

Using process to maximise the health benefits of plant-based foods



IMPROVE

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BRIDGE2FOOD
EUROPE

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Who are we?



- R&D platform dedicated to the **extraction and transformation of sustainable proteins** (*plant-based, insects, micro-algae, yeast, precision fermentation...*) and their **by-products**
- 25 employees, 800 m² pilot plant facility / 170 m² lab, ~ 20 m€ investment to date
- Mission: Support **ingredient producers** and **food manufacturers** in their R&D
- **700+ customers** since 2013 from **Europe, north America, Asia and Australia**



Our originalities – process development



Common equipment for R&D trials

Solid / liquid separation



Centrifuge

Thermal treatment



Water bath

Drying



Freeze-drier

Disconnected from “real-life” conditions:
different technologies, batch mode

Pilot equipment



Decanters

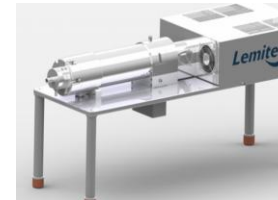


Heat exchanger



Spray drier, ring drier

Small-scale pilot equipment



Decanters

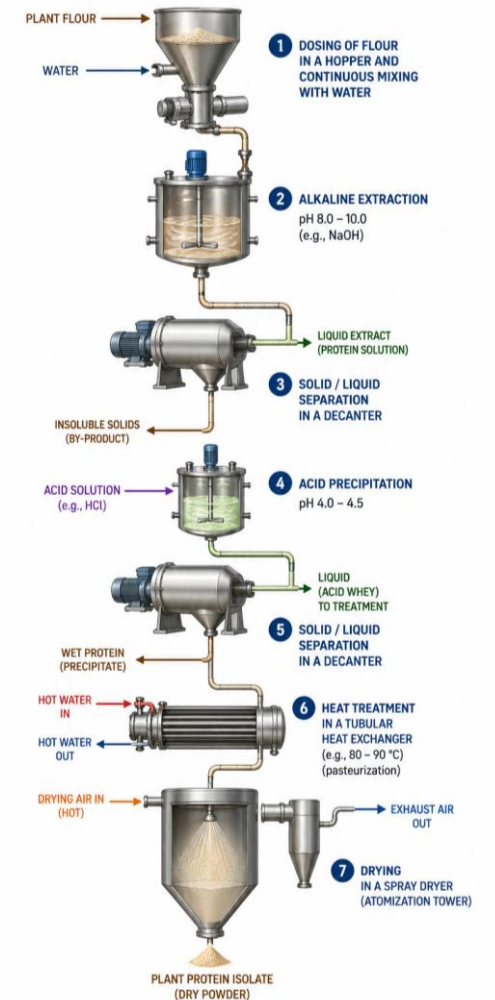


Heat exchanger



Spray drier

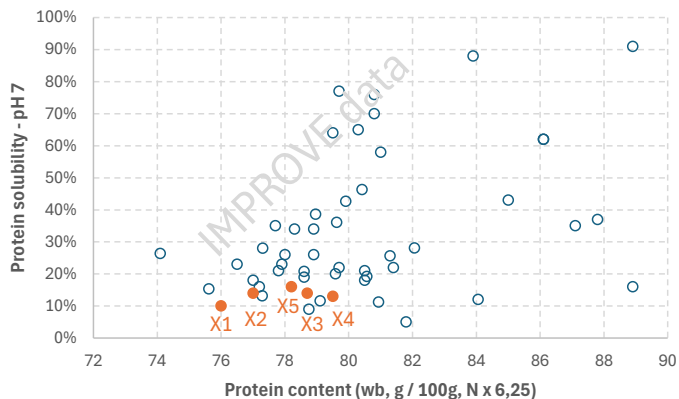
Continuous pilot process line



Our originalities – analytical lab



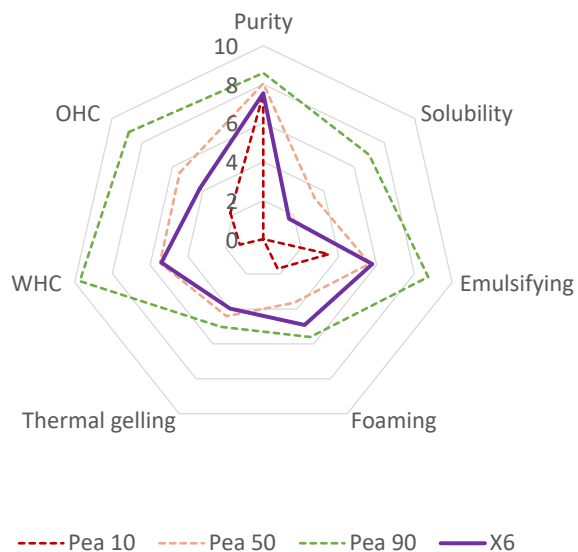
~ 500 different protein samples in our database
(R&D and commercial)



