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Institut Mutualisé pour les PROtéines VEgétales

The protein challenge: Value creation in the protein ingredients market

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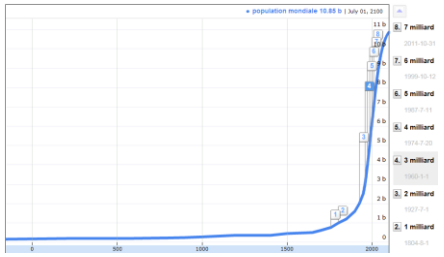
World challenge for proteins

Growing demand in protein

- World population expansion and ageing
- More people willing to eat animal protein in developing countries
- Protein ingredient market price is raising (x 3 during the last 15 years)



Durable agriculture

- Compromise between yield and entrants usage
- Land sanitary evolution

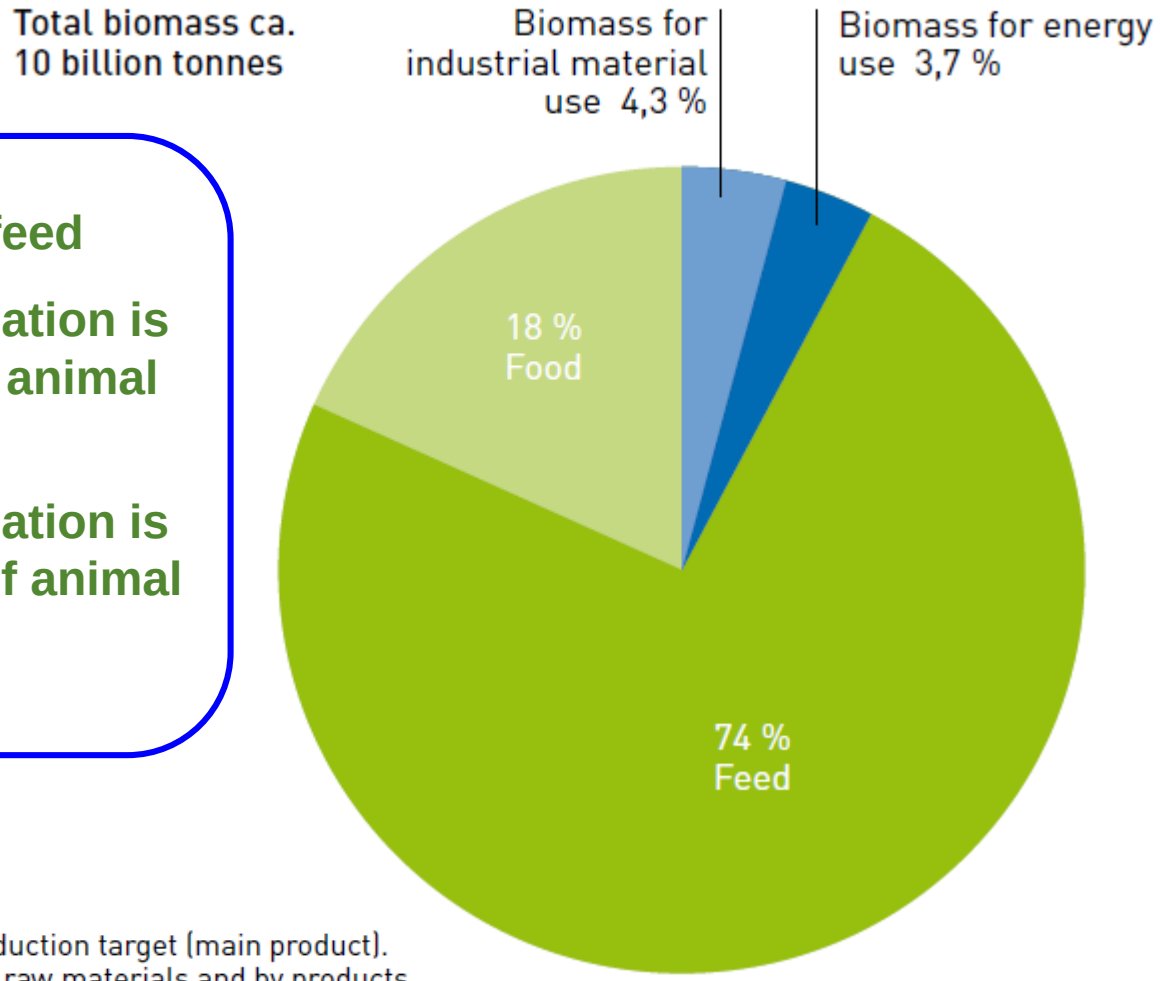
Multiple potential sources

- Seeds
- Roots
- Leaves
- Coproducts
- algae
- Microorganisms
- Insects
- ….

