

## Transforming residual biomass into quality food & feed products

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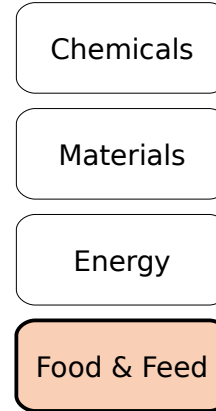
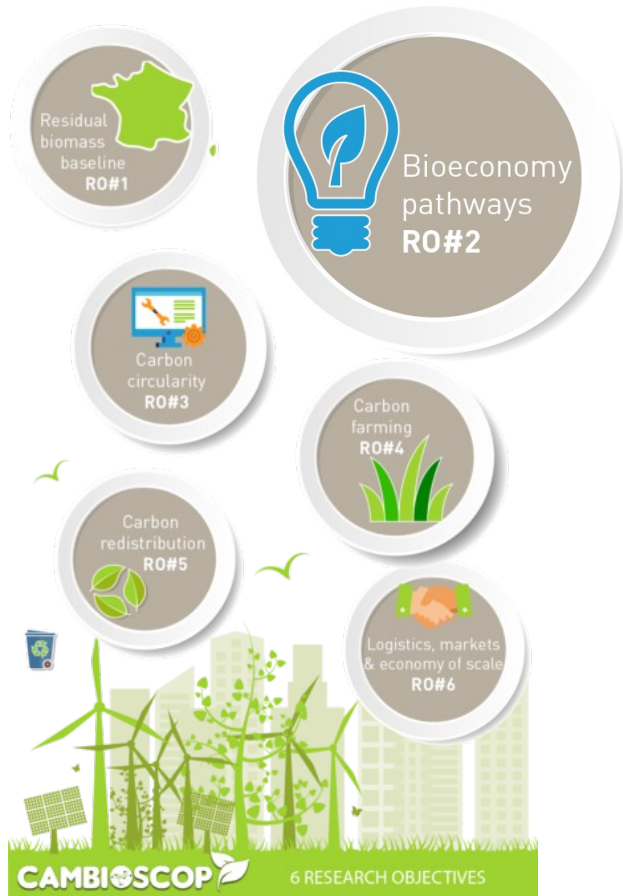
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# Context & objectives



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# Context



What role can play residual biomass for France future food supply ? Can we quantify it ?

# Objectives

## Step 1

Identification of waste-to-nutrition conversion pathways

## Step 2

**Selection** and modeling of the most relevant options regarding France bioeconomy strategies

Drivers :

- Land use
- Climate change

## Step 3

Building a consolidated LCA of waste-to-nutrition platform for France

## Step 4

Allocation of the available residual biomass to produce food and feed - optimization