Benchmarking
against the
alternative protein
landscape

Comparison of
prototype against:

- Top 10% protein
- Median
- Low 10% protein



Protein characterisation

- **Physicochemical properties** (composition, denaturation...)
- **Functionality** (gelling, emulsifying, foaming...)
- **Nutrition** (PDCAAS, anti-nutrients)

By-products characterisation

- **Starch**: total, damaged, resistant starch, amylose / amylopectin, SEM observation, glycaemic index, swelling, viscous and gelling
- **Fibre**: water absorption, rheology
- **Bioactive molecules**: antioxidant activity, phenolics, colorant

Evaluation in model food systems

- **Dairy**: milk, yogurt, cheddar-like, spreadable cheese
- **Bakery**: bread, biscuit, pasta, puffed cereals
- **Meat**: HM / LM extrusion, burger
- **Egg-replacement**: mayonnaise, desserts...

Successes and new challenges for sustainable proteins

Plant-based protein are no longer “alternative”

- Significant growth of **dairy alternatives** and **high-protein market**
- **Price parity** with meat in some areas
- Dozens of **new factories** for multiple sources: pea, fava bean, lentils, sunflower, yeast, fungi, single-cells organisms...

Higher consumption means more impact

- More potential effect on **consumers’ health**
- Higher attention from the **food safety agencies**
- Higher attention from the **media, interest groups and lobbies**

A cautionary tale from France, 2025

l’Humanité

“French Agency ANSES is raising the alarm about isoflavones, plant-based substances similar to female hormones with **potentially harmful effects on health**”

Le Monde

“Soy-based foods **should not be served in institutional catering**”



“Isoflavones, plant compounds similar to female estrogens, are **found in excessive amounts in soy-based products.**”



Soy: a danger for health?

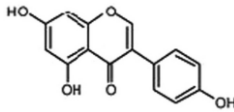


“Say yes to soy, no to what the food industry makes from it”

