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Improving Rainbow Trout (*Oncorhynchus Mykiss*) environmental footprint through insect meal use in aquafeed

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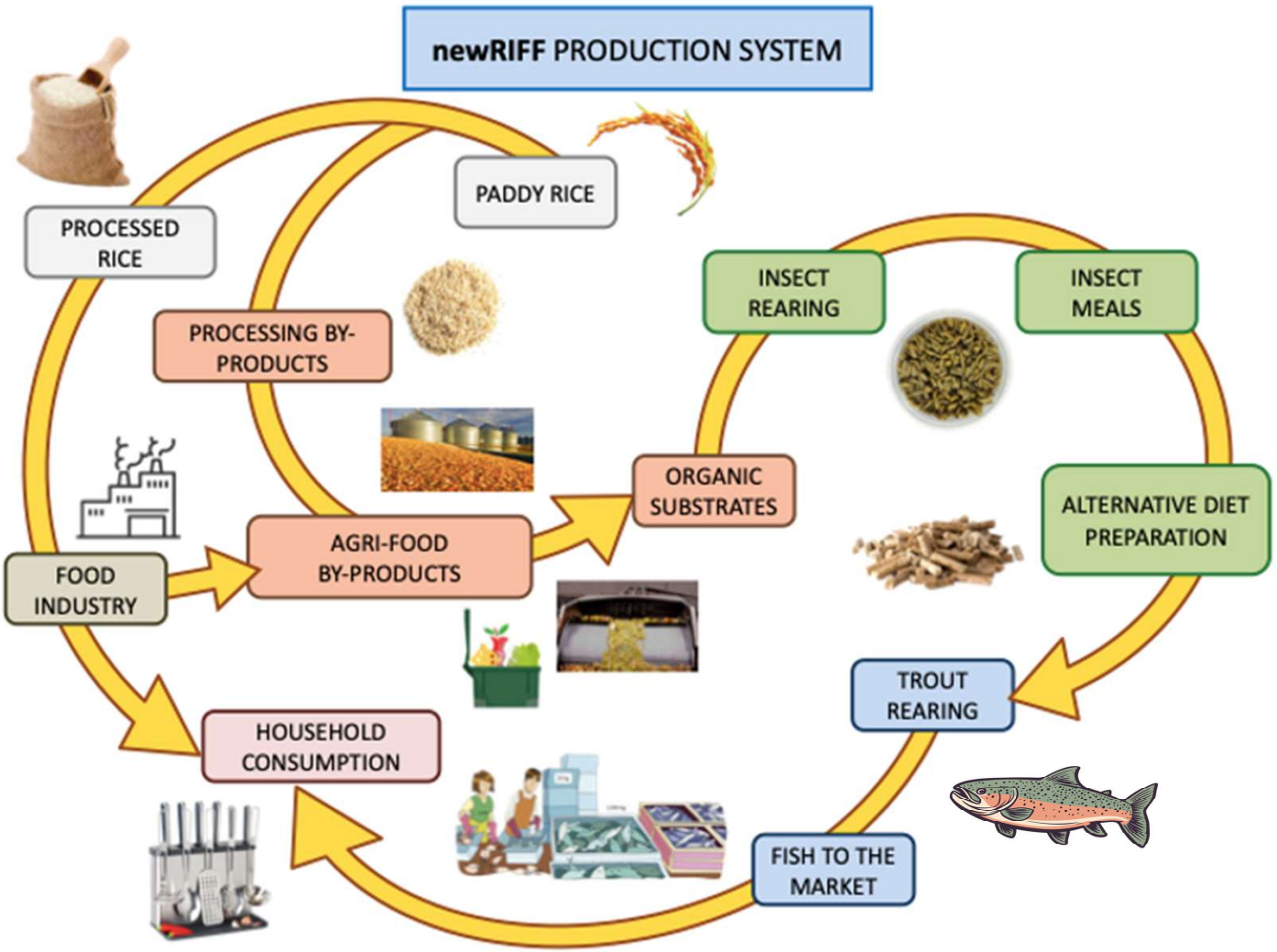

newRIFF project aims at exploring the possibility of replacing traditional protein sources in rainbow trout farm feeds with protein meal from two insect species (*Hermetia illucens* and *Tenebrio molitor*) bred on locally available waste matrices, including by-products of rice processing.

