



# Environmental Sustainability Assessment of Valorizing Orange Peels Waste in Animal Feed Production

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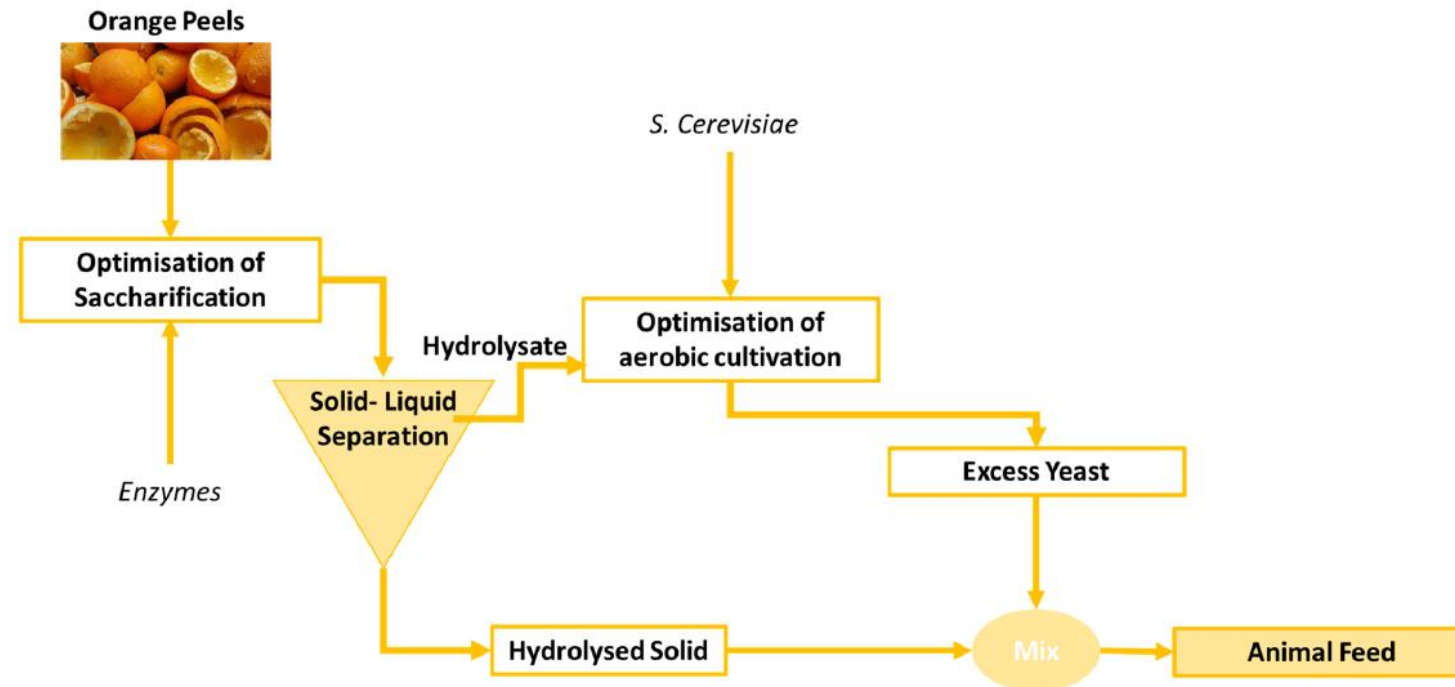


<sup>3</sup>AZTI, Bizkaiko Zientzia eta Teknologia Parkea, Astondo Bidea, Derio (Bizkaia) Spain



# Waste valorization for animal feed production

- Need for sustainable development in terms of the safe reuse of waste biomass.
- Production of high-value **secondary feedstuff for dairy sheep** from **waste orange peels** has been suggested<sup>1</sup> as a sustainable option:



<sup>1</sup> Andrianou, C.; Passadis, K.; Malamis, D.; Moustakas, K.; Mai, S.; Barampouti, E.M. Upcycled Animal Feed: Sustainable Solution to Orange PeelsWaste. Sustainability, 2023,15(3), 2033.

## **The environmental benefits and impacts of this valorization strategy?**

- The environmental impacts of turning waste orange peels into high-value secondary feedstuff for dairy sheep were quantified through LCA

# Life Cycle Assessment

Functional Unit: **1 ton of animal feed produced**

System Boundary: Cradle to Grave

Inputs: Pilot plant data

Software Tool: SimaPro 9.3.0.3

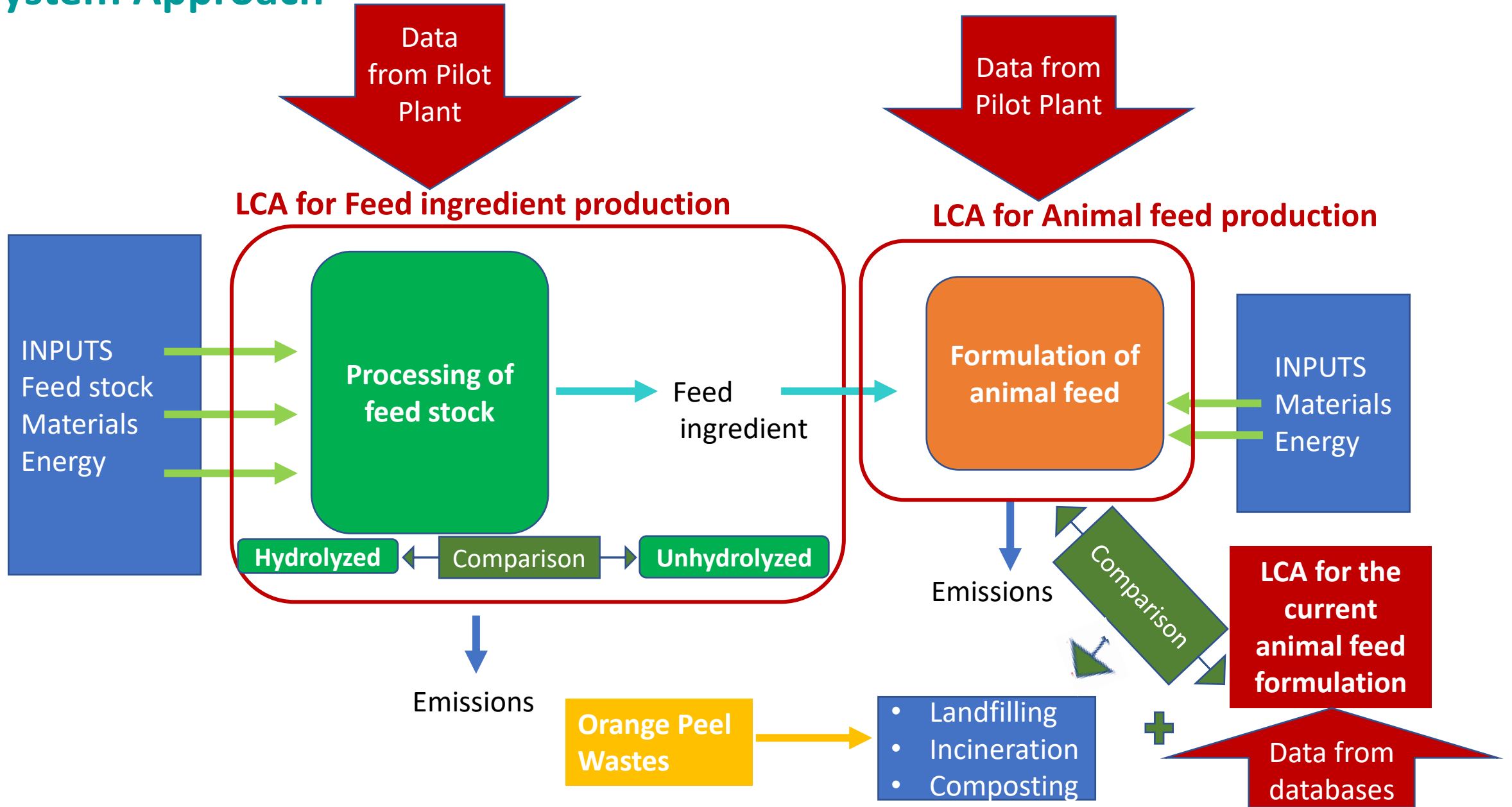
Database: Ecoinvent 3.7 (primarily)