Plant-based industry may lose the communication battle if it isn’t prepared

Some antinutrients from “novel” sources of protein

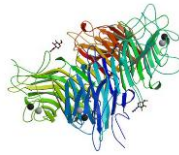
Isoflavone



Soy

Structure similarity with oestrogens
 ⇒ **Endocrine disruptor?**

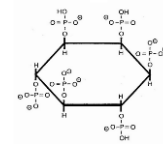
Lectins



Beans, pulses

Red blood cells agglutination
 ⇒ **Nausea, vomiting**

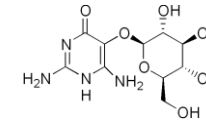
Phytic acid



Pulses, oilseeds

Binds minerals, proteins
 ⇒ **Reduce mineral bio-availability**

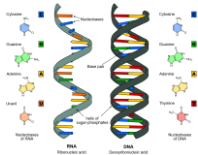
Vicine / convicine



Fava bean

Reaction with genetically disposed individuals
 ⇒ **Anemia (favism)**

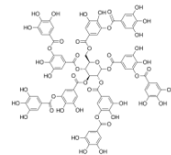
Nucleic acid



Single-cells organisms

Adenine / guanine metabolised into uric acid
 ⇒ **Kidney stones, gout**

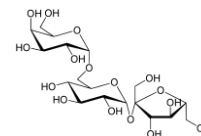
Polyphenols / tannins



Pulses, oilseeds

Bind to proteins
 ⇒ **Reduced protein digestibility**

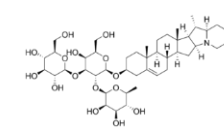
Alpha-galactosides



Pulses

Metabolised by intestinal flora
 ⇒ **Flatulence and poor digestion**

Saponins



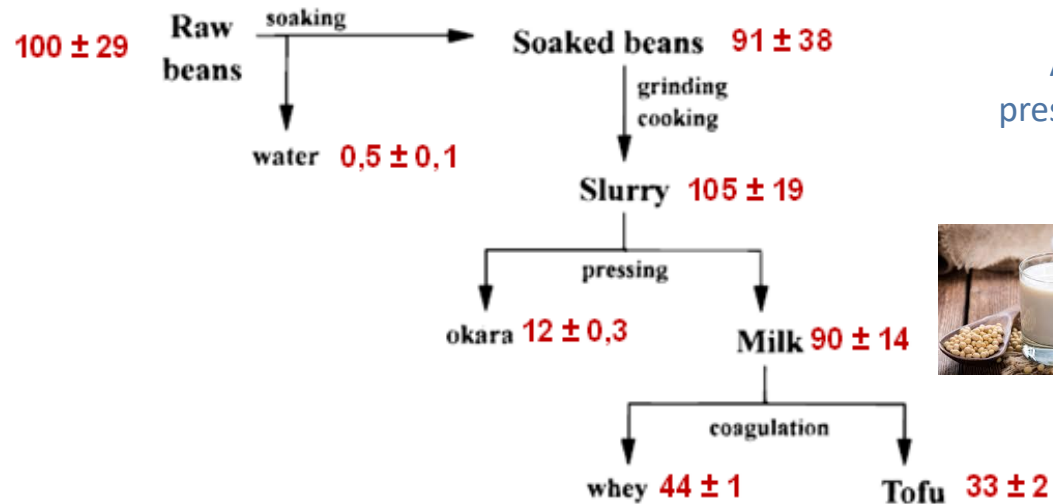
cereals, pulses

hemolytic activity, cytotoxicity
 ⇒ **Intestinal damage**

How process can reduce ANF?

The example of isoflavones

- **Soaking:** elimination of 1 to 10% of isoflavones
- **Cooking / UHT:** transform isoflavones from one form to another, no global reduction
- **Filtration / pressing:** isoflavones go preferentially into milk
- **Coagulation:** distribution in whey and tofu; some variations depending on coagulant used



About 90% isoflavone still present in a home-style soybean milk



About 30% isoflavone still present in a home-style tofu



How process can reduce ANF?

The example of isoflavones

Ultrafiltration

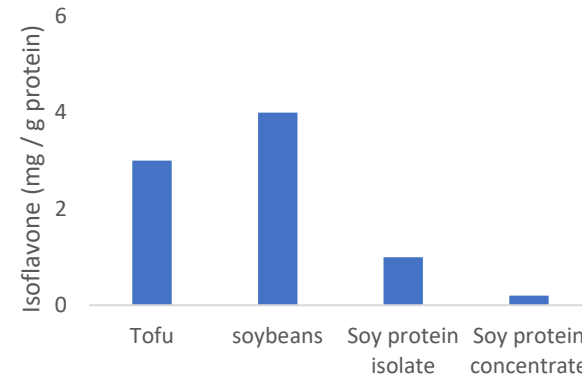
- Filtration of soy milk between 5- 10 kDa
- Elimination of **80% of isoflavones**



Significant reduction of soy isoflavone with membrane filtration

Solvent washing

- Soy protein concentrate: elimination of most isoflavones after ethanolic washing to produce
- **Protein isolates**: higher isoflavone content, although protein content higher



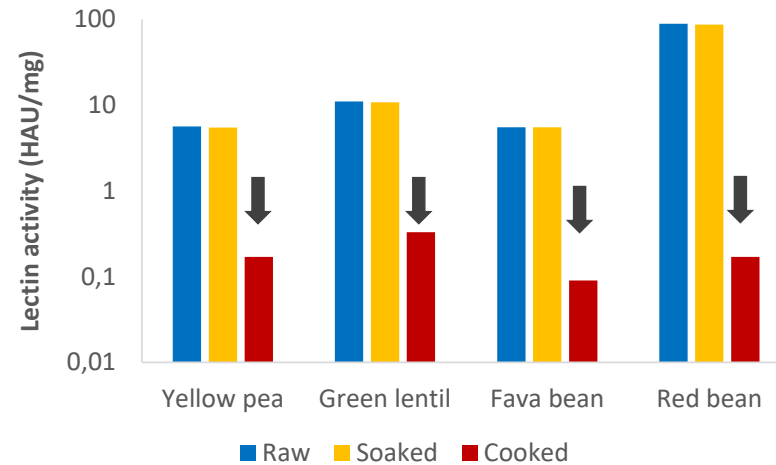
Elimination of soy isoflavone with adapted washings

How process can reduce ANF?