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- Quantifying and characterising the environmental impact of different substrates for *Tenebrio Molitor* breeding through the Life Cycle Assessment (LCA) approach;
- Report results with sensitivity analysis: avoided waste management and different transport distance;
- Discuss with the audience about challenges and critical point of LCA application in this sector

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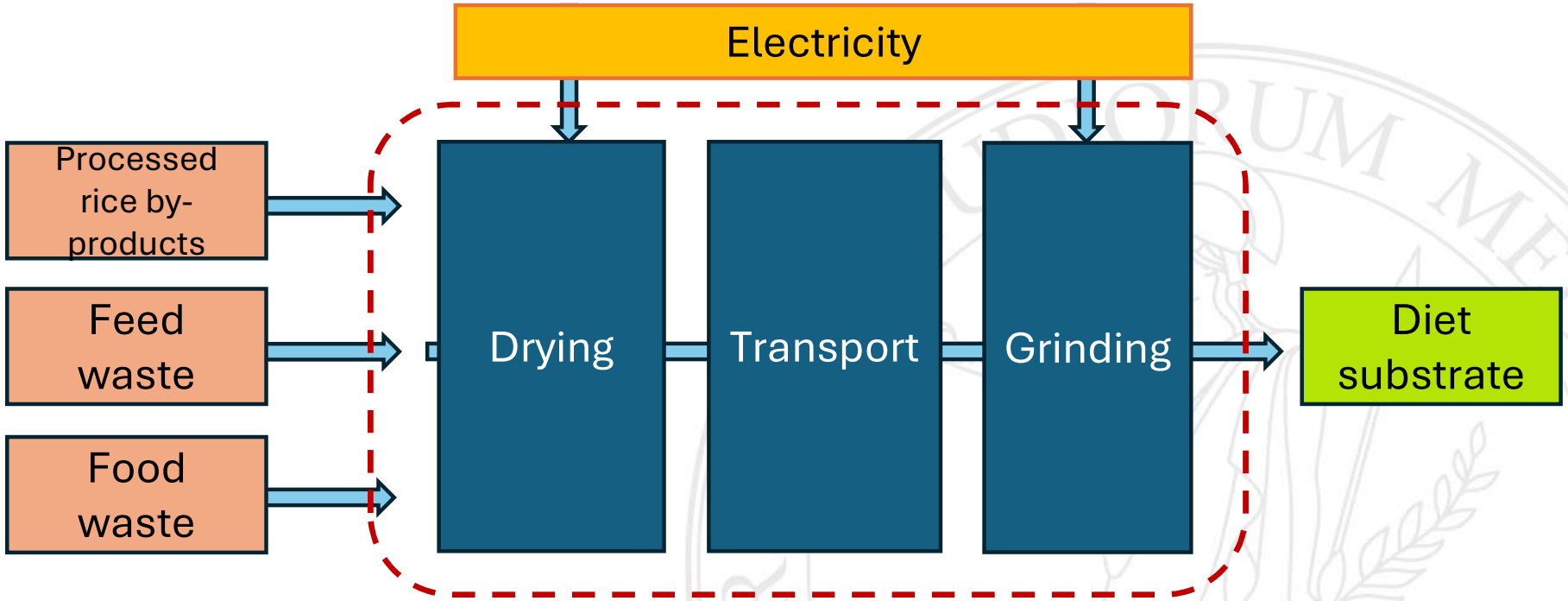
- Main goal: compare the environmental impact of 5 substrates (1 baseline and 4 new substrates) for Tenebrio Molitor breeding
- Functional unit: 1 kg of substrate
- System boundaries: from cradle to gate



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- Primary data: compositions of diets

INGREDIENTS	CONTROL DIET	DIET 1	DIET 2	DIET 3	DIET 4
Breading waste	46.9	9.3		1.9	
Feed waste	39.6	75.2	64	78.6	43.5
Dry distillery stillage	5.4	2.5	9.5	2.5	12.2
Coffee silver film	6.6	1.9			2.1
Hazelnut film	1.5	0.6			
Broken rice		1.5	3.5		
Broken parboiled rice				3.5	8
Green grain			3		2
Rice husk		2.5	2		
Parboiled rice husk				2	
Rice bran		5	15.5		
Parboiled rice bran				9	5
Other rice by-products		1.5	2.5		
Other parboiled rice by-products				2.5	27.2
TOTAL RICE BY-PRODUCT		10.5	26.5	17	42.2

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- Primary data: impact of the rice by-product based on economic allocation

