

Challenges for Protein Processing Diversity

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2nd Food Proteins
ASIA 2019



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 resources usages

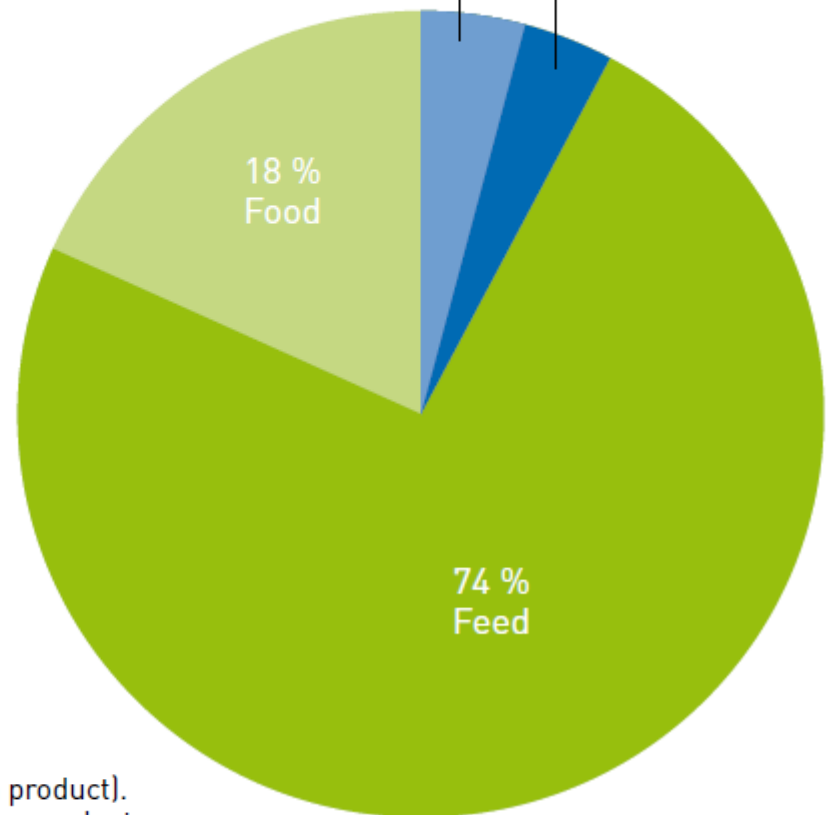
Use of harvested agricultural biomass worldwide (2008)
(source: nova-Institute)

Total biomass ca.
10 billion tonnes

Biomass for
industrial material
use 4,3 %

Biomass for energy
use 3,7 %

- 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

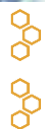
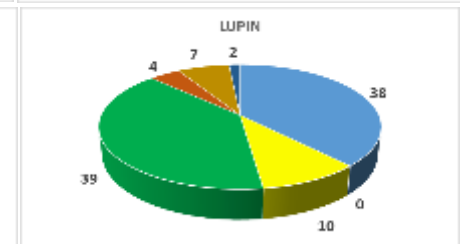
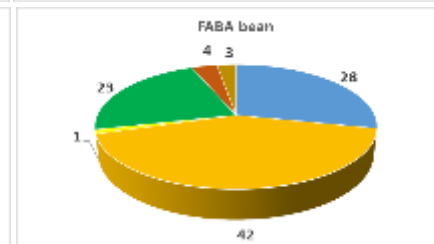
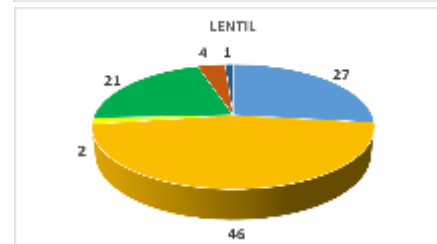
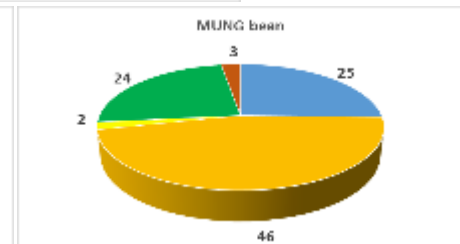
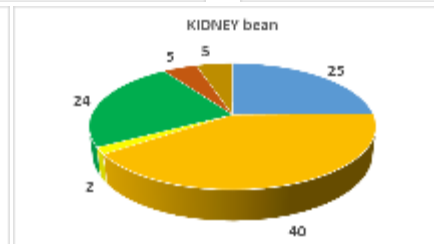
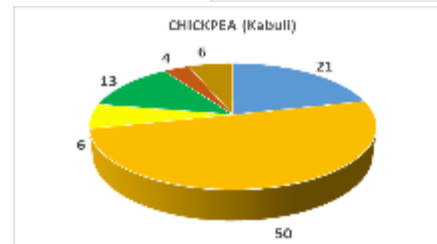
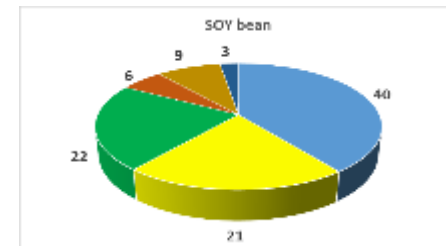
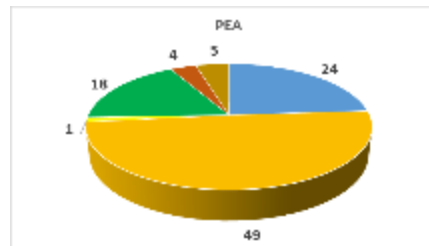
Shape



