Biorefinery approach for conversion of organic side-streams into multiple marketable products using insects – BBI-InDIRECT project

L. Bastiaens (VITO, Belgium) & InDIRECT consortium

EAAP Gent 26-30/08/2019

Fact sheet InDIRECT

Title:

Direct and indirect biorefinery technologies for conversion of organic side-streams into multiple marketable products

Acronym: InDIRECT

Project partners: 2 research partners; 7 industrial partners (5 SMEs)

Funding scheme: Research & Innovation Action

BBI.R10-2015-call on 'Innovative efficient biorefinery technologies'

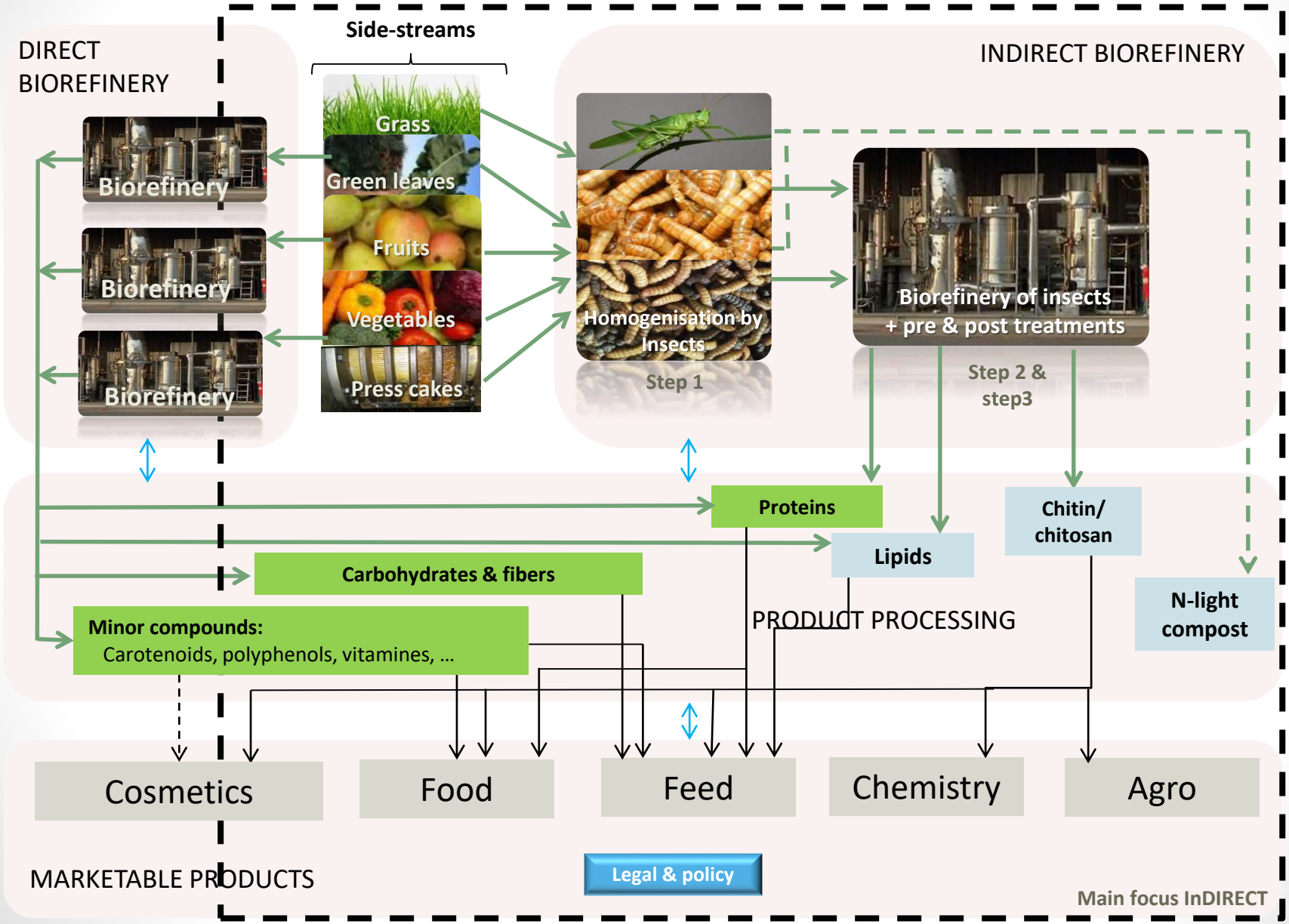
Total project costs: 2,089,670 euro

Grant: 1,347,948 euro

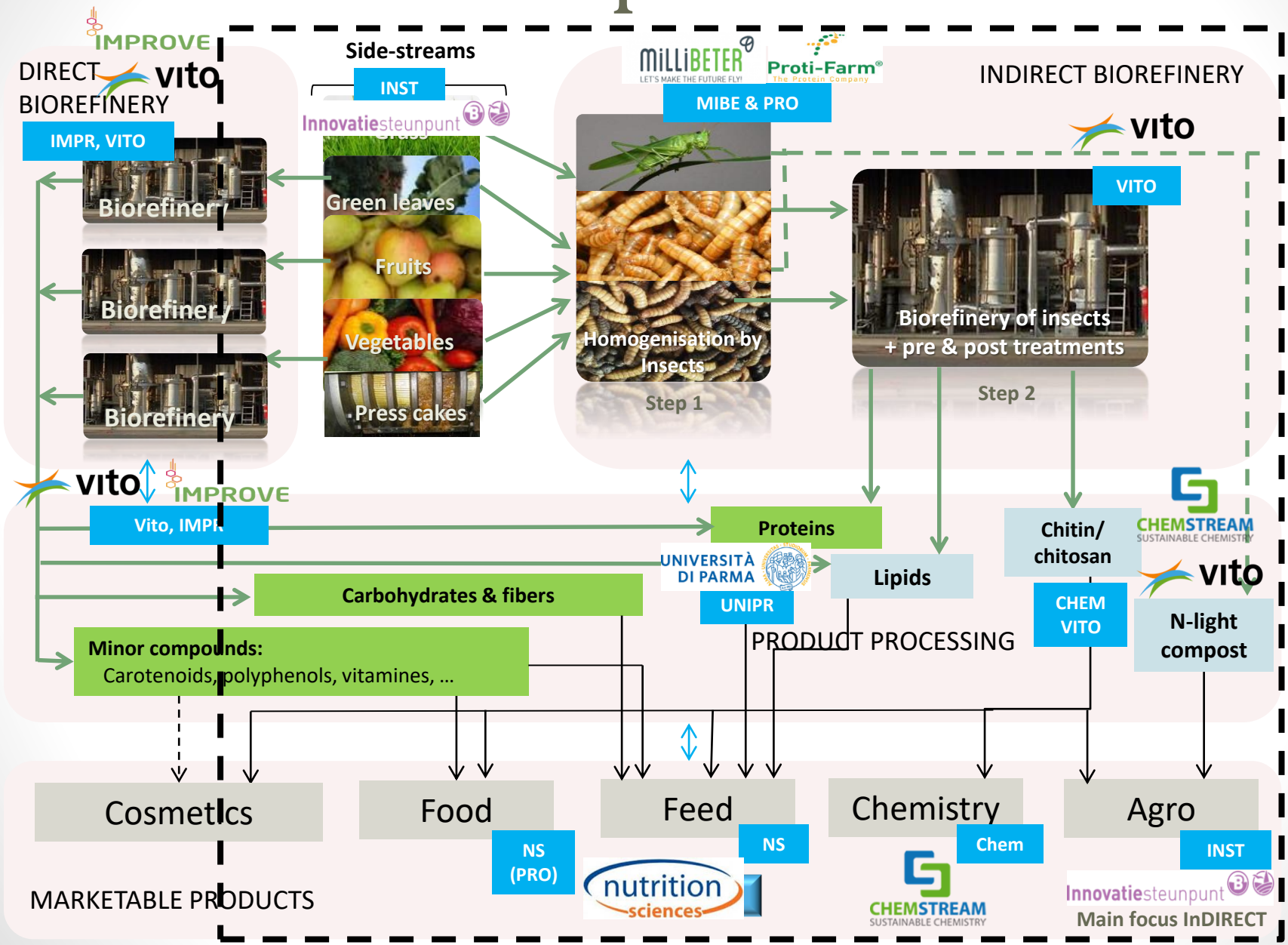
Duration: 36 months (official start 1/11/2016)

Coordination: VITO (Belgium)