2

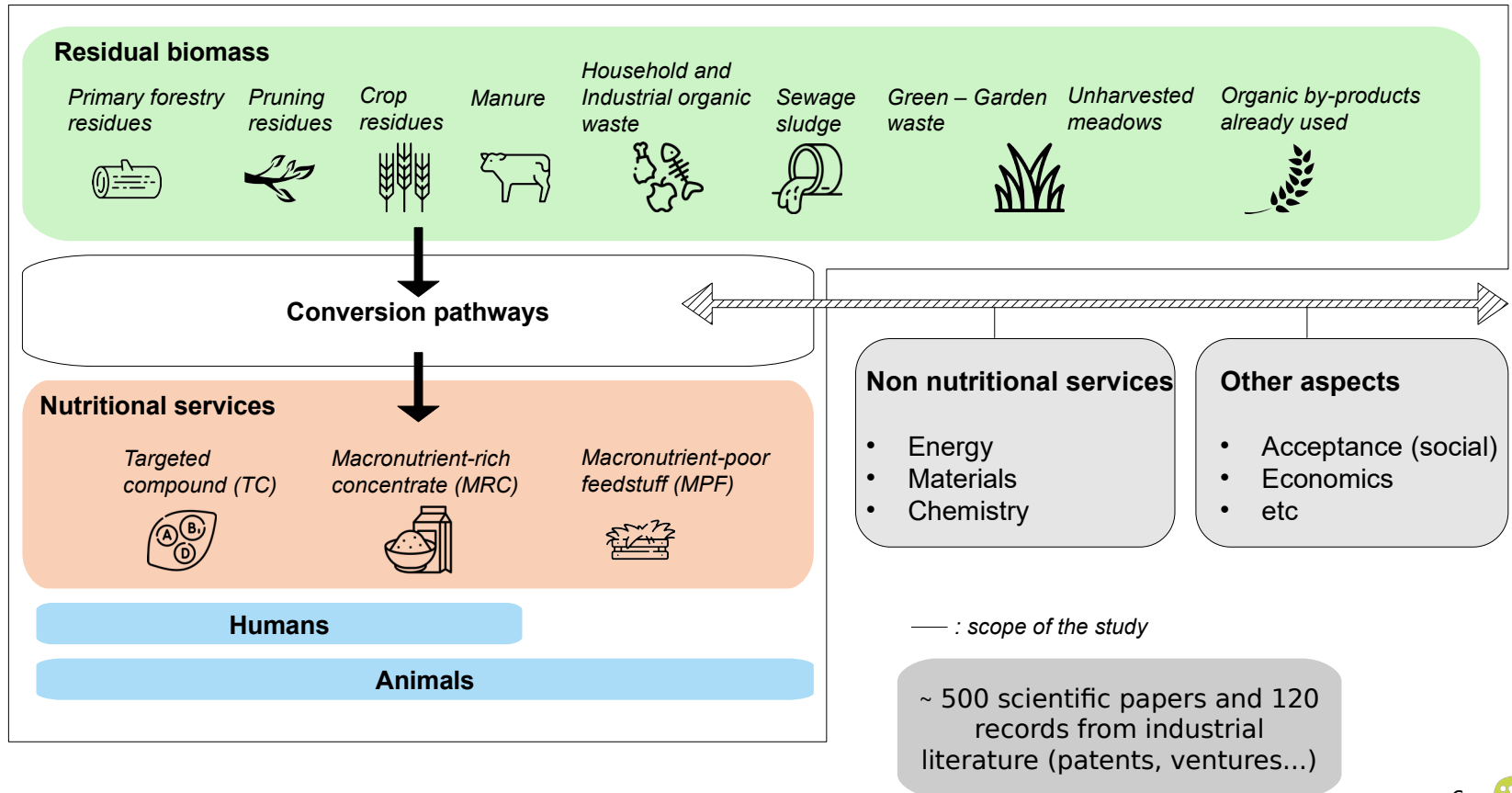
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# Waste-to-nutrition pathways



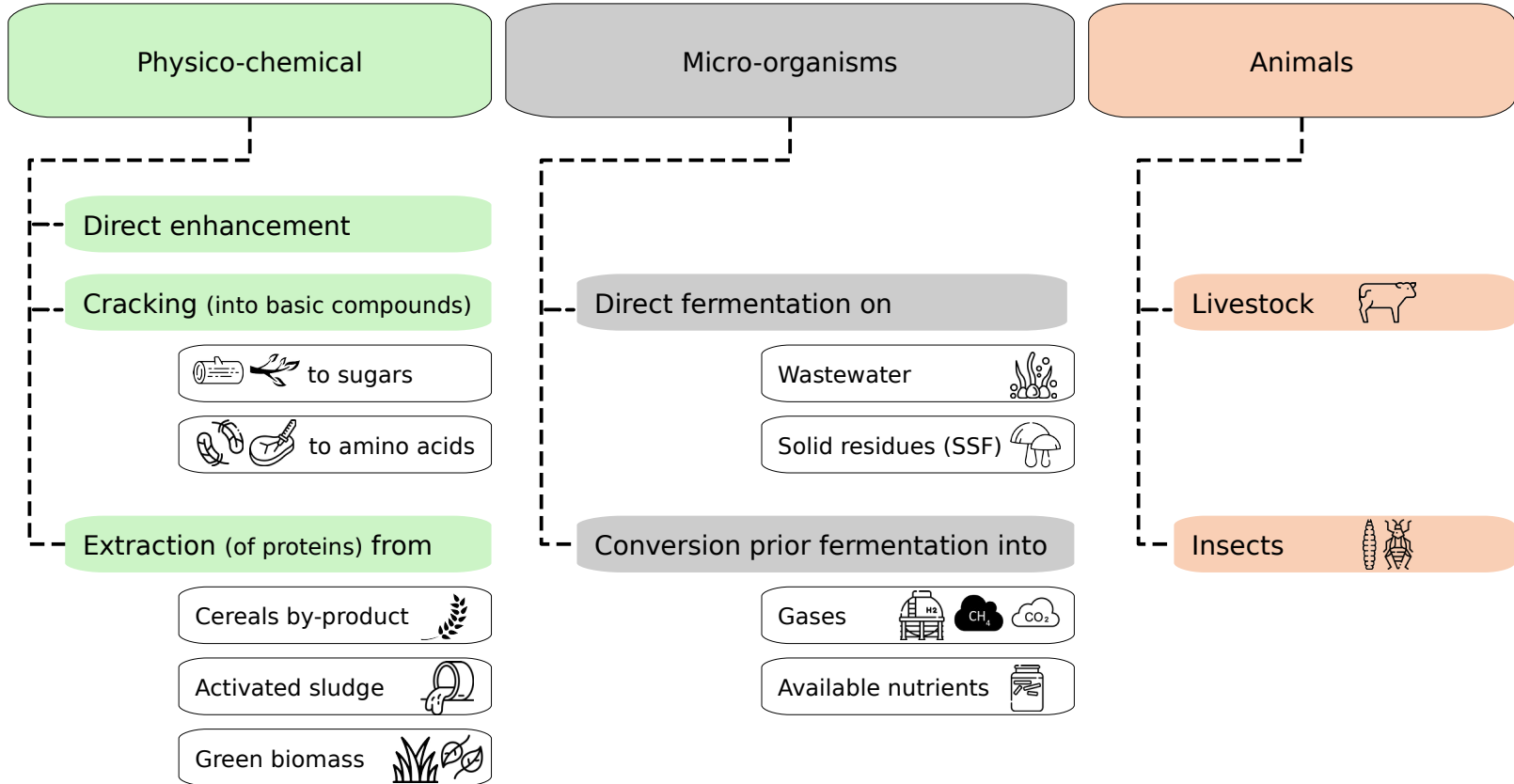
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# Identification