Used as is or after processing

Agricultural ressources usages

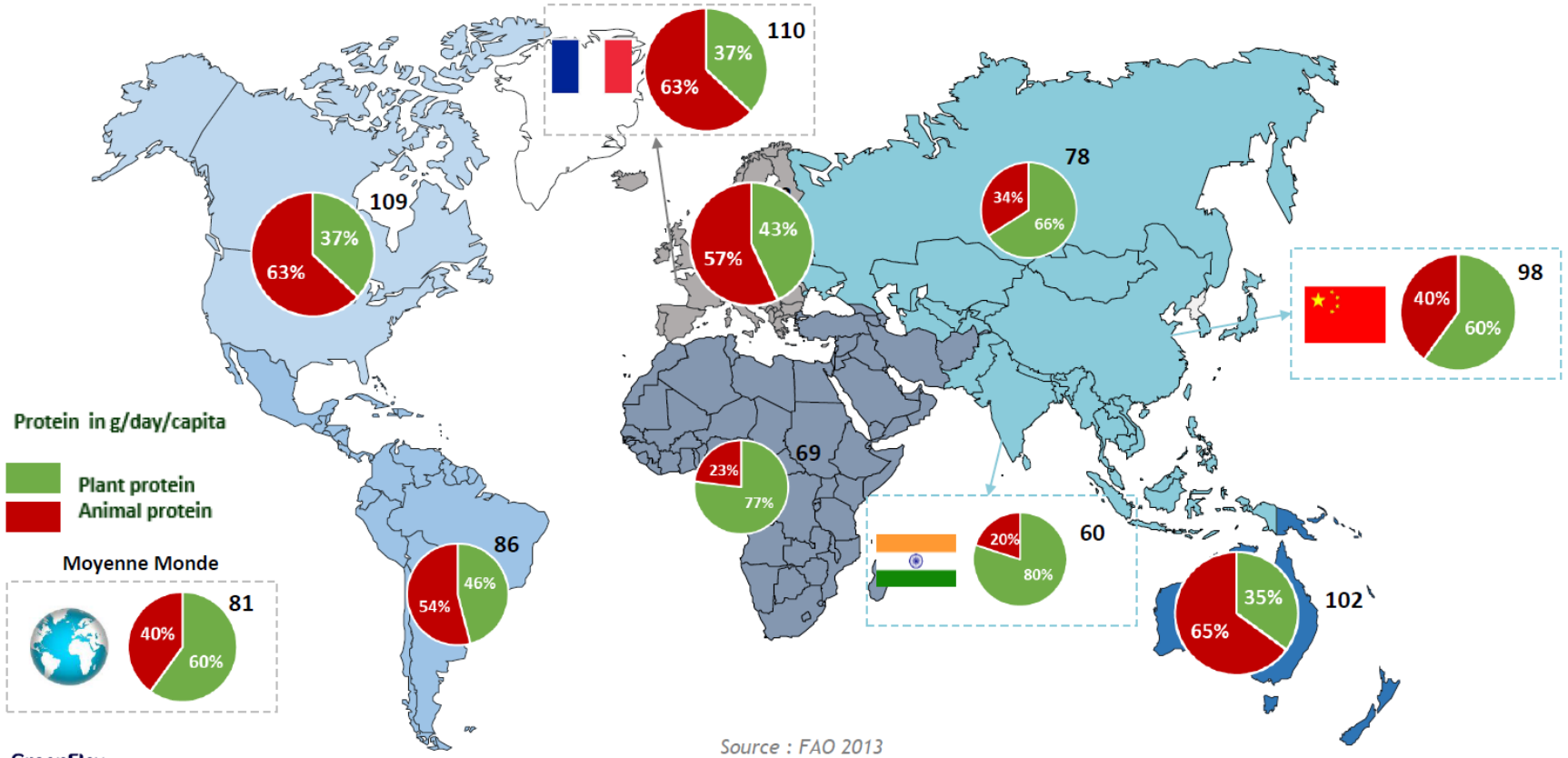
Use of harvested agricultural biomass worldwide (2008) (source: nova-Institute)



- **Usages dominated by feed**
- **50% of the world population is using less than 25 g of animal proteins/day**
- **18% of the world population is using more than 60 g of animal proteins per day**

Allocation of biomass to production target (main product). Respective amounts include raw materials and by products, even if their use fall into a different category.

World protein diet diversity



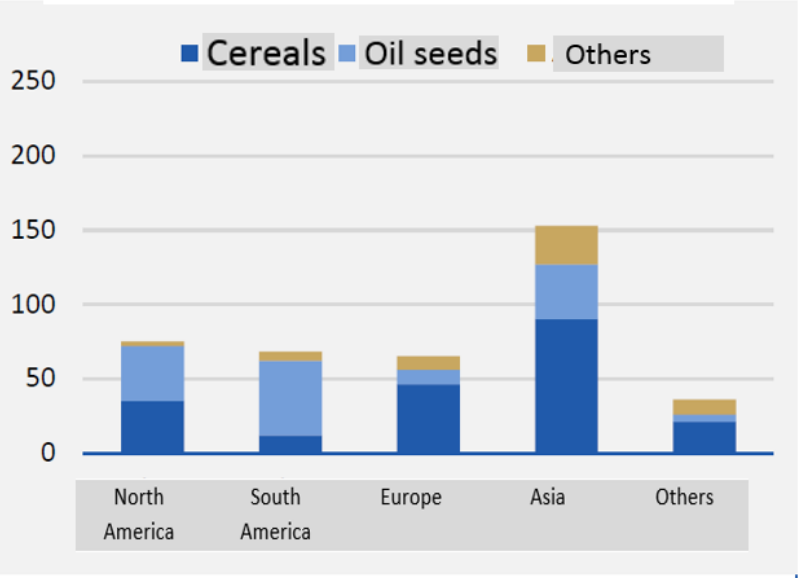
GreenFlex

- High animal protein diets are only possible in rich countries

European Challenges

World Protein Exchanges

Plant protein production in the world (Fodder excl)
Unit = million tons of proteins



Source : GIS – Élevages Demain, 2017

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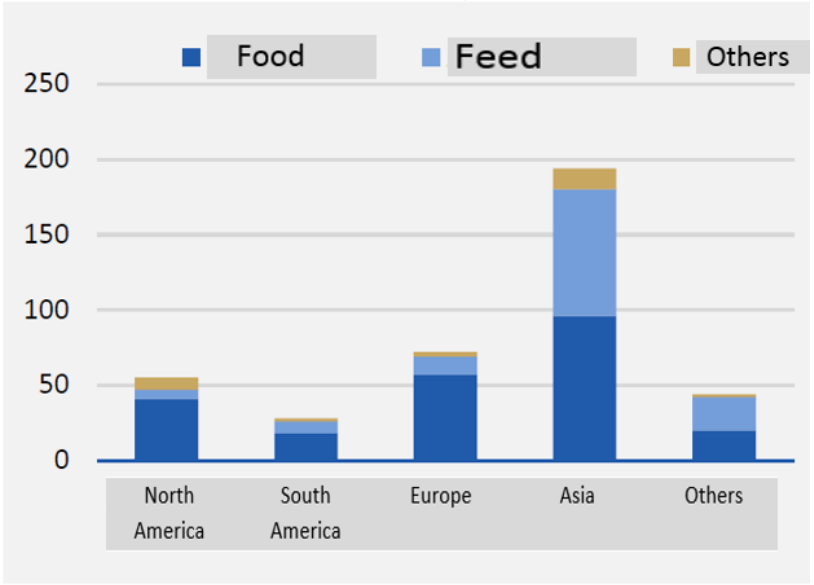


Source : GIS – Élevages Demain, 2017

Europe has favorable soils & pedoclimatic conditions

European challenges

Europe is importing 60% of its protein needs

- Mainly from North & South America
- From soy (seed or meal)

France is importing 40% of its protein needs

- Mainly from North & South America
- The gap is linked to the rape seed cake available after biodiesel production.

