in design of healthier plant-based alternatives
Nutritional profile, gastrointestinal digestion, and consumer perception
Plant protein sources
Plant-based alternatives
Plant-based beef
Nutrition Facts
Serving size 4 oz (113g)
Amount per serving
Calories 250
% Daily Value*
Total Fat 14g 18%
Saturated Fat 8g 40%
Trans Fat 0g
Cholesterol 0mg 0%
Sodium 370mg 16%
Total Carbohydrate 9g 3%
Dietary Fiber 3g 11%
Total Sugars <1g
Includes <1g Added Sugars 1%
Protein 19g 31%
Vitamin D 0mcg 0%
Calcium 170mg 15%
Iron 4.2mg 25%
Potassium 610mg 15%
Thiamin 28.2mg 2350%
Riboflavin 0.4mg 30%
Niacin 5.3mg 35%
Vitamin B6 0.4 mg 25%
Folate 115mcg DFE 30%
Vitamin B12 3 mcg 130%
Phosphorous 180mg 15%
Zinc 5.5mg 50%
* The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.
Nutritional facts and gastrointestinal digestion
Tofurky
PLANT-BASED ORIGINAL SAUSAGE
BEER BRATS
CERTIFIED PLANT BASED
CERTIFIED VEGAN
VEGAN.ORG
Regulatory framework and certification
sale!
Plant-based alternatives
Consumer perception and acceptance

Conclusions and take-home message

- ✓ Emerging technologies (HPP and US) to legume proteins for the improvement in encapsulation properties and their application in design of novel foods
- ✓ The use of legume proteins as wall materials allowed the development of novel functional foods enabling the controlled release of bioactive compounds at a specific target site
- ✓ Consumer interest in shifting towards more sustainable and clean-label plant-based diets made a way for growth in the legume protein market

Thank you for your incomparable attention !!!