Comparative Life Cycle Costing and Life Cycle Assessment of Animal Feed Ingredient Production from Grape Stems, Orange Peels, and Olive Cake

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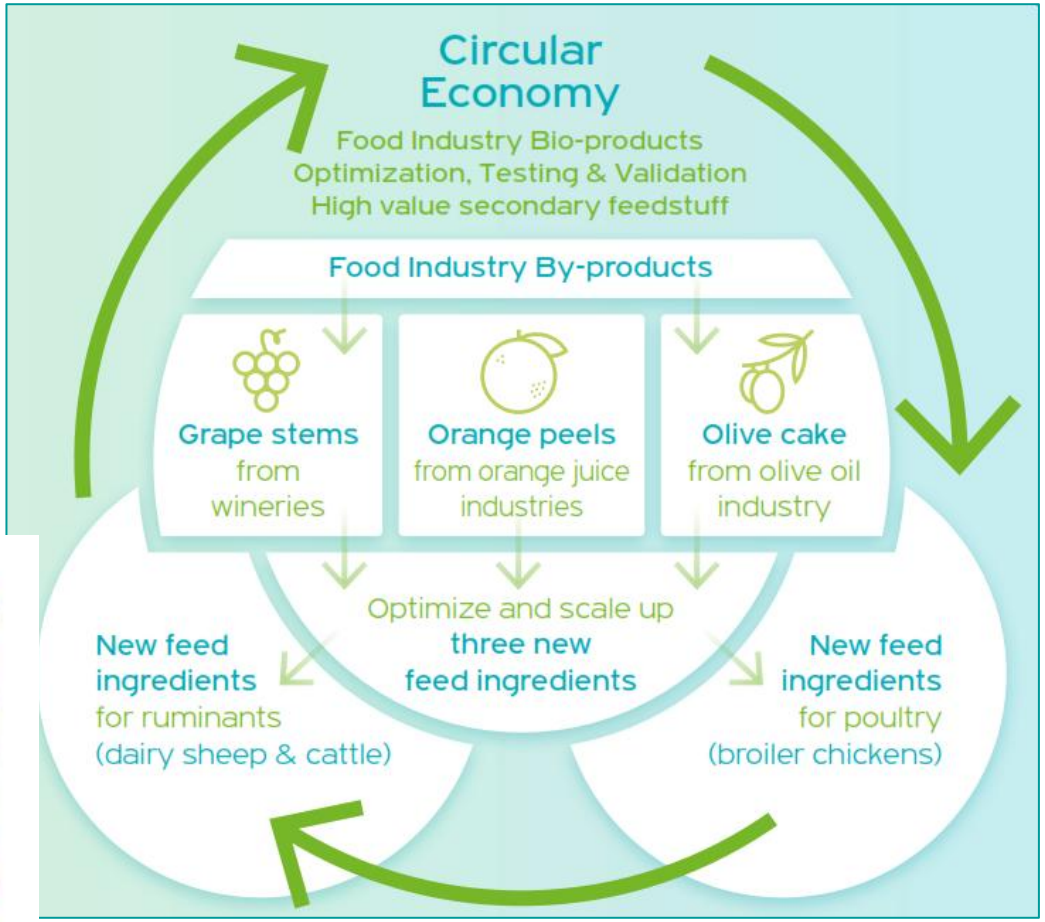
Outline

- The chains considered
- Life cycle assessment (LCA) Results
  - Animal feed ingredient production
  - Animal feed production
- Life cycle costing (LCC) Results

Three value chains

Production of high-value secondary feedstuff for animals from waste grape stems, waste orange peels, and waste olive cake as a sustainable option



Two main components:

The environmental impacts of turning wastes into high-value secondary feedstuff for animals were quantified through LCA

The life cycle costing of turning wastes into high-value secondary feedstuff for animals were quantified through LCC

LCA Results for Animal Feed Ingredient Production

Grape Stem Study - Approach

OPTION 1

OPTION 2

Comparison

Comparison

STAGE 1 Production of GS Feed Ingredient w/ Hydrolysis

STAGE 2 Production of Animal Feed with Hyrolyzed GS
- For dairy sheep
- For dairy cow

Other Ingredients

Data from Pilot Plant

STAGE 1 Production of GS Feed Ingredient w/o Hydrolysis

STAGE 2 Production Animal Feed with Non-hydrolyzed GS
- For dairy sheep
- For dairy cow

Other Ingredients

Data from Pilot Plant

BUSINESS-AS-USUAL

Disposal of GS
Scenario 1 Incineration
Scenario 2 Composting
Scenario 3 Landfill

+

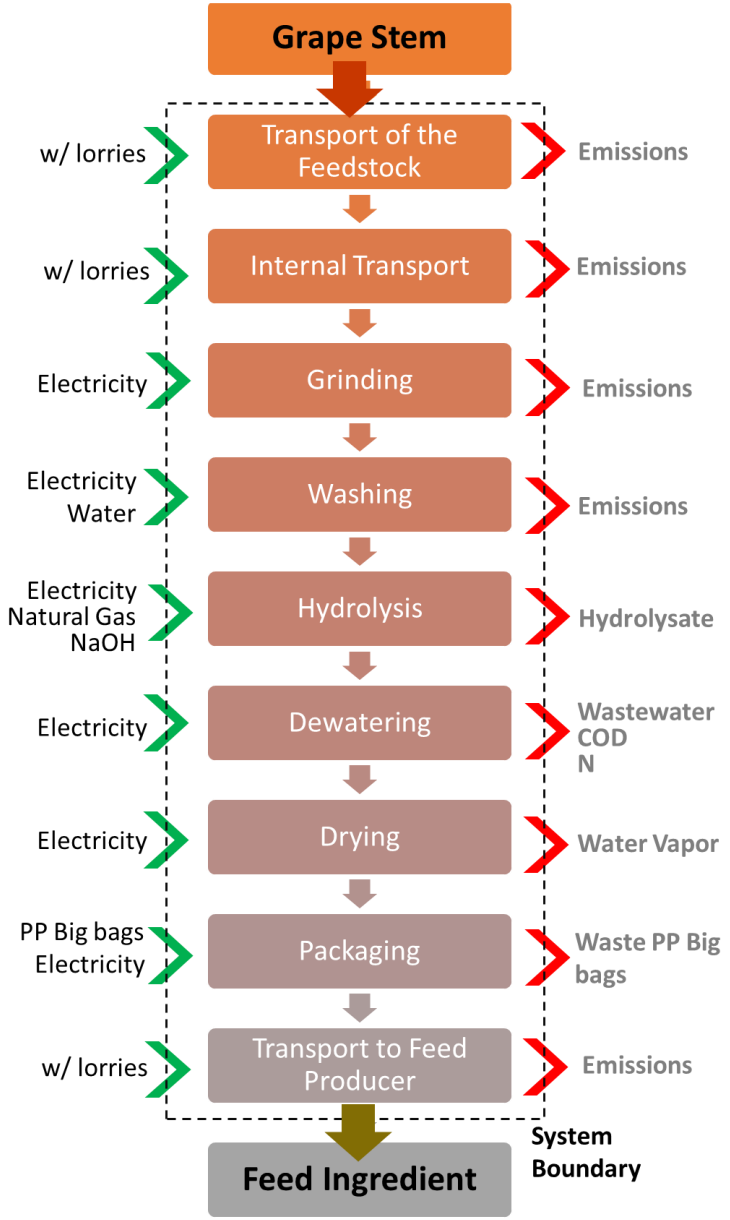
Production of Conventional Animal Feed
- For dairy sheep
- For dairy cow

