IMPACT OF THE RAW MATERIALS AND NUTRIENTS AVAILABILITY ON OVERALL ECONOMIC PERFORMANCE

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NEW STAKES AND CHALLENGES

OF THE INDUSTRIAL INSECT REARING INDUSTRY

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PROCIDYS PRESENTATION

PROCIDYS is a consulting/R&D company specialized in the valorization of by products and development of food processing.

Fish

- Fish
- Shrimp
- Shellfish

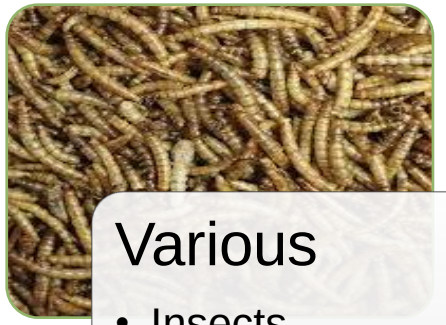
Seaweed

Macro algae

Micro algae

Vegetal

- Vegetables
- Cereals
- Plants



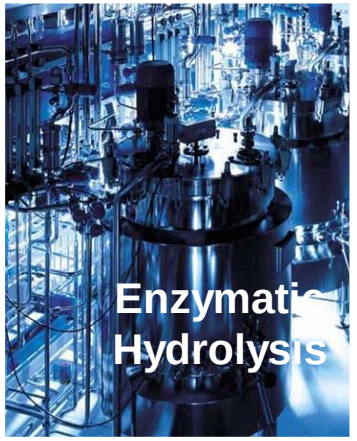
Various

- Insects
- Wood by products

Areas of expertise

➢New product and concept development, new process development (Lab scale, Pilot Plants)
➢ Improvement of existing process, identification of the most suitable technologies,
➢Support Engineering : Industrial equipment selection, establishment of a Preliminary Draft Design

➢Training support for new processes ,energy requirements evaluation and optimization
➢Business plan and Business case support



I/ PROSPECTS FOR THE DEVELOPMENT OF THE INSECT PROTEIN INDUSTRY

- The forecast of production of the European insect sector is
  - To generate more than **2 or 3 million tons of insect protein** (for food and feed) by 2030;
- This results in the use of **4 to 6 Million tons of dry biomass** → **20 to 40 Million tons of crude biomass** depending on the dry matter.

- The development of the sector and the capacities of production of insect protein are essentially linked to the biomass and foodstuff :
  - Availability of these raw material and volumes
  - Access or purchase price
  - Composition and nutritional properties
  - regulations that apply to these raw material and sector.

I/ PROSPECTS FOR THE DEVELOPMENT OF THE INSECT PROTEIN INDUSTRY

Regulation is a key point to study the different insect feed

Two categories of materials used as insect feed,

those that are legally permitted (A and B)

those that are not (C, D, E, F, G).

The European Food Safety Authority (EFSA) considers the following seven categories (from A to G) of substrates:

A. Animal feed materials according to the EU catalogue of feed materials (Commission Regulation (EU) No 68/2013) and authorised as feed for food producing animals (EC, 2013).

B. Food produced for human consumption, but which is no longer intended for human consumption for reasons such as expired use-by date or due to problems of manufacturing or packaging defects. Meat and fish may be included in this category.

C. By-products from slaughterhouses that do not enter the food chain but originate from animals fit for human consumption.

D. Food waste from food for human consumption of both animal and non-animal origin from restaurants, catering, households.

E. Animal manure and intestinal content.

F. Other types of organic waste of vegetable nature such as gardening and forest material.

G. Human manure and sewage sludge.

II/ WHAT ARE THE BIOMASS SELECTION CRITERIA ?

Important criterion “We provide valorization solutions and service for waste and by products "

Do not compete with other recovery sectors and other industries : animal Feed and human consumption

Main criteria

- Purchasing price of these raw materials : negative price or free
- Rich in nutrient intake: proteins, lipids, polysaccharides
- By products resources are close to the factory so low logistic cost

Advantages compared to other valuations

- Insect feed can accept non-standard products
- Shelf life of the products may be exceeded
- Microbiological quality of raw materials : certain types of contaminated or rotten products can be accepted
- Degraded freshness of some products
- BSF is omnivorous which makes it flexible and adaptable to different diets

Disadvantages:

- Raw materials with high dry matter are required so the final substrate has a final dry matter adapted to the larvae growth

II/ WHAT ARE THE BIOMASS SELECTION CRITERIA ?

- **Availability** : What types of by-products are available in France for the larvae?