Scope InDIRECT project



Role of Indirect partners



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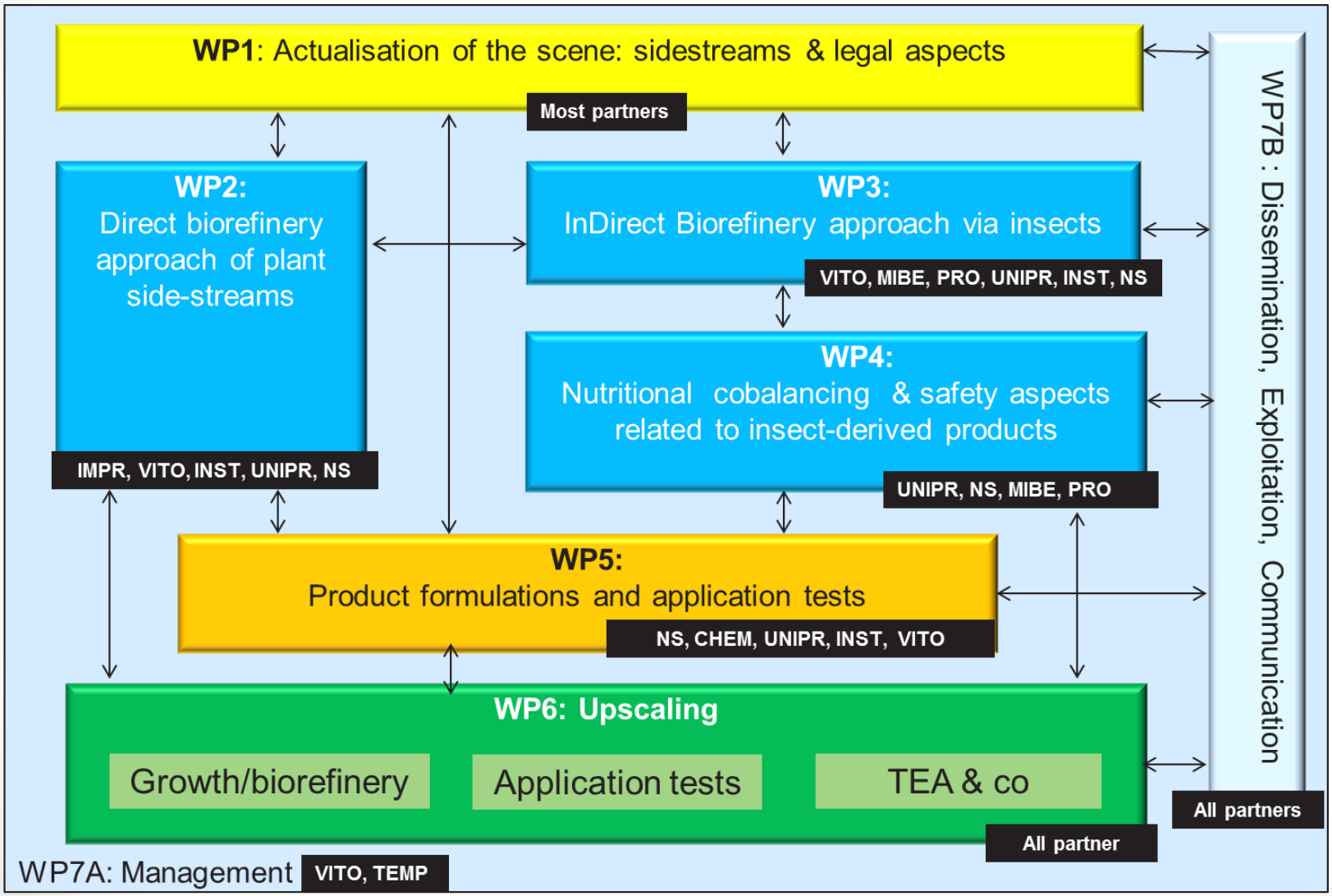
InDIRECT WP-Structure



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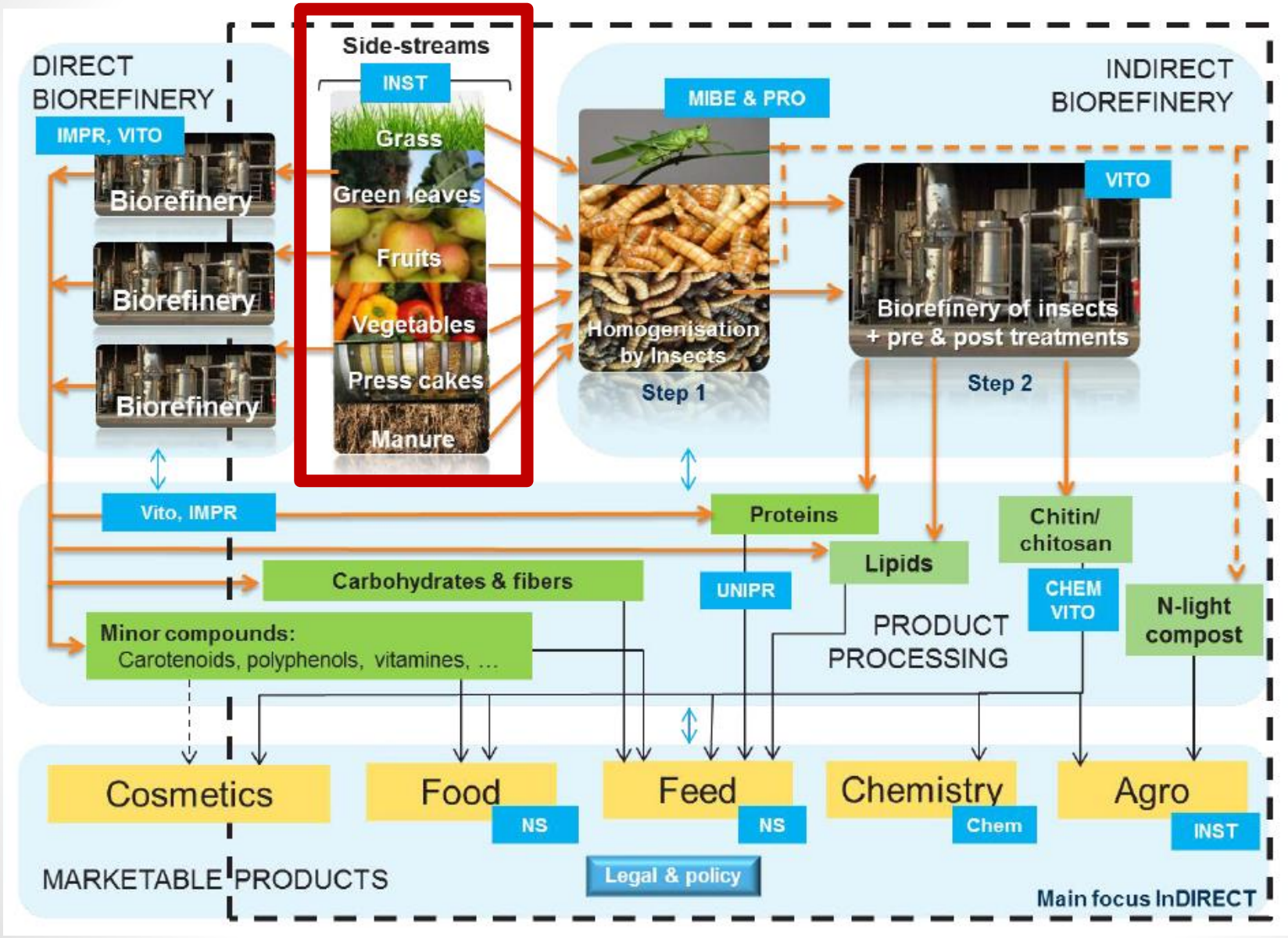
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Carotenoids, polyphenols, vitamines, …
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MARKETABLE PRODUCTS
Legal & policy
Main focus InDIRECT

Side-stream examples

Leek 0

Sugar beet leaves

Alfalafa (reference)

200
Corn DDGS

250
Rapeseed meal

170
corn gluten

100
rice bran

Plant based side-streams: fresh & ensiled

	Potato
	Potato peel
	Onion
	Carrot
33	Apple pomace
	Banana
146	Wheat middling
	Olive pomace
	Spent mustard
	Coffee
	Citrus peel
	Beetroot
	Cacao husk
	Pea flower
	…