Europe is consuming less and less pulses, in France

- 7,4 kg/capita/year beginning of the 20th Century
- 1,7 kg/capita/year now
- 50% are imported

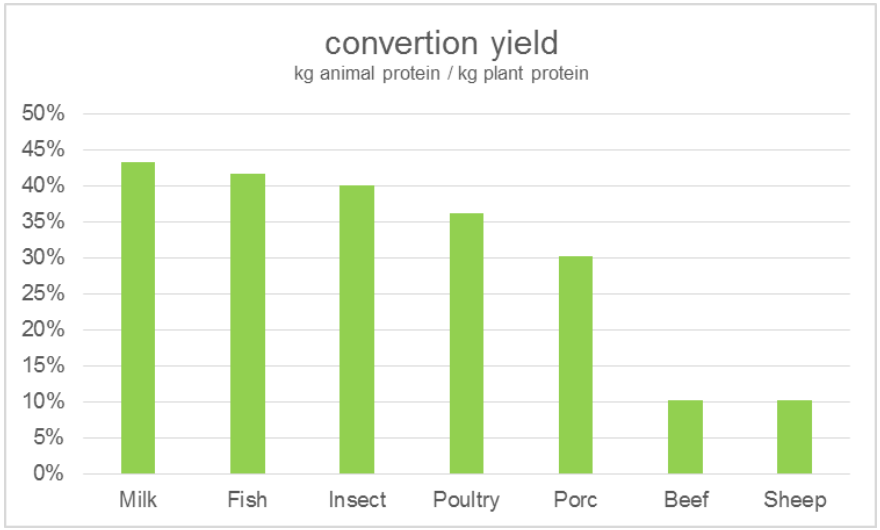
Environmental impact

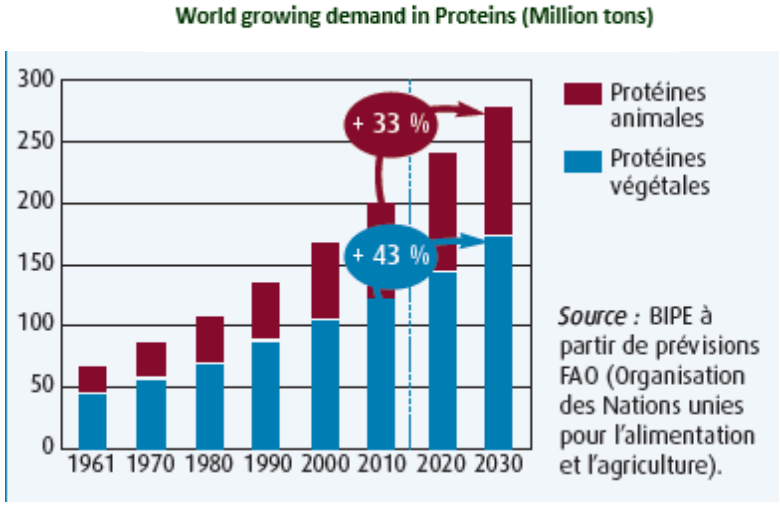
- Actual protein usage cycles are not sustainable
  - Symbiotic N drop from 100% after World War II down to less than 5%
  - In Europe
    - 11,2 Million tons of N are coming from fertilizers
    - 7,1 Million tons are coming from animal farming
    - 5,8 Million tons are coming from “green fertilizers”
    - ONLY 1 Million tons is coming from symbiotic fixing !

European key challenges

Rebalance plant vs animal protein in food

- In Europe the protein diet is including 65% of animal protein



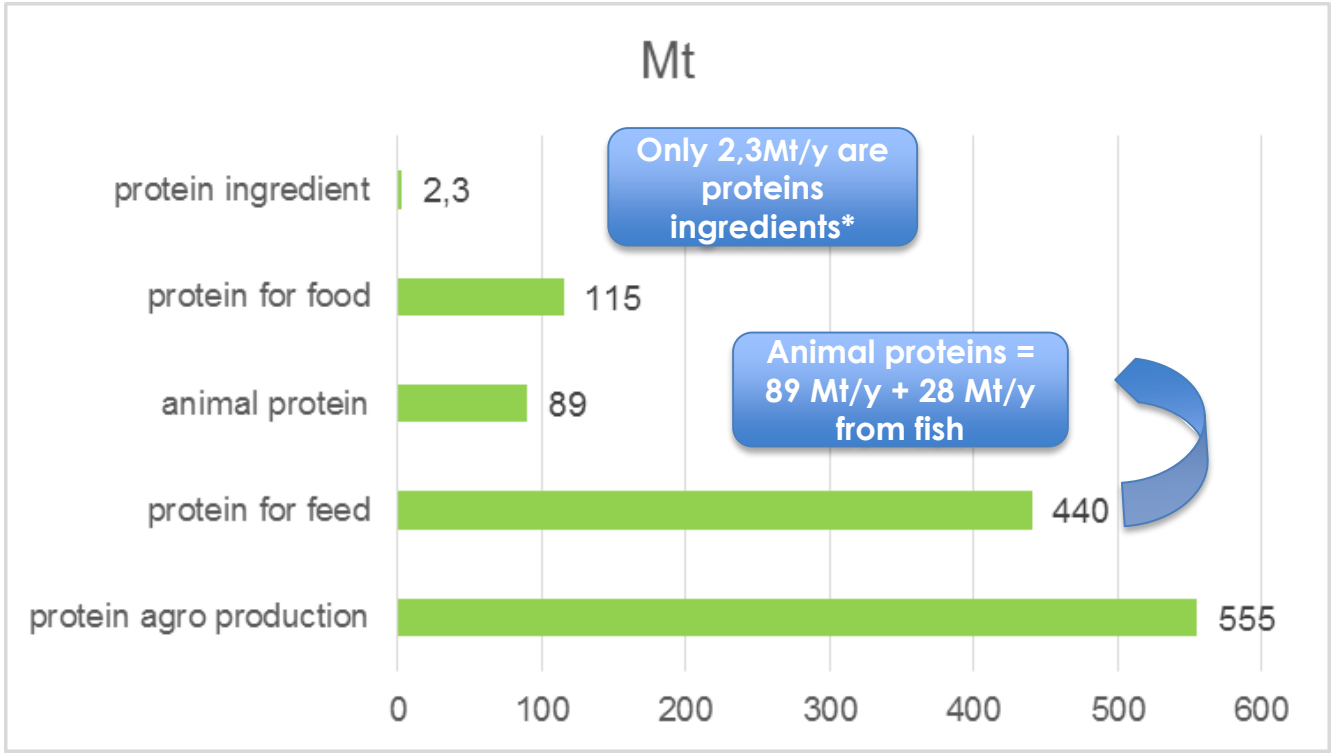


- With a convention efficiency between 10 to 40% it is key **to bypass as much as we can the animal conversion**
- **Develop new crop rotations**

→ Better answer Market & Societal demand for more plant based protein

How do we utilize proteins?