Composition

Proteins Starch Lipids Ash Sugars Other

■ ■ ■ ■ ■ ■

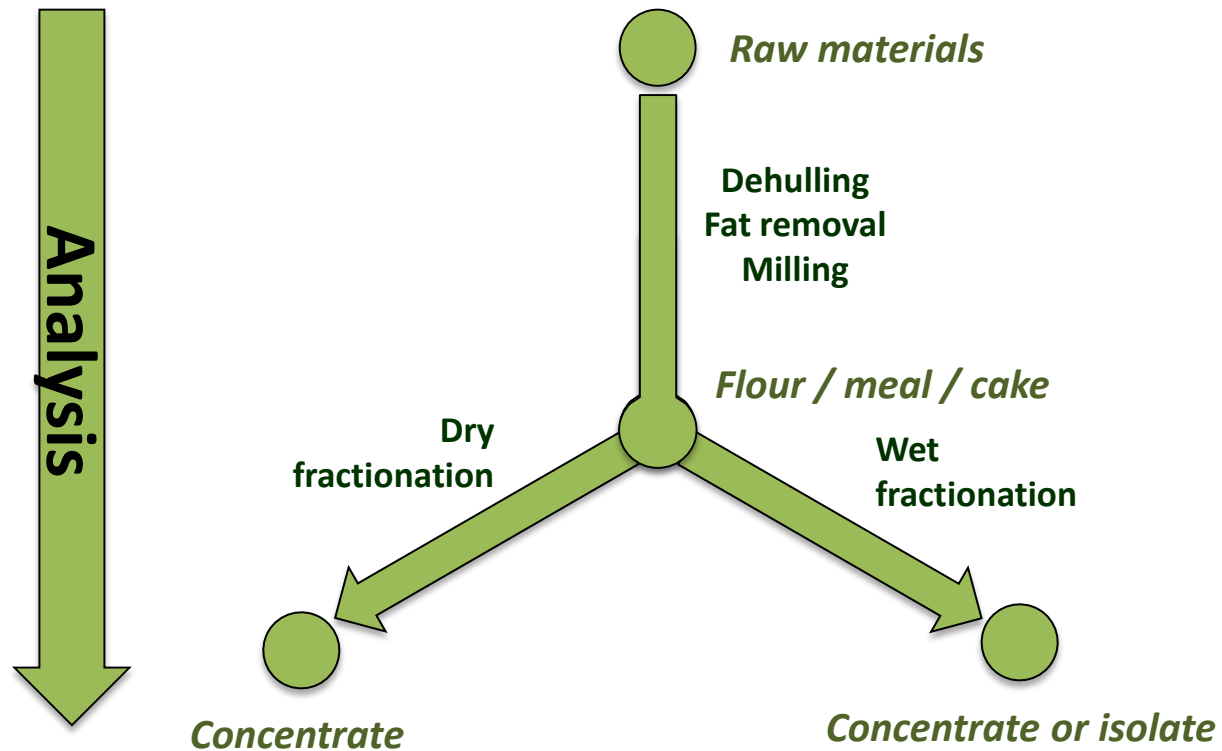


Raw materials are **diverse** in shape, composition, texture...

Antinutritional factors are often present (α -galactosides, Phytic acid, Polyphenols, Tannins, Chlorogenic acid, Phytoestrogens, Saponins, Alkaloids, Cyanogenic Heterosides, ...)