Costs in euro/ton.%DM

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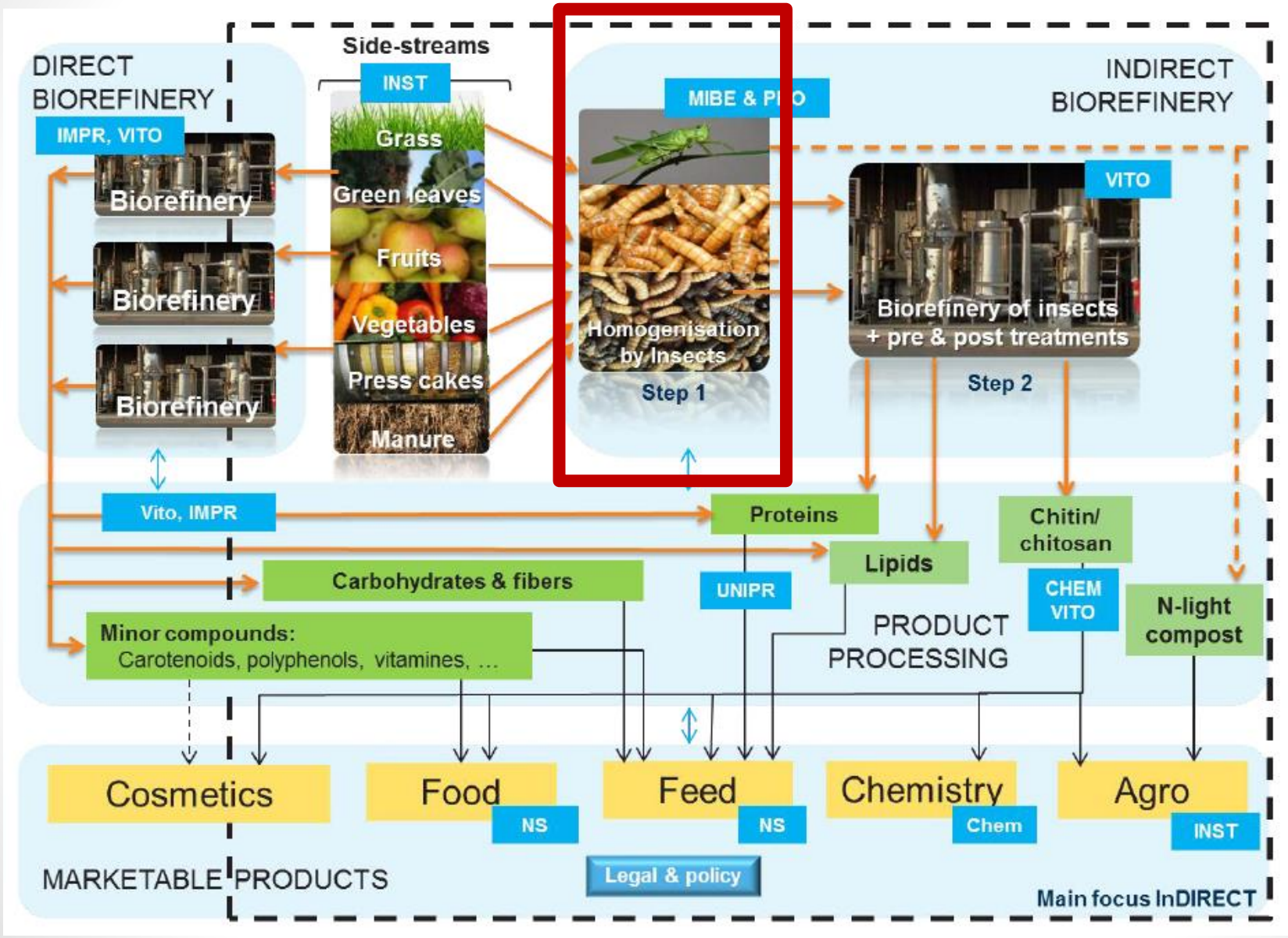
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Insect species considered

Black soldier fly larvae (BSF) -> 'Wet' side-stream (15-40 % DM)

Chemical applications

Feed applications

Technical applications

MILLIBETER
LET'S MAKE THE FUTURE FLY!

Circular Organics

Lesser mealworm larvae (LMW) → Dry side-stream

- Towards food & feed applications

Protifarm
effective nutrition

Insect growth tests

Approach:

- Growth tests with single side-streams
- Growth tests with mixed side-streams

Conclusions:

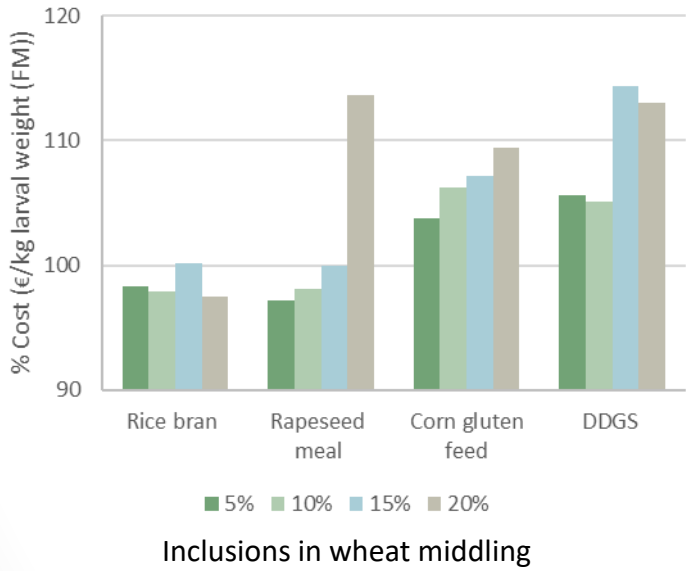
- Side-streams have different impacts on larvae growth
- Mixtures perform better than single side-streams
- Lesser Mealworm: FCE of 30 % reached (FCR = 3.3) → OK
- Black soldier fly: FCE of 23 % reached (FCR = 4.3) → ongoing

FCE = feed conversion efficiency
FCR = feed conversion ration

Side-streams in diet of lesser mealworm

Part 1: Impact on insect growth

- Side-stream inclusion in diet is possible
- Can be also economically feasible



Inclusions in wheat middling

Part 2: Impact on insect composition

Approach:

- Determine composition of the feed (side-streams) & larvae
- Parameters considered: crude lipid, crude proteins, AA, fatty acids, chitin
- Correlation analyses

Conclusions:

- Variation in some parameters
- Composition (nutrient profile) of the larvae is relatively stable in case of good growth
- Altering side-streams (through-out the year) is possible !

Poster session 16 – Monday evening (16-13)