Impact Analysis Method: Recipe 2016 (H) 

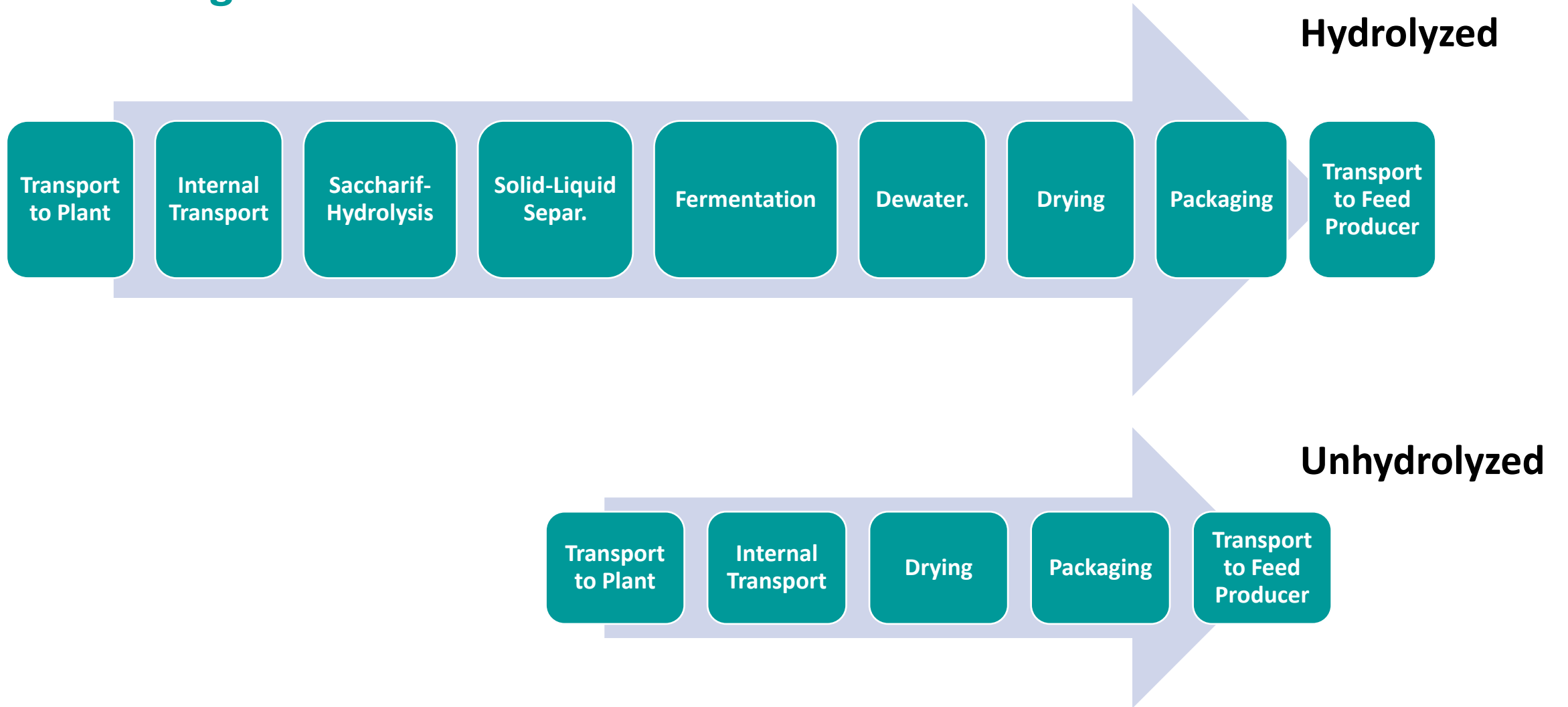
## Impact categories

Midpoint	Endpoint
Global warming	Human Health
Stratospheric ozone depletion	Ecosystems
Ionizing radiation	Resources
Ozone formation, Human health	
Fine particulate matter formation	
Ozone formation, Terrestrial ecosystems	
Terrestrial acidification	
Freshwater eutrophication	
Marine eutrophication	
Terrestrial ecotoxicity	
Freshwater ecotoxicity	
Marine ecotoxicity	
Human carcinogenic toxicity	
Human non-carcinogenic toxicity	
Land use	
Mineral resource scarcity	
Fossil resource scarcity	
Water consumption	