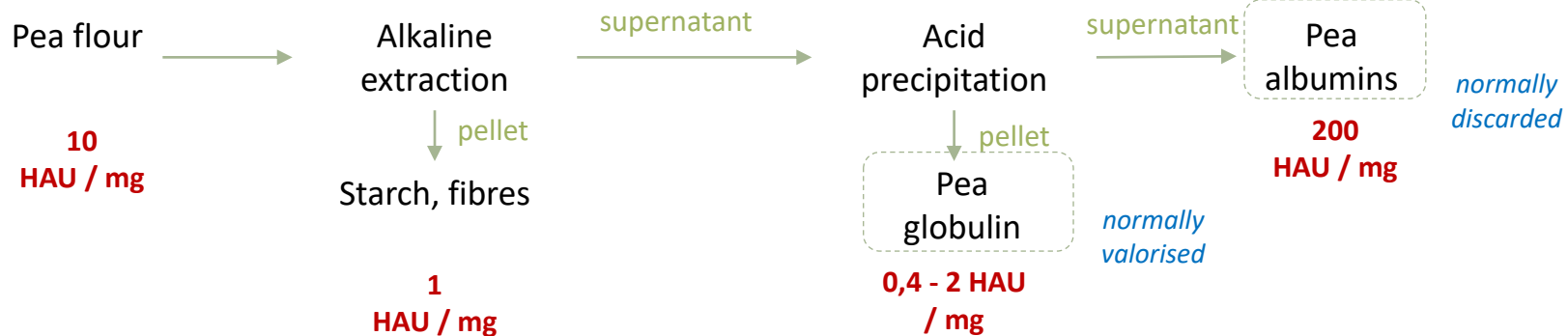
The example of lectins

Whole grain preparation

- No impact of soaking
- **Strong impact of thermal treatment** above protein denaturation temperature



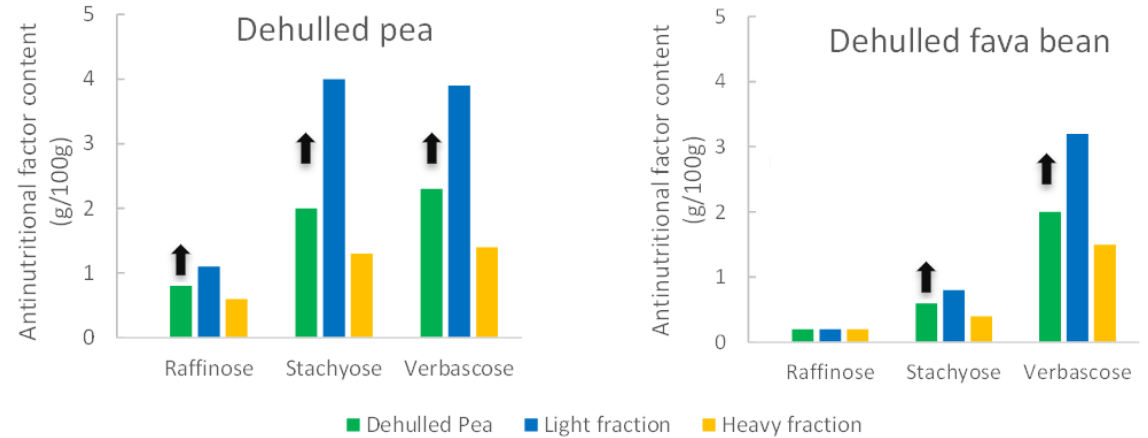
Protein fractionation



How process can reduce ANF?