- World proteins balance: from 10 billion tons of agro material



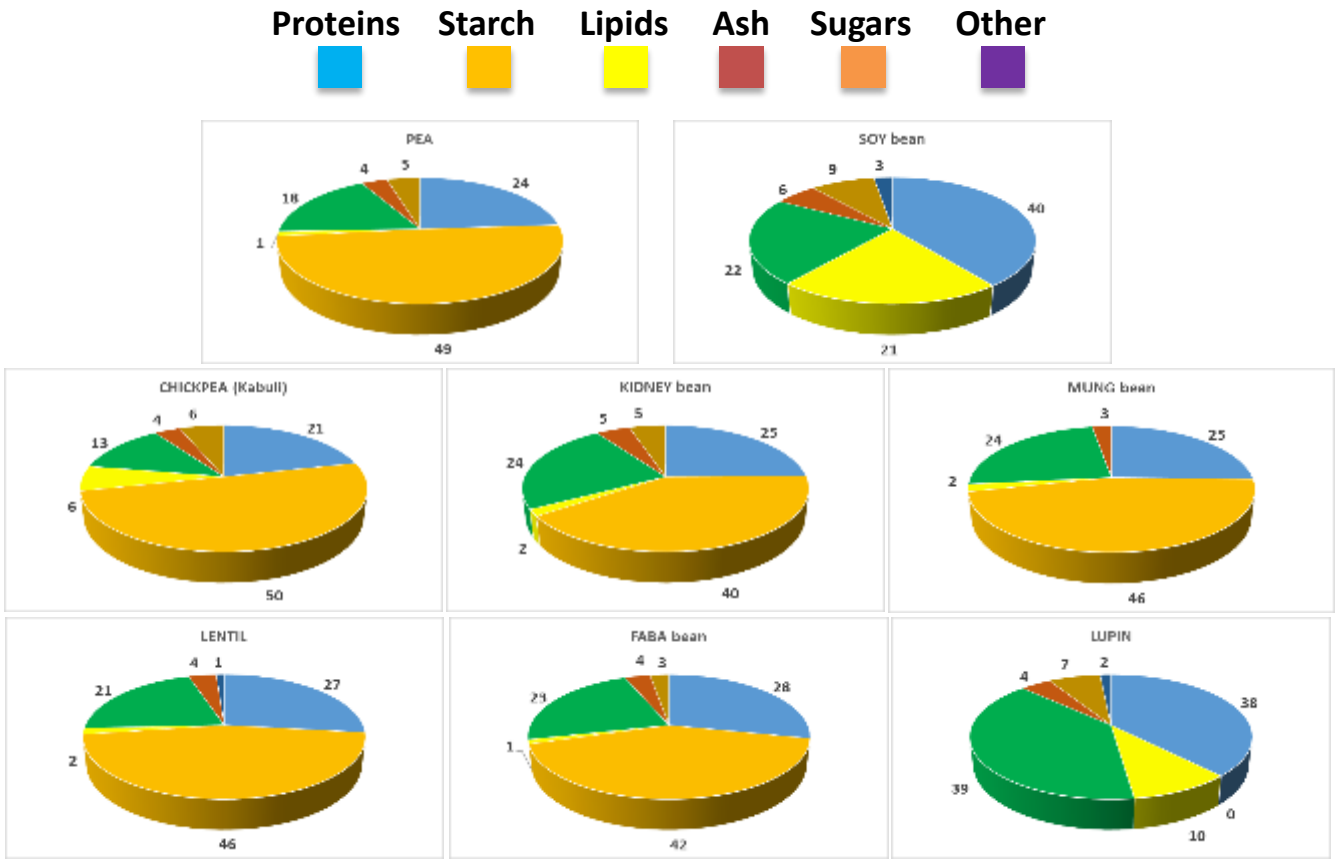
Average conversion ratio = 4,9

56% from soy, 43% from wheat and less than 1% for pea, rice, potatoes, rape seeds, faba beans, lupine, sun flower, algae's, ….