# System Approach



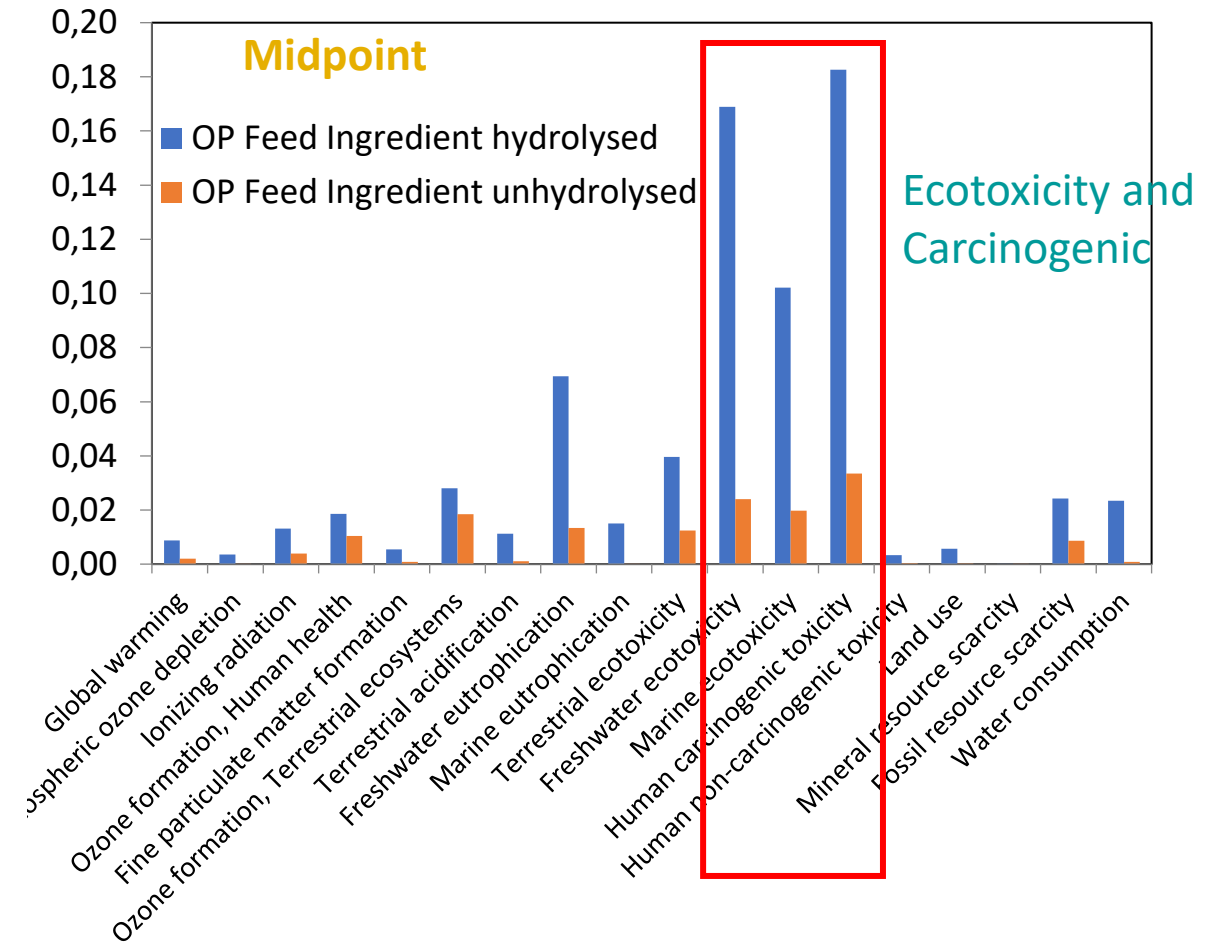
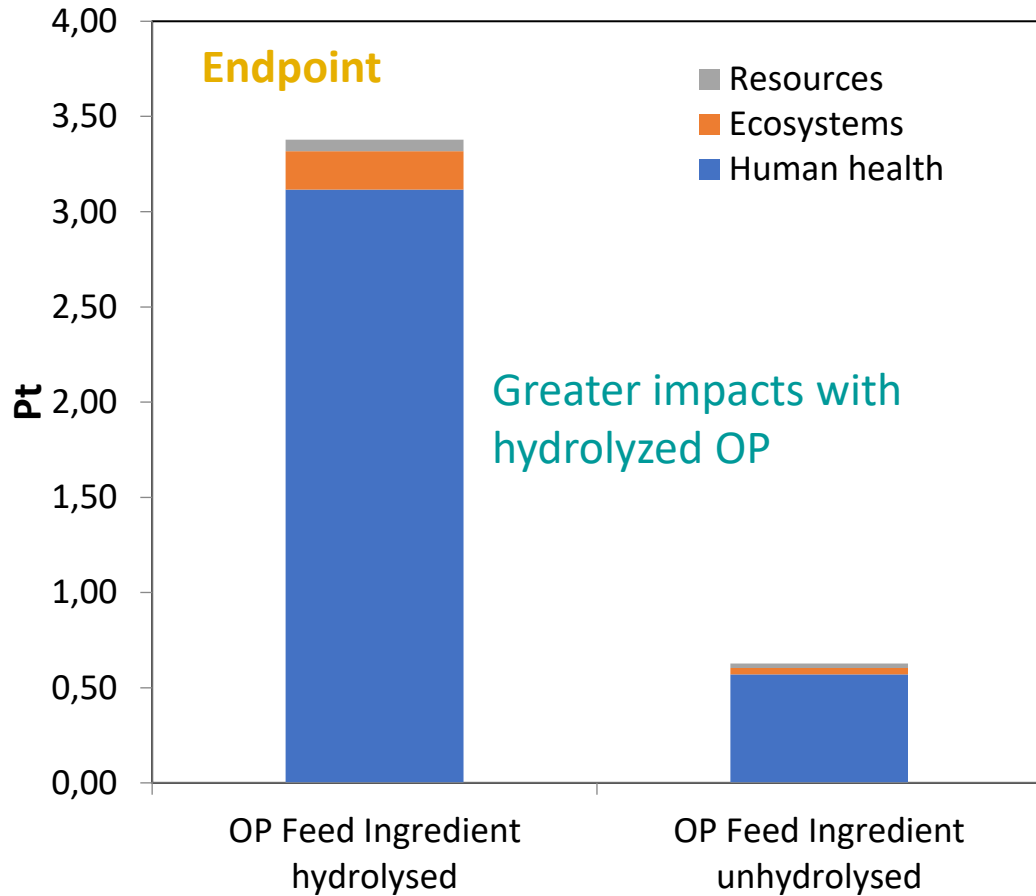
# Feed Ingredient Production - Process Flow