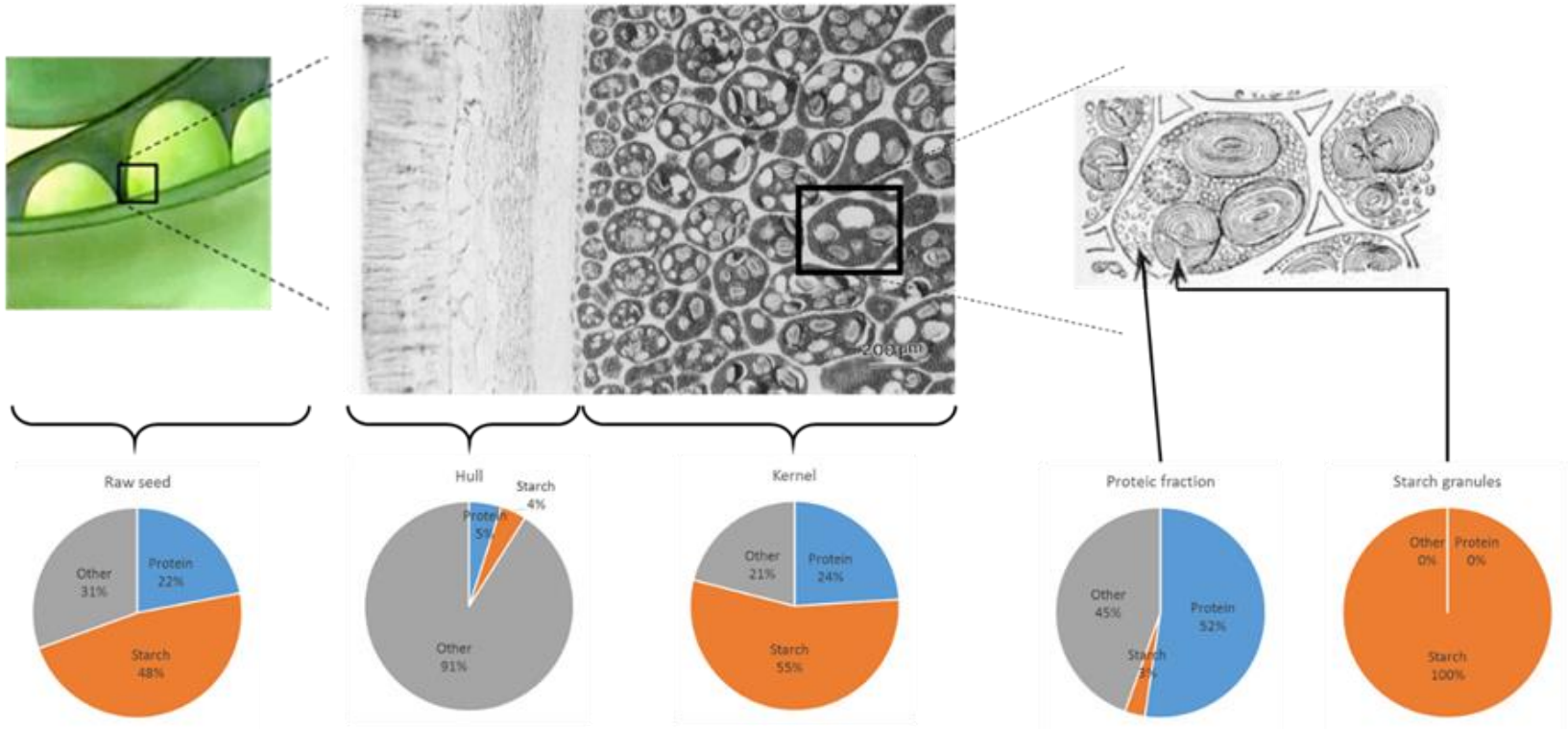
Protein extraction strategies



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



Transformation process

Harvesting /
storage

Dehulling

Fractionation

Cleaning
Preparation

Milling



Batches?



Yields?



Functionality?



Protein
enrichment
?

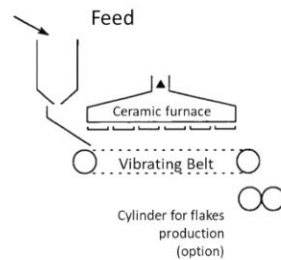


Starch or
fiber
enrichment
?

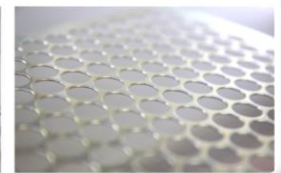
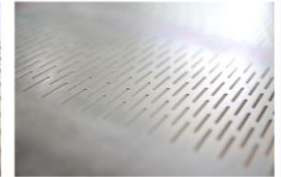
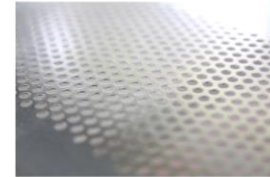


Seed preparation technology

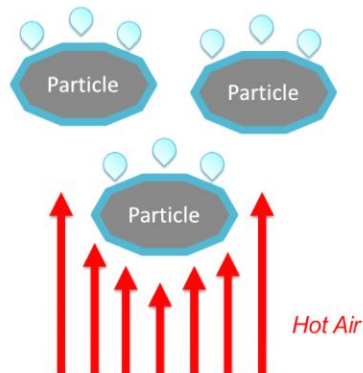
Micronizing (micronizing company®)



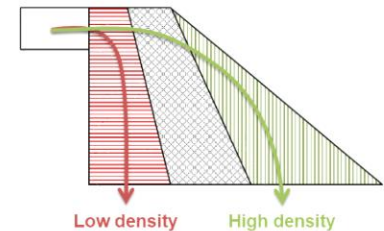
Seed cleaner – SLN3 (Pfeuffer®)



Fluid bed dryer – TG 200 (Retsch®)

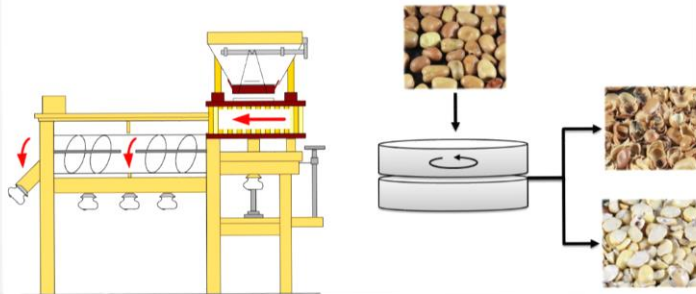


Densimetric table – LAK (Westrup®)

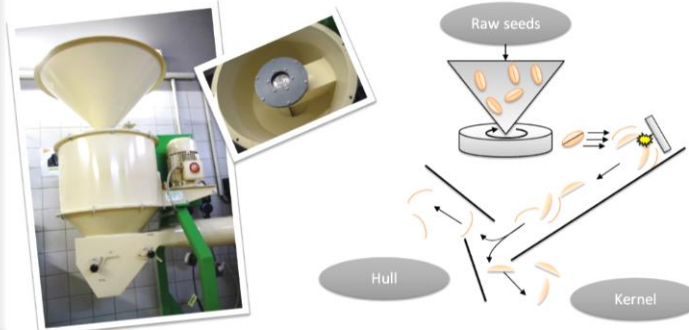


Seed dehulling techniques

Stone mill and stone dehuller (Alma®)



Impact dehuller (Alma®)



Whitening/Shelling Machine (Schule®)



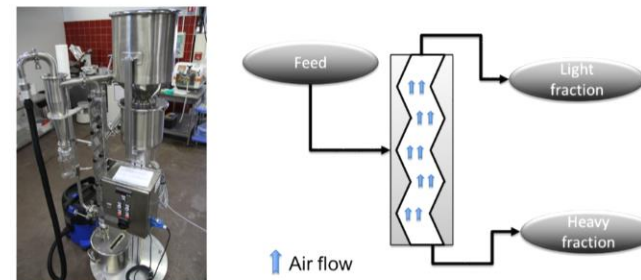
Knife mill - SM300 (Retsch®)



Roll crusher (Satake®)



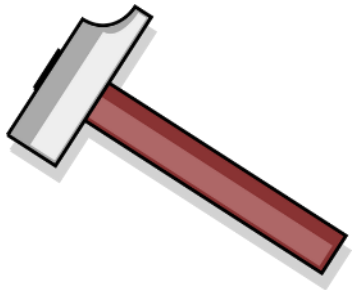
Gravity classifier ZIGZAG – MZM 1-40 (Hosokawa-Alpine®)



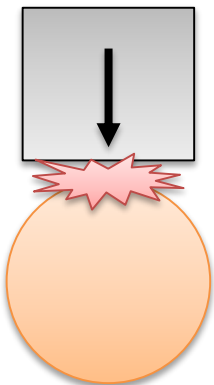
Particle size reduction

How deconstruct the material?