Fruits and vegetables

Cereals by-products

Oilseeds by-products

Fish by- products

Organic waste

- **Volumes, and access prices**
- **Nutritional intake and composition**: source of proteins, lipids, carbohydrates, polysaccharids, cellulose, vitamins
- **Possible processes to improve nutritional performance of this biomass ?** Digestibility, solubility, pre hydrolysis
  - Pretreatment
  - Fermentation
  - Silage process
  - Enzymatic or acid Hydrolysis

III/ NUTRITIONAL IMPACT OF SUBSTRATES

- **Main expected effects on insects :** nutritional composition, expected effects on the insect species
  - such as weight gain
  - feed efficiency (feed conversion ratio),
  - the time needed to reach the harvesting stage, and steady year-round supply.

- **In terms of the quality of the derived insect biomass, the key issues are :**

  - **protein** concentration and amino acid profile, → protein larvae/protein biomass ↗ 2.1 and 2.8 in protein
  - the **lipid** and fatty acid profile → lipid larvae/lipid biomass ↗ 5,2 in lipid
  - micronutrients (such as **minerals**), → similar
  - **Carbohydrates** → insects are able to convert carbohydrates into protein, lipids
  - Vitamins and trace elements

- **Other criteria**
  - **substrate moisture content** ↘ biomass conversion ratio and survival rate of the larvae,
    wet weight, development time
    body size and body thickness of the larvae.

III/ NUTRITIONAL IMPACT OF SUBSTRATES

➢ **Quality and composition of biomass influence the ratios of increase in proteins and lipids.**

Table 1. Selected studies on black soldier fly (BSF) considered in this review and the main inputs considered.[1,2]

Study	Substrates							Insect larvae (BSF)						
		W	CP	EE	ash	IDF/ NDF*	NFC*	Energy*	Development time (day)	Production g DM	CP* (kp 4.76)	CP* (kp 6.25)	EE	Ash	Energy*
		g/kg	g/kg DM					kcal/kg DM			kg DM				kcal/kg DM
Meneguz *et*	Brewery by-products	917	200	86	40	447	225	2,910	8	2.29	403	530	299	73	5,107
al., 2018	Winery by-products	868	117	79	103	566	134	1,724	22.2	3.09	262	344	322	146	3,950
	Fruit waste	641	46	28	30	139	756	3,590	22	2.63	234	307	407	72	4,825
	Fruit and vegetable waste	768	120	26	91	178	585	3,028	20.2	3.29	319	419	263	130	3,994
Spranghers	Restaurant waste	738	157	139	45	41	618	4,451	19	5.87	328	431	386	27	5,548
et al., 2017	Fruit and vegetable waste	873	86	21	108	331	449	2,239	15.5	5.75	304	399	371	96	4,805
	Digestate	757	246	62	299	381	7	785	15	3.5	321	422	218	197	3,335
	Chicken feed	742	175	53	115	175	425	3,030	12.3	8.51	314	412	336	100	4,653
Mean		788	143	62	104	282	400	2,720	17	4	311	408	325	105	4,527

[1] CP = crude protein; DM = dry matter; EE = ether extract; IDF/NDF = [illegible] fibre/neutral detergent fibre; NFC = non-fibre carbohydrates; W = water [illegible]ntent.

[2] * = estimated or calculated from Meneguz *et al.*, (2018) and Spranghers *et al.* (2017).