# **LCA Results for Animal Feed Ingredient Production**

# LCA Results for Animal Feed Ingredient Production

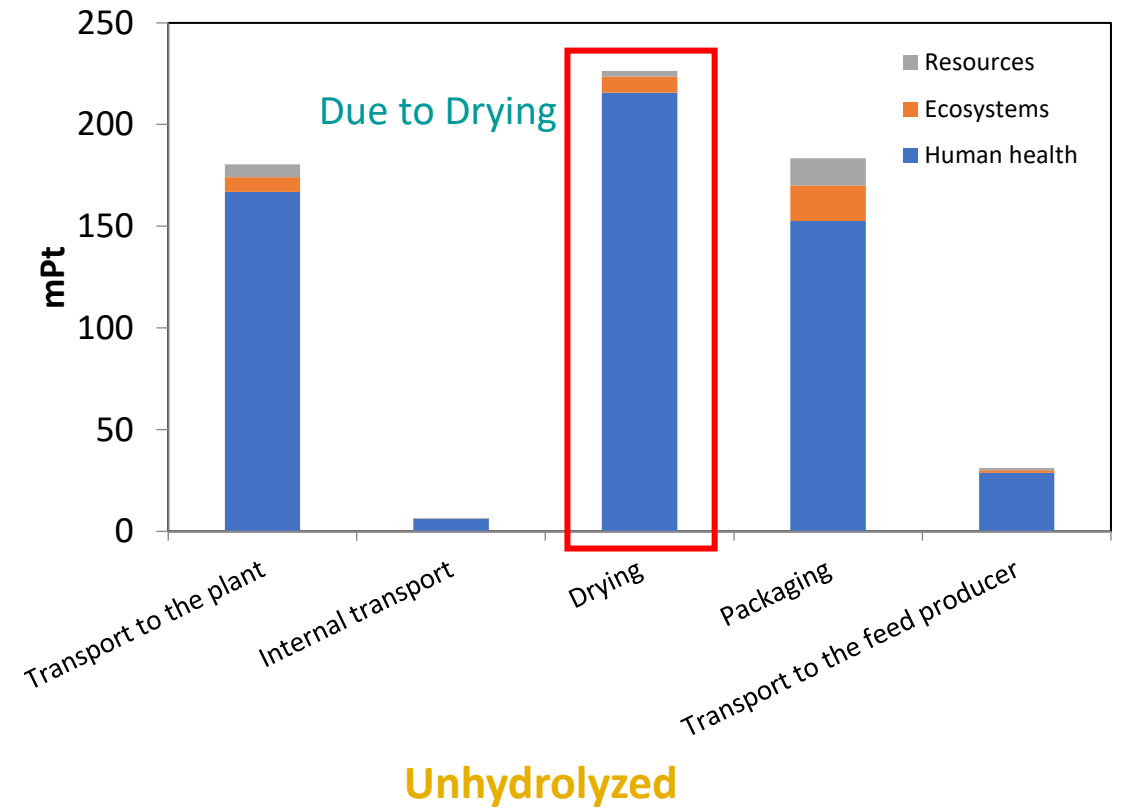
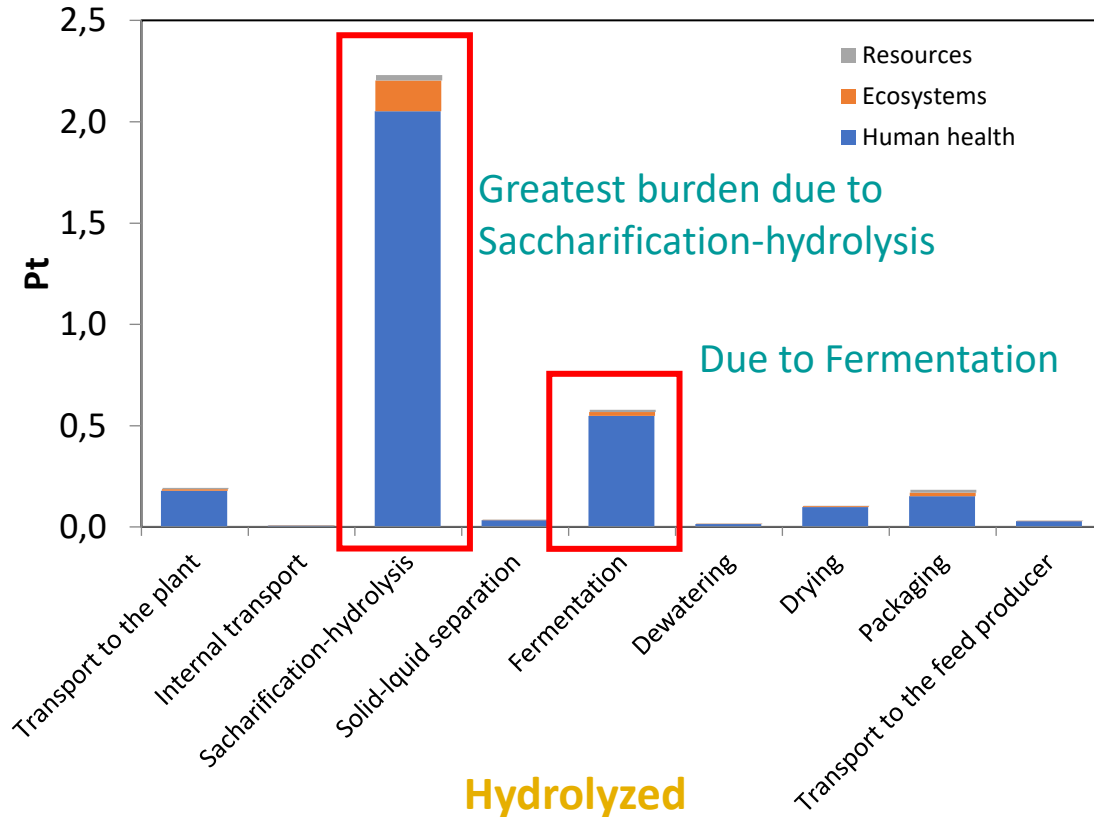
ReCiPe