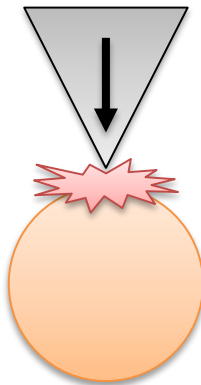
The different mechanical forces involved



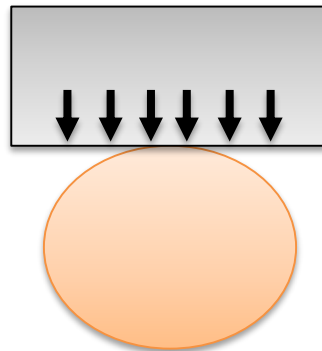
Impact



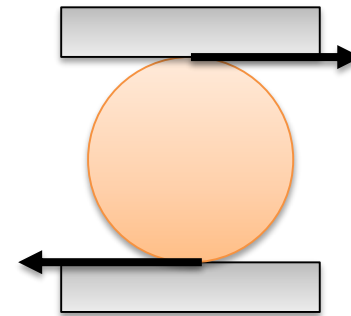
Cutting



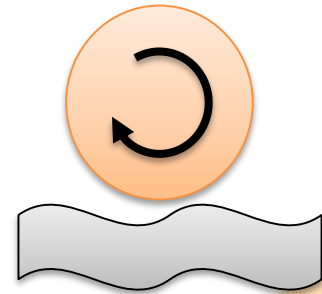
Compression



Shearing



Abrasion

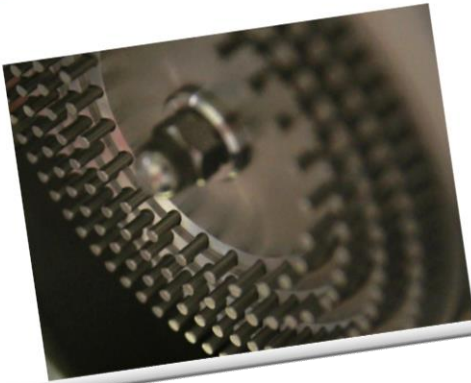


Each milling technology is a combination of these forces



Milling technologies

Pin mill - 100 UPZ (Hosokawa-Alpine®)



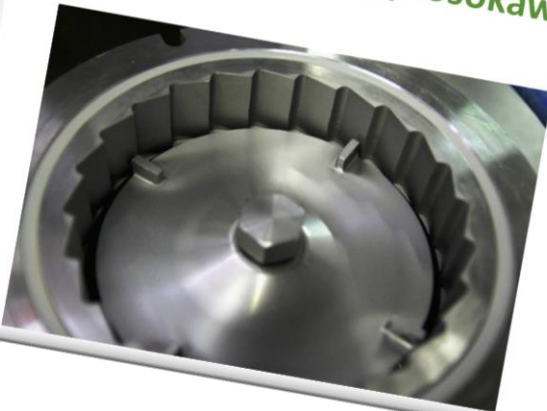
Beater mill - 100 UPZ (Hosokawa-Alpine®)



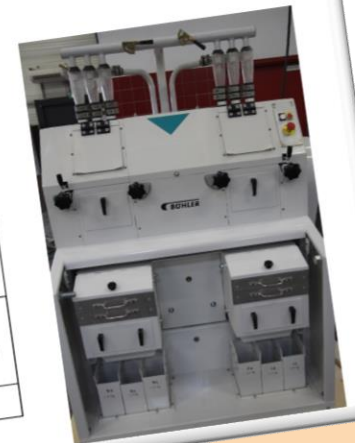
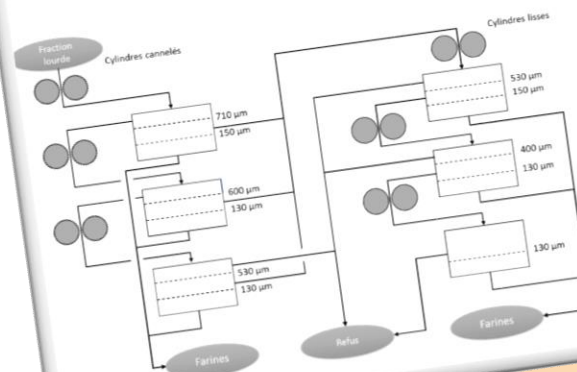
Knife mill - SM300 (Retsch®)



Impact mill - 70 ZPS (Hosokawa-Alpine®)

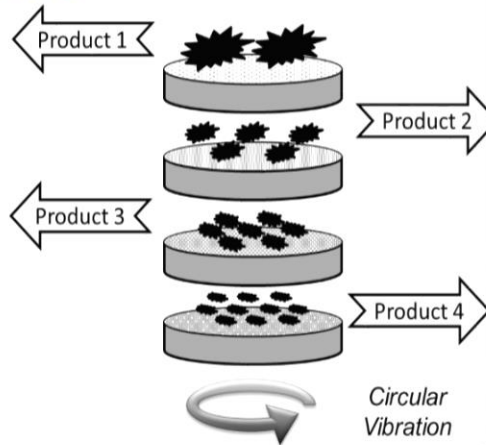


Roll mill – MLU 202 (Bühler®)