Protifarm effective nutrition

vito

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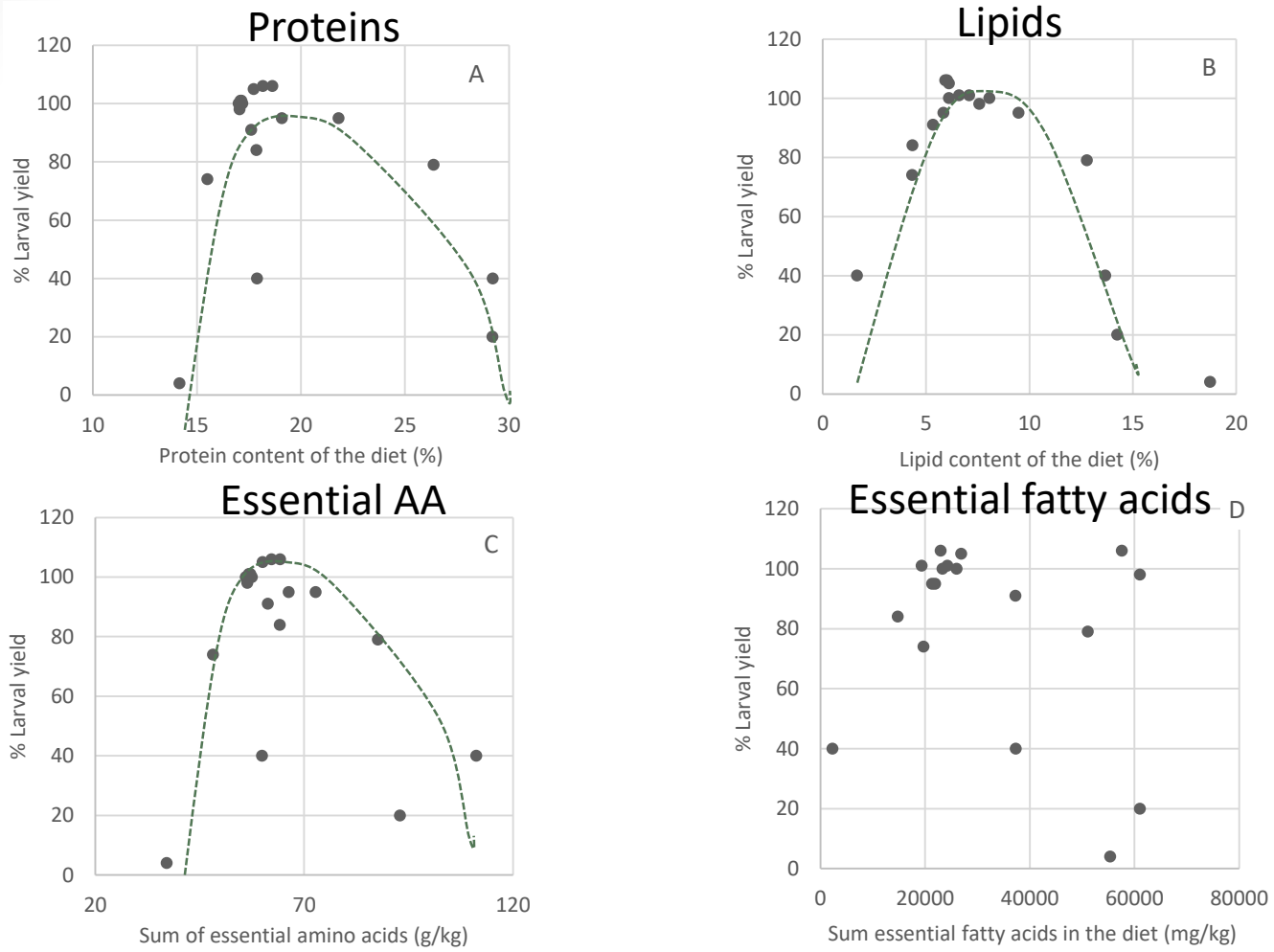
Impact of side-streams on insect compositions



Highest larval yield: 15-22 % proteins; 5-10 % lipids;

Essential amino acids → same pattern as for crude proteins

Essential fatty acids → no trend

Soetemans, Gianotten, & Bastiaens. Agri-food Side-stream Inclusions in the Diet of Alphitobius diaperinus Part 2: Impact on Larvae composition (being submitted).

Co-balanced feed for insects

Insects need co-balanced feed for a good growth

Not much known about the needs of insect

Co-balanced feed = side-streams + premix

No tools available for feed formulations

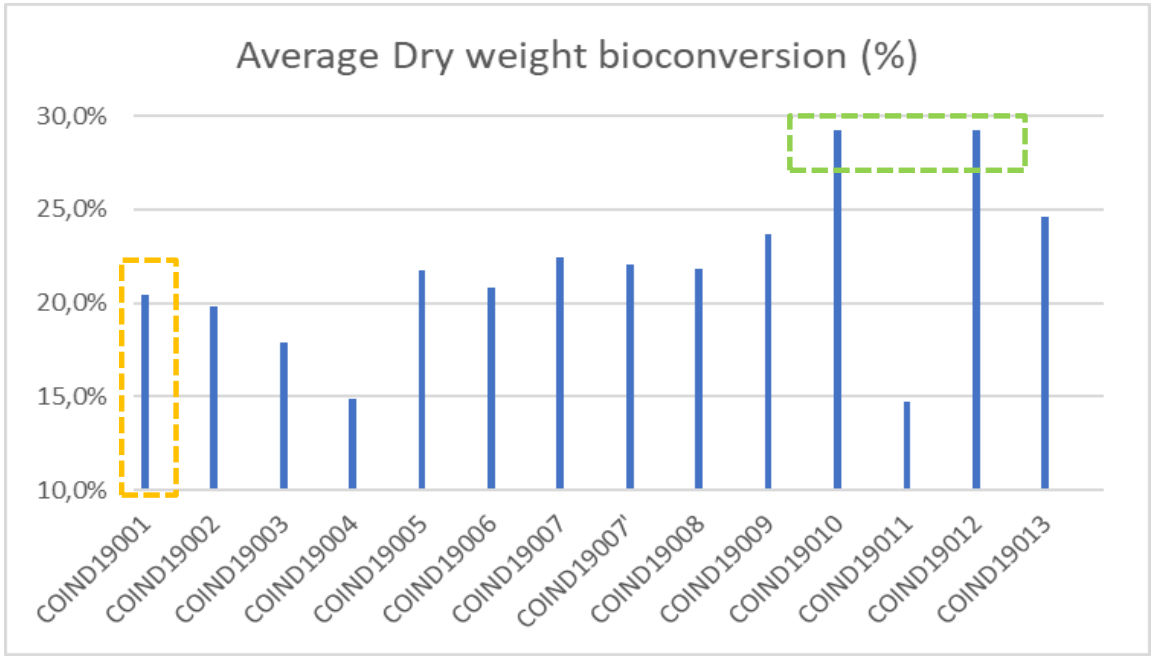
Premix development for insect feed → specific for insect species

- Step 1: chemical analyses & insect growth data → data base
- Step 2: develop tool based on mathematics
- Step 3: Evaluate tool with available data sets
- Step 4: improve tool *
- Step 5: prepare premix for growth test with BSF & LM

* further extensive research is needed on digestibility indices and metabolic losses for raw materials for insects

Impact of premix

Evaluation for black soldier fly:



Reference without premix
(mixed side-stream diet)

Premix + mixed side-stream diet
with clearly improved performance

Reference: beetroot, potato, citrus & DDGS

Insect biomass → next?