Ingredients

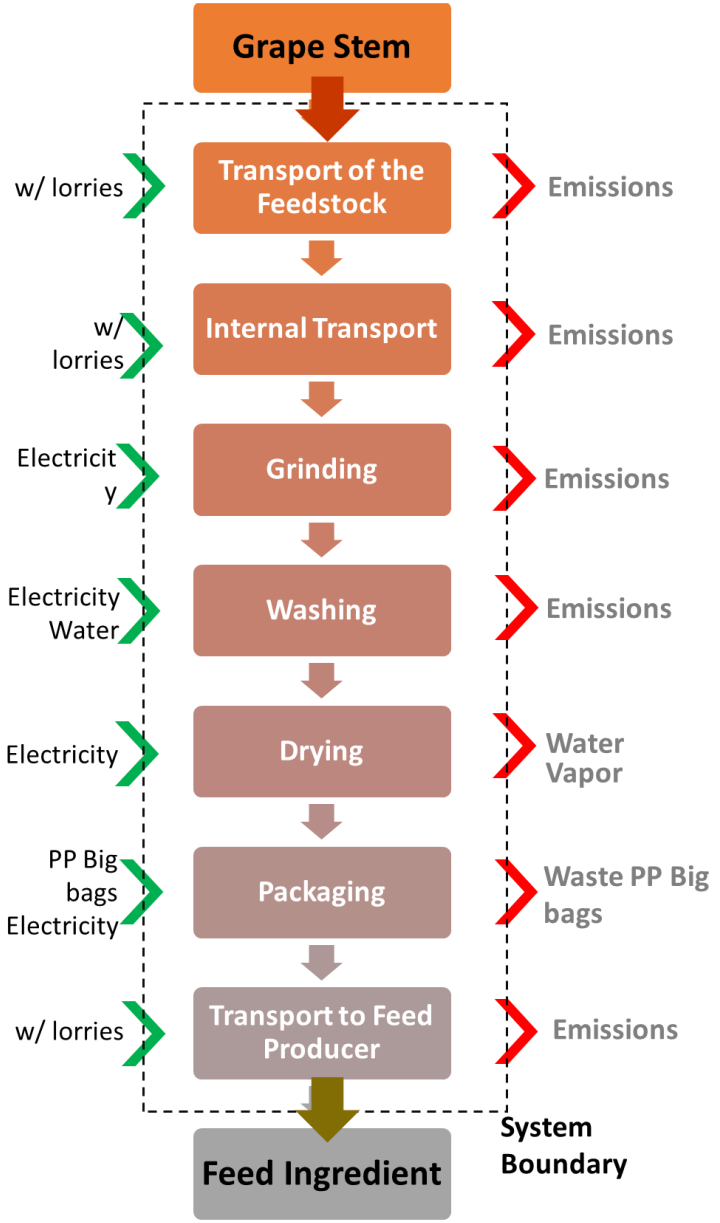
Data from Databases

Grape Stem - Stage 1

Hydrolyzed Feed Ingredient

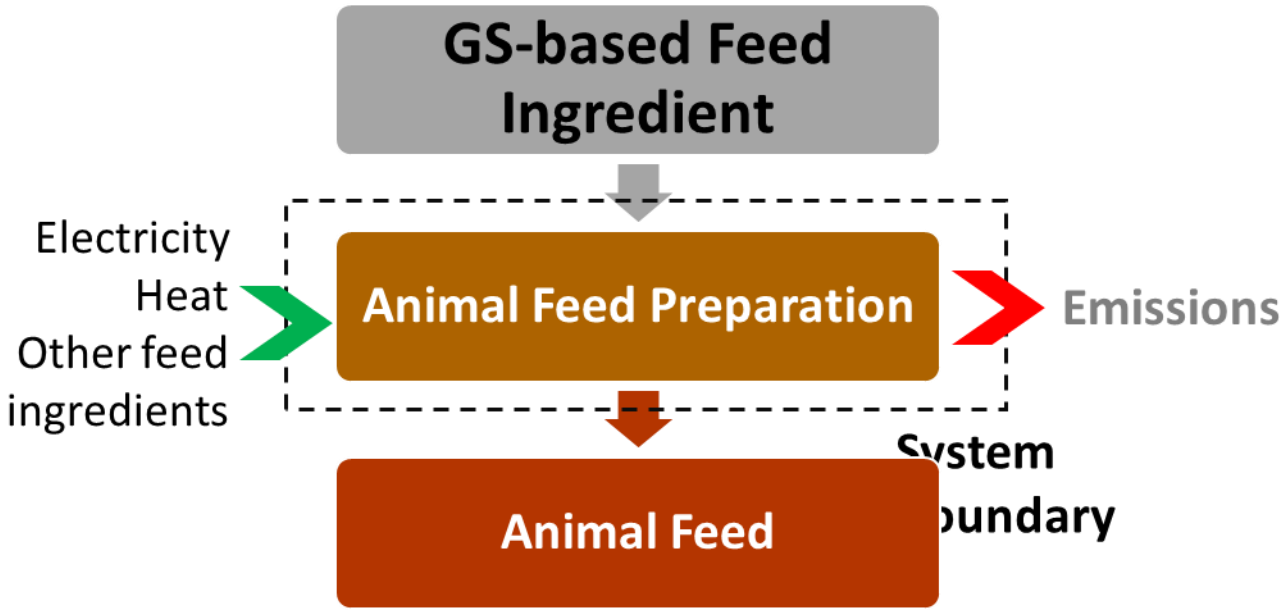


Non-Hydrolyzed Feed Ingredient

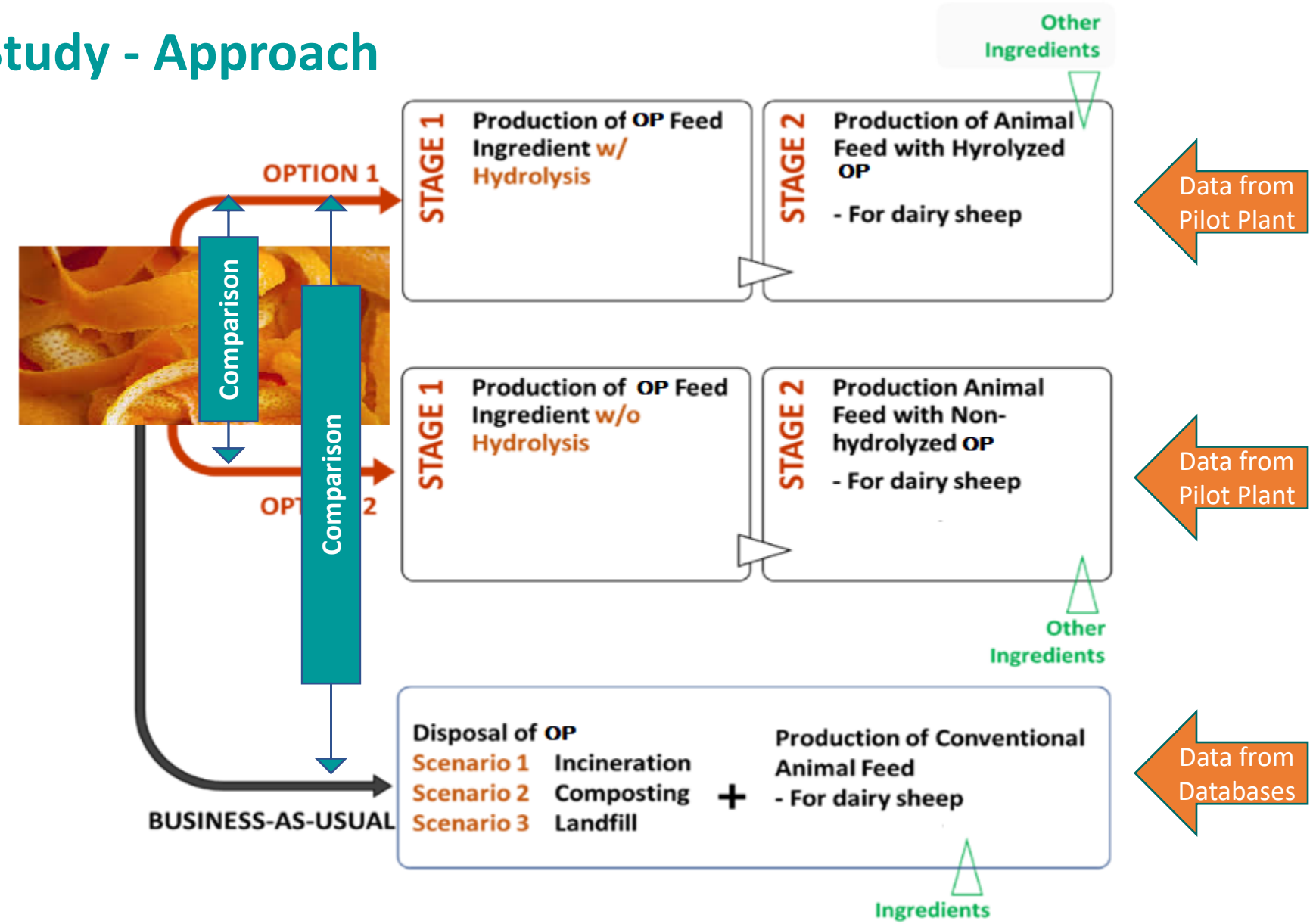


Animal Feed Production

Grape Stem - Stage 2

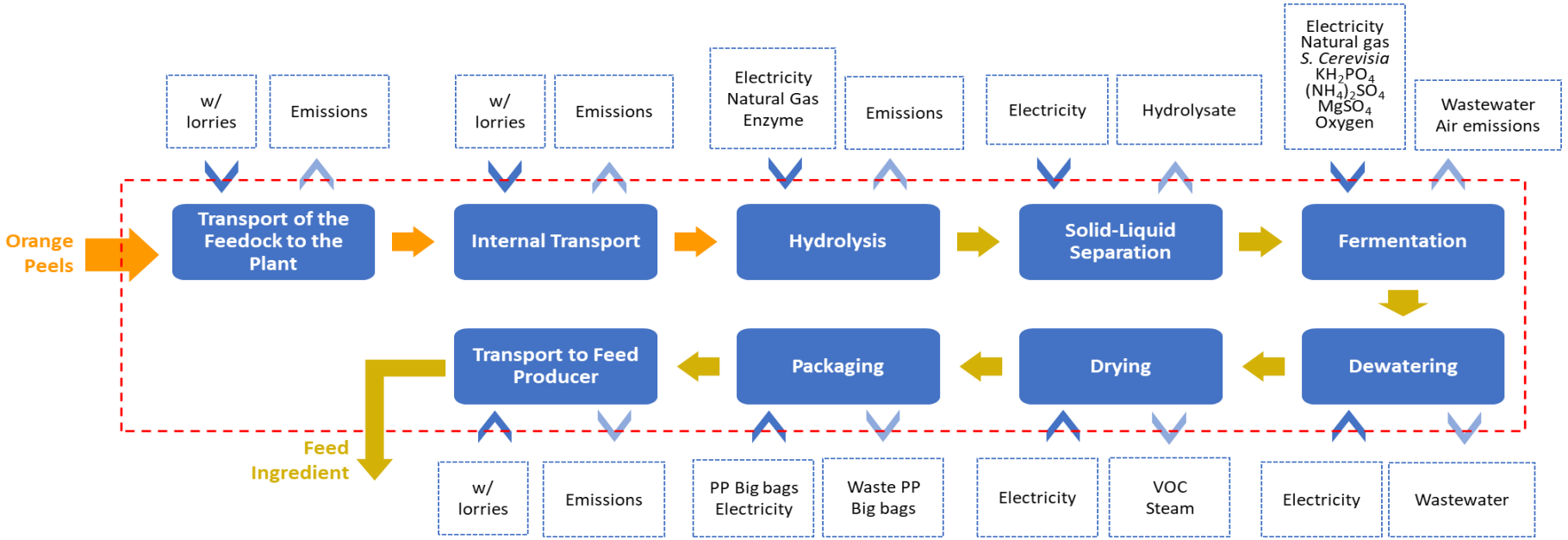


Orange Peel Study - Approach

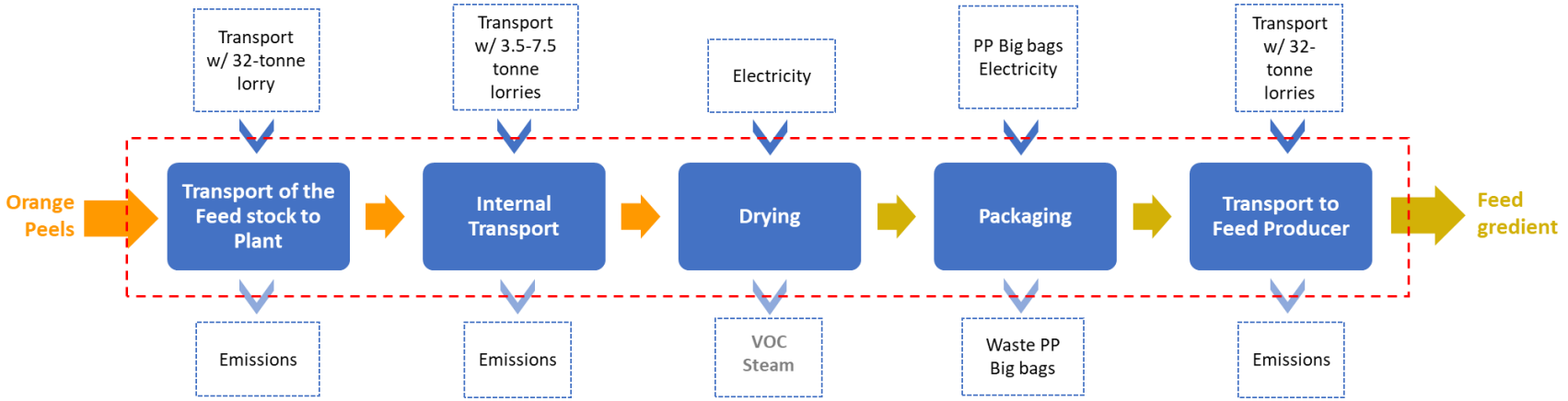


Orange Peel - Stage 1

Hydrolyzed Feed Ingredient

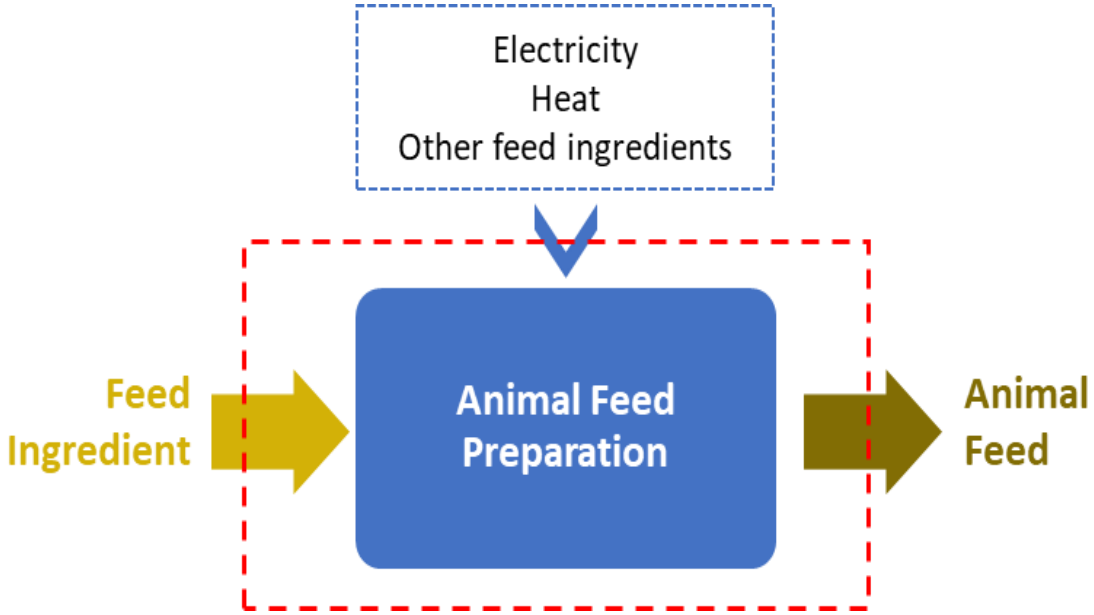


Non-Hydrolyzed Feed Ingredient



Animal Feed Production

Orange Peel - Stage 2



Olive Cake - Approach

STAGE 1
- Production of OC Feed Ingredient w/ SSF

OPTION 1

Other Ingredients

STAGE 2
- Production of OC-based Animal Feed w/o Supplements
- For Poultry

Data from Pilot Plant

OPTION 2

STAGE 2
- Production of OC-based Animal Feed w/ Supplements
- For Poultry

Data from Pilot Plant

Other Ingredients Supplements

BUSINESS-AS-USUAL

Disposal of OC
- Scenario 1 Incineration
- Scenario 2 Composting
- Scenario 3 Landfill