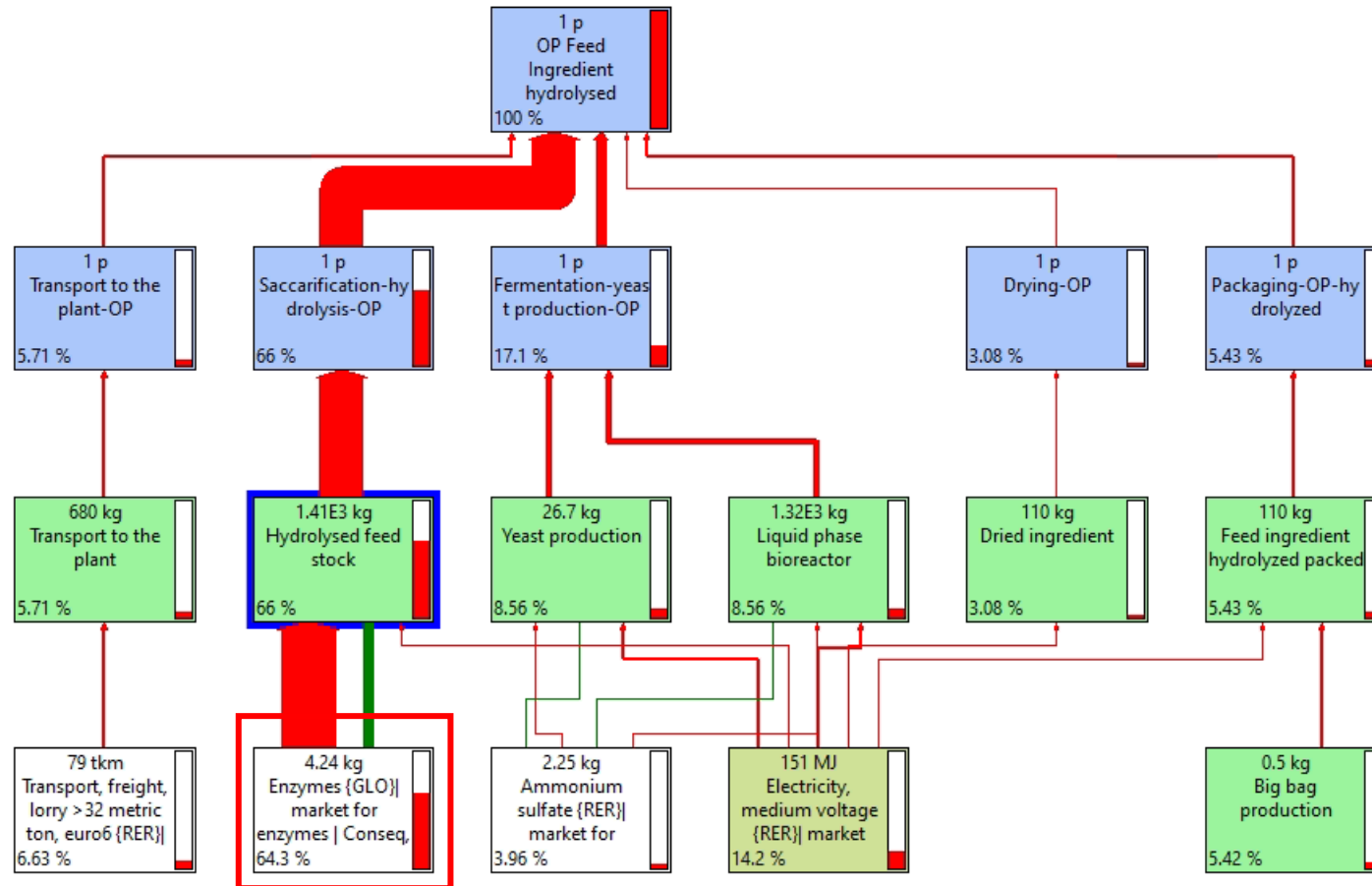
# LCA Results for Animal Feed Ingredient Production

## ReCiPe Endpoint



## Process impact contributions

# Contribution by Enzyme is 64.3%!



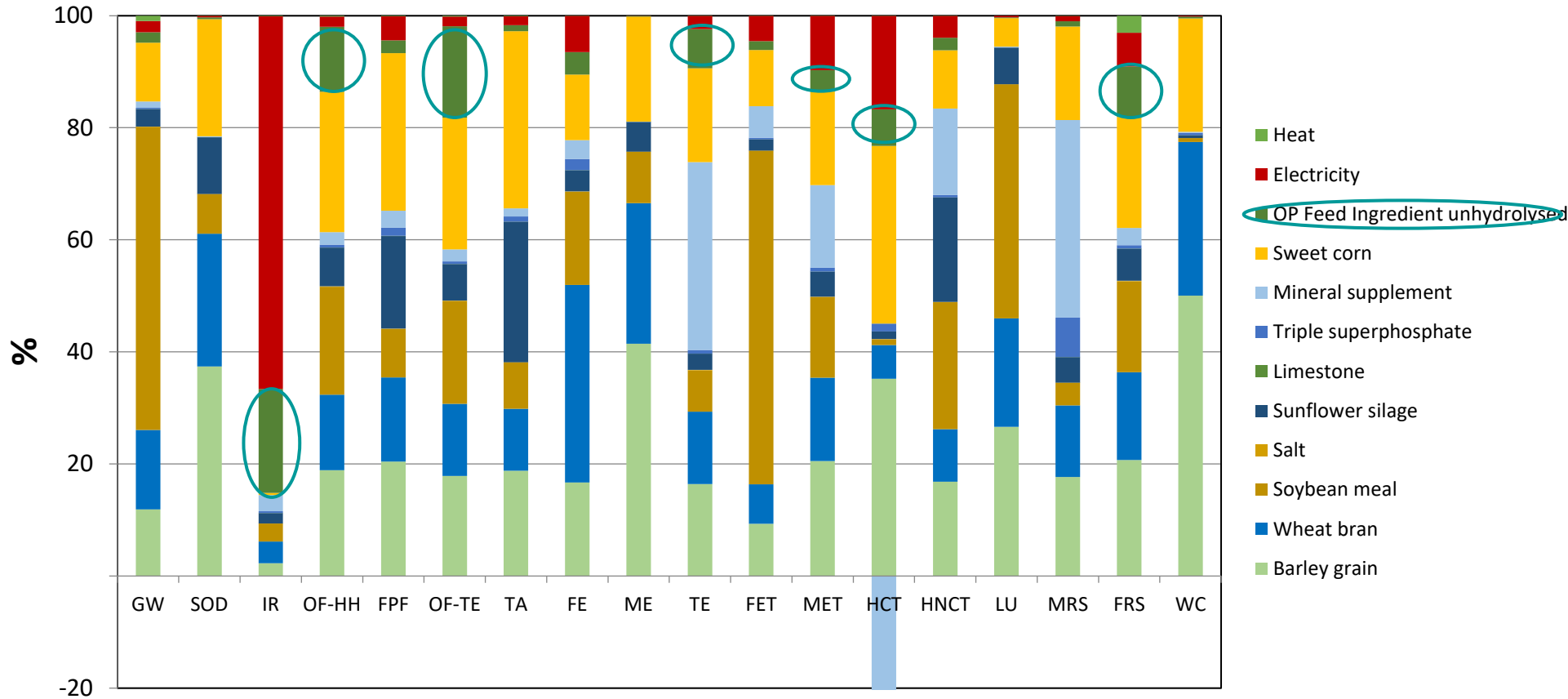
# LCA Results for Animal Feed Preparation