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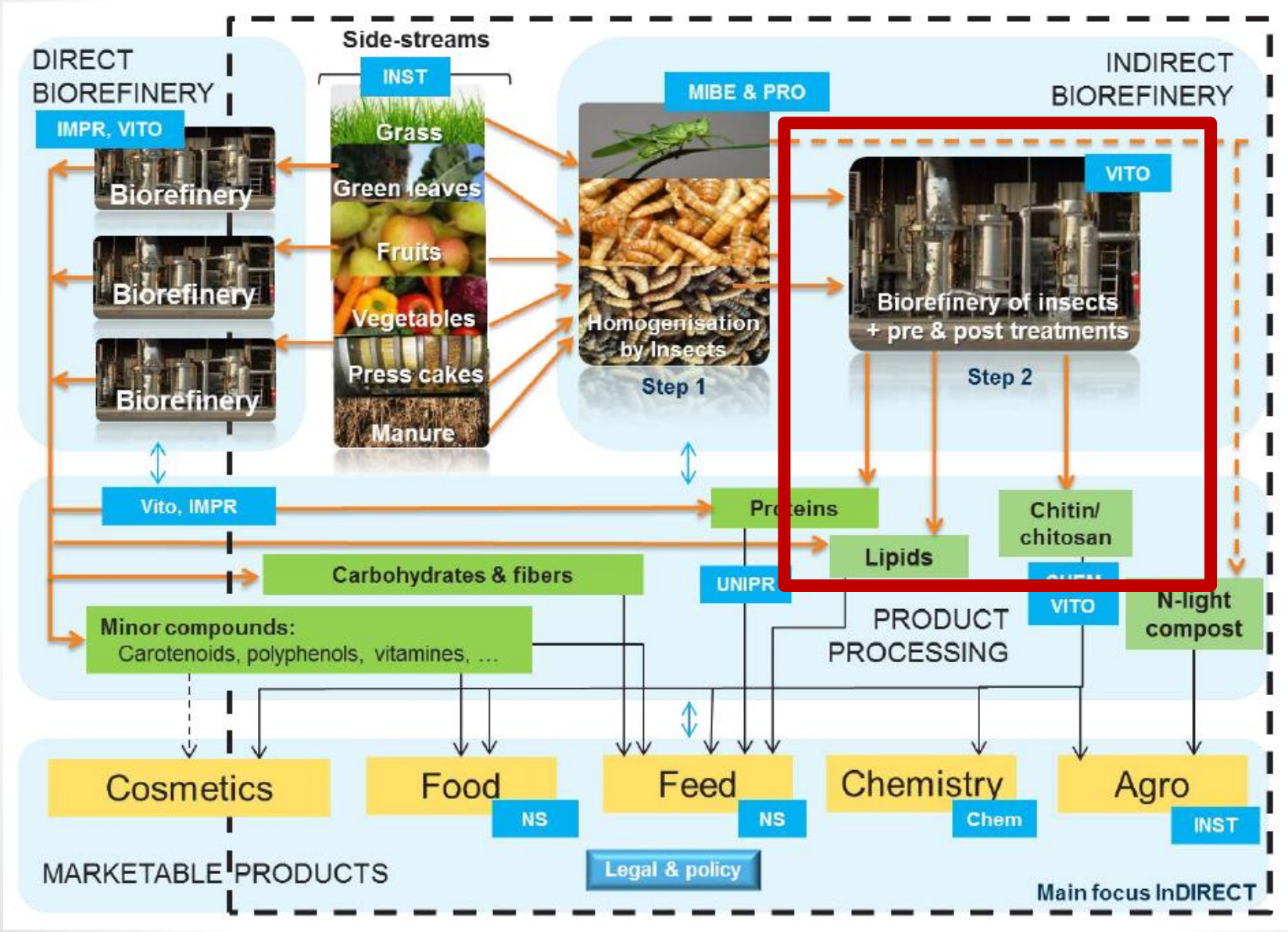
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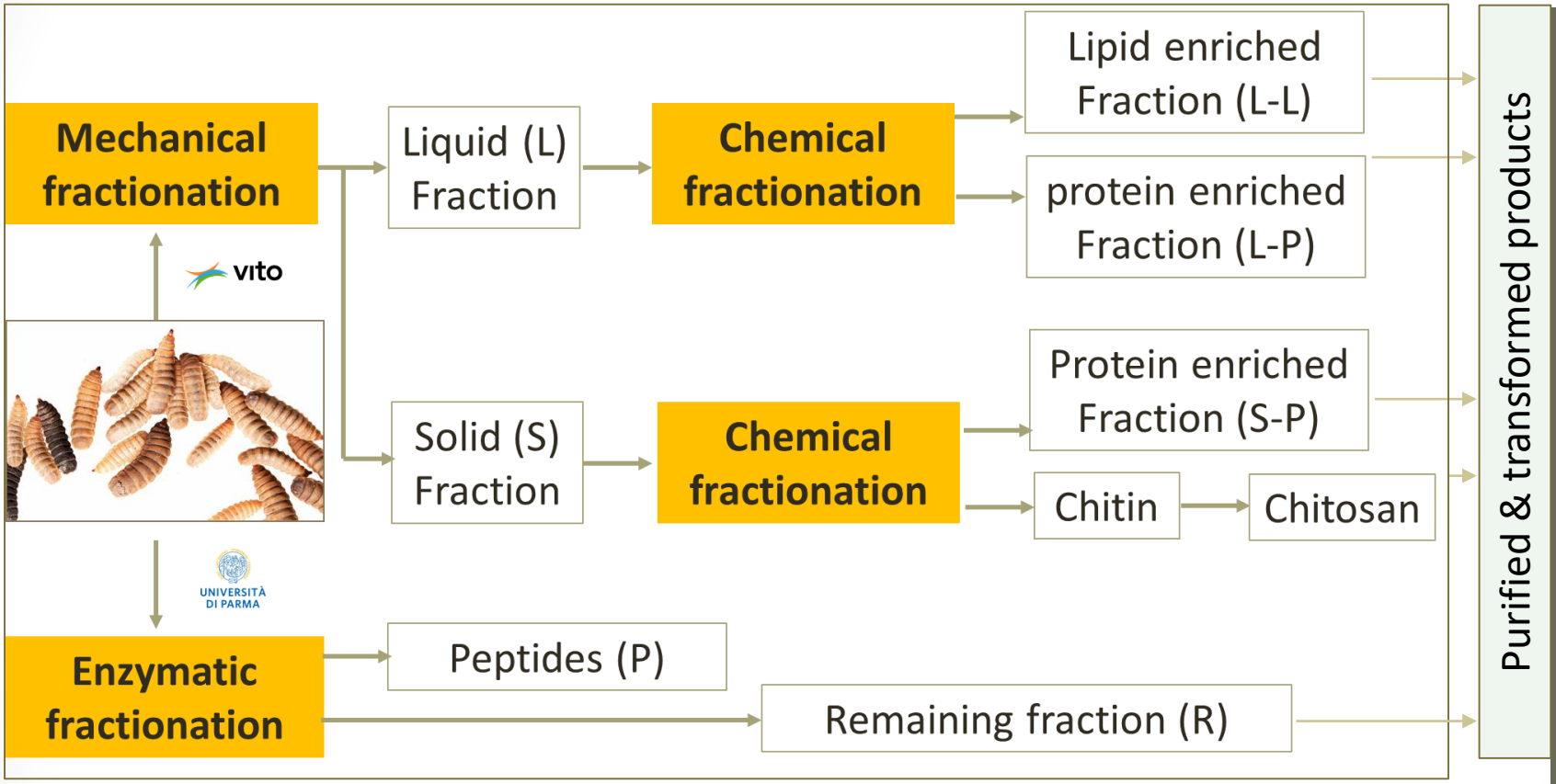
Insect biorefinery approaches

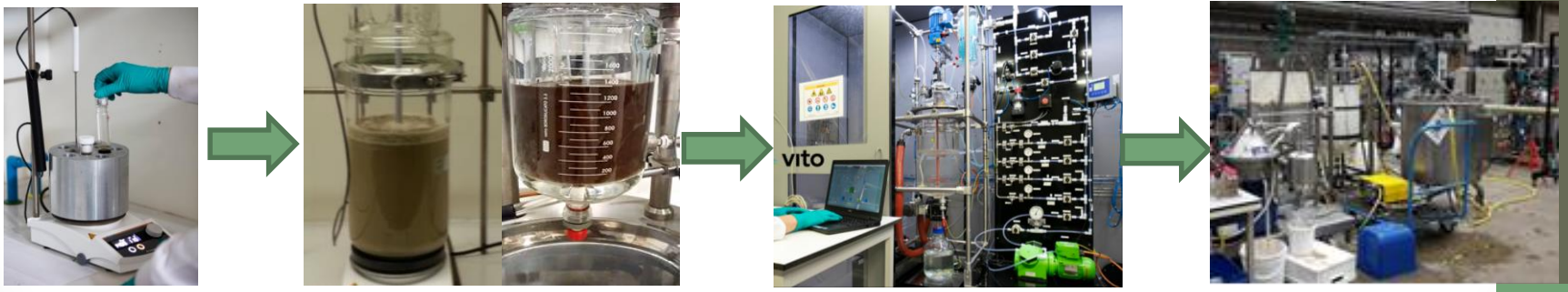


- Fractionation on wet biomass
- Chitosan removal from protein (and lipid) enriched fractions

Insect biorefinery approaches

Approach:

- Cascading biorefinery & preservation of functionality
- Small lab-scale
- First upscaling 5L scale → produce 100 g samples for application tests
- Further scaling 30-100 L → > 10 kg samples