Seed diversity

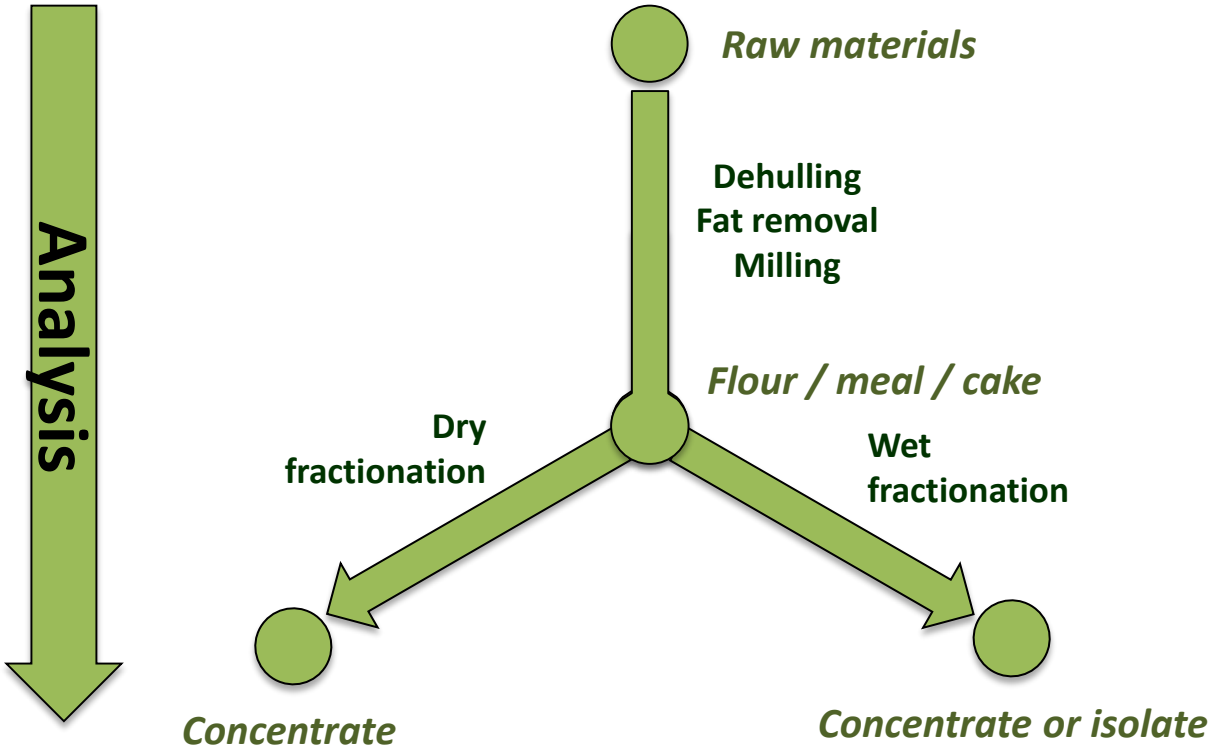
Shape

Composition



- Raw materials are **diverse** in shape, composition, texture…
- **Antinutritional factors** are often present (α-galactosides, Phytic acid, Polyphenols, Tannins, Chlorogenic acid, Phytooestrogens, Saponins, Alkaloids, Cyanogénic Heterosides, …

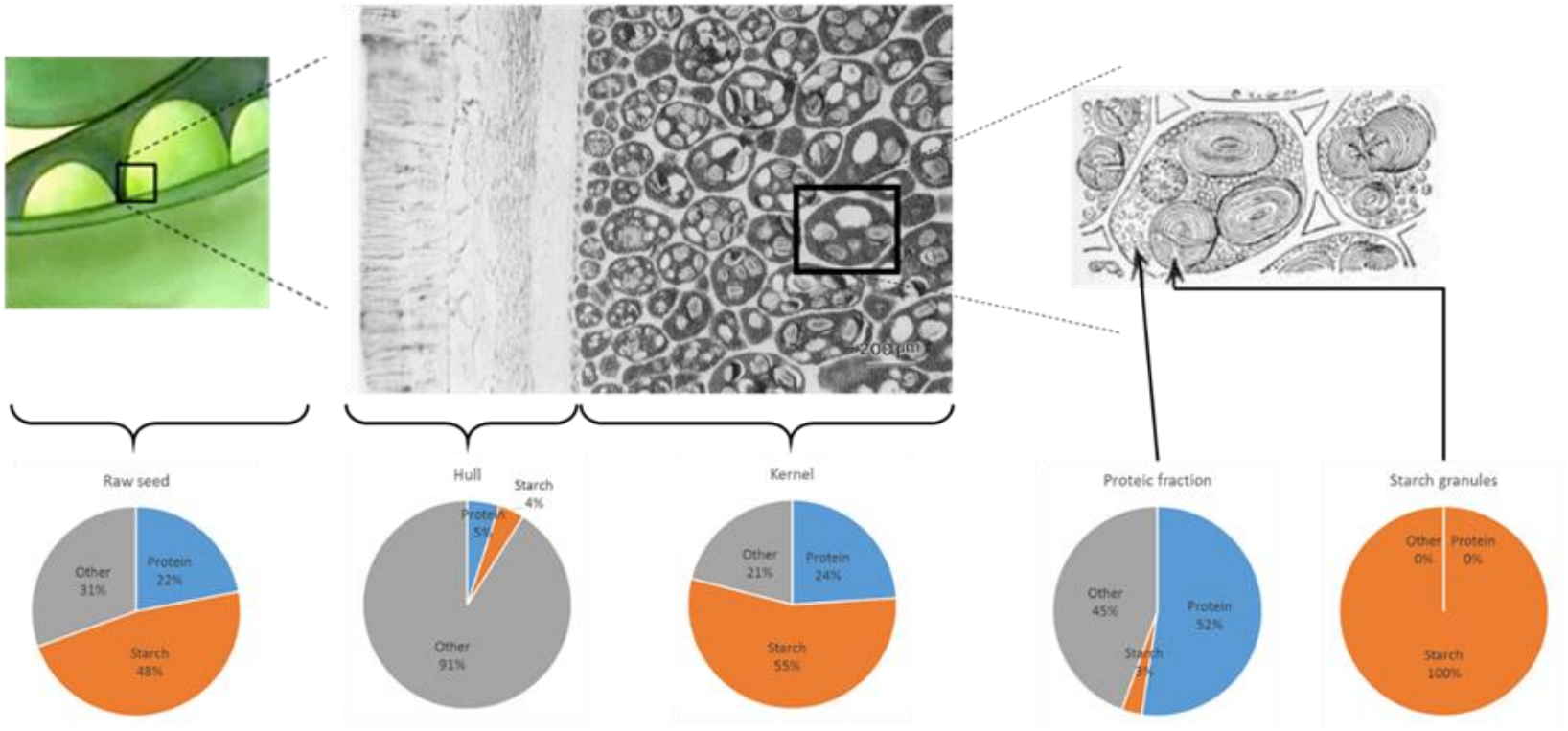
Protein extraction strategies



Dry processes – example of pea

Morphology (macroscopic scale)

Histology (microscopic scale)



Dry fractionation processes use the structural heterogeneities of the materials to produce specialized products → plant deconstruction

Transformation process

Harvesting / storage

Dehulling

Fractionation

Cleaning Preparation

Milling

Functionality?

Protein enrichment?

Batches?

Yields?

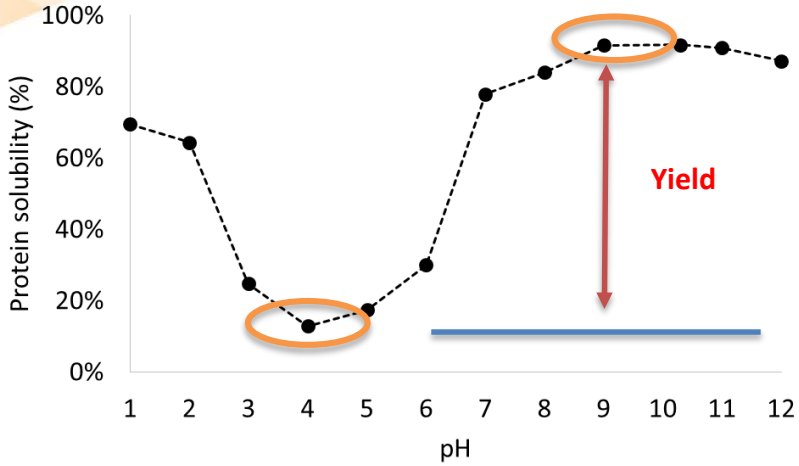
Starch or fiber enrichment?