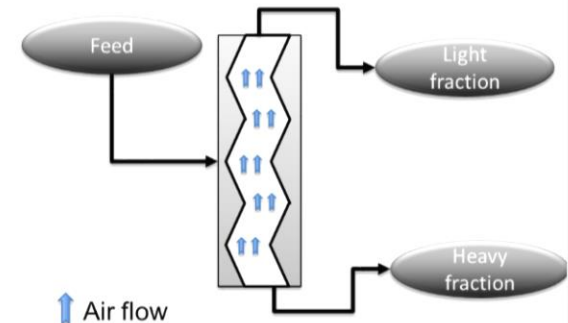


Powder fractionation

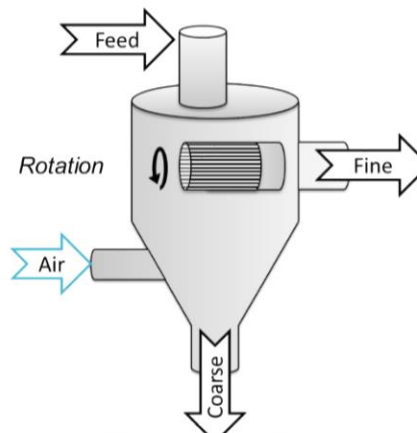
Vibration round screener
VRS600 (Allgaier®)



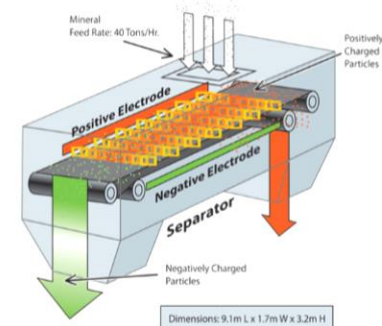
Gravity classifier ZIGZAG –
MZM 1-40 (Hosokawa-Alpine®)



Air classifier - 70 ATP (Hosokawa-Alpine®)



Electrostatic separation (STET®)



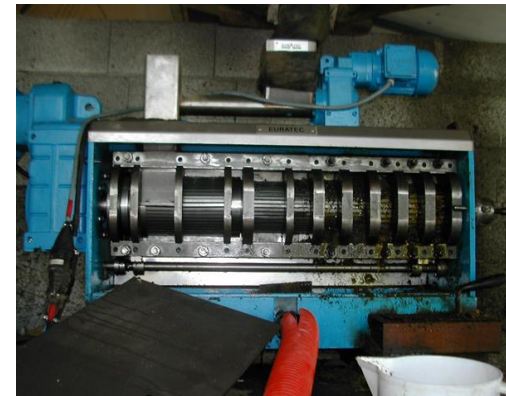
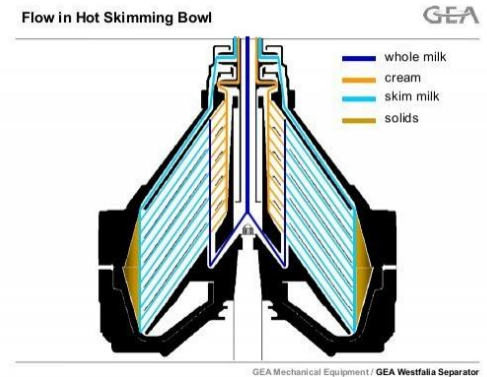
Extraction of lipids and micro-constituents using solvents

- Hexane extraction → remove lipids
- Alcohol extraction → phenolics and saponins
- Microwave & ultrasound assisted extraction of oil
- CO₂ Supercritical extraction and subcritical Water extraction
- Alternative green solvents
- Alternative ionic liquids
- ...



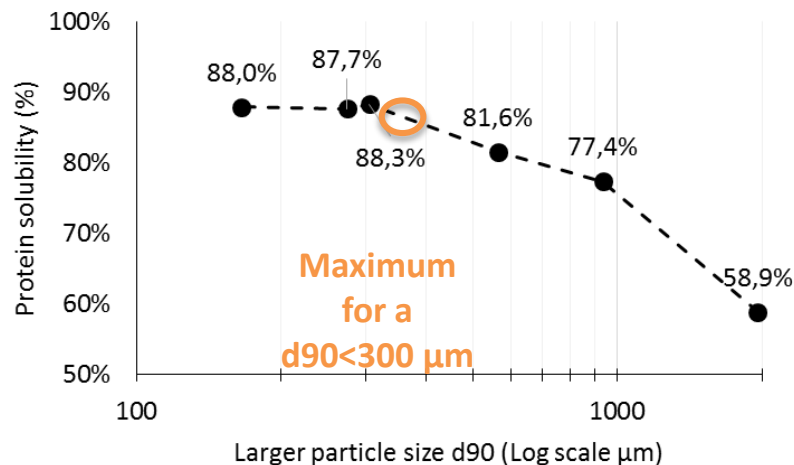
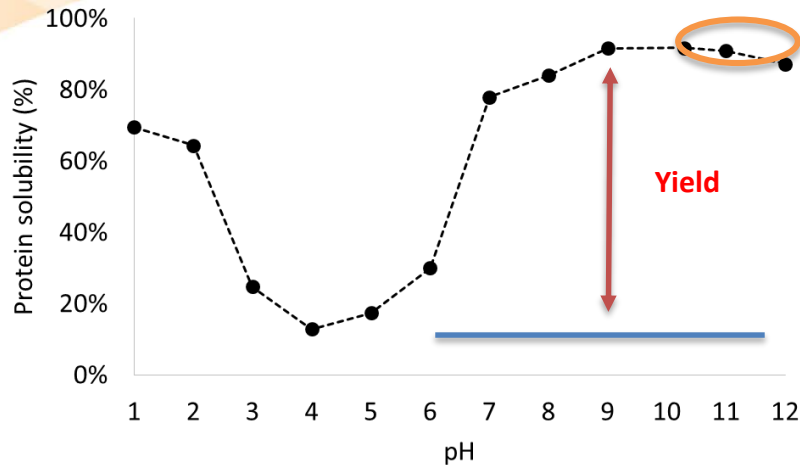
Solvent free extraction

- 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 $d_{90} = 166 \mu\text{m}$