Protein increase X 2,5

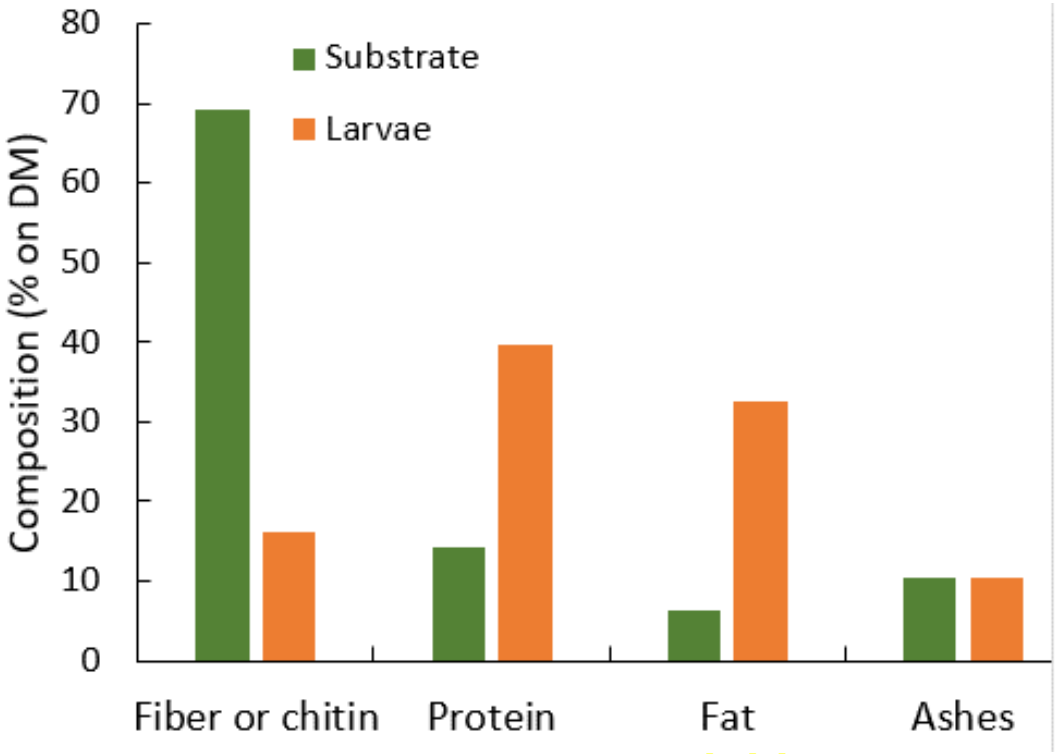
X 2,5

Lipid increase X 5

X 5

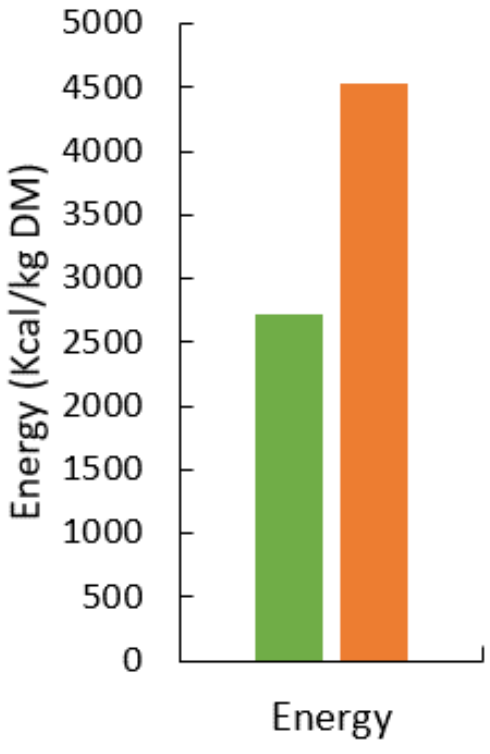
III/ NUTRITIONAL IMPACT OF SUBSTRATES

➢ **Quality and composition of biomass influence the ratios of increase in proteins and lipids.**



Protein increase X 2,5

Lipid increase X 5



Energy increase X 1,8

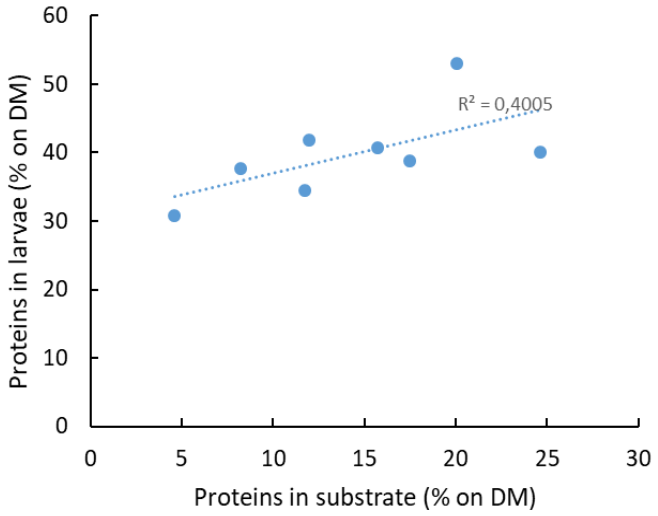
Despite substrates not very rich in protein and oil
→ larvae will produce proteins and oil

→ Protein content of larvae:
31-53% depending on the substrate

→ Fat content of larvae:
22-41% depending on the substrate

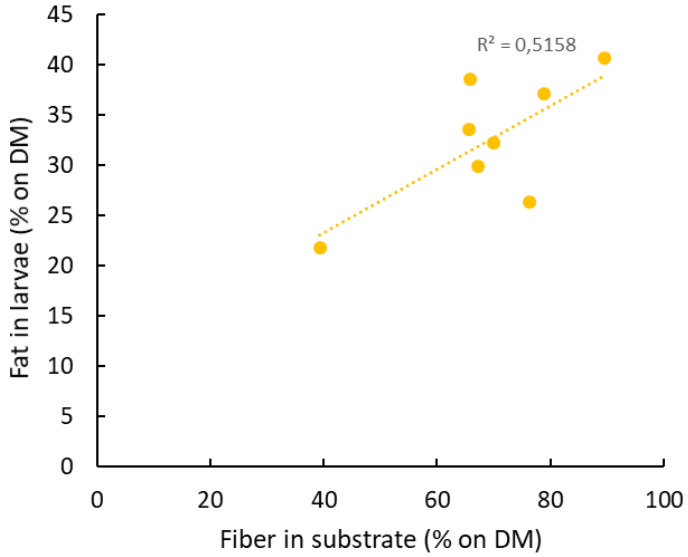
Vegetable-fruit mix produces almost as much protein as chicken feed.