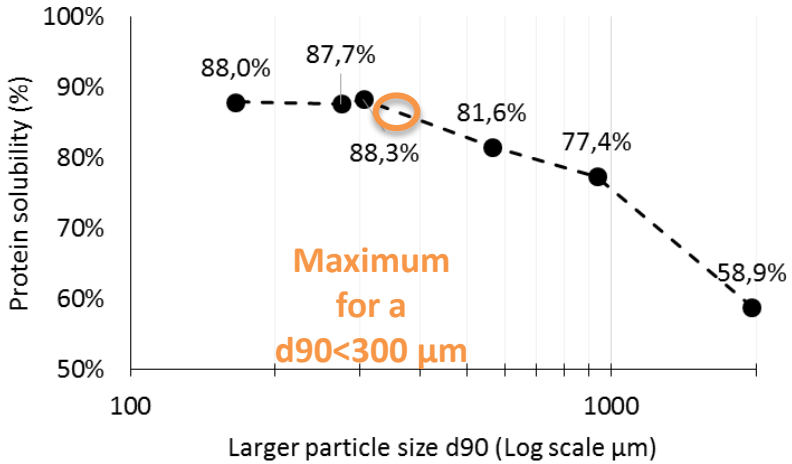
Extraction of lipids and micro-constituents using solvents

- Hexane extraction → remove lipids
- Alcohol extraction → phenolics and saponins
- Microwave & ultrasound assisted extraction of oil
- CO_2 Supercritical extraction and subcritical Water extraction
- Alternative green solvents
- Alternative ionic liquids
- Physical separation (tricanter, skimming separator…)
- …

Wet fractionation

Solubilisation step





Faba Flour

Maximum of solubility: pH 9 - 10

Minimum of solubility : pH 4

Pin mill powder

↓

Evaluation of the protein solubilizing at pH 9.5

Protein solubility vs. flour's PSD

↓

Compromise between energetic cost and protein extraction yield

↓

For next step we selected a powder d90 = 166 µm

4 complementary ways to characterize protein

Nutritional

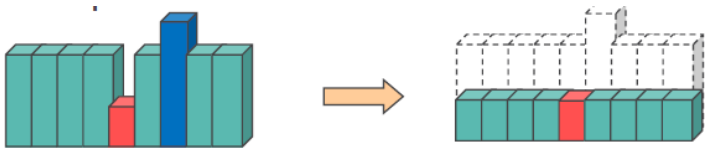
Functional

Organoleptic

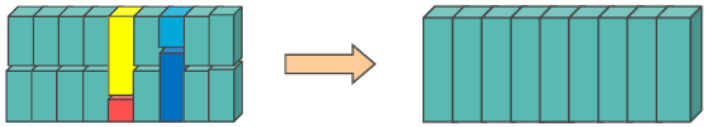
Marketing

Nutritional properties

Essential AA balance



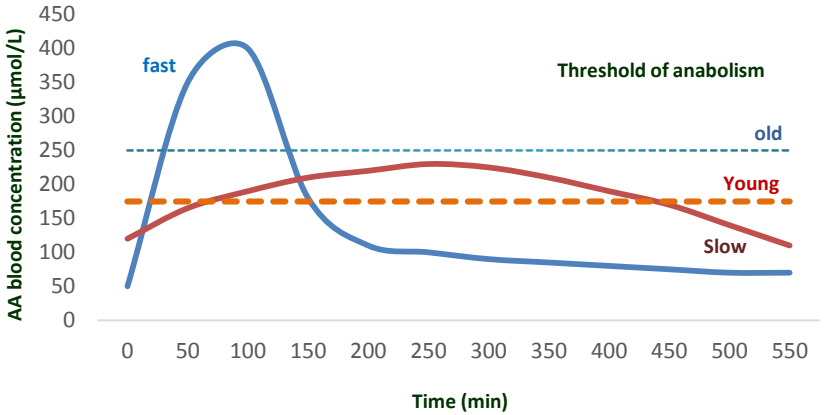
Unbalanced diet leading to AA oxidation



Well balanced diet leading to an optimal protein anabolism

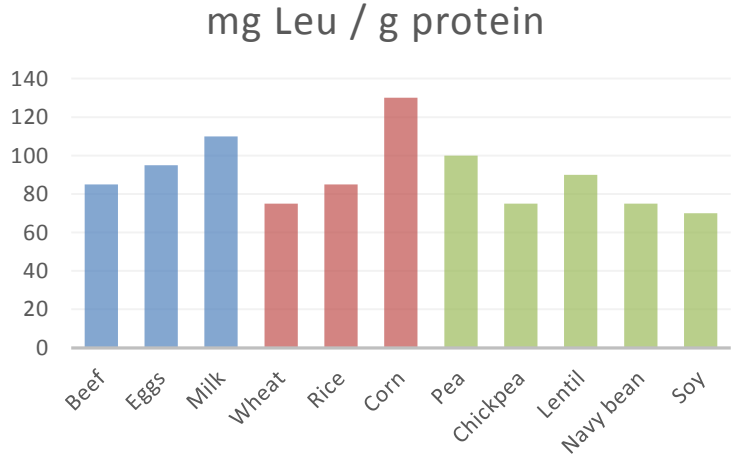
Protein digestibility: PDCAAS

Protein digestion speed

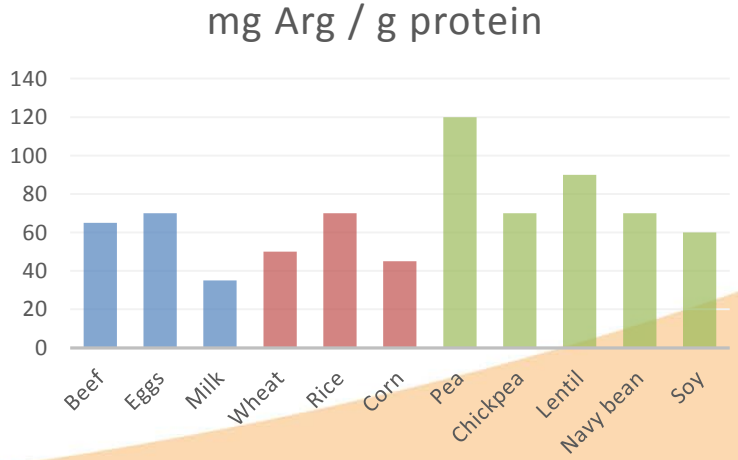


AA having messenger function

Leucine is known to stimulate protein anabolism



Arginine is known to reduce blood pressure



Proteins functional properties

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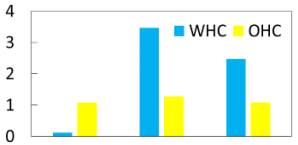
FUNCTIONAL ATTRIBUTES