## Animal Feed Diet for Dairy Sheep

Ingredient	Control (kg/ton)	w/ Orange peel hydrolyzed (kg/ton)	w/ Orange peel unhydrolyzed (kg/ton)
Corn grain	300	300	300
Barley grain	200	200	200
Wheat bran	200	120	120
Soybean meal	110	110	110
Sunflower meal	150	120	120
Limestone	5	5	5
Monocalcium phosphate	5	5	5
Salt	5	5	5
Vitamin & mineral premix	25	25	25
Orange peel based feed ingredient	0	110	110

# LCA Results for Animal Feed Preparation

## ReCiPe Midpoint

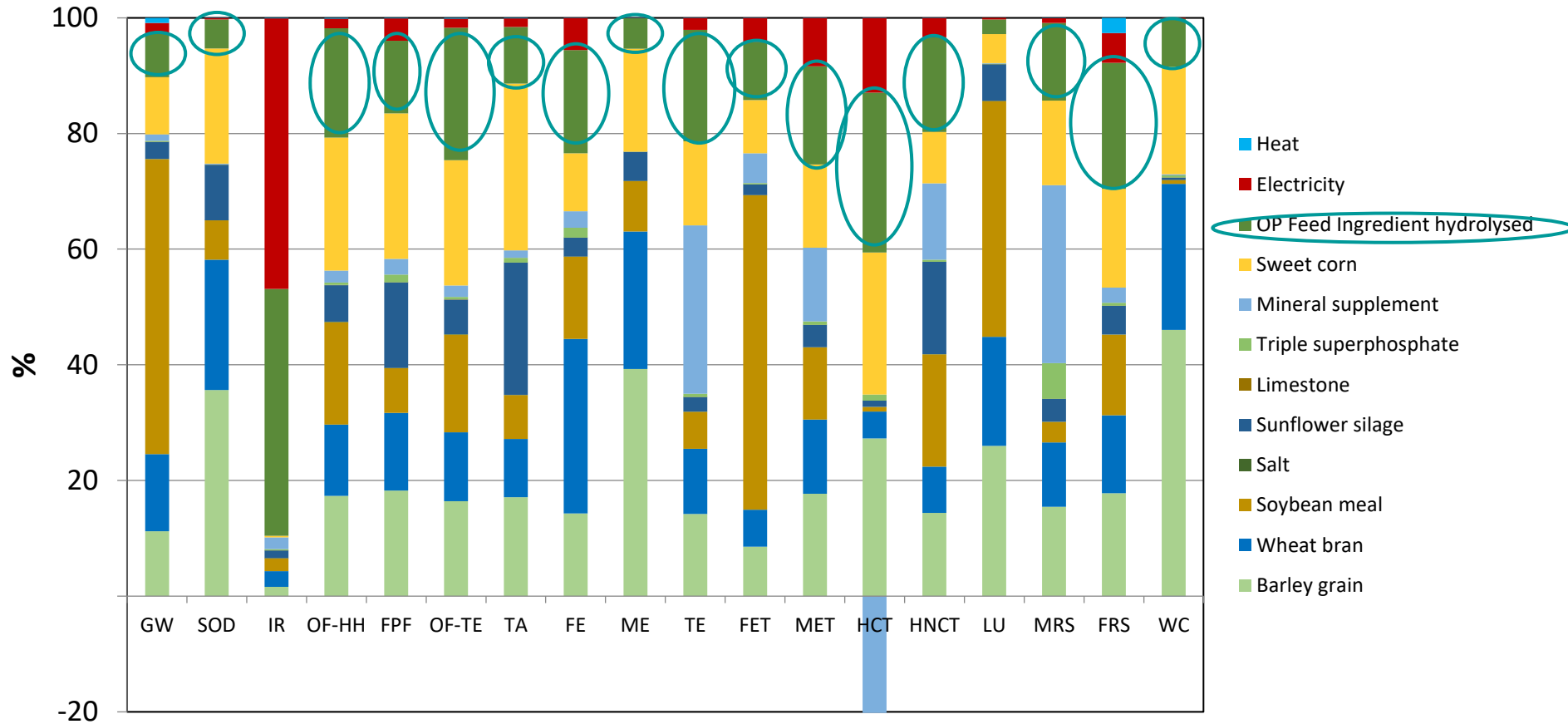


GW	Global warming
SOD	Stratospheric ozone depletion
IR	Ionizing radiation
OF-HH	Ozone formation, Human health
FPF	Fine particulate matter formation
OF-TE	Ozone formation, Terrestrial ecosystems
TA	Terrestrial acidification
FE	Freshwater eutrophication
ME	Marine eutrophication
TE	Terrestrial ecotoxicity
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MET	Marine ecotoxicity
HCT	Human carcinogenic toxicity
HNCT	Human non-carcinogenic toxicity
LU	Land use
MRS	Mineral resource scarcity
FRS	Fossil resource scarcity
WC	Water consumption