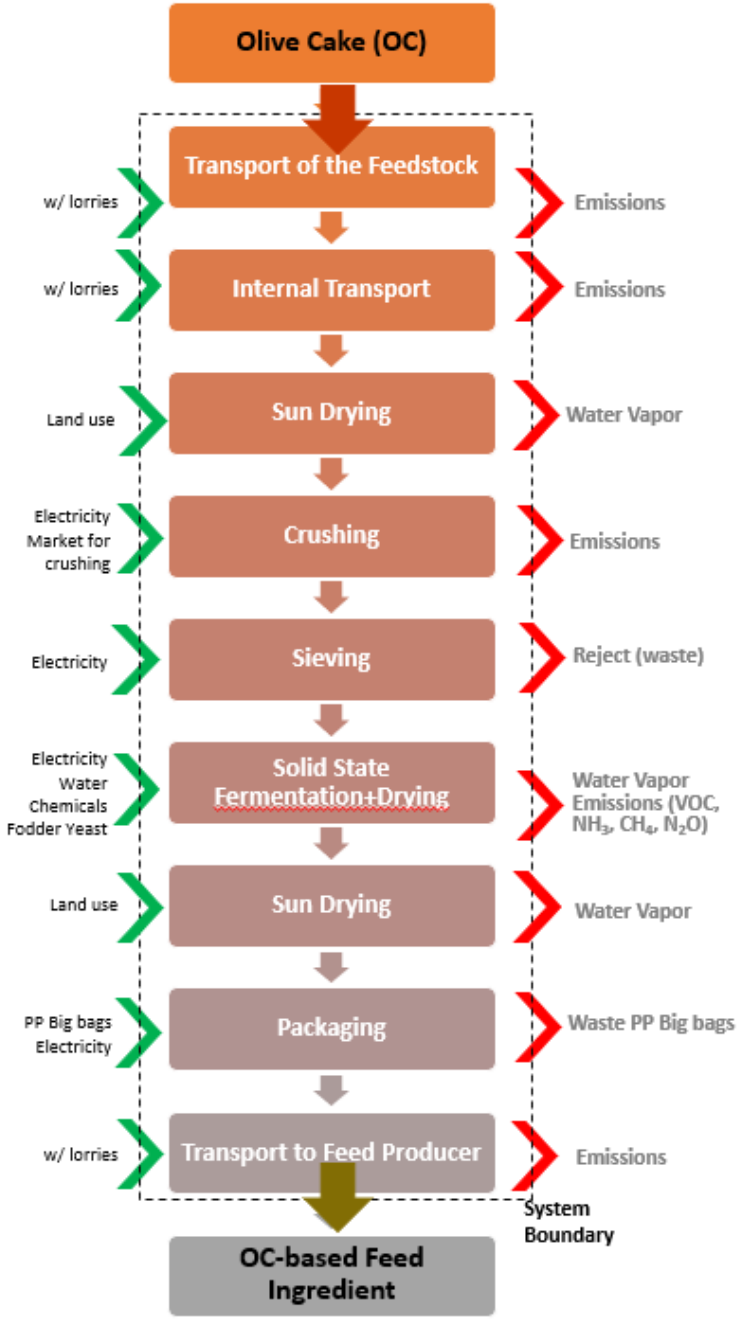
+

Production of Conventional Animal Feed
- For Poultry

Data from Databases

Ingredients

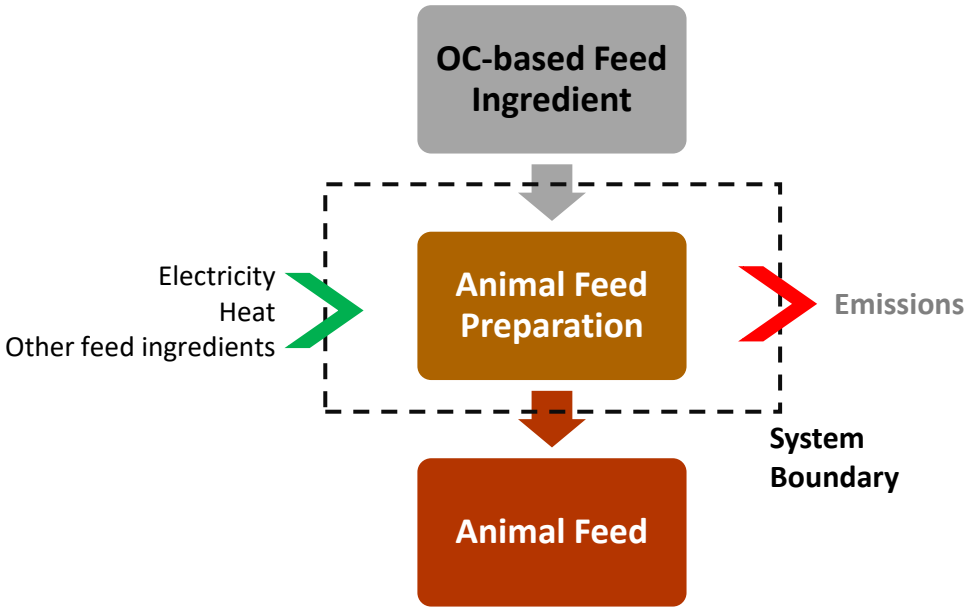
Olive Paste - Stage 1



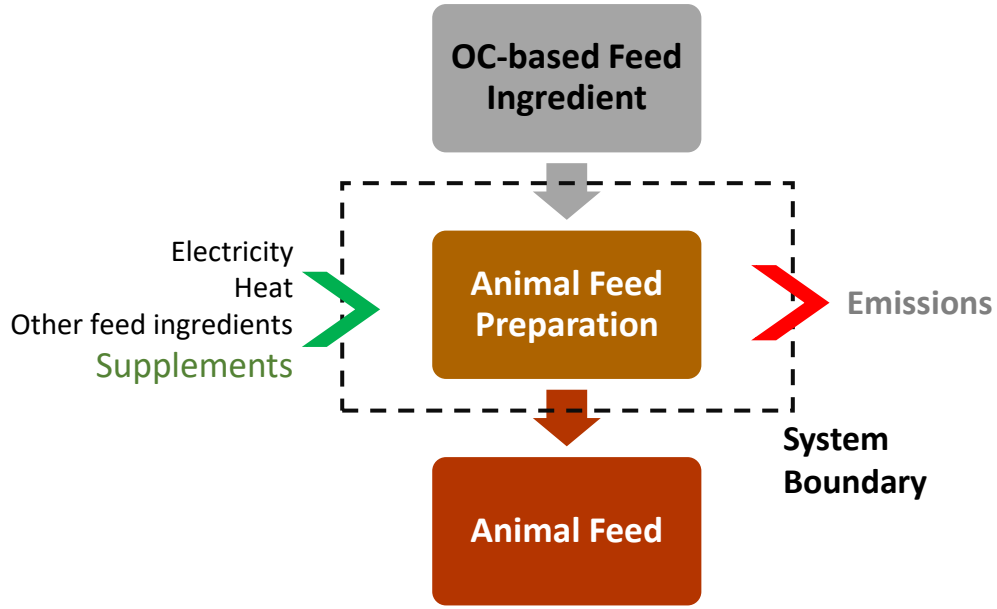
Animal Feed Production

Olive Paste - Stage 2

w/o Supplements

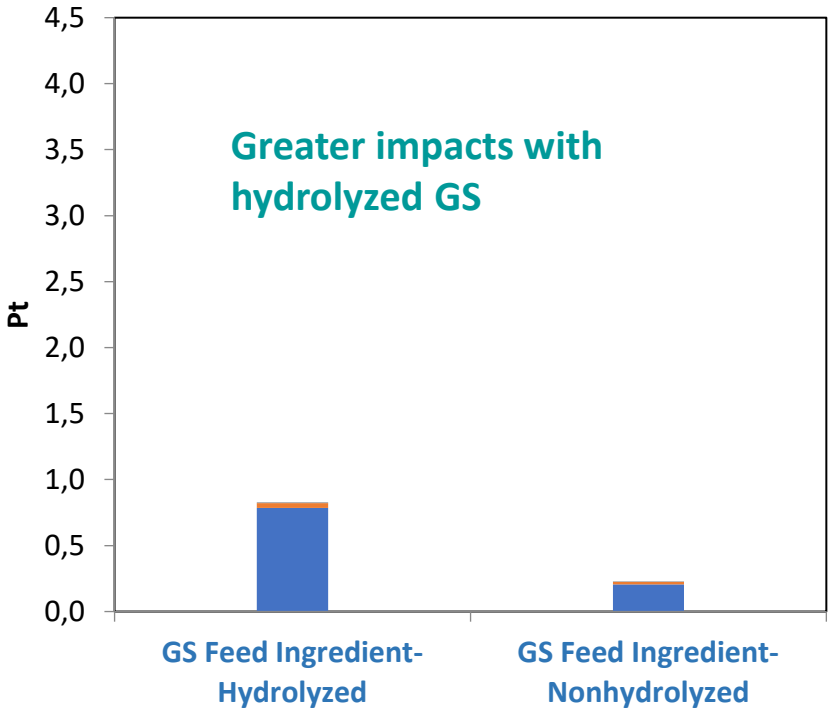


w/ supplements (Yeast+Herbs)