WATER & OIL HOLDING CAPACITIES

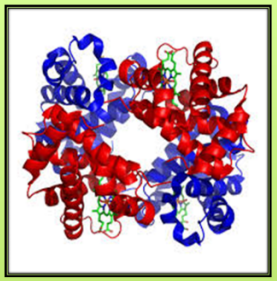


Cooked meats

FOAMABILITY

Foamscan

Mousses, desserts



INSTANT PROPERTIES

Wettability test

Instant drinks

GELLING

Texture analyser, rheometer

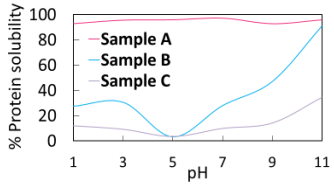
Gellies, meat replacers

EMULSIFICATION

Mastersizer 3000

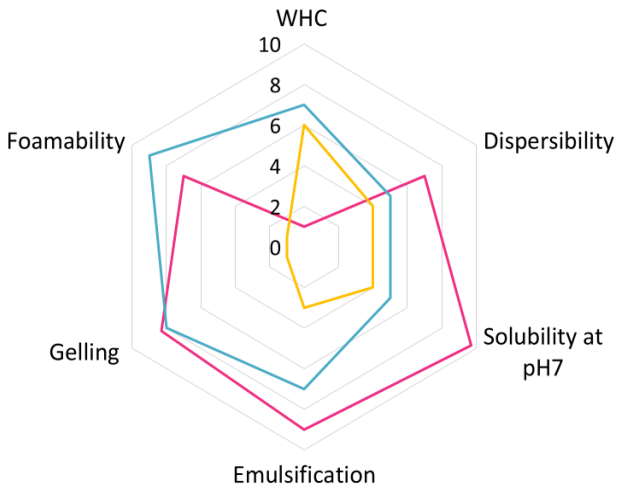
Dairy alternatives, sauces

SOLUBILITY



High protein drinks

FUNCTIONALITY SCORE



- Comparison of protein sources
- Process optimization
- Scoring and benchmarking
- animal proteins replacement

Organoleptic properties

- Plant proteins
  - **Often associated with off notes**
    - Astringency
    - Bitterness
    - Beany, hay, cardboard aroma

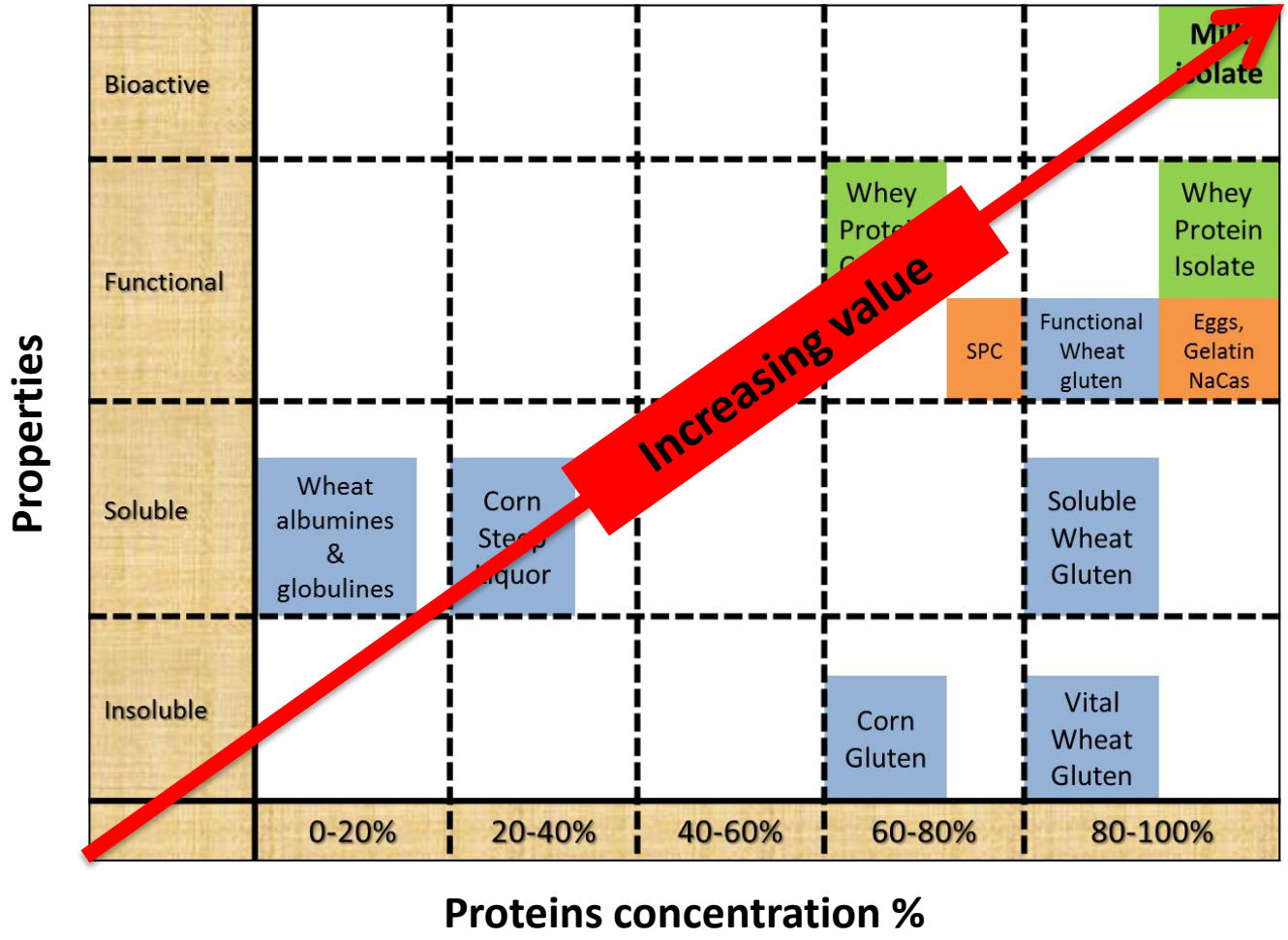
  - **5 strategies to deal with off-notes**
    1. Selecting favorable **raw material** (variety selection, storage conditions...)
    2. **Prevent** by processing (dehulling, enzymes deactivation, microbio control …)
    3. **Eliminate** by post processing (flash under vacuum,….)
    4. **Masking**
    5. **Formulate**

  - What is perceived is most of the time a combination of aroma and taste.