III/ NUTRITIONAL IMPACT OF SUBSTRATES

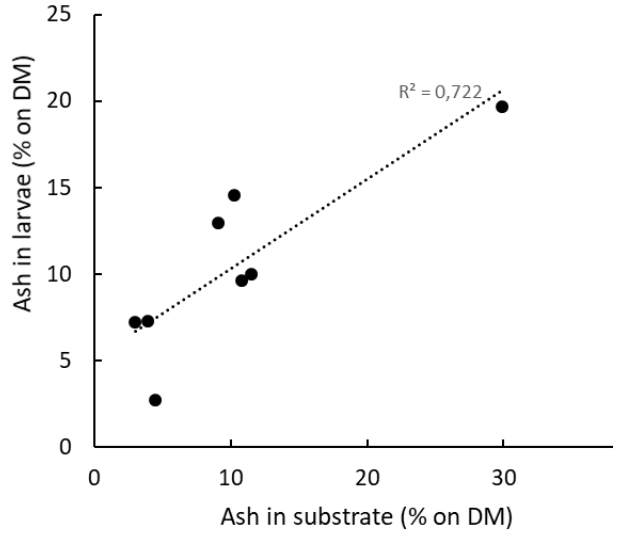


Protein :+/- correlation between substrate and larvae

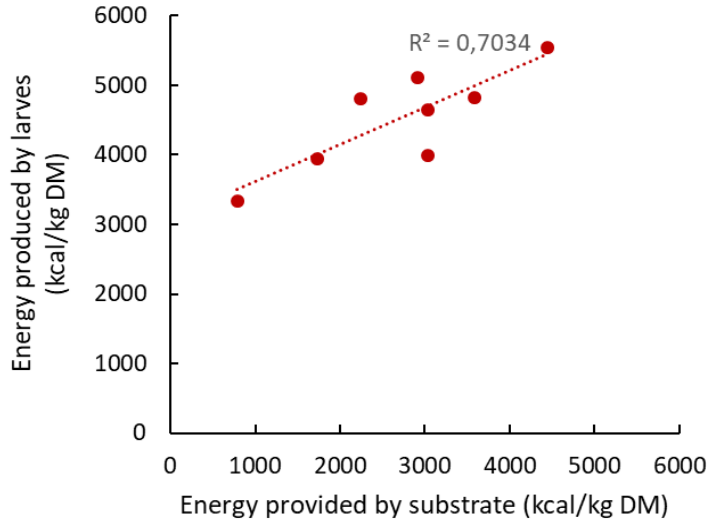
- protein in the substrate,
- the protein in the larvae.



→ Larvae convert part of the carbohydrates into lipids explaining fatter larvae on substrates rich in fruits



Ashes:
- ashes in the substrate,
- Ashes in the larvae.



→ Larvae develop on low energy substrates
→ and produce energy

III/ NUTRITIONAL IMPACT OF SUBSTRATES

One of the key point:
The time needed to reach the harvesting stage seems to be linked to the protein content in growing substrate.