# Identification

## Waste-to-nutrition pathways



# Classification

## Waste-to-nutrition pathways

Physico-chemical

Micro-organisms

Animals

Variety of processes  
reduced in 4 functions :

- Enhancement
- Cracking
- Extraction
- Bioconversion



# Classification

Nutrient recovery ratio:  
high

**Enhancement**  
(of nutritional content and / or assimilation level)

- Drying, milling
- Solid substrate fermentation, ensiling
- ...etc

**Cracking**

- Hydrolysis
- Saccharification
- ... etc

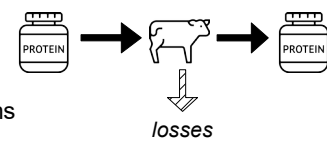
Composition-structure  
change : low

Composition-structure  
change : high

**Extraction**  
(and separation of a fraction)

- Press
- Filtration
- ... etc









**Bioconversion**








- Animals
- Micro-organisms

Nutrient recovery ratio:  
low

# Classification

	FER (kcal kcal <sup>-1</sup> )	PCE (≈NCE) (g <sub>prot</sub> g <sub>prot</sub> <sup>-1</sup> )
	29 [18]	15 [6]
	6 [2.6]	3.3 [1.1]
	5.3 [4.2]	3.5 [1.5]
	5.8 [2.4]	3.7 [1.1]
	4.2 []	3.8 [1.2]
	17.1 [2.9]	7.5 [1.6]
	2.8 [0.8]	4.6 [5.8]
	3 []	2 []

	FER (kcal kcal <sup>-1</sup> )	NCE (g <sub>N</sub> g <sub>N</sub> <sup>-1</sup> )
	5.5 [2.3]	---
	9.7 [4.3]	---
	4.2 [2.1]	<1.1
	1.7 [0.5]	1.8 [0.4]
	---	<1.3