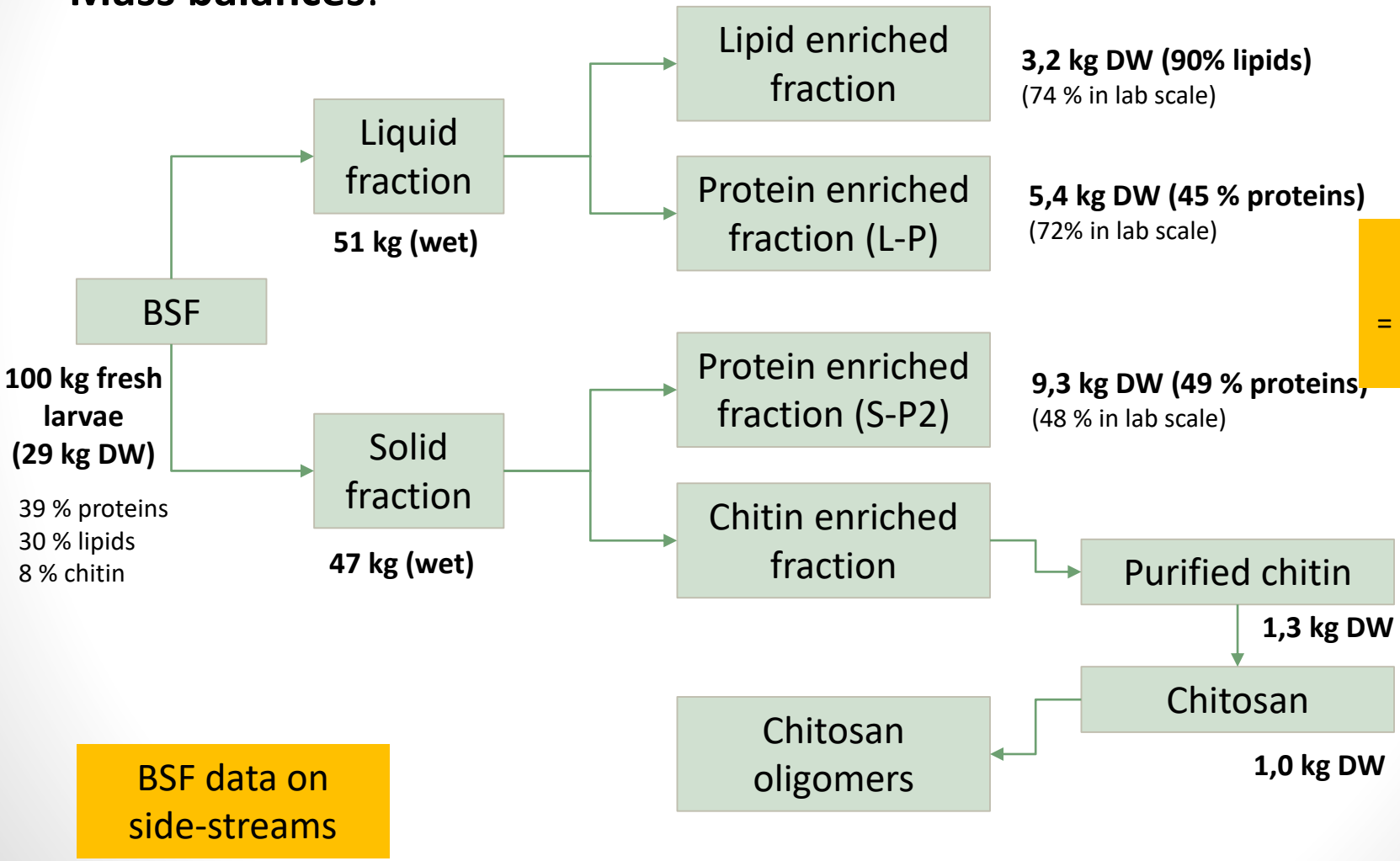


ml scale **Up to 5 L** **30 L** **300 L**

Poster session 16 – Monday evening (6-18)

Mechanical/chemical fractionation approach

Mass balances:



4 main fractions = 66 % of initial dry weight

BSF data on side-streams

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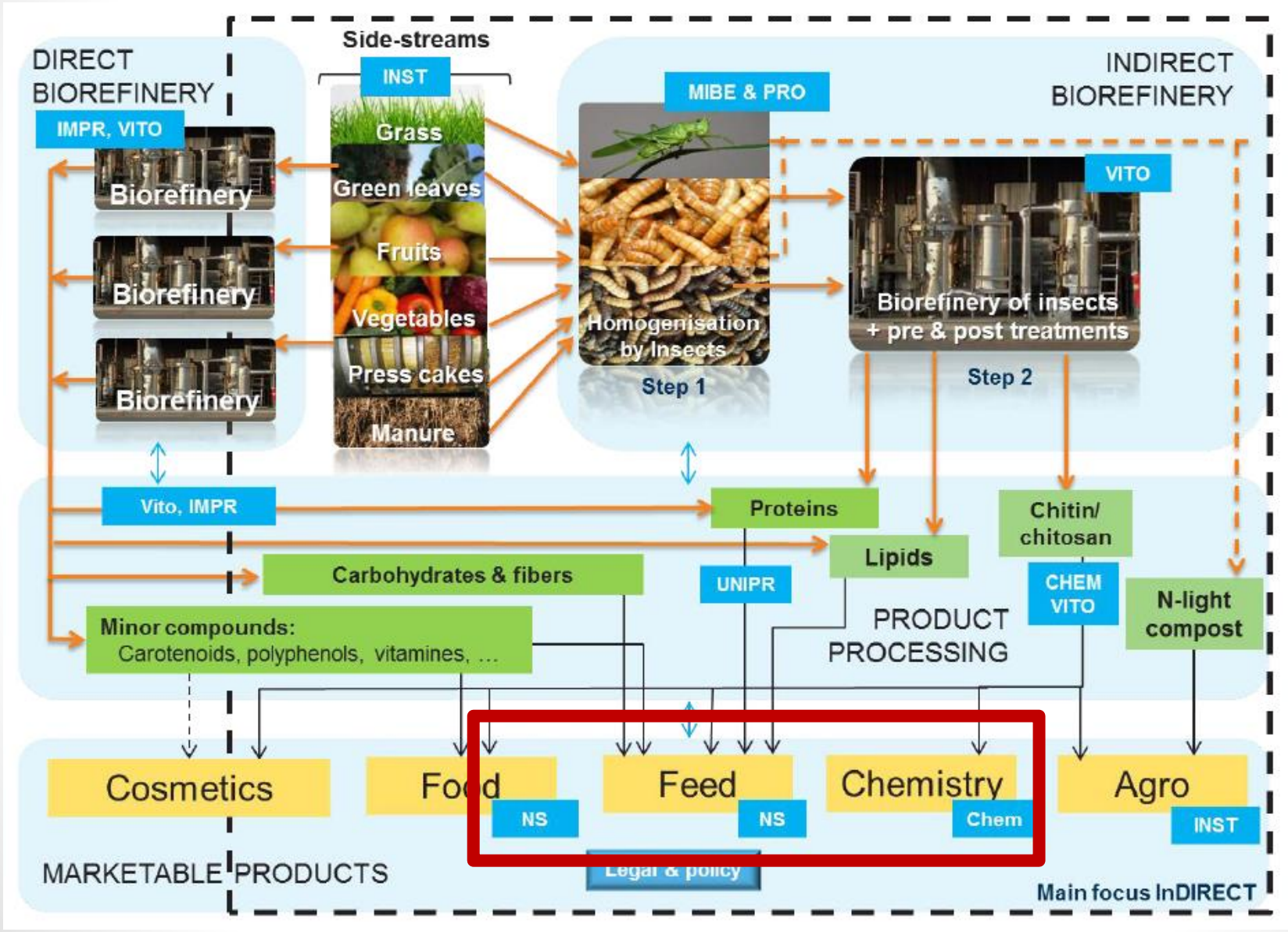
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Safety aspects

Safety aspects evaluated:

Oral session 6 – Monday

- Contaminants in side-streams:
  - Mycotoxins below regulatory limits
  - Pesticides detected – below regulatory limits
  - No accumulation of mycotoxins in insect biomass detected

- Allergens:
  - In-silico analyses based on protein composition data (proteomics)
  - Tropomyosin = most relevant allergen
  - Enzymatic hydrolysis could reduce allergenicity

Feed application

Application tests

Step 1: tests with 2-100 g DW extract

- Bioactive properties present
- Gut simulation test (in vitro test) confirm this
- Digestibility profiles

Step 2: upscaling (> 10 kg DW fractions) → animal tests

- Poultry test - ongoing

Oral session 38 – Wednesday (9:45)

Poster session 38 – Wednesday evening (38-14)

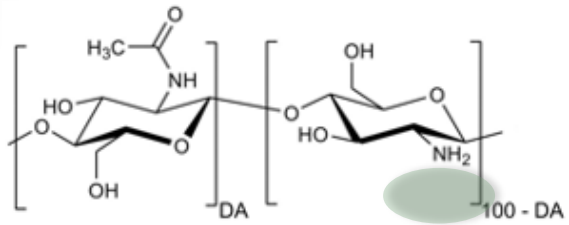
Chitine processing

Deacetylation

Chitine → **Chitosan**

Depolymerisation

→ **Applications**



DA -degree of *N*-acetylation

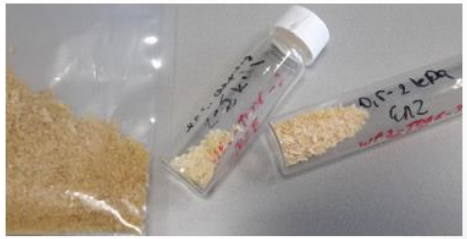
chitin DA > 50%
chitosan DA < 50%

Polymer of N-acetylglucosamine

Enzymatic & chemically

- Biopolymer as building block (biodegradability)
- Antimicrobial properties
- Anticholesterol properties
- Antioxidant properties
- Dietary fiber
- …