Solid/Liquid separation

3 phases decanter



Flottweg, Alpha Laval

Clarifier



GEA, Alpha-Laval

Hydro-cyclone

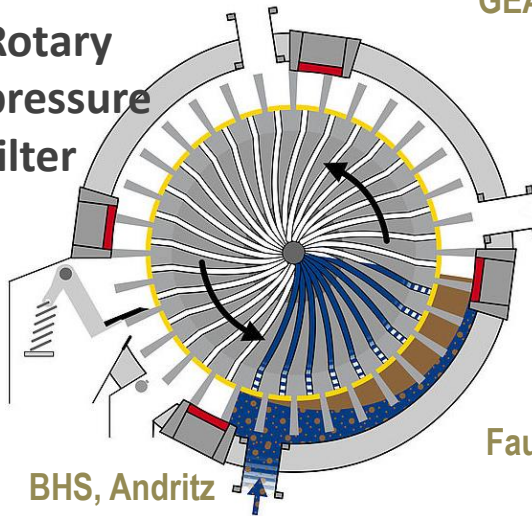


Basket centrifuge



BMA, Robotel

Rotary pressure filter



BHS, Andritz

Filter press

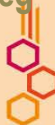


Faure, BHS, Alfa Laval, Andritz,



Belt filter

Andritz, Flottweg



Membranes, material and design



Tami industries, Noyons



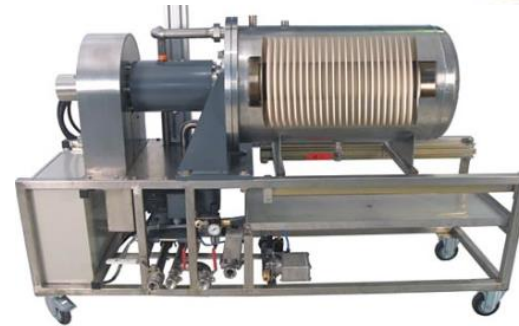
Pall-Exekia, Bazet



Tubular
membranes



Spiral wound
membranes



Dynamic
Cross
Flow Filter

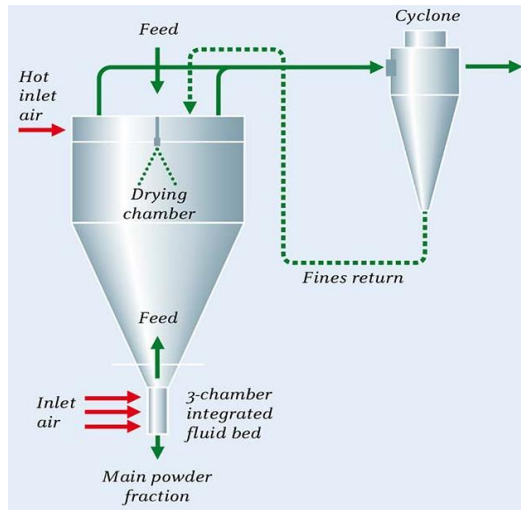


Padovan, Andritz



Drying technologies

Spray dryer



GEA – Sicca Dania – Alfa Laval...