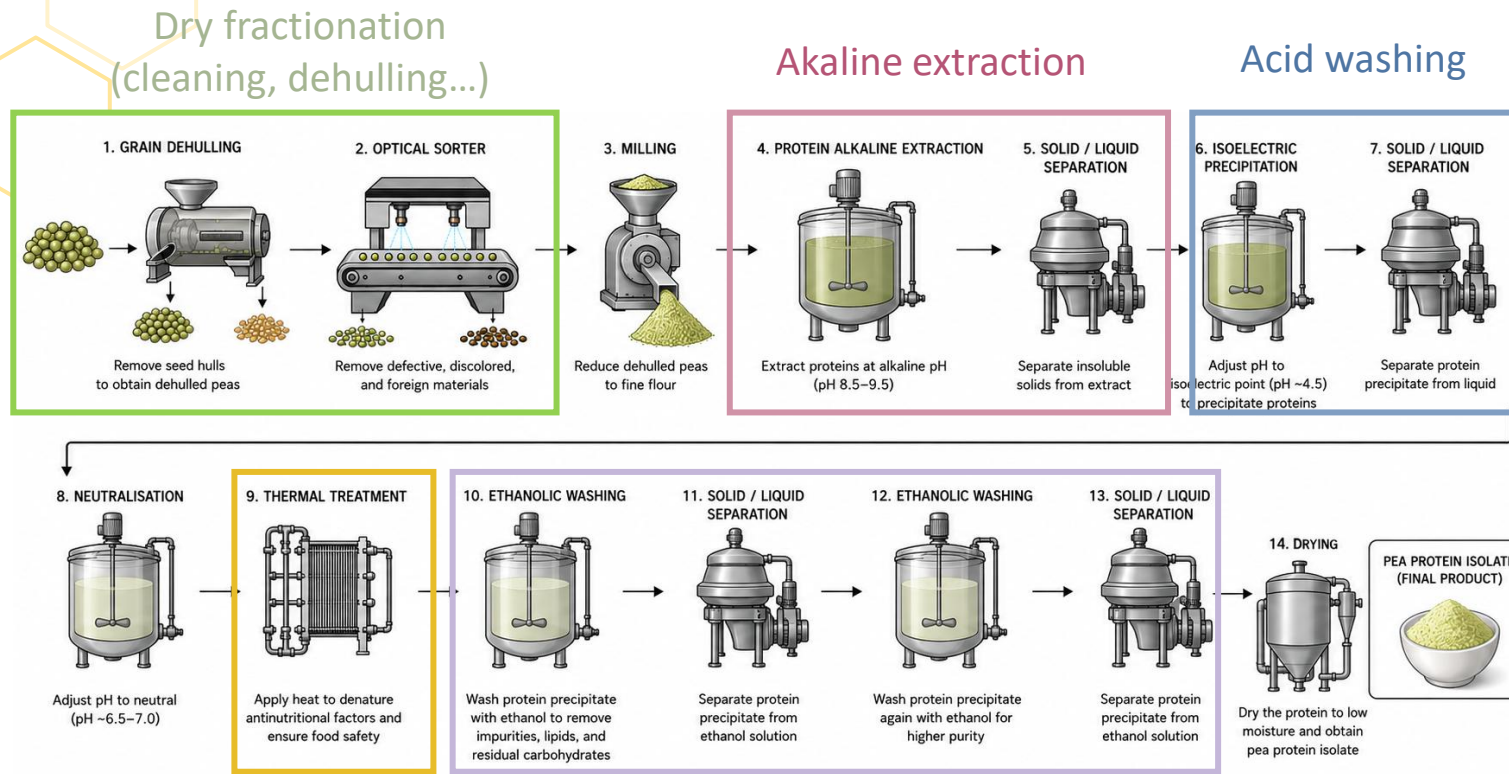
The example of alpha-galactosides

- **Dry fractionation**
Undigestible sugars are **concentrated** in the protein fraction
- **Washing**
Variable reduction depending on **solvent used**
- **Wet fractionation**
Almost **total elimination** during isoelectric precipitation or membrane filtration
- **Germination**
Elimination after 2-3 days



	Acid washing	Coagulation + water	Ethanol washing
Protein content	70.7%	72.2%	70.7%
Stachyose remaining (initial 4.57%)	0.0%	0.54%	1.8%