LMW & BSF chitosan (DDA 80-93%)
> 800 g produced

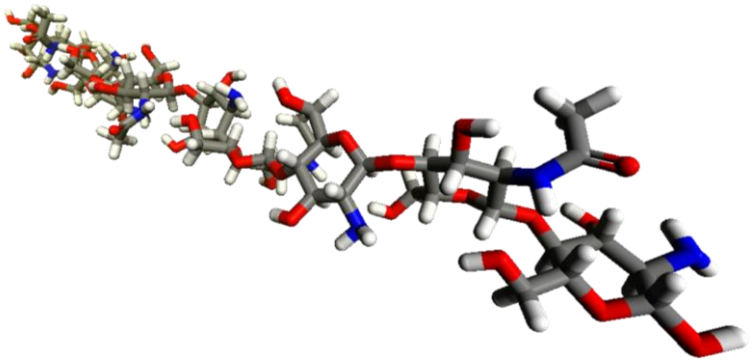


Chitosan after size reduction
> 100 g produced

Chemical application

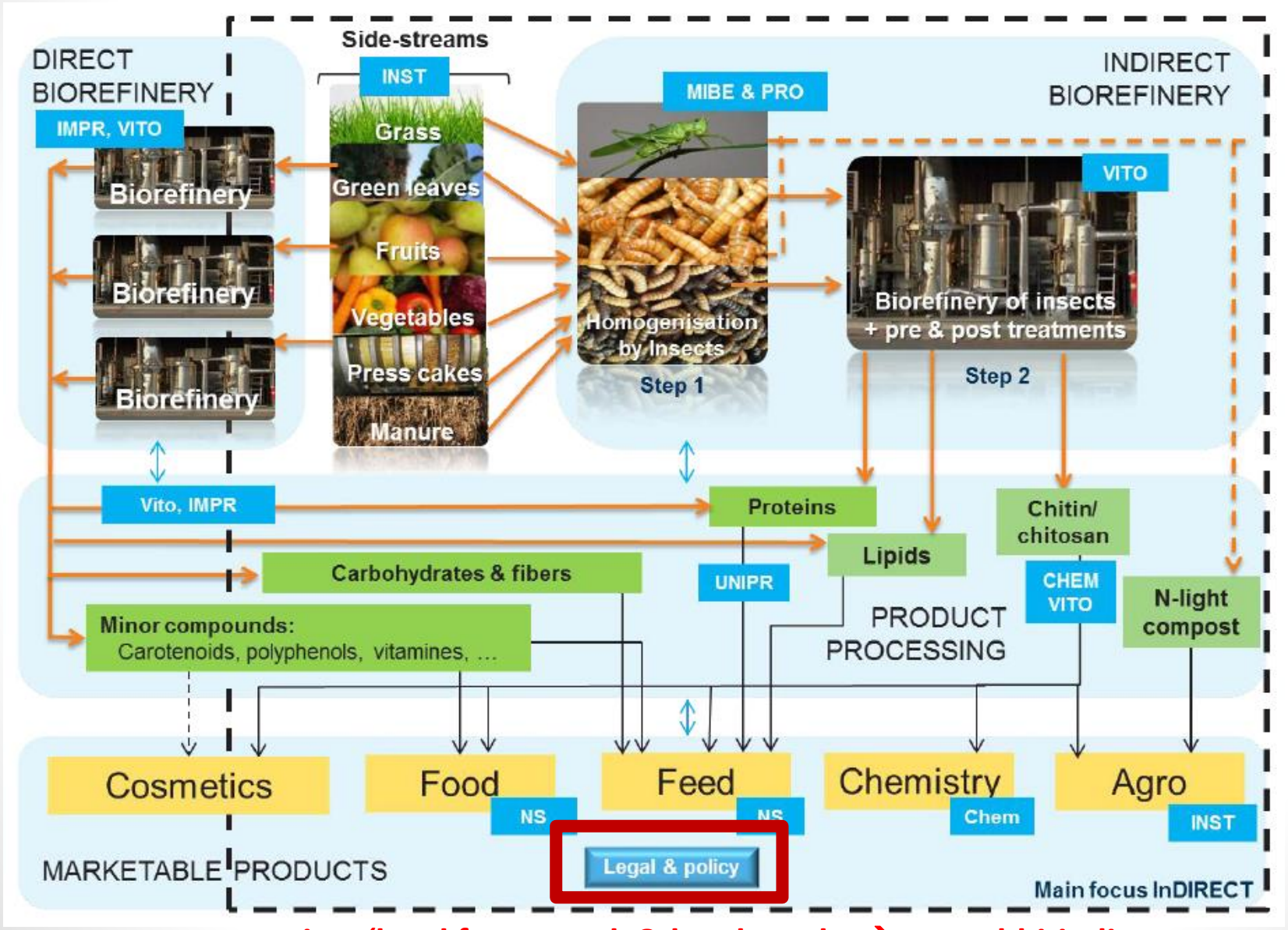
Focus on surface active agents based on chitin/chitosan derivatives

- Step 1= production of functional compounds
  - Chitin/chitosan = backbone for modifications
  - Chemical & enzymatic modifications
  - Synthetic organic chemistry
- Step 2: application tests
  - Dispersion
  - Emulsification
- Step 3: upscaling



Work in progress

Legal aspects in InDIRECT



Document overview 'legal framework & bottlenecks → www.bbi-indirect.eu

Oral session 6 – Monday

Take home message

- Valorisation of side-streams: Insects have potential as part of the biorefinery process
- Growth of insects on side-streams has been proven
- Larvae composition is rather stable, despite change of diet
- Tool (beta-version) has been developed for species specific premix development
- Premixes have potential for optimization of conversion ration
- Different approaches of insect biomass fractionation are applied → chitin, lipids, proteins, peptides
- Bioactive properties proven for multiple fractions
- Application tests ongoing
- Legal aspect = point of attention towards commercial applications.

InDIRECT consortium

vito vision on technology

nutrition sciences

UNIVERSITÀ DI PARMA

Circular Organics

IMPROVE Institut Mutualisé pour les PROtéines VEgétales

CHEMSTREAM SUSTAINABLE CHEMISTRY

Innovatiesteunpunt voor landbouw en platteland

Protifarm effective nutrition

Temperio

Coordinator: leen.bastiaens@vito.be

www.BBI-indirect.eu

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 720715.

BIO-BASED INDUSTRIES Public-Private Partnership

Bio-based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

General Objectives of InDIRECT

- Development of indirect cascading biorefinery processes for converting a variety of underspent **side streams/residues** into useful **marketable products** via:
  - Step 1: Homogenisation of the biomass with insects
  - Step 2: Fractionation of the insect biomass into crude extracts
  - Step 3: Purification & conversion of compounds
- Development of direct biorefinery processes for a selection of underspent side streams/residues, for comparison with the indirect approach.
- Optimisation of the biorefinery processes to increase the **conversion efficiency** (product/ton biomass input) and maximise the **values** of the feedstock (euro/ton biomass input).
- Exploration of application areas of the extracted compounds for use in different sectors like feed, chemistry and food.
- Hereby taking into account the whole value chain and the associated economic, environmental, legal and practical aspects – lab to pilot.