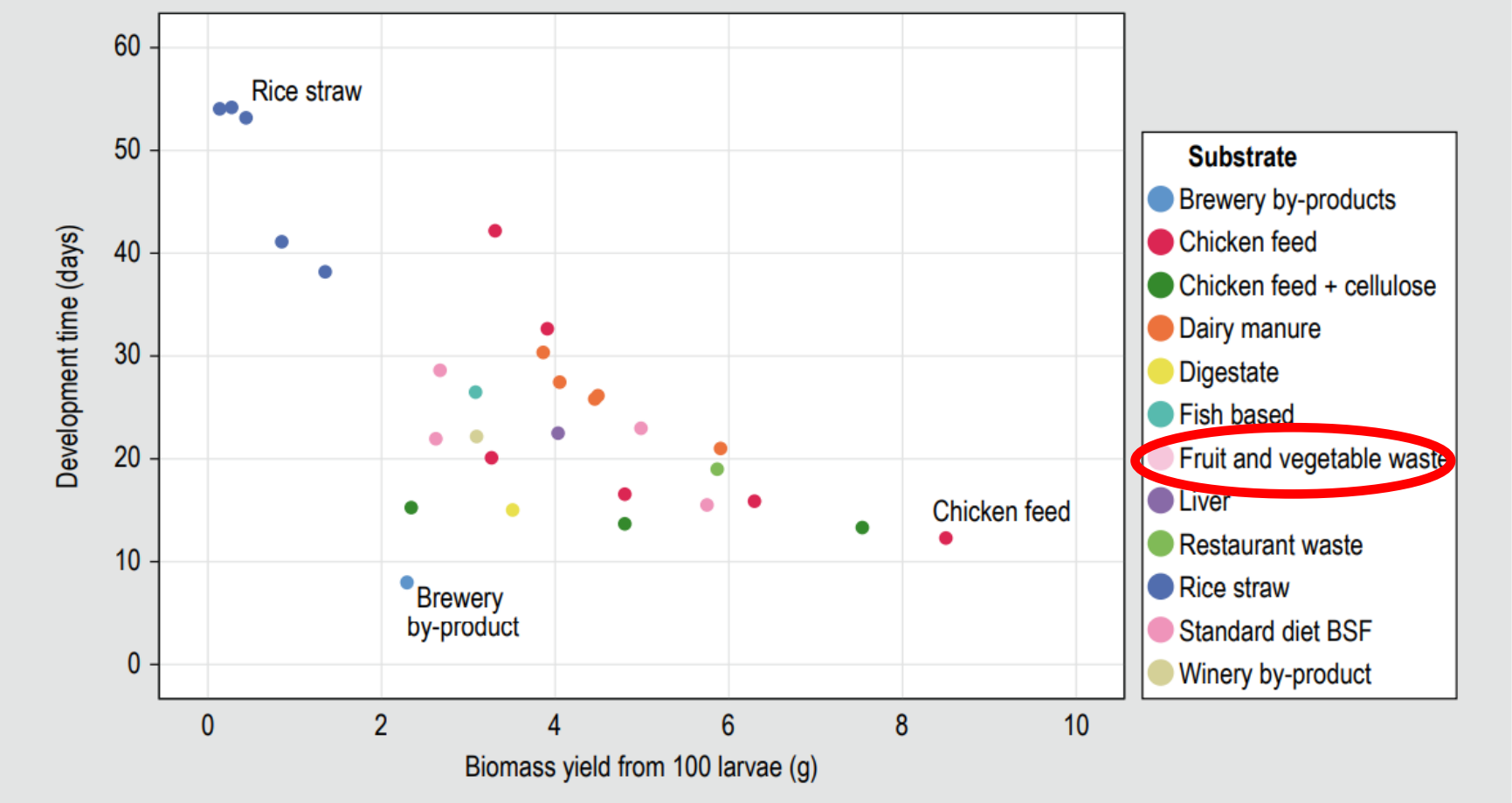


Figure 7. Biomass yield from 100 larvae (g) plotted against development time (days). Data elaborated from studies reported in Table S1.

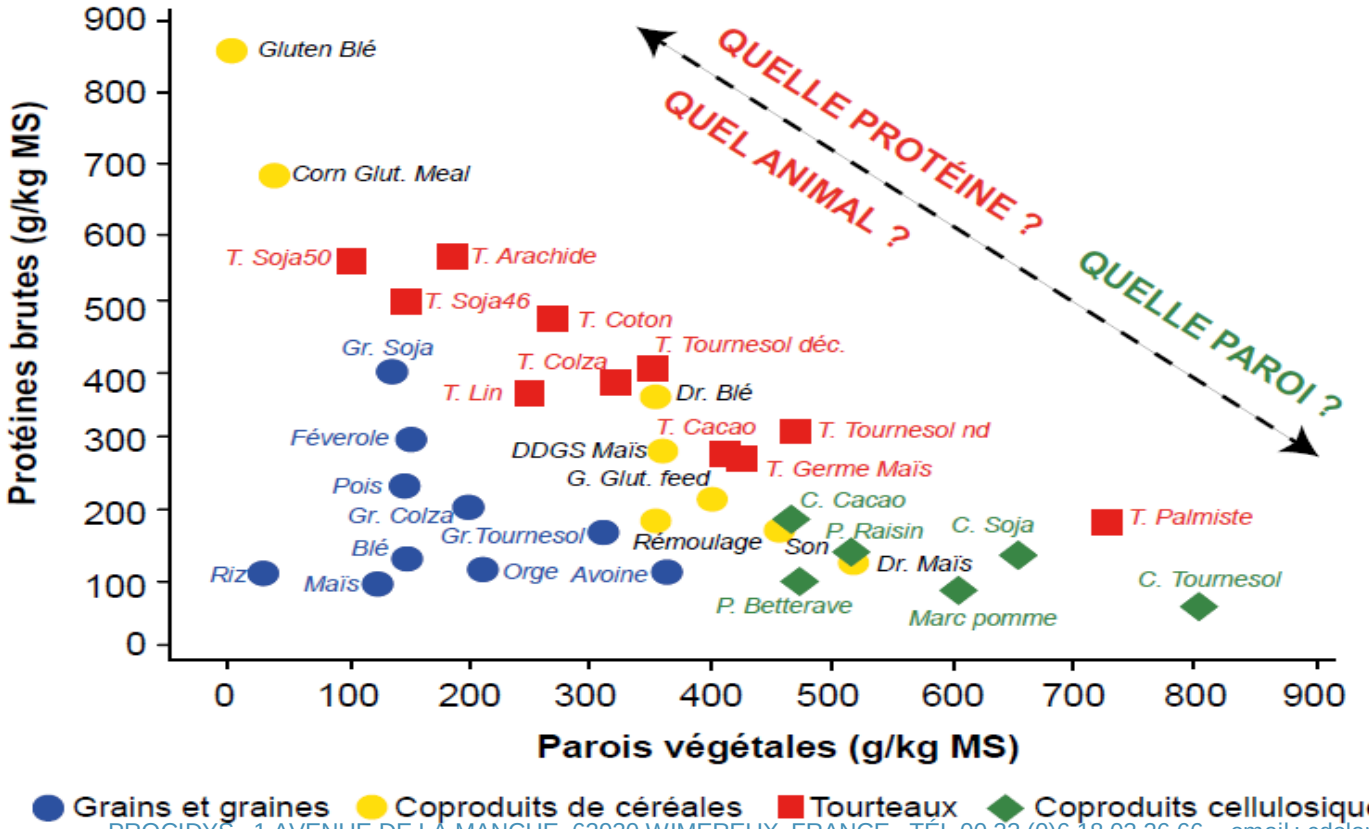
→ Most substrates are able to guarantee the harvesting within four weeks
→ (instead of rice straw)