FER : Feed energy conversion to edible energy ratio

PCR : Protein conversion ratio

NCR : Nitrogen conversion ratio

<sup>a</sup>salmon

<sup>b</sup>black soldier fly

<sup>c</sup>mealworm

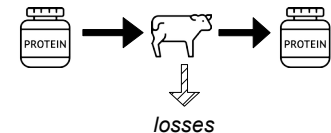
[] : range

<sup>d</sup>mycoprotein

<sup>e</sup>H<sub>2</sub>/CH<sub>4</sub> bacteria

<sup>f</sup>chlorella

<sup>g</sup>spirulina



# Classification

## Waste-to-nutrition pathways

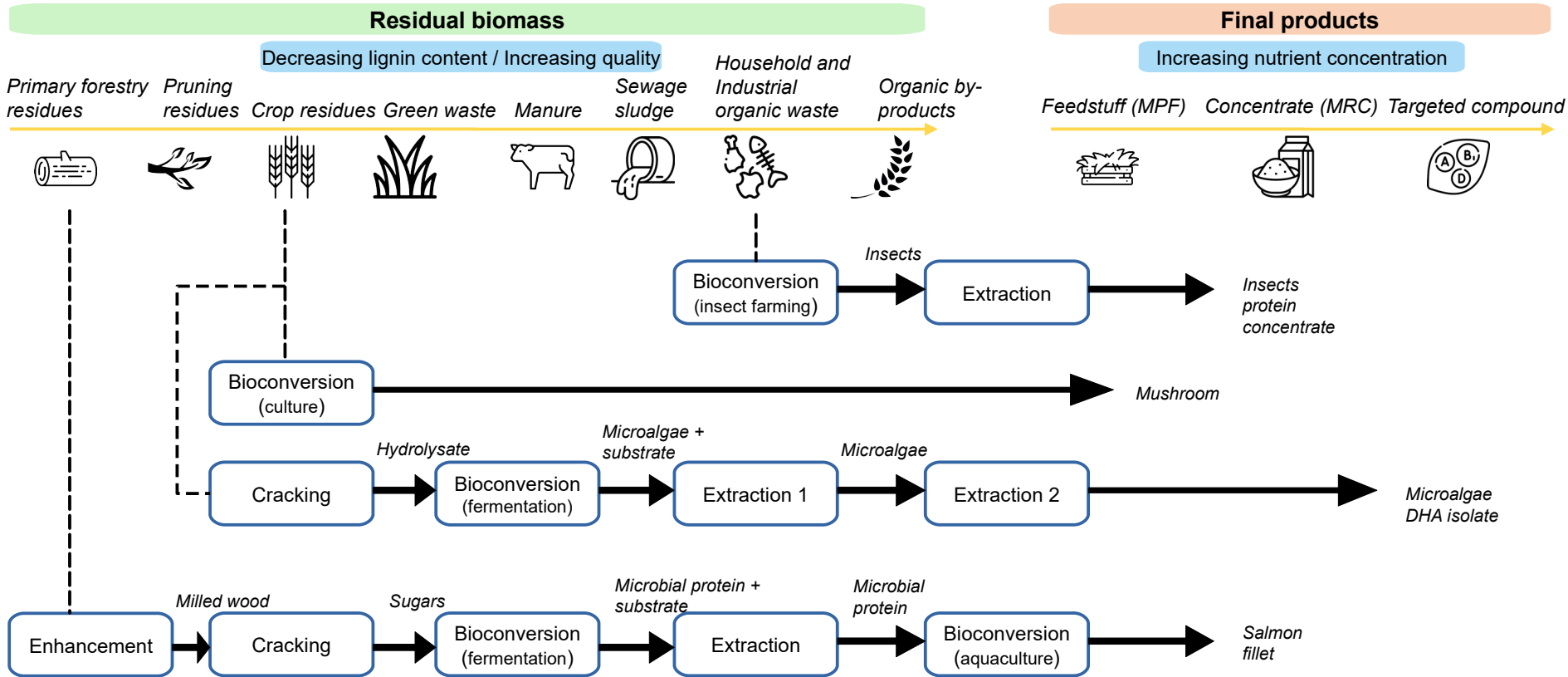
Physico-chemical

Micro-organisms

Animals

Often combined together  
→ Transformation chain

# Classification



# Classification

## Waste-to-nutrition pathways

Physico-chemical

Micro-organisms

Animals

Cumulative drawbacks  
vs  
Multi-function synergies  
→ Need of full assessment

# Classification

## Waste-to-nutrition-related platforms

Physico-chemical

Micro-organisms

Animals\*

Green biorefinery

Lignocellulosic biorefinery

Slaughterhouse recovery

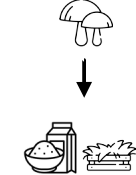
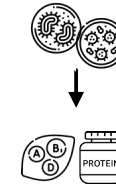
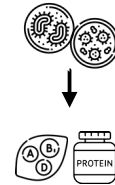
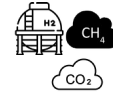
Diverse protein extraction

Gas-intermediate biorefinery

Liquid substrate alternative

Solid substrate fermentation

Insect biorefinery



Development stage

B-C

B

D

B-D

C-D

C-D

D

A

A : already commercialized

B : significant steps to commercialization

C : lab-pilot-scale

D : in development

\*: common livestock not displayed here as already established

# Thanks for your attention



Carbon management towards low fossil carbon use

<https://cambioscop.cnrs.fr/>



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