Continuous vacuum dryer



LIST

Roller dryers



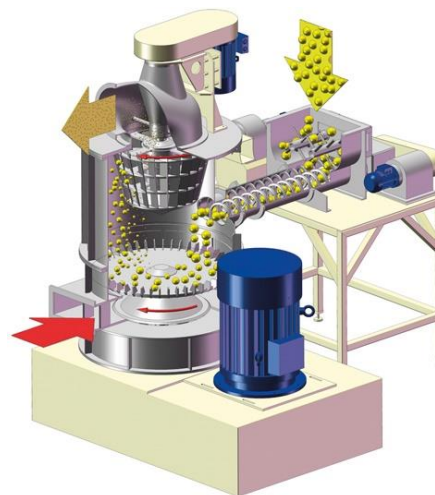
GOUDA ANDRITZ

Ventilated dryers



WOMM

Attrition dryers



HOSOKAWA

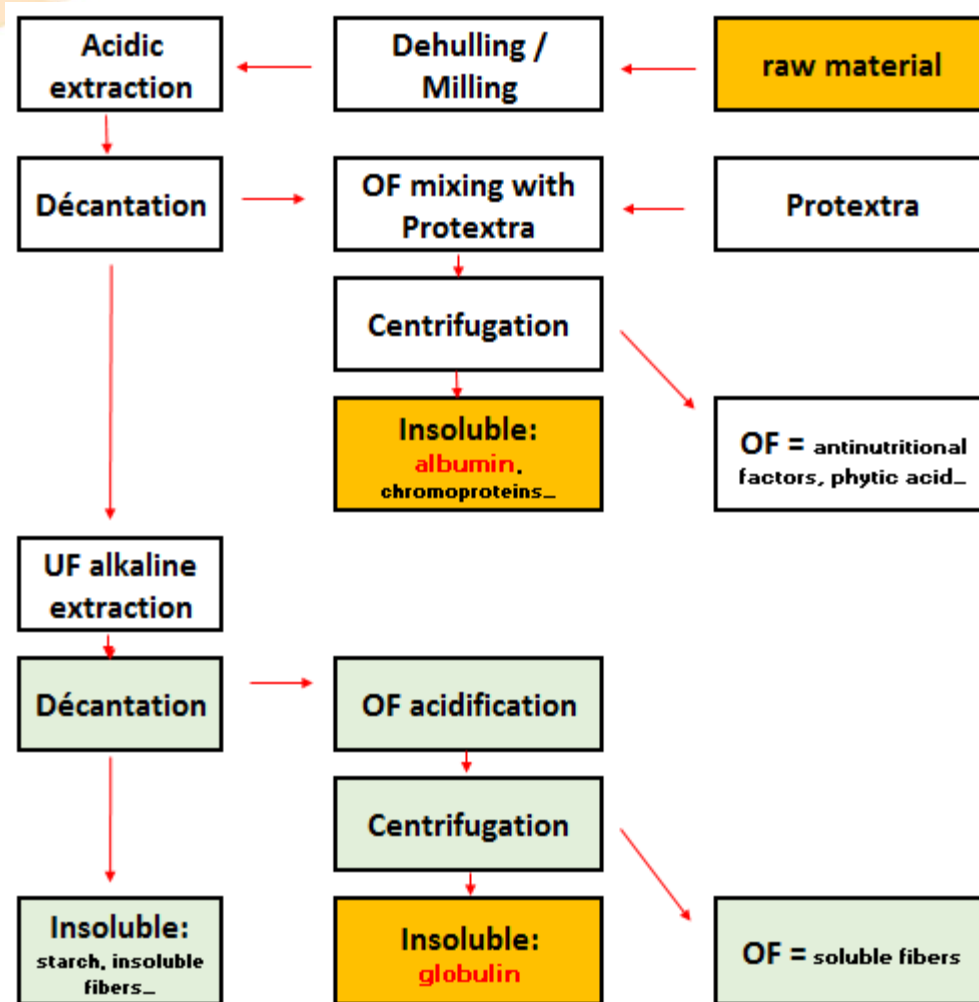


Organoleptic properties of pulse protein

- 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, microbio 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