Side-stream selection

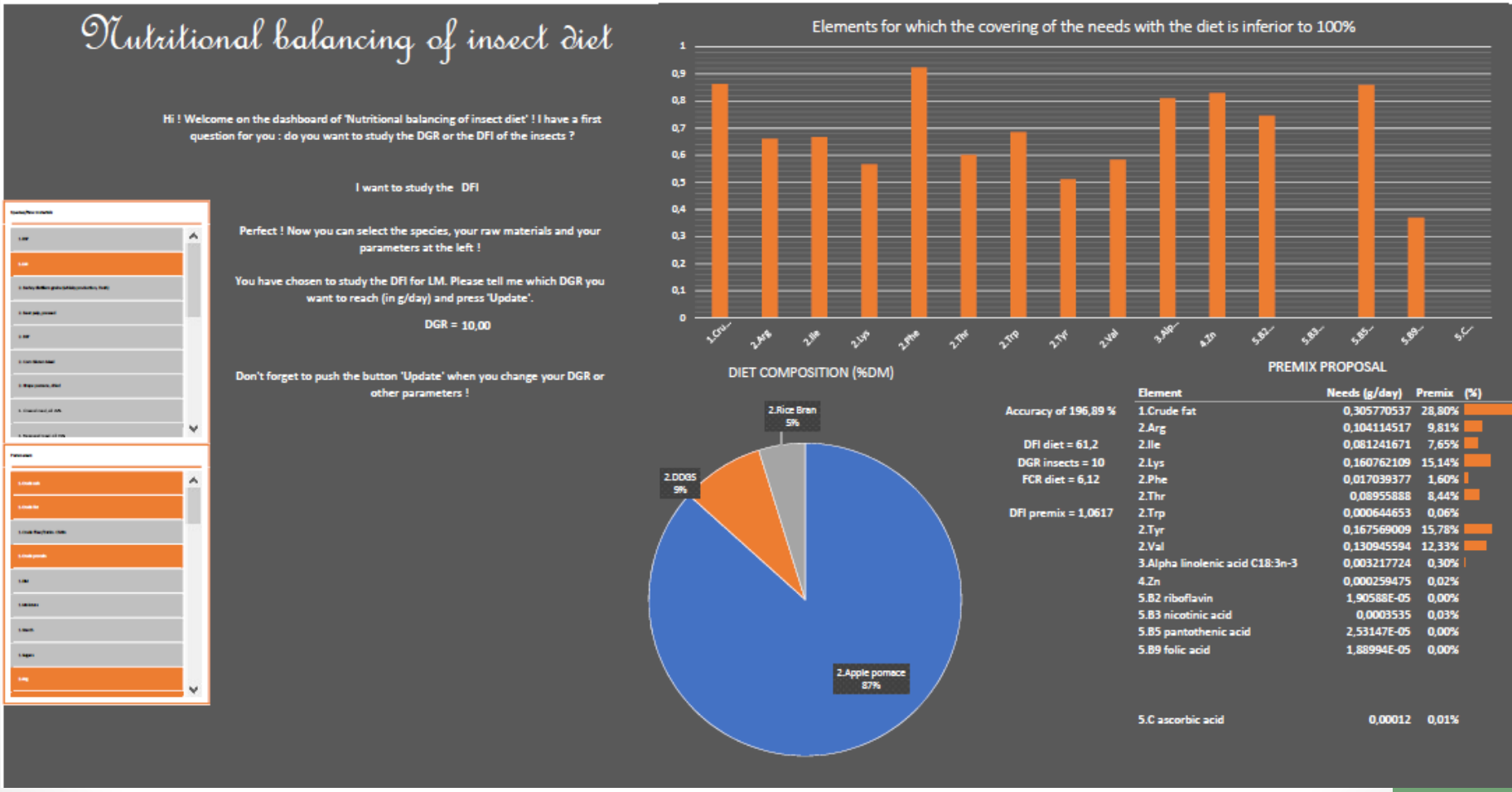
Step 1 = An **Inventory** based on European data from NOSHAN, FAO, VISIONS, Feedipedia database, etc. and national data from the different partner countries (WP1) → **Gives general idea of side-streams in big amounts**

Step 2 = Selection criteria for indirect biorefinery approach (WP3)

- Needs from the insects: % dry matter, % protein, nutritional value in general, other
- Available amounts at the offering company (min.100 kg)
- Availability throughout the year (crf. Seasonality)
- Texture
- Logistics
- Cost in €/ton.%DM
- Also: contaminants + allergens

Step 3 = Collect more background information for **side-stream selected** (WP1)

Deshboard



- Beta version = basis for further tailoring towards insect feed

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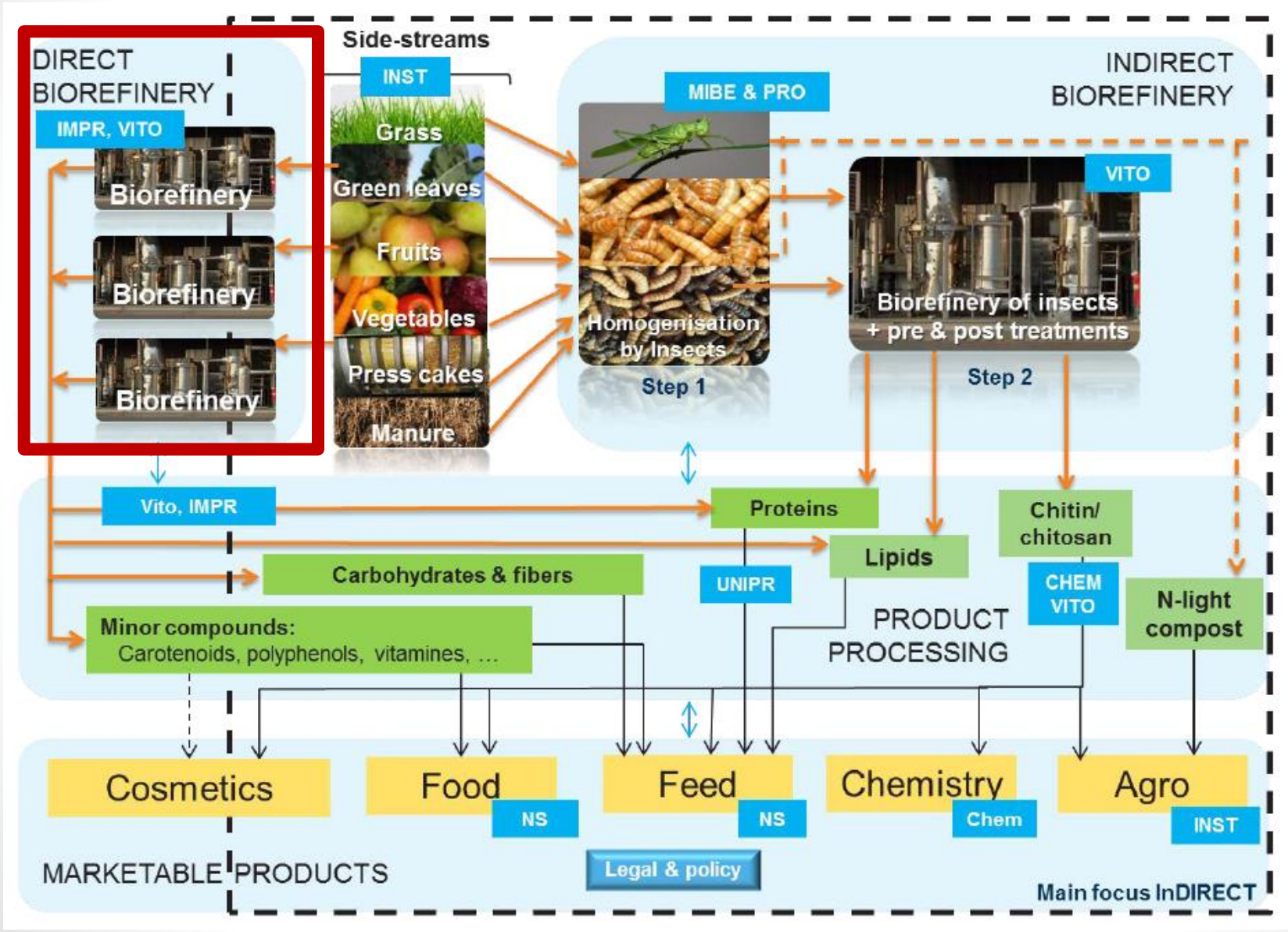
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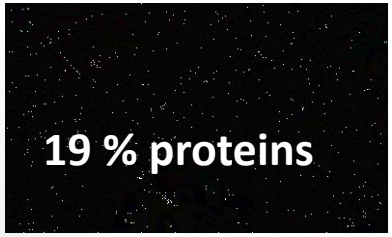
Direct biorefinery

Green leaves

Leek

Sugar beet leaves



Alfalafa (reference)

Can be preserved by ensiling

Direct fractionation

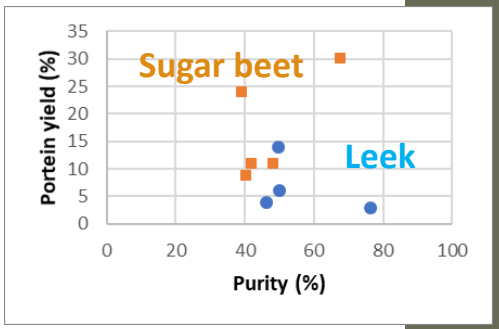
1. Pressing + thermal treatment
2. Pressing + acid precipitation
3. Pressing + acid precipitation at high temperature
4. Pressing + ultrafiltration

Target compounds

Proteins

Purity: 39 – 76 %

Yield: 3 – 30 %



Polyphenols

Increase & shift during extraction

Distributed over different fractions