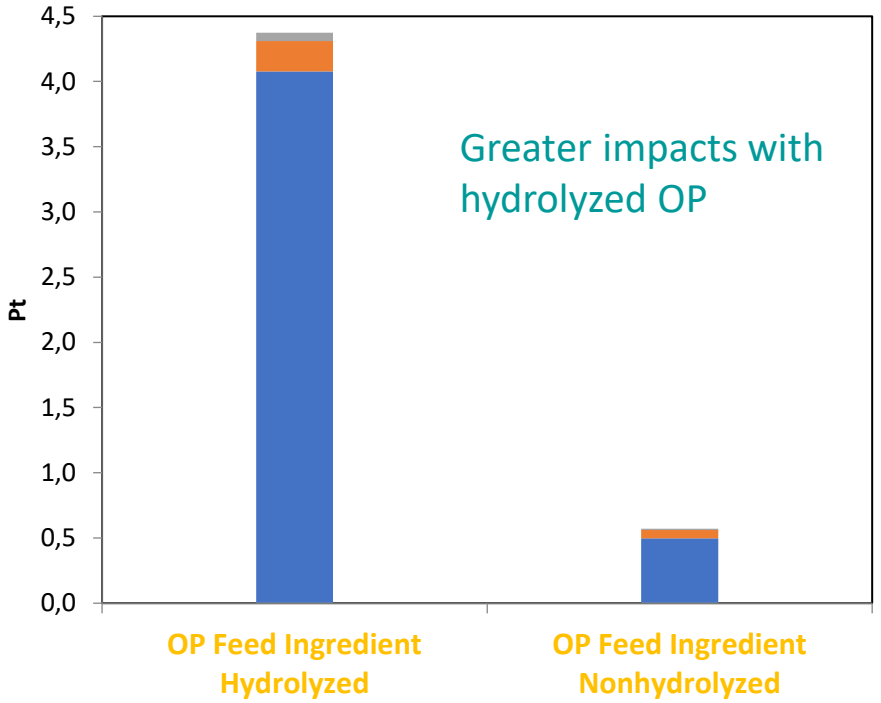


LCA Results for Animal Feed Ingredient Production

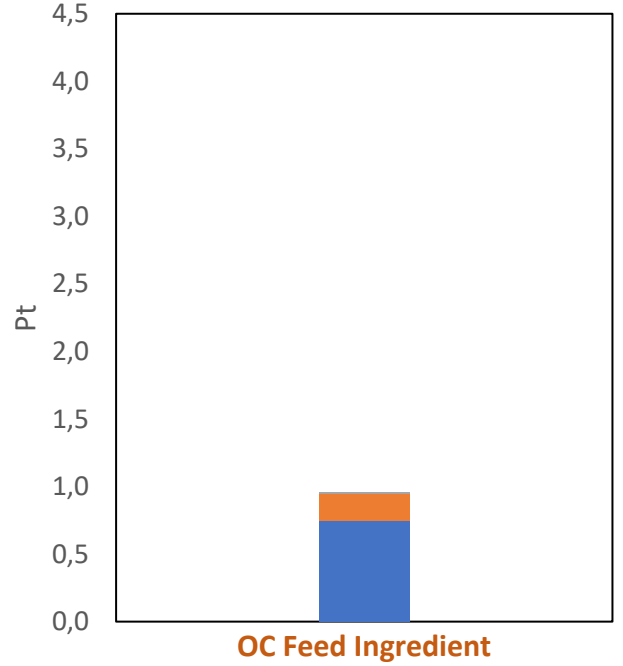
Grape Stem



Orange Peel

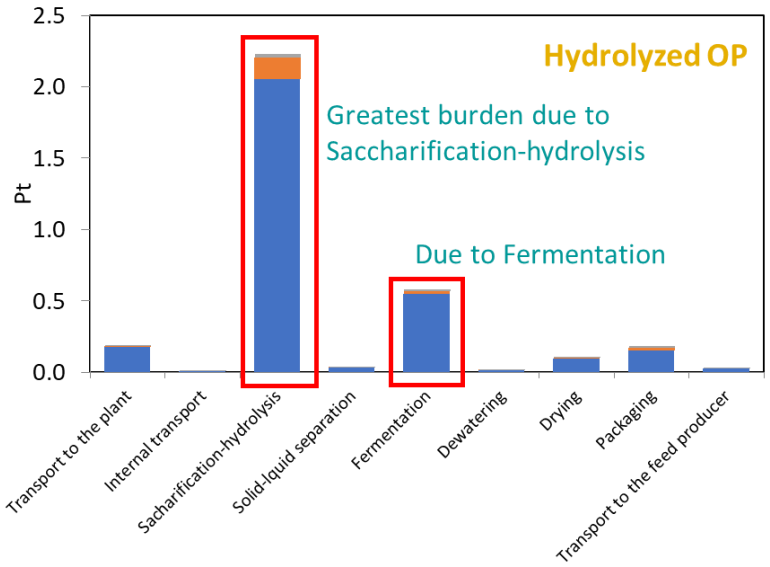


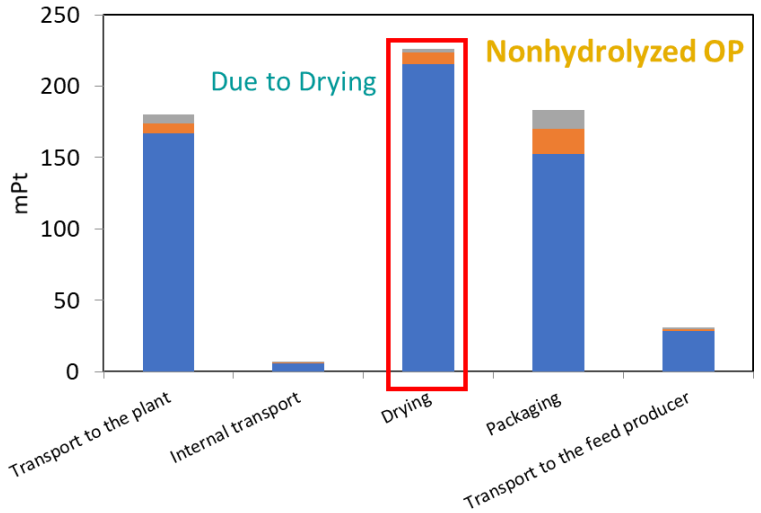
Olive Paste

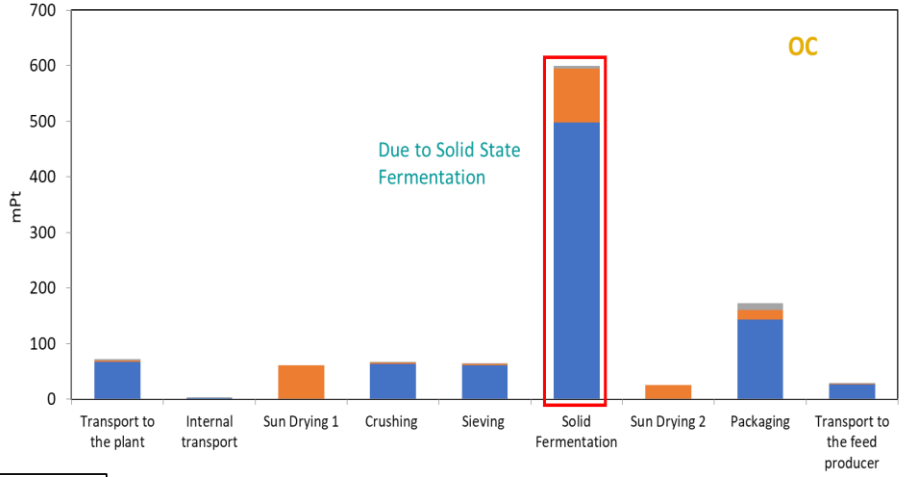


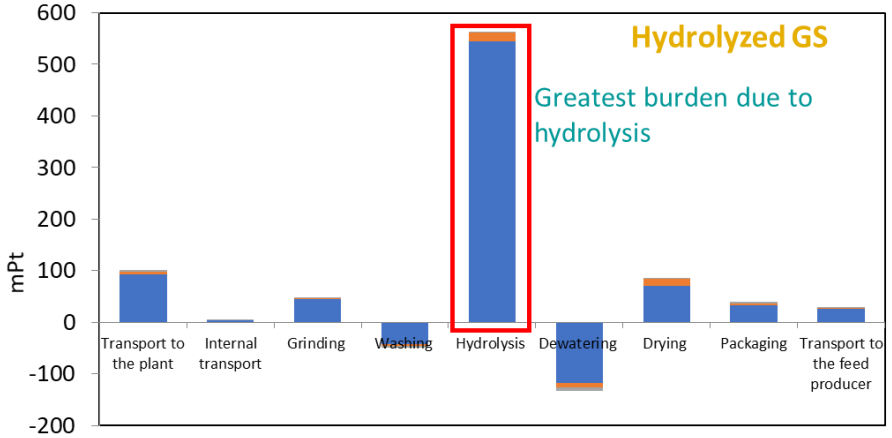
Resources Ecosystems Human health

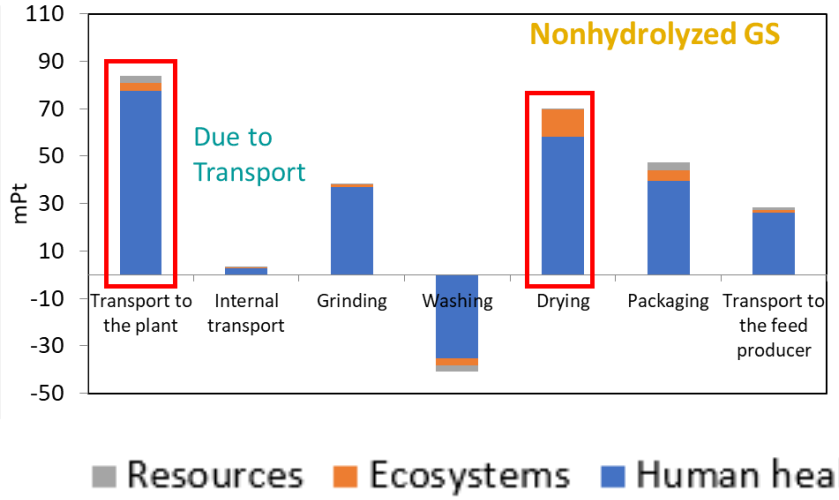
LCA Results for Animal Feed Ingredient Production- Process Contributions











