Challenges for Protein Processing Diversity

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Challenge for proteins

• Growing demand in protein
  – World population expansion
  – More people willing to eat animal protein
  – Protein market price is raising (x 3 during the last 15 years)

• Durable agriculture
  – Compromise between yield and entrants
  – Land sanitary evolution

• Multiple potential sources
  – Seeds
  – Roots
  – Leaves
  – Coproducts
  – algae
  – Microorganisms
  – Insects
  – ….

Used as is or after processing
Agricultural ressources usages


- 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.
Seed diversity

**Shape**

**Composition**

- **Proteins**
- **Starch**
- **Lipids**
- **Ash**
- **Sugars**
- **Other**

- 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

**Analysis**

- **Raw materials**
  - Dehulling
  - Fat removal
  - Milling

**Concentrate**

- Dry fractionation
- Concentrate

**Flour / meal / cake**

- Wet fractionation
- Concentrate or isolate

**Concentrate**
Dry fractionation processes use the structural heterogeneities of the materials to produce specialized products.
Transformation process

Harvesting / storage

Cleaning Preparation

Dehulling

Milling

Fractionation

Batches?

Yields?

Functionality?

Protein enrichment?

Starch or fiber enrichment?
Seed preparation technology

Micronizing (micronizing company®)

Seed cleaner – SLN3 (Pfeuffer®)

Fluid bed dryer – TG 200 (Retsch®)

Densimetric table – LAK (Westrup®)
Seed dehulling technics

**Stone mill and stone dehuller (Alma®)**

**Whitening/Shelling Machine (Schule®)**

**Roll crusher (Satake®)**

**Impact dehuller (Alma®)**

**Knife mill - SM300 (Retsch®)**

**Gravity classifier ZIGZAG – MZM 1-40 (Hosokawa-Alpine®)**
Particle size reduction

How deconstruct the material?
The different mechanical forces involved

Impact
Cutting
Compression
Shearing
Abrasion

Each milling technology is a combination of these forces
Milling technologies

Pin mill - 100 UPZ (Hosokawa-Alpine®)

Beater mill - 100 UPZ (Hosokawa-Alpine®)

Knife mill - SM300 (Retsch®)

Impact mill - 70 ZPS (Hosokawa-Alpine®)

Roll mill – MLU 202 (Bühler®)
Powder fractionation

Vibration round screener
VRS600 (Allgaier®)

Gravity classifier ZIGZAG – MZM 1-40 (Hosokawa-Alpine®)

Air classifier - 70 ATP (Hosokawa-Alpine®)

Electrostatic separation (STET®)
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
- ...

...
Solvent free extraction

- Extraction of oil using **mechanical separation**
  - Cold-pressing using a screw press
    - temperature of 50-60°C
    - energy consumption reduction
    - 8 to 12% residual oil in the pressed cake
  - Skimming oil separator

- **Aqueous defatting** method
  - Simultaneous recovery of oil and proteins
  - Minimal proteins denaturation during fat removal
  - Removal of water-soluble undesirable components
  - Require a de-emulsification stage to break the emulsion
  - Can be combined with pre-treatments or specific enzymes
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

Graphs showing:
- Protein solubility vs. pH
- Protein solubility vs. flour’s PSD

Notes:
- Maximum for a d90 < 300 µm
- Yield
- 15%
Solid/Liquid separation

3 phases decanter
- Flottweg, Alpha Laval

Clarifier
- GEA, Alpha-Laval

Hydro-cyclone

Basket centrifuge
- BMA, Robatel

Rotary pressure filter
- BHS, Andritz

Filter press
- Faure, BHS, Alfa Laval, Andritz

Belt filter
- Andritz, Flottweg
Membranes, material and design

Tami industries, Noyons

Tubular membranes

Pall-Exekia, Bazet

Spiral wound membranes

Tubular membranes

Padovan, Andritz

Dynamic Cross Flow Filter
Drying technologies

**Spray dryer**

GEA – Sicca Dania – Alfa Laval...

**Roller dryers**

GOUDA ANDRITZ

**Ventilated dryers**

WOMM

**Attrition dryers**

LIST

**Continious vacuum dryer**

HOSOKAWA
Organoleptic properties of pulse protein

• Associated with **off-notes**
  – Astringency
  – Bitterness
  – Beany, hay, cardboard aroma

• Strategies to deal with off-notes
  – Selecting favorable raw materials
    *Specie selection, storage conditions*
  – Prevent by processing
    *Dehulling, enzymes deactivation,微生物 control ...*
  – Eliminate by post processing
    *Flash under vacuum,...*
  – Masking
    *Sugars, salts, acids, flavouring, food matrix components, fermentation...*
Disruptive technology with natural flocculent

- Precipitation process with natural flocculent
- Whole seed cracking
- Natural flocculent also targets the valorization of the hulls and/or brans through several fractionation and precipitation steps: pectin, pentosans, etc.

Process developed by Labiocrac
Successful industrial protein project

Brilliant brains

Smart ideas

Strong market understanding

Regulatory expertise
Market selection

Properties

Bioactive

Functional

Soluble

Wheat albumines & globulines
Corn Starch & Flour

Functional Wheat gluten
Soluble Wheat Gluten

Whey Protein Concentrate
Whey Protein Isolate

Eggs, Gelatin, NaCas

Insoluble

Corn Gluten
Vital Wheat Gluten

Proteins concentration %

0-20%  20-40%  40-60%  60-80%  80-100%

Increasing value
Raw material selection

- More than 1000 PC/PI worldwide.
- 35 different raw materials
- 138 different producers
- 66 distributors

Different forms:
- Flour
- Protein concentrate
- Protein isolate
- Protein hydrolysate

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Pick the right scale

- It is key to know which market is targeted in order to define the size of the project.
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** to support innovation in the alternative protein world

IMPROVE can carry out **lab and pilot work** in order to process a wide range of raw materials (seeds, roots, leaves, by-products, microorganisms biomass, algae, insects...)

Who are we?
Get the most out of your Protein R&D budget!
Help us to make Proteins strong again!

Thanks

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