→ Not fast
→ but good yield production

III/ NUTRITIONAL IMPACT OF SUBSTRATES

Another key point:
The protein content and plant cell walls (more or less digestible) can influence the feed efficiency.

Figure 4. *Teneurs moyennes en protéines et parois végétales de quelques coproduits (d'après INRA, 2018).*



- Significant accumulation of parietal constituents (cell walls) in some by-products generally reduces their digestive use.
- However, some co-products rich in plant cell walls less lignified can be properly valued at moderate rates.

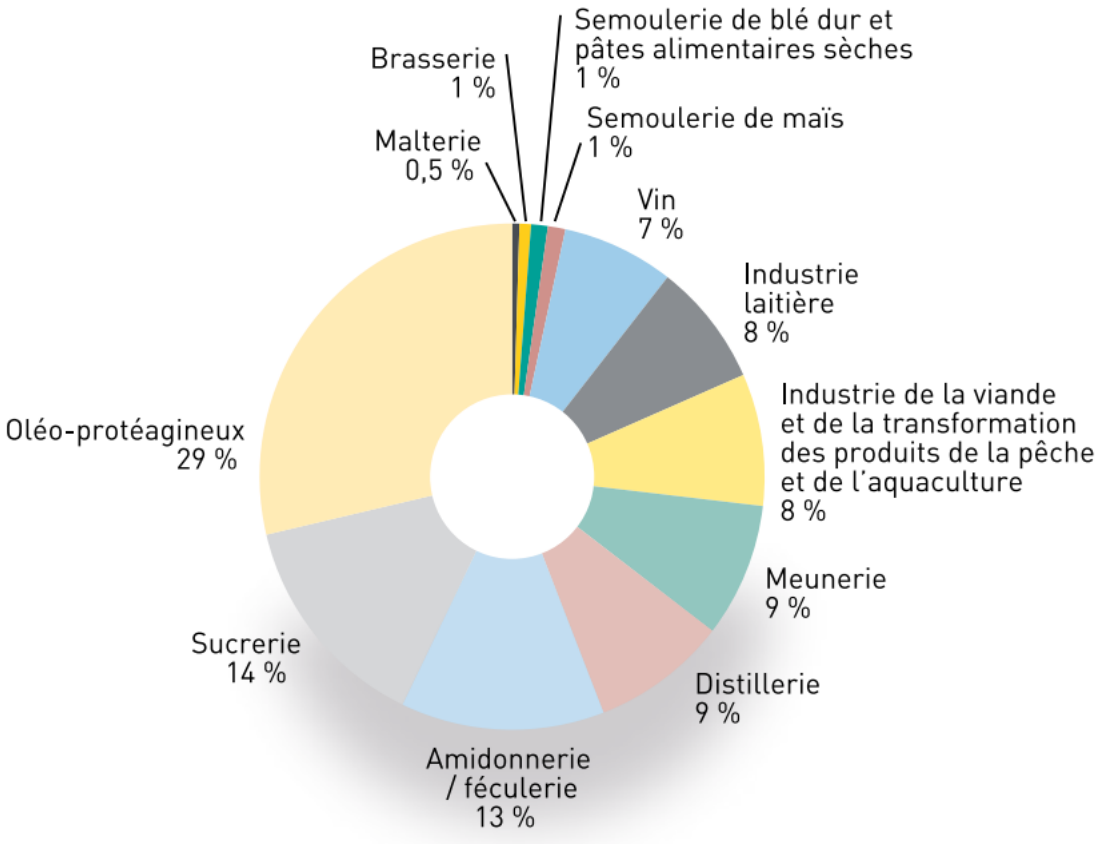
IV/ AVAILABILITY OF BY PRODUCTS IN FRANCE