Resources Ecosystems Human health

LCA Results for Animal Feed Preparation

Animal Feed Diets

Ingredient	Control kg/ton	w/ GS kg/ton
Barley grain	50	190
Oats	530	240
Maize	100	150
DDG	0	50
Rapeseed Meal	210	160
Rapeseed oil	50	50
Molasses	30	30
Vit. & mineral	30	30
GS feed ingredient	**0**	**100**

Dairy Sheep- GS

Ingredient	Control kg/ton	w/GS Kg/ton
Maize	342	370
SoybeanMeal	251	287
Palm Kernel Meal	150	80
Wheat Middl.	144	40
Rapeseed M.	20	30
Sunflower Meal	11	10
Fat Salts	29	29
Molasses	20	20
CaCO3	17	17
NaHCO3	11	11
NaCl	2	2
Vit&Mineral	3	3
GS feed Ingredient		**100**

Dairy Cattle- GS

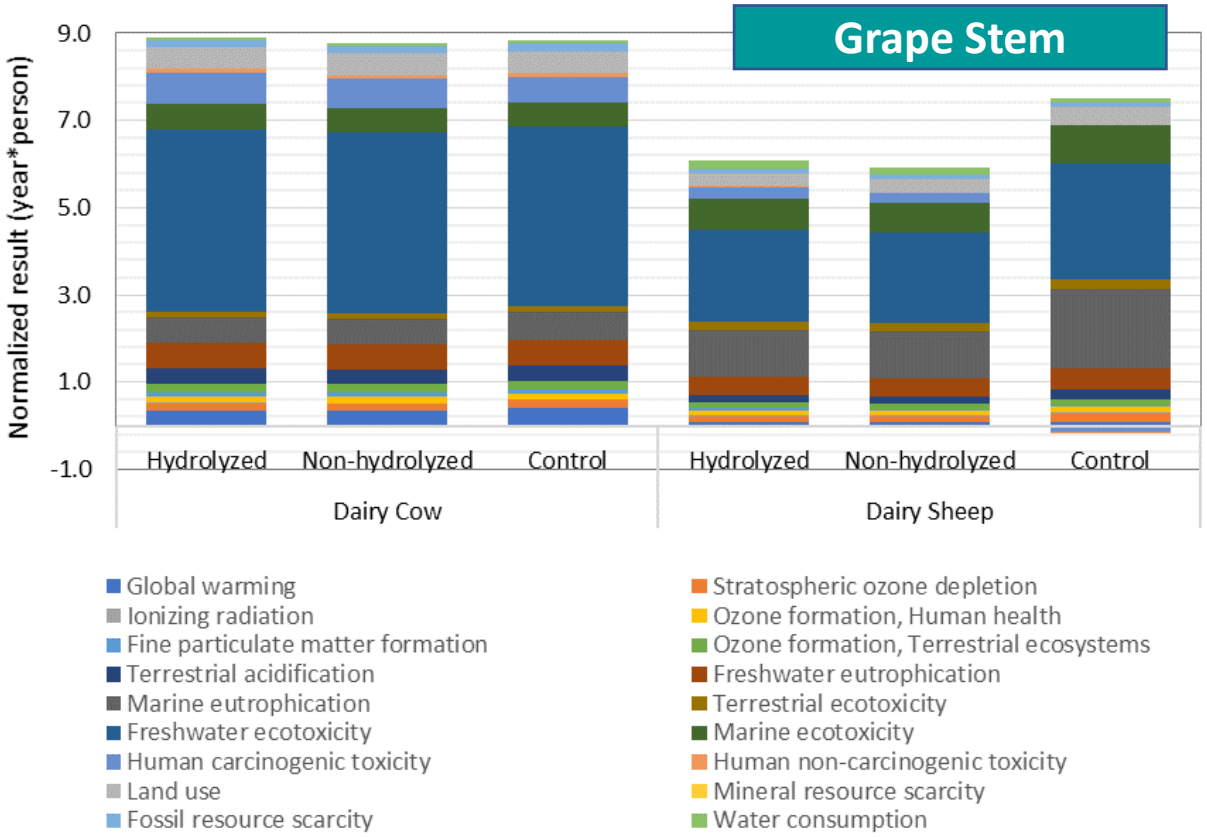
Ingredient	Control kg/ton	w/ OP kg/ton
Corn grain	300	300
Barley grain	200	200
Wheat bran	200	120
Soybean meal	110	110
Sunflower meal	150	120
Limestone	5	5
Monocalcium phosphate	5	5
Salt	5	5
Vitamin & mineral premix	25	25
OP feed ingredient	**0**	**110**

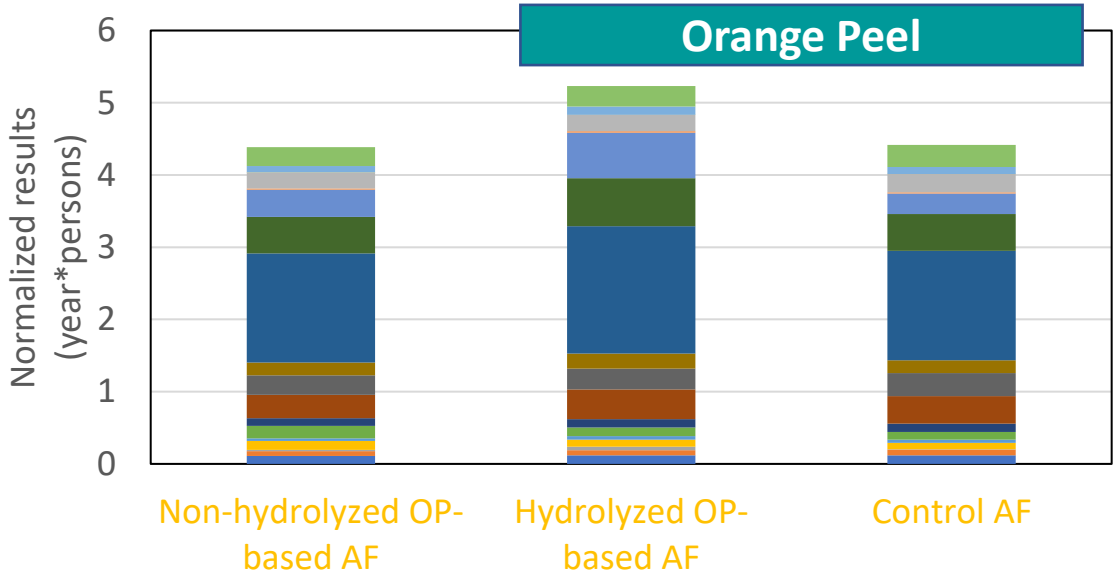
Dairy Sheep- OP

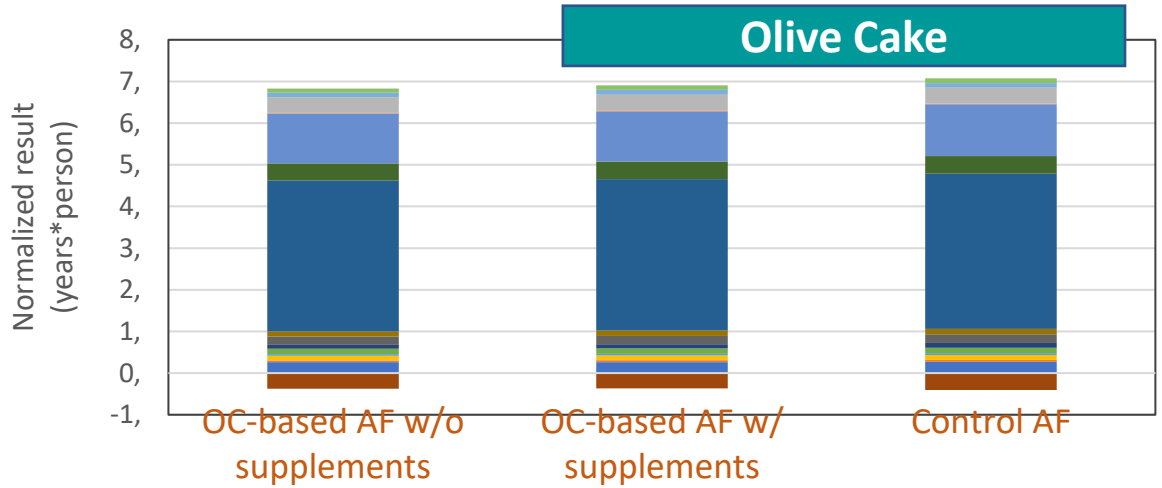
Ingredient	Control kg/ton	OC w/suppl. kg/ton	OC w/out suppl.kg/ton
Yellow Corn	503.5	417	417
Soybean Meal	420	410	410
Soybean Oil	36.5	34.5	34.5
Ca Carbonate	13	13	13
Ca Dibasic Phosphate	16	15	15
Salt	3	3	3
Premix	3	3	3
DL-Methionine	2.5	2	2
Lysine	1.5	1.5	1.5
Toxenil	1	1	1
OC feed ingredient	**0**	**100**	**100**
Suppl.(Yeast &Herbs)	**0**	**50**	**0**