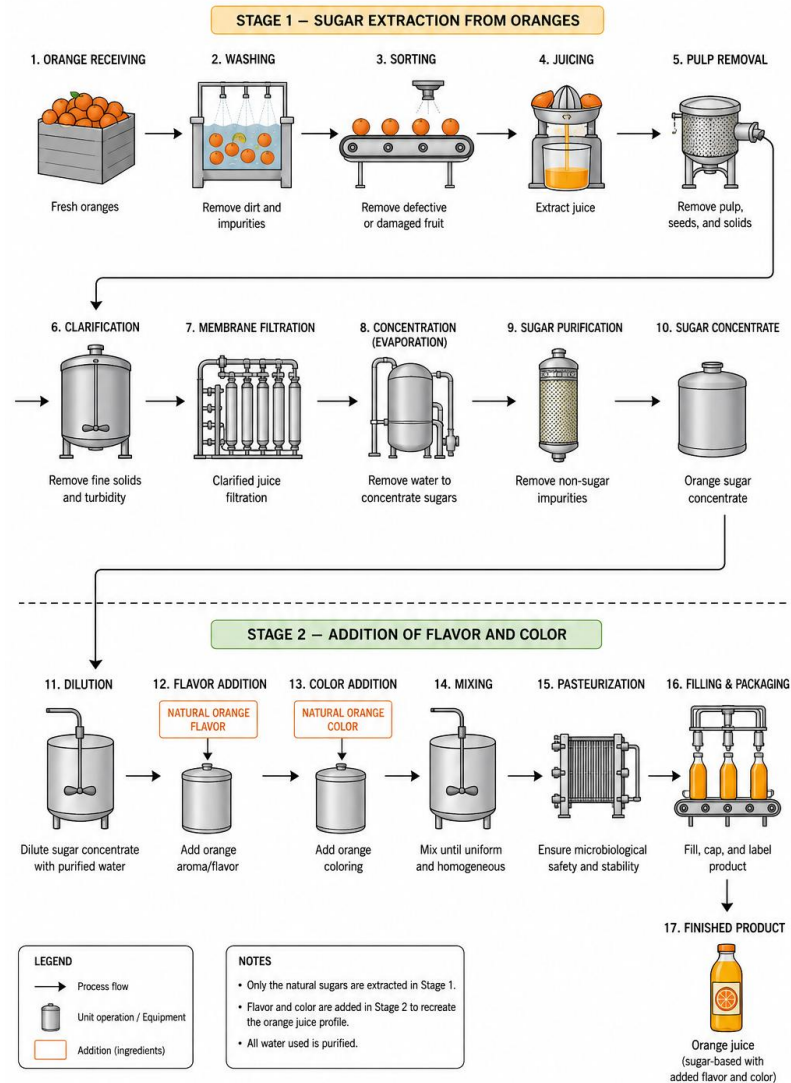
Process for a protein with >97% purity



- ◆ Reduction of contaminants (microbiological load, pesticide residues, mycotoxins...) and insoluble fibre
- ◆ Elimination of starch + residual fibre
- ◆ Elimination of soluble molecules (albumins, sugars)
- ◆ Elimination of thermally sensitive ANF
- ◆ Elimination of lipids and residual molecules (isoflavones)

The perfect ingredient for plant-based milk and plant-based foods?

An analogy – tentative process for orange juice production



Stage 1: combination of dry and wet fractionation technics to extract molecule of interest (sugar)

Stage 2: rehydration and reformulation

Limits compared to « conventional » orange juice production:

- **Many unit operations:** high CAPEX / OPEX, complex to operate
- High **water** and **energy** use
- Generation of a **large amount of by-products** difficult to valorise
- **Loss of valuable molecules:** fibre, vitamins, minerals...

⇒ Limits of « total » purification (protein, lipid, sugar...)

Positive health effects of plant-based milk and phytonutrients

Cardiovascular health

Unsaturated fatty acids, phytosterols, soluble fibers, isoflavones

Gut microbiota support

β -glucans, arabinoxylans, oligosaccharides

Cholesterol reduction

β -glucans, phytosterols



Antioxidant activity

Polyphenols, tocopherols (vitamin E), flavonoids

Reduced saturated fat intake

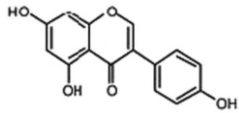
Replacement of dairy fat with unsaturated fats

Glycemic control

Soluble fibres

Functional effects of some “antinutrients”

Isoflavone



Soy

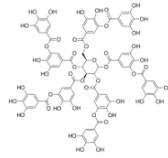
Structure similarity with oestrogens
 ⇒ **Endocrine disruptor?**



Cardiovascular health
 Lower risks of breast and prostate cancer



Polyphenols / tannins



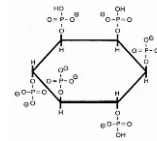
Pulses, oilseeds

Bind to proteins
 ⇒ **Reduced protein digestibility**



Anti-oxidant activity
 Anti-inflammatory
 Cardiovascular protection

Phytic acid



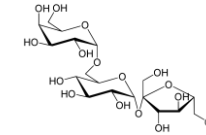
Pulses, oilseeds

Binds minerals, proteins
 ⇒ **Reduce mineral bio-availability**



Reduce free radicals formation (iron chelation)