Agricultural sector Volume/year	Type of by products	Estimated volume /year
oilseeds and protein crops sector *6,3 Mt of oilseeds products*	Rapeseed, Sunflower and soy meals (cakes)	4 Mt
wheat mill 5,34 Mt	Milling by products are wheat bran, remouldings, poor flour	0,76 MT 0,4MT 50 000 T
other cereals :potato, maize, soft wheat, potatoes (starch) barley and malt : *8 Mt*	wheat gluten feed, corn gluten feed, corn solubles, dregs, potatoes Barley by products	1,2 Mt 70 000T
sugar beets :*34 M tons of sugar beets*	beet pulp, molasses, leaf, collars and rootlets	2.8 M T of crude beet pulp
fruits and vegetables *Volume/y : 2,9 Mt + 5,2 Mt = 8,2Mt*	Sorting rejects − Processing waste peelings	1,3 Mt
Wine *46 800 000 Hl*	Grape pomaces (residues from the pressing of fresh grapes) Wine lees, must residues, stillage (vinasses)	1 Mt (grape pomace) 1,5 Mt (lees + residues)
slaughtering and cutting meat *3,5 Mt (bovine) + 1,5 Mt (poultry and rabbit)*	Skins, blood, fats, bones, certain offal, legs, heads, feathers and down -→ category 3 and Food (A) Category 1 & 2 (B)	A : 2,5 Mt B : 0,93 Mt
milk industry *25 MT of milk*	Whey and butter milk	1,2 Mt (crude) 50 000T
fish industry 380 000 T + import	Trimmings, heads, skins, fishbones, visceras	160 000 T
brewery + distilleries: 19 M HL + 18,2 MHl	Draughts, yeasts, others	0,33Mt + 1,4 Mt crude

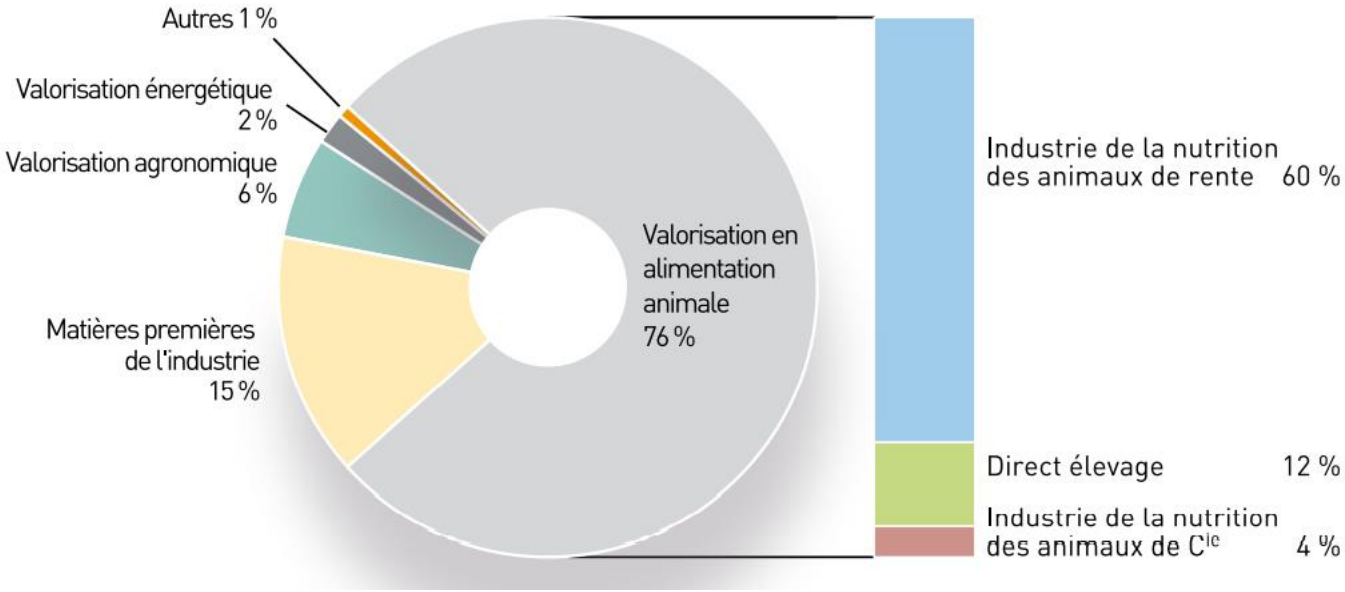
(Source : Enquête Réséda 2017)