Poultry- OC

Impacts of Animal Feed Production compared to Conventional Feeds

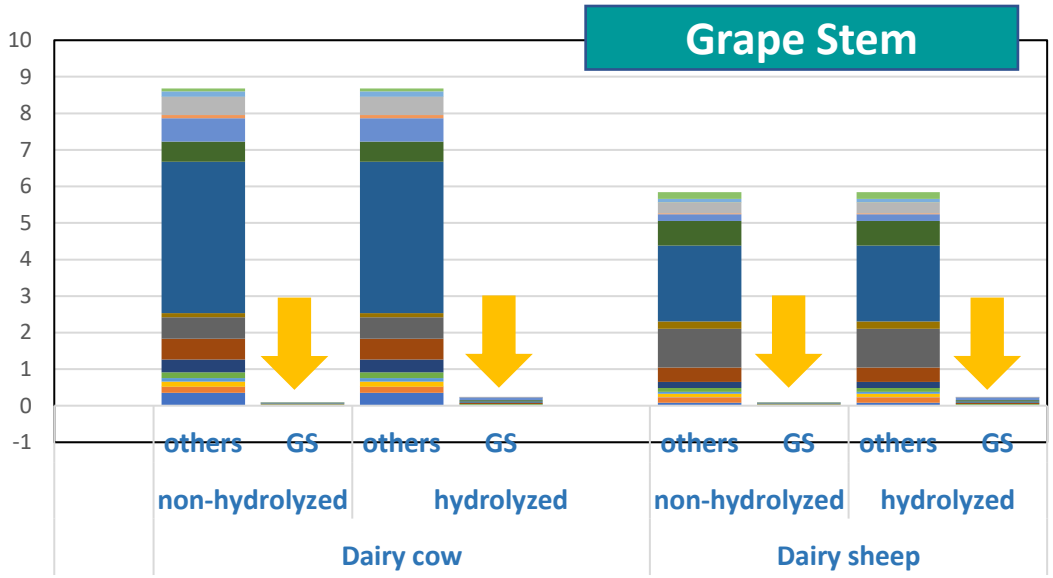


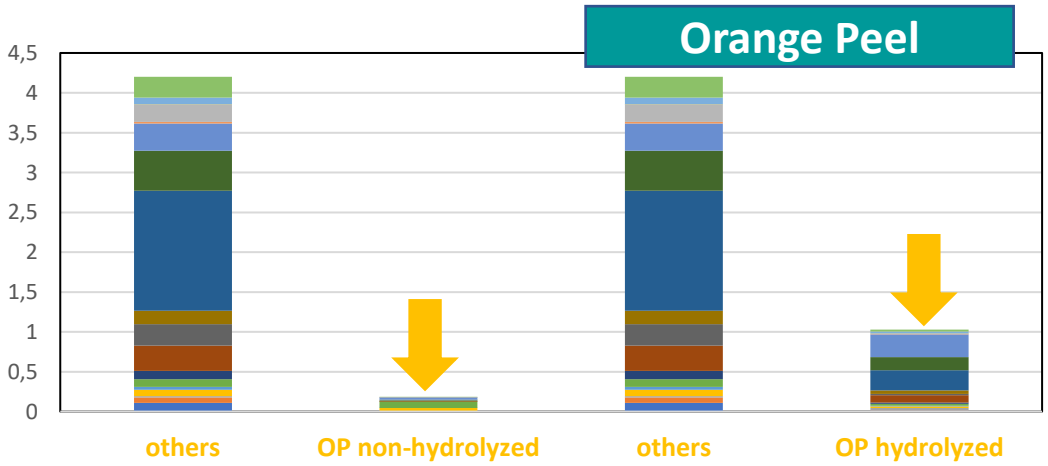


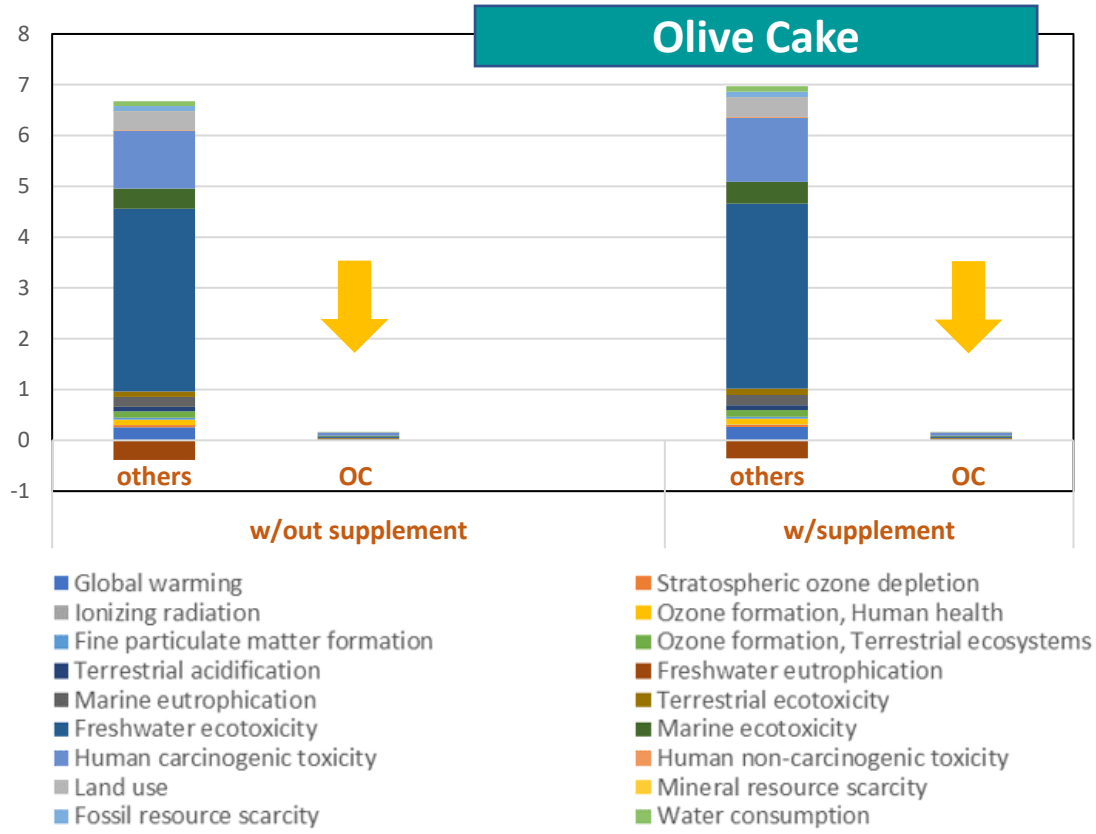


No remarkable difference!