Unhydrolyzed feed stock

# LCA Results for Animal Feed Preparation

## ReCiPe Midpoint

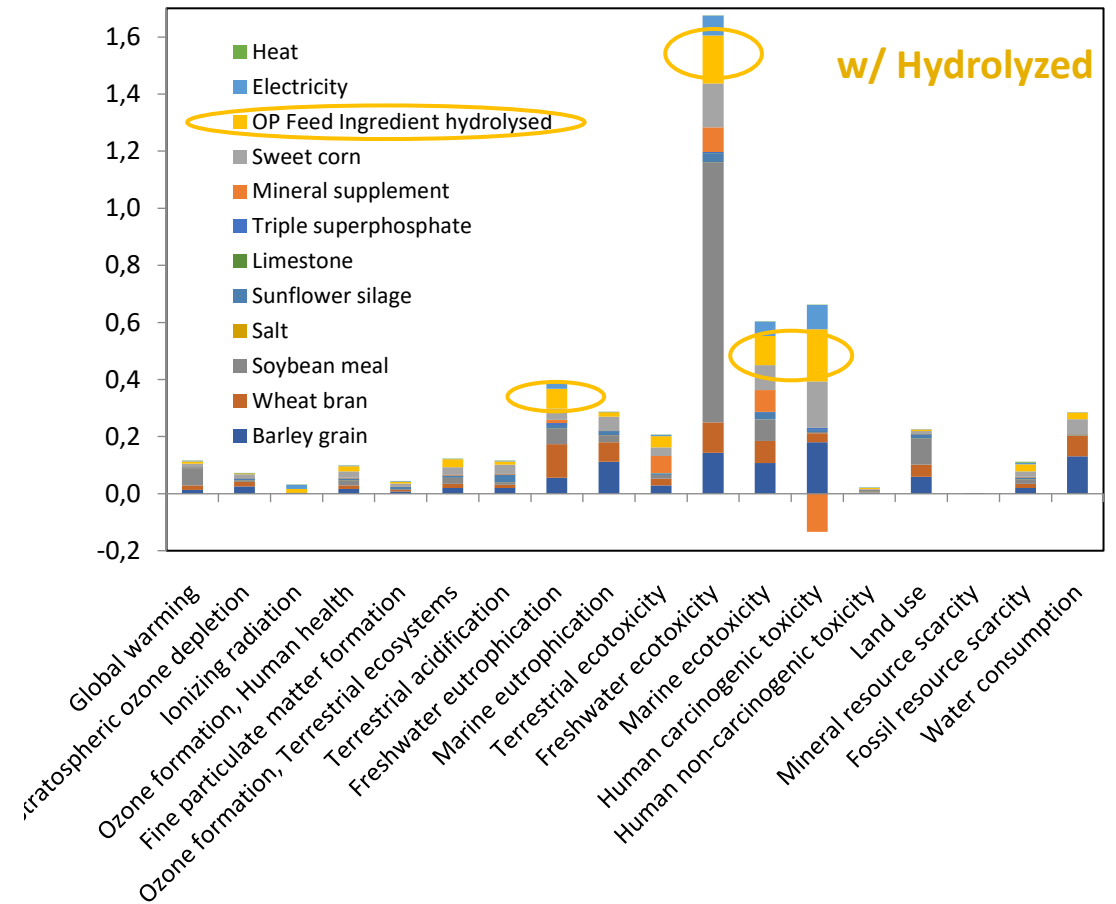
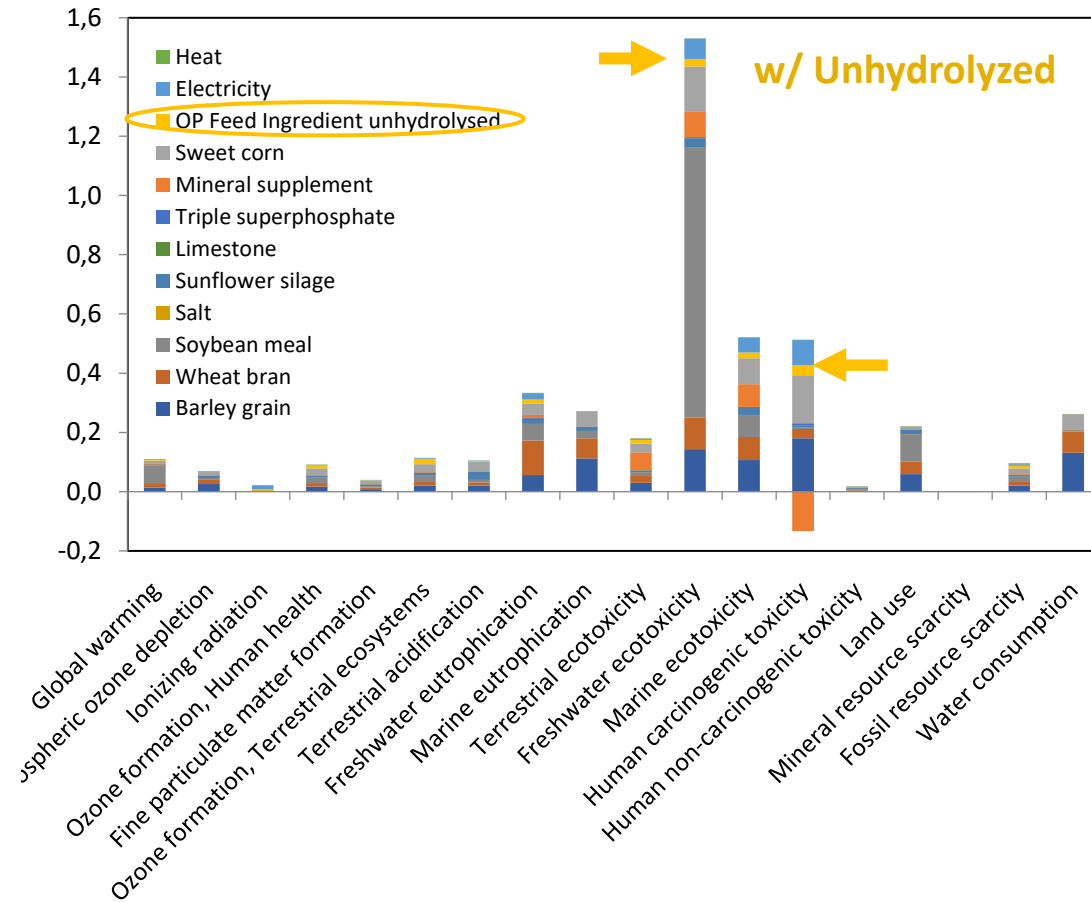