IV/ AVAILABILITY OF BY PRODUCTS IN FRANCE

In 2016, the source of by-products from the agri-food industries surveyed is 12.1 million Tons of Dry Matter



% of volumes of by-products by sector in France (in tons of dry matter)



% of by-products in the different recycling sectors

IV/ AVAILABILITY OF BY PRODUCTS IN FRANCE

Agro food sector	By product vol (DM)	Animal feed Mt	Energy Mt	Fertilisers Mt	Others + human food	% per sector
Oilseeds	**3900**	3900				30,4
Sugar beets	**1715**	1097		618		13,4
Starch industry	**1600**	1600				12,5
Distillery	**1051**	770	99	63	119	8,2
Wheat meal (wheat bran)	**1037**	1030			7	8,1
Meat and fish	**1022**	563	125	60	275	8,0
Milk	**952**	360			593	7,4
Wine	**868**				868	6,8
Fruits and vegetables	**280**	60		200	20	2,2
Others cereals	**250**	250				1,95
Brewery	**90**	88	0,3	1	1	0,7
Others	**56**	56				0,4
TOTAL	**12820**	**9780**	**224**	**942**	**1883**	**100**

IV/ AVAILABILITY OF BY PRODUCTS IN FRANCE

- Volume of agro food by-products in France is 12.1 million tons (Mt) of Dry Matter (DM). (Reseda 2017 survey)

  - Insects are a solution for recovering by products from food waste,
  - An important issue : 1/3 of the food produced in the world will never be consumed.
  - Insect larvae can consume unsold supermarket food, food scraps or production scraps from the agri-food industry.

  - Animal feed absorb almost 76% of the total volume : difficult to compete
  - Human consumption absorb 15% of the total volume : impossible to compete
  - The insect industry must try to focus on raw materials oriented towards energy (2%) and fertilization (6%)

    but ↗ *energy price*

  - **So 1M tons available for insect feed ?**

IV/ AVAILABILITY OF BY PRODUCTS IN FRANCE

By product raw material	Vol in DM	Availability and current use	Actual Access Price €/T	Nutritional interest	Regulation	Interest as insect feed
Rapeseed, Sunflower and soy meals (cakes)	3,9Mt	Feed	500 to 600€/T	High protein 35 – 45%	Yes	
Sugar beets by products	1,7 Mt	Feed + fertilizers	350 to 400€/T	Low Protein 8% High NDF	Yes	
wheat & corn gluten feed, solubles, dregs, potatoes BP	1,6 Mt	Feed	250 300€/T	Protein 18%	Yes	
distillery	1,05Mt	Feed Energy fertilizers	?	Protein 50% Salt sugar	yes	
Wheat bran, remouldings and poor flour	1,04Mt	Feed	250 300€/T	protein 18% Fibers : 50%	Yes	
Meat & Fish by products	1,02Mt	Feed + Food Energy	100€ to 200€/T	High protein 70% DM Lipids	X	
Milk by products	0,95Mt	Food Feed	> 5000€/T	Protein sugar	Yes	
Wine by products	0,86Mt	Food	High	Sugar soluble fibers	Yes	
Fruits and vegetables	0,28 Mt	Feed fertilizers	0	Low protein Fibers cellulose	Yes	
Others cereals brewery BP	0,146Mt	Feed	Variable	Protein fibers	yes	

IV/ AVAILABILITY OF BY PRODUCTS IN FRANCE

- Focus on vegetables and fruits by products
- The access price vary greatly depending on the production context: linked to
  - Available volumes
  - Quality, composition, freshness, energy value
  - Transport and storage cost
- Example of prices for some by products *(source : fiches techniques du Comité national des coproduits)*

Fruits and vegetables by products	Price for one ton
Canning peas or green beans	Variable, sometimes free
fresh apple pomace	3 to 4,5 €, sometimes free
tomatoes pulp	3 to 9 €
beet leaves and tops	Around 13 €
fresh citrus or orange pulp	Often given away for free
dehydrated fresh citrus pulp	130 to 155 €, ex works

V/CONCLUSION

- Less and less availability of agro food by products and foodstuff in France
  - At attractive prices and good proximity
  - More and more competition (with animal feed, human food, energy via biogas, natural fertilizers) especially on interesting and protein-rich raw materials (wheat bran, cereal by-products, vegetables)
- The sector must lobby to allow the use of new raw materials not yet authorized or unknown : organic fraction of household waste, restaurant food waste, animal by products, seaweeds
- It is necessary to improve the nutritional performance of certain biomasses by pre-treatments, digestion, hydrolysis treatment.
- Shouldn't we work with non-recovered biomasses: plants, tops, leaves, peelings?
- Prioritize the construction of new insect farms in less developed countries where the valuation of biomass and recycling of agricultural by products is not yet developed.

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