Impacts of Animal Feed Production- Contribution by Value Chains

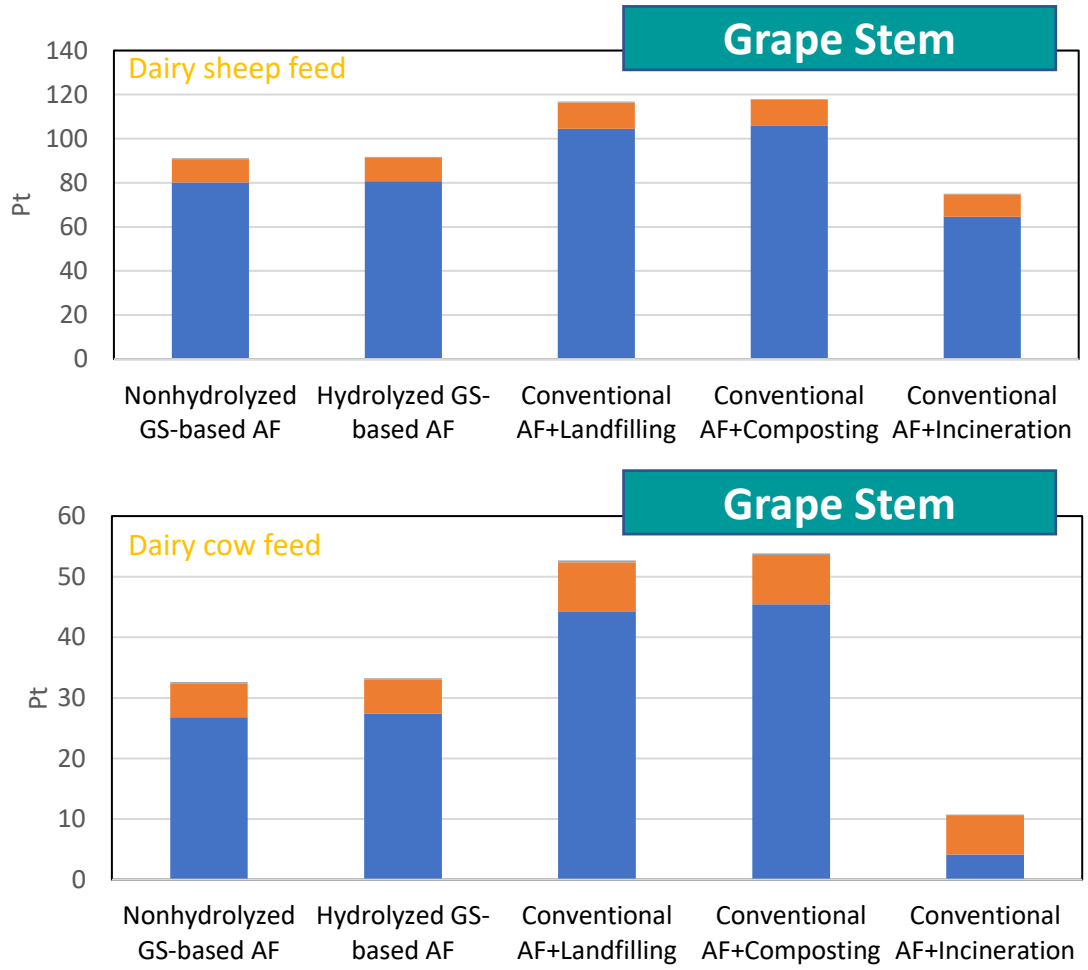


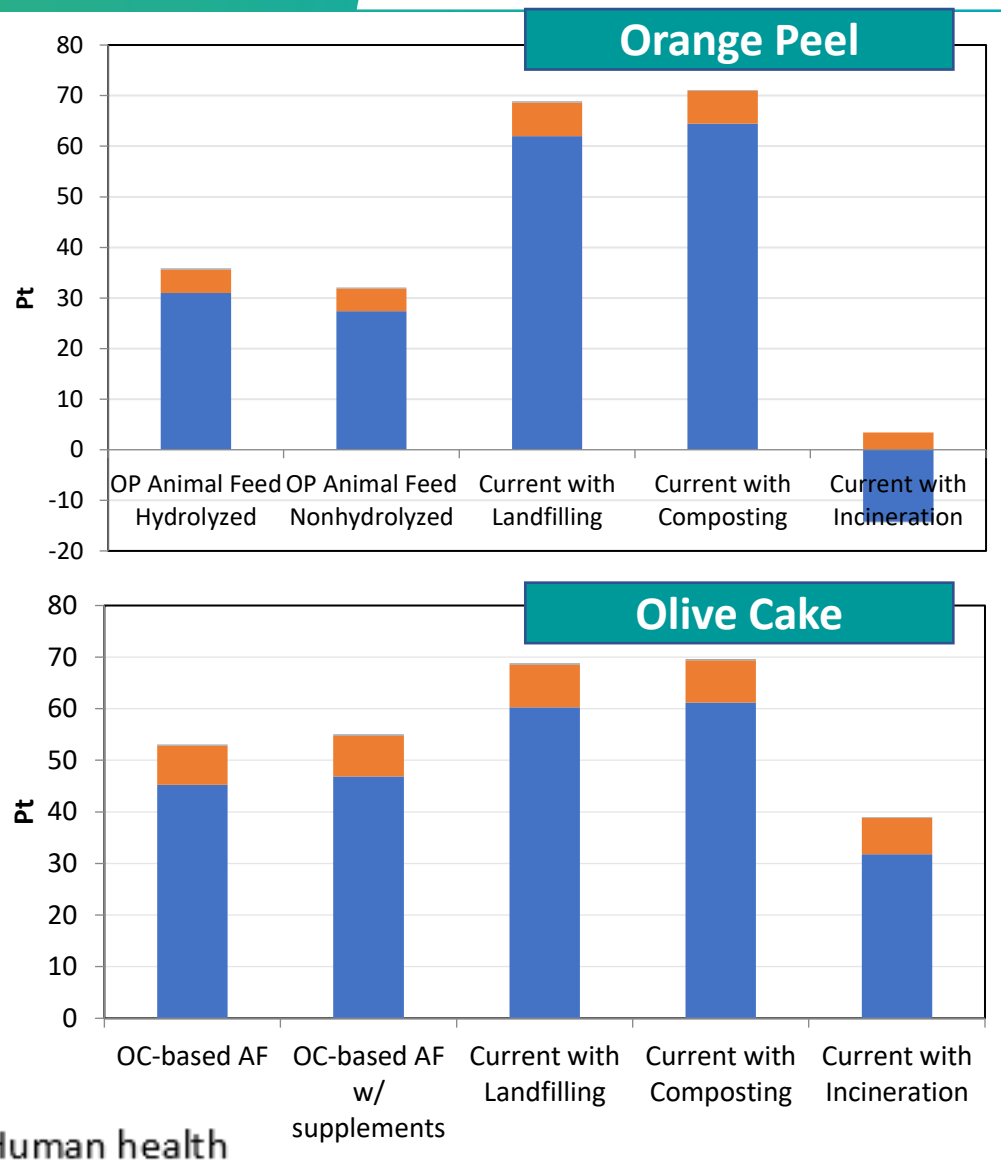




Negligable effects of value chains!

Comparison with current situation





- Smaller burden than the current situation with control feed + composting & landfilling, but higher than + incineration

Life Cycle Costing

- ISO 15686–5:2017
- Life Cycle Cost (LCC): the total cost or cash flow incurred over the entire life cycle or selected stages for products, services, or assets under analysis.
- LCC considers;
  - financial costs (CAPEX and OPEX)
  - environmental costs (economic loss of well-being (e.g., human health and biodiversity) due to an impact as well as the mitigation cost of any necessary intervention)
  - Benefits (revenues to be obtained from selling of the feed ingredients)

Net Costs and Cost Effectiveness for a GS-based Feed Ingredient Production Plant with a Capacity of 1000 kg/d (Project life span: 20 years)

COST ITEMS	Non-hydrolyzed GS-based feed ingredient	Hydrolyzed GS-based feed ingredient
REVENUES		
PV, €	560,157	588,165
€/kg of feed ingredient sold	0.31	0.33
CAPEX		
PV	157,295	209,297
€/kg of feed ingredient produced	0.09	0.12
OPEX		
PV, €	277,932	367,536
€/kg of feed ingredient produced	0.15	0.20
ENVIRONMENTAL COST		
Cost, EUR2015	18,164	89,569
€/kg of feed ingredient produced	0.01	0.05
TOTAL COST (PV), €	453,391	666,402
TOTAL ANNUAL COST (PV), €	22,670	33,320
Total Cost (PV), €/kg of feed ingredient produced	0.25	0.37
NET TOTAL COST (NPV), €	-106,766	78,237
Cost effectiveness (€/kg of feed ingredient produced)	-0.059	0.043
Cost (€/kg of GS processed)	-0.020	0.012

LCC of Current Disposal Options

Cost Item	Incineration	Composting	Landfilling
CAPEX			
PV, €/ kg	0.587	0.098	0.204
OPEX			
PV, €/kg	0.023	0.006	0.007
ENV*IRONMENTAL* COST			
Cost, EUR2015 per kg food waste	-0.387	0.73*1*	0.194
TOTAL COST, €/kg of food waste	**0.223**	**0.83*5***	**0.405**

Overall LCC Findings

	Value Chains					EoL		
	GS Feed ingredient		OP feed ingredient		OC feed ingredient	Incineration	Composting	Landfill
	Non-hydrolyzed	Hydrolyzed	Non-hydrolyzed	Hydrolyzed	Solid-state Fermented			
€/kg of feed ingredient	**-0.059**	**0.043**	**0.09**	**1.40**	**0.25**	-	-	-
€ per kg of food waste processed	**-0.020**	**0.012**	**0.01**	**0.15**	**0.10**	-	-	-
€ per kg of food waste disposed	-	-	-	-	-	**0.223**	**0.835**	**0.405**

Conclusions

Feed Ingredient

- Hydrolyzed GS and OP has a remarkably higher impact than nonhydrolyzed ones.
- NaOH consumption in GS, Enzyme use in OP, Fodder yeast use in OC case plays a critical role in the proposed valorization processes.
- Life cycle costs of value chains were all smaller than that of EoL disposal options.

Animal Feed

- When integrated into the animal feed this remarkable difference almost disappears, with sensitivities to NaOH, Enzyme and Fodder Yeast consumption almost diminished.
- The proposed valorization process is superior to the disposal scenarios of composting and landfilling, though not for incineration.

- **All three value chains resulted in lower environmental impacts than conventional waste disposal options.**
- **All three value chains are cost effective!**

All three valorization chains are sustainable options for the livestock sector…

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION
IN THE MEDITERRANEAN AREA

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Thank you for listening...

Any question?

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