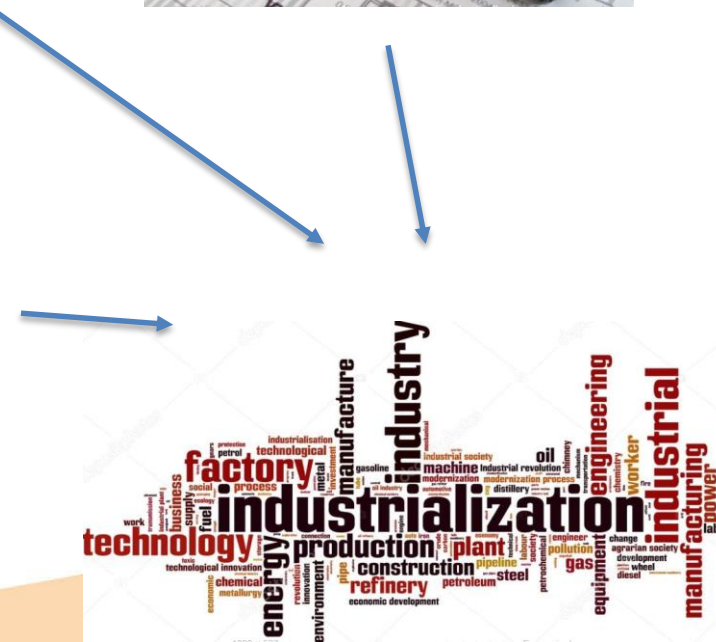


Smart ideas

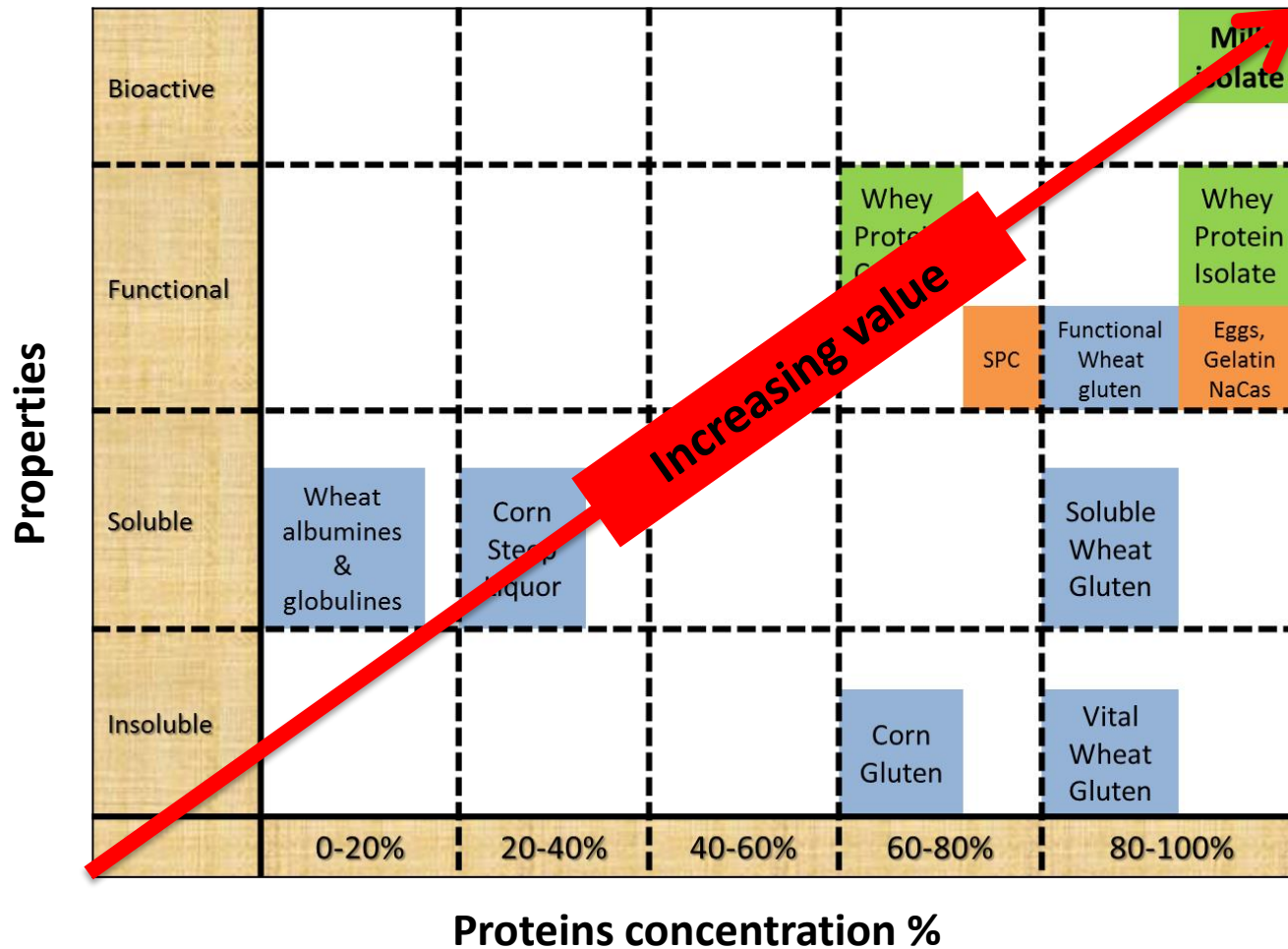
Strong market understanding



Regulatory expertise



Market selection



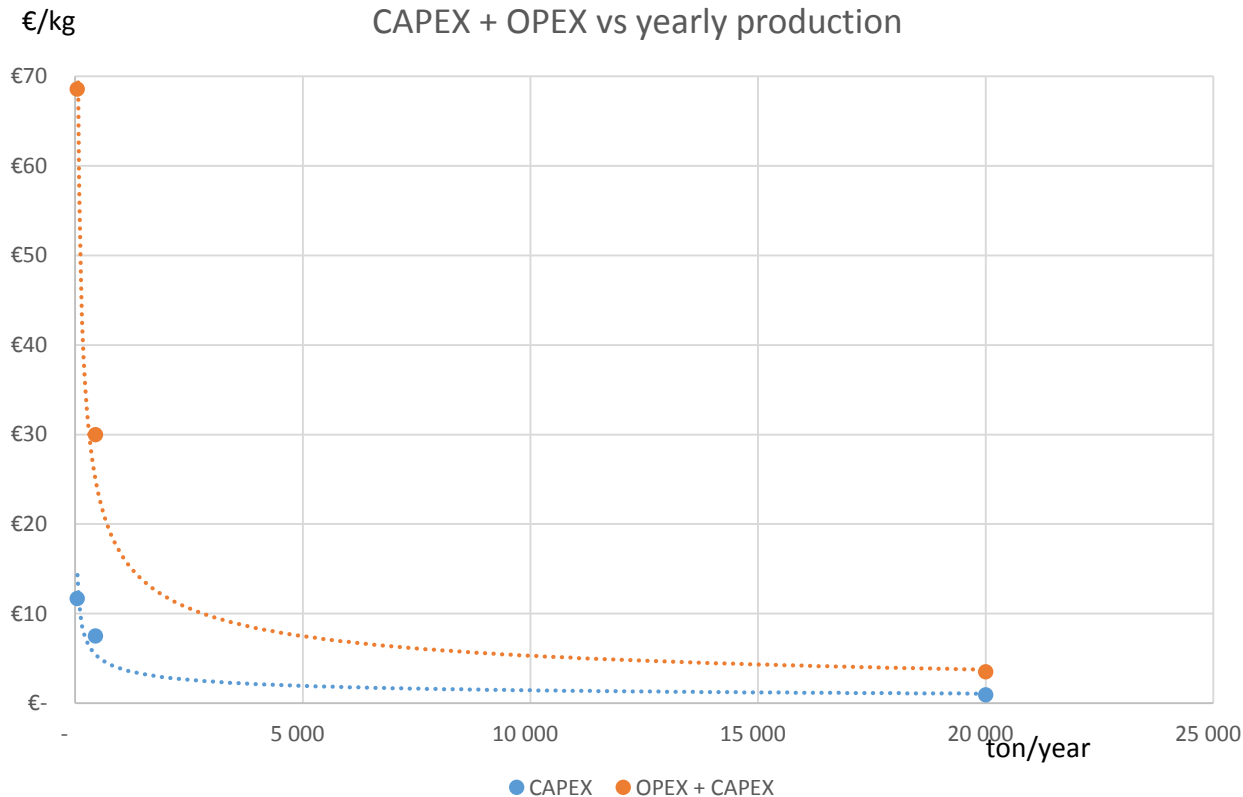
Raw material selection

- More than 1000 PC/PI world wide.
- 35 different raw materials
- 138 different producers
- 66 distributors
- Different forms :
 - Flour
 - Protein concentrate
 - Protein isolate
 - Protein hydrolysate

Raw material	Nb of references	Raw material	Nb of references
Total	1019	unidentified	4
soy	465	alfalfa	3
pea	134	Lentil	3
wheat	123	microorganisms	3
rice	85	oat	3
yeast	42	black bean	2
Hemp	20	chia	2
potato	20	mung bean	2
pumpkin	16	sesame	2
plant proteins	13	broadbean	1
algae	12	carob	1
almond	9	chickpea	1
corn	9	coconut	1
faba bean	9	cottonseed	1
lupin	8	flaxseeds	1
rapeseed	8	mankai	1
sunflower	8	psyllium	1
sacha Inchi	5	water lentils	1

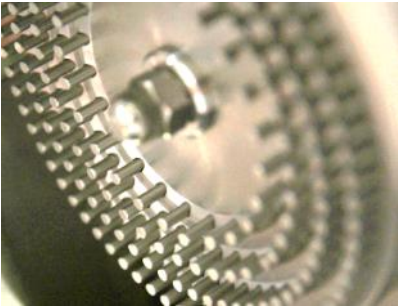
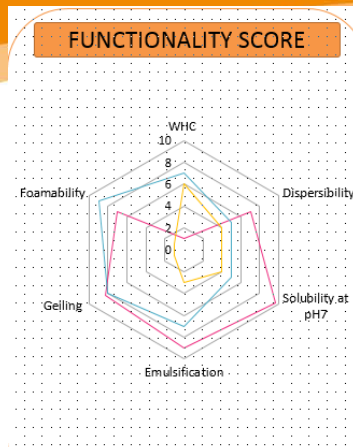


Pick the right scale



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





Who are we?

- ❖ 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...)





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



Help us to make Proteins strong again!



Thanks