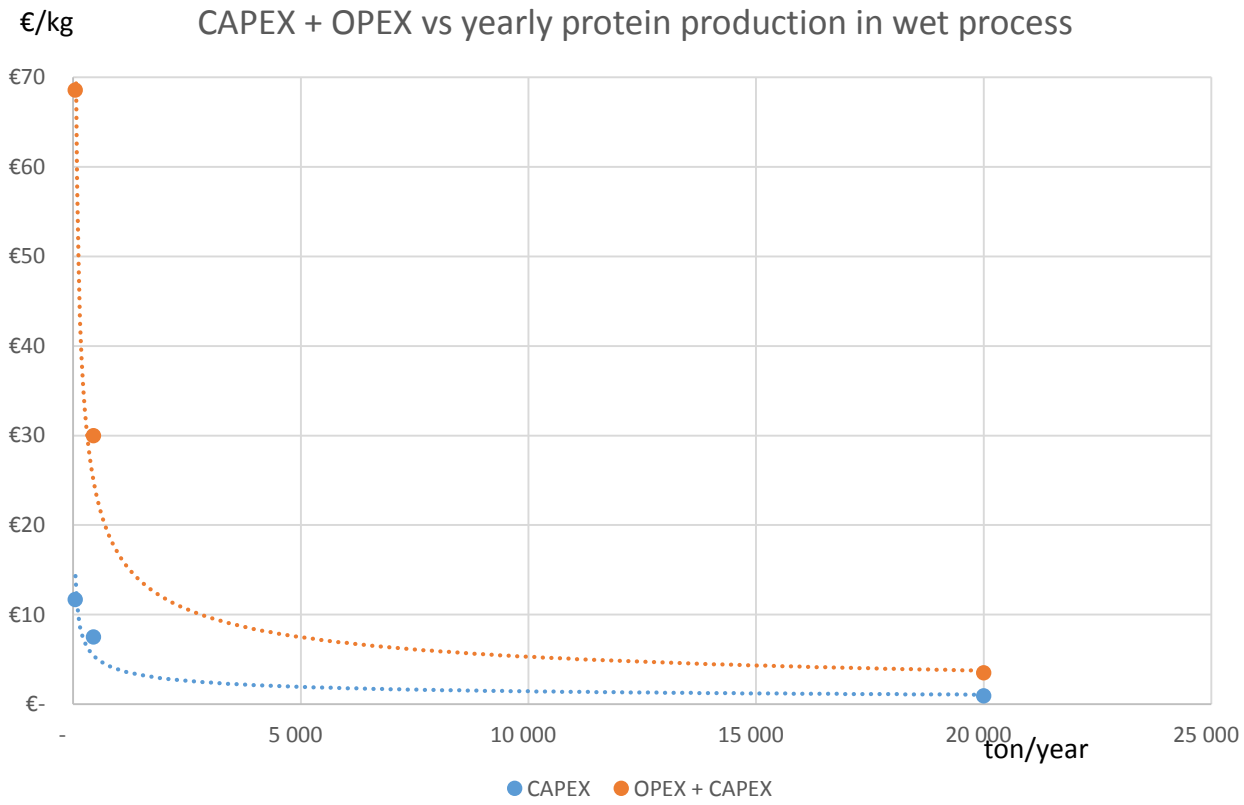
Marketing

Items for communication	raw material	process
Food Allergens (8 in USA, 14 in Europe, 27 in Japan…)	✓	✓
Anti nutritional factors	✓	✓
Bio activities (more than 30 linked to peptides)		✓
Clean label		✓
GMO free	✓	
Organic	✓	✓
Plant origin	✓	
Protein purity		✓

Market selection



Pick the right scale



- It is key to know which market is targeted in order to define the size of the project.

Successful industrial protein ingredient project

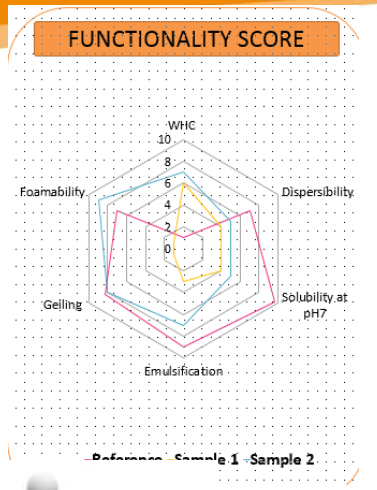
Brilliant brains

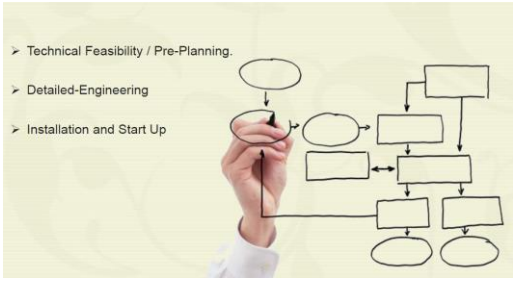
Smart ideas

Strong market understanding

Regulatory expertise

Robust hypothesis





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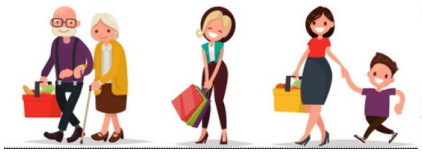

IMPROVE: Protein R&D Center

- IMPROVE is a **protein innovation center**, located in France 1 hour north of Paris.

- **Private – public partnerships** between
  - **industrials** from the cereals, oilseed and pulses processing sectors
  - **Academics** like Amiens University or INRA (French Institute of Agronomy)
  - **Financial investors** including various banks and the French government

- IMPROVE **started in 2014**, it can offer **22 brains** and **5,5 Million € equipment** to support innovation in the alternative protein world.

- IMPROVE can carry out
  - **dry or wet processing at pilot scale** on a wide range of raw materials (seeds, roots, leaves, by-products, microorganisms biomass, algae, insects…)
  - **Labs characterization** (composition, in vitro digestibility, functional properties…)
  - **Intellectual support**: literature review, brainstorming session, plant audit, market survey, consulting…

IMPROVE

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Get the most out of your Protein R&D budget !

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