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## Hydrolyzed feed stock

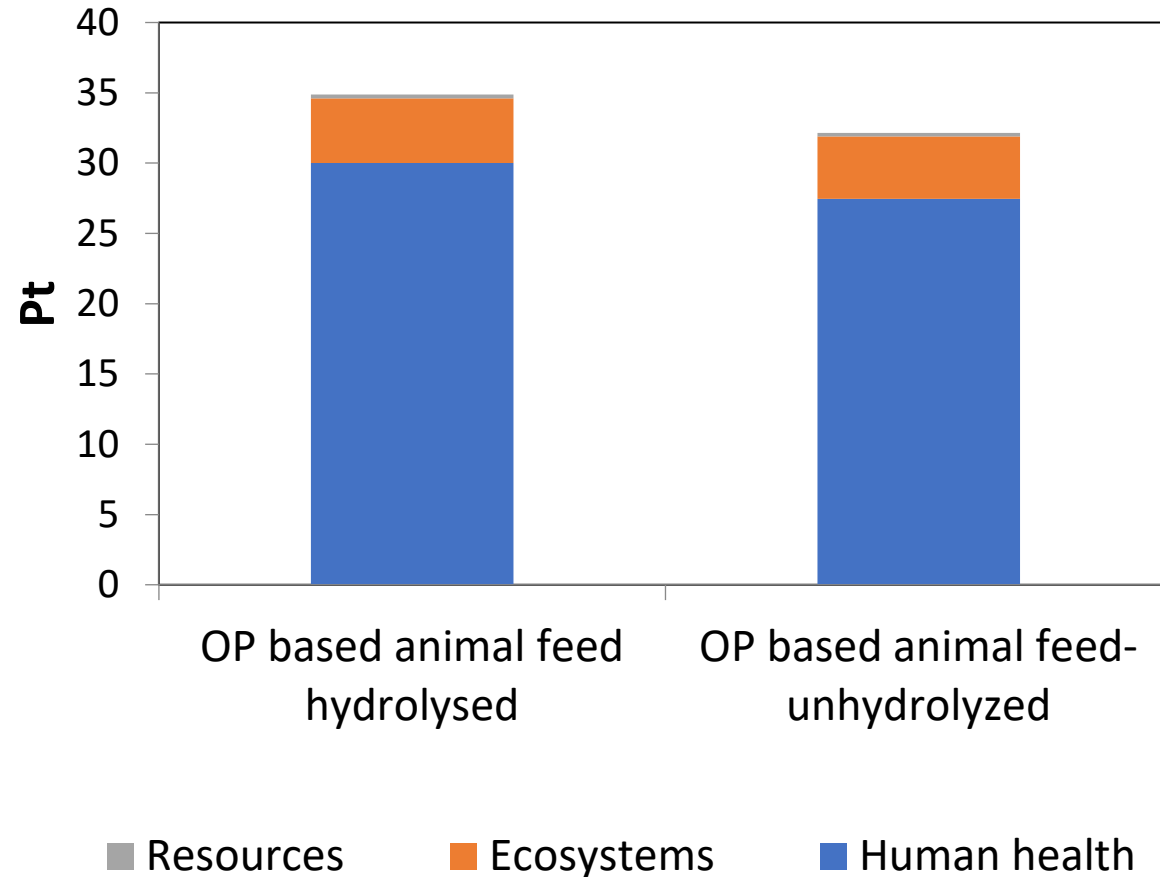
# Normalized Impacts: Animal Feed Preparation

## ReCiPe Midpoint



# Animal Feed: with Hydrolyzed vs Unhydrolyzed Feed Ingredient

ReCiPe Endpoint



No remarkable difference!



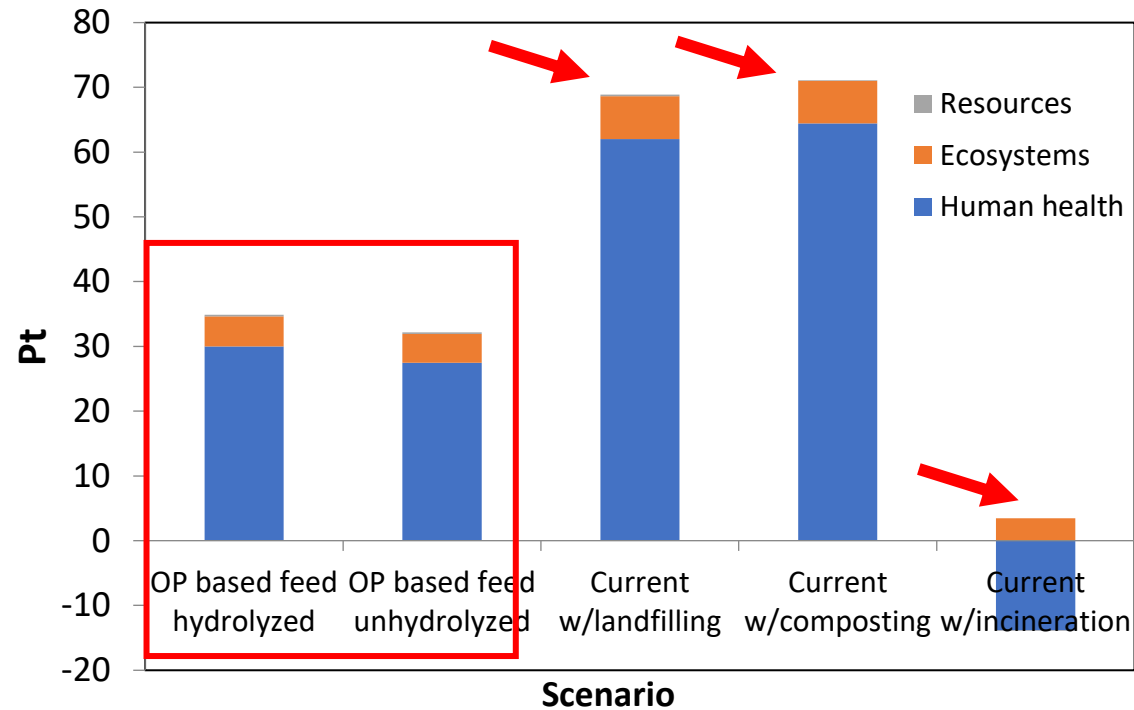
# Comparison with Current Situation

- Conventional feed for dairy sheep

Ingredient	Kg/ton feed
Corn grain	300
Barley grain	200
Wheat bran	200
Soybean meal	110
Sunflower meal	150
Limestone	5
Monocalcium phosphate	5
Salt	5
Vitamin & mineral premix	25

- Possible waste disposal scenarios
  - Waste Treatment, composting of food waste, EU27
  - Waste Treatment, Incineration of waste, food, EU27
  - Waste Treatment, Landfill of waste, food, EU27

# Comparison with Current Situation



- No remarkable difference between hydrolyzed and unhydrolyzed OP based feed animal
- Smaller burden than the current situation with control feed + composting & landfilling, but higher than + incineration

# Conclusions

- Hydrolyzed orange peel has a remarkably higher impact (80%) than unhydrolyzed one.
- Enzyme consumption plays a critical role in the proposed valorization process and may require the optimization of enzyme use.

However,

- When integrated into the animal feed this remarkable difference decreased remarkably (8% only)
- Comparison to the current situation revealed that the proposed valorization process is superior for the disposal scenario of composting (45%) and landfilling (50%), though not for incineration (-7%).

So, the proposed valorization process offers a good sustainable option for the livestock sector.



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FEED FROM FOOD INDUSTRY  
BY-PRODUCTS

## Acknowledgment

Turn food industry by-products into secondary feedstuffs  
via circular-economy schemes

Thank you for listening...