Alpha-galactosides



Pulses

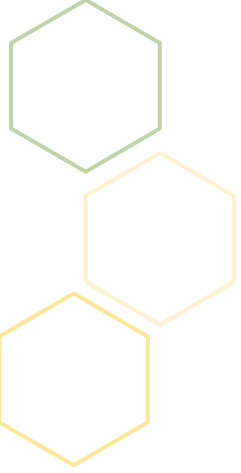
Metabolised by intestinal flora
 ⇒ **Flatulence and poor digestion**



Prebiotic
 Improved gut health

Some ANF are toxic, others have more contrasted impacts on human health





How can process enhance the nutrition of plant-based milk or plant based ingredients?

“Less is more” – consider partial purification

Full dehulling: **elimination of fibres + micronutrients**

⇒ Consider **partial dehulling** rather than total refining

Challenges to tackle	Possible solutions
Control microbiological load present on grain surface, mycotoxins	Grain toasting before production, adaptation of pasteurisation conditions, raw material selection
Presence of insoluble fibre ; too much viscosity due to fibre increase; grittiness	Elimination of insoluble fibre during decantation ; use of enzymes solubilise part of insoluble fibre; micronisation
Presence of ANF / tannins / off-flavour molecules	Targeted elimination later in the process , cultivar selection

⇒ enrichment in **fibre, vitamins, antioxidant, mineral**



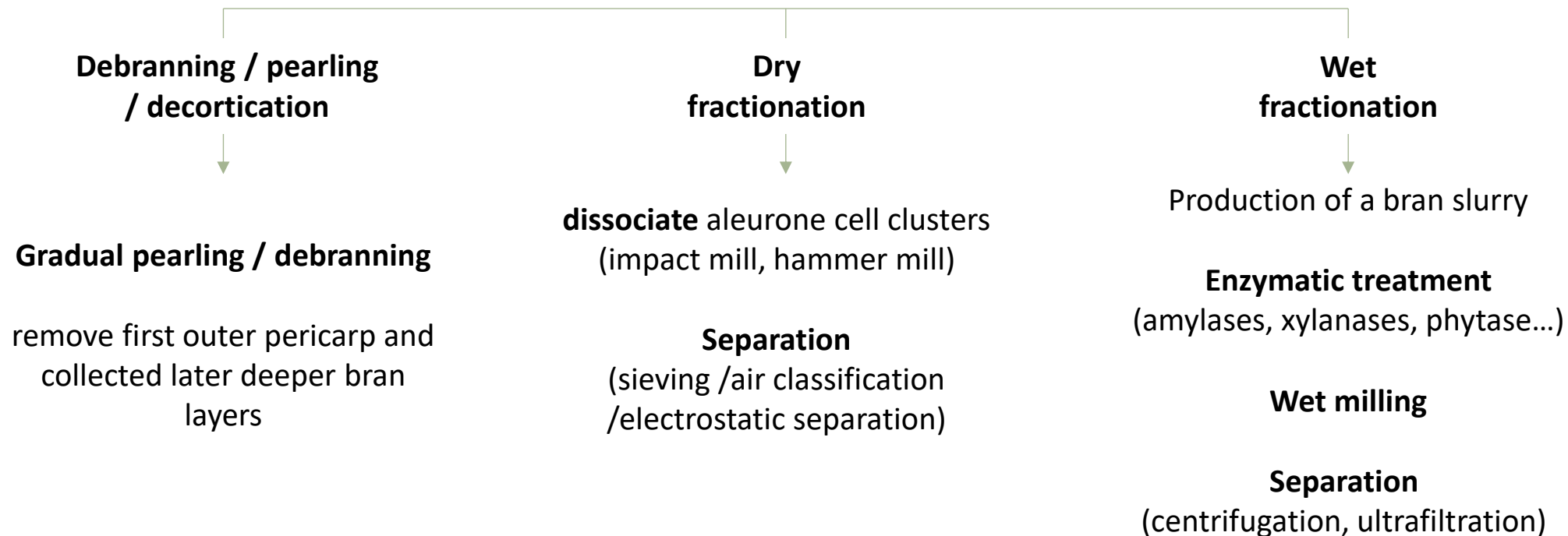


How can process enhance the nutrition of plant-based milk or plant based ingredients?

“Less is more” - Recovery of the aleurone layer from cereals

Aleurone: innermost layer of bran, between seed coats and starchy endosperm, usually lost in bran
Rich in **fibres** (arabinoxylans, β -glucans), **minerals**, **B vitamins**, **phenolic antioxidants** (ferulic acid)...

Aleurone enrichment / separation





How can process enhance the nutrition of plant-based milk or plant based ingredients?

Soaking, germination and fermentation

Soaking

- Partial reduction of water-soluble ANF (phytates, tannins, oligosaccharides...)
- Also causes nutrient leaching (minerals, phenols...)

Germination

- Activation of grain metabolism
- Activation of phytase, protease and amylase
- Increase in antioxidant activity and reduction of sugars, phytic acid and trypsin inhibition

Fermentation

- Potential activity of other enzymes or shorter action, in addition to improvement of aroma
- Reduction of some ANF and potential enhancement of antioxidant activity and micronutrient availability



How can process enhance the nutrition of plant-based milk or plant based ingredients?

Assisted extraction

Micronutrients and some fibres: difficult to fully recover because **embedded in insoluble grain matrix**

Assisted extraction methods

Enzyme-assisted extraction

Disrupt cell wall structure
(cellulase, pectinase...)
and/or **complex** (phytase)

Higher release of phenolics,
soluble fibre and/or minerals
(phytase)

Ultrasound-assisted extraction

Cavitation
(local high shear due to
microbubbles)

Higher release of phenolics, flavonoids
(careful to avoid degradation due to
heat and oxogen)

High Pressure-assisted extraction

High shear and turbulence,
reduce particle size, better
emulsion

Better extraction of
phytonutrients and
incorporation in oil droplets



How can process enhance the nutrition of plant-based milk or plant based ingredients?

By-product treatment and reincorporation

Some valuable molecules are eliminated with ANF / by-products during standard production

⇒ Process by-product to **recover valuable molecules** and **reincorporate them in ingredient or milk**



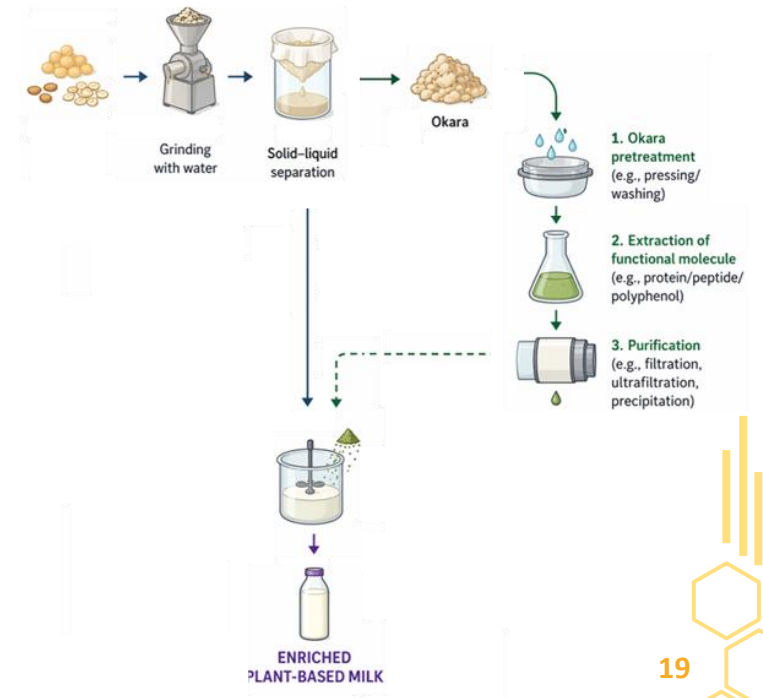
Okara: -> extraction of **soluble fibre** / beta-glucan along with some phytonutrients (sterols, phenols) using technics like enzymatic treatment and/or HHP



Molasse (acid extract): separation of sugars, proteins and micronutrient using technics like membrane filtration



Starch washing: separation of **specific fibre** using technics like sieving





Key takeaways

- Some natural molecules found in non-animal resources can be toxic **at different extents**
- These anti-nutrients can also have **health promoting effects**
- « made at home » unit operations (cooking, soaking) **may not be sufficient** to eliminate ANF
- Industry processing steps can significantly **reduce** or **eliminate** potentially hazardous molecules
- Plants also contain **nutritionnaly valuable molecules in addition to proteins**
- Ideal process should eliminate or reduce antinutrients **when significant**, but **also enhance the recovery of nutritional molecules**