Average prizes of room of commerce of Pavia, Vercelli and Novara in 2023

RICE BY-PRODUCT	PRIZE (€/t)
Broken rice	568.4
Risina	475.1
Risetto	480.4
Risetto parboiled	424.4
Pula vergine	234.6
Farinaccio	326.6
Green grain	286.7
Pula	221.5
Parboiled Lolla	126.0
Lolla	86.0
Other rice by-products	323.0

PROCESSED RICE	PRIZE (€/t)
Barone	568.4
Carnaroli	475.1
Caravaggio	480.4
Lungo B	424.4
Barone Parboiled baldo	234.6
Parboiled long B	326.6
Tondo/Originario	286.7

CLASS	% ON TOTAL 2023 PRODUCTION
Tondi	34%
Lungo B	33%
Lungo A - Ribe	15%
Lungo A - Carnaroli	9%
Lungo A - Arborio	9%

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Carnaroli (Lungo A)

RICE BY-PRODUCT	kg/1000 kg	PRIZES (€/t)	TOTAL VALUE (€)	€ ALLOCATION
Processed rice	568	1625.00	923.00	88.65%
Green grain	42	283.65	11.91	1.14%
Farinaccio	37.5	314.84	11.81	1.13%
Pula vergine	37.5	232.36	8.71	0.84%
Risetto	10	478.89	4.79	0.46%
Lolla	171	80.46	13.76	1.32%
Rottura	104	568.43	59.12	5.68%
Pulettta	16	221.48	3.54	0.34%
Altro di riso bianco	14	322.97		

Same for:

- Barone (Lungo A);
- Volano (Lungo A);
- Caravaggio (Lungo A);
- Barone Parboiled (Lungo A);
- PVL024 (Lungo B);
  PVL136 (Lungo B);
- Mare (Lungo B);
- Mare (Lungo B);
- Omega CL (Tondo)

Sole (Tondo)

RICE BY-PRODUCT	kg/1000 kg	PRIZES (€/t)	TOTAL VALUE (€)	€ ALLOCATION
Riso bianco	637	1312.50	836.06	91.2%
Grana Verde	/	471.06	0.00	0.0%
Farinaccio	33	283.65	9.36	1.0%
Pula vergine	38.5	314.84	12.12	1.3%
Risetto	38.5	232.36	8.95	1.0%
Lolla	30	478.89	14.37	1.6%
Rottura	171	80.46	13.76	1.5%
Pulettta	28	568.43	15.92	1.7%
Altro di riso bianco	16	221.48	3.54	0.4%

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- Secondary data: impact of the other ingredients, processing (grinding and drying) and transport. In particular:

Input	Secondary data
Dry distillary stillage	Ecoinvent V3.8
Food waste	No impact
Feed waste	No impact
Grinding	Ecoinvent V3.8
Drying	Ecoinvent V3.8
Transport	Data: 30 km (assumption) Italian average transport from ISPRA (2022) report

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LCA application – Environmental results

Impact category	Unit	Control	Substrate 1	Substrate 2	Substrate 3	Substrate 3
Climate change	kg CO2 eq	0.098	0.108	0.232	0.122	0.408
Ozone depletion	mg CFC11 eq	0.014	0.011	0.025	0.013	0.040
Photochemical ozone formation	g NMVOC eq	0.169	0.207	0.390	0.258	0.802
Particulate matter	disease inc./1M	0.003	0.006	0.011	0.008	0.027
Human toxicity, non-cancer	CTUh/10M	0.002	0.005	0.006	0.005	0.012
Human toxicity, cancer	CTUh/10M	0.000	0.000	0.000	0.000	0.001
Acidification	mol H+ eq/100	0.049	0.097	0.168	0.128	0.412
Eutrophication, freshwater	kg P eq	0.000	0.000	0.000	0.000	0.000
Eutrophication, marine	kg N eq	0.000	0.000	0.001	0.001	0.002
Eutrophication, terrestrial	mol N eq/100	0.143	0.358	0.630	0.491	1.670
Ecotoxicity, freshwater	CTUe	0.846	1.769	3.580	1.494	5.079
Land use	Pt	3.965	3.869	10.977	2.782	12.585
Water use	m3 depriv.	0.703	1.009	2.531	2.696	11.263
Resource use, fossils	MJ	1.495	1.179	2.565	1.363	4.137
Resource use, minerals and metals	mg Sb eq	0.091	0.179	0.396	0.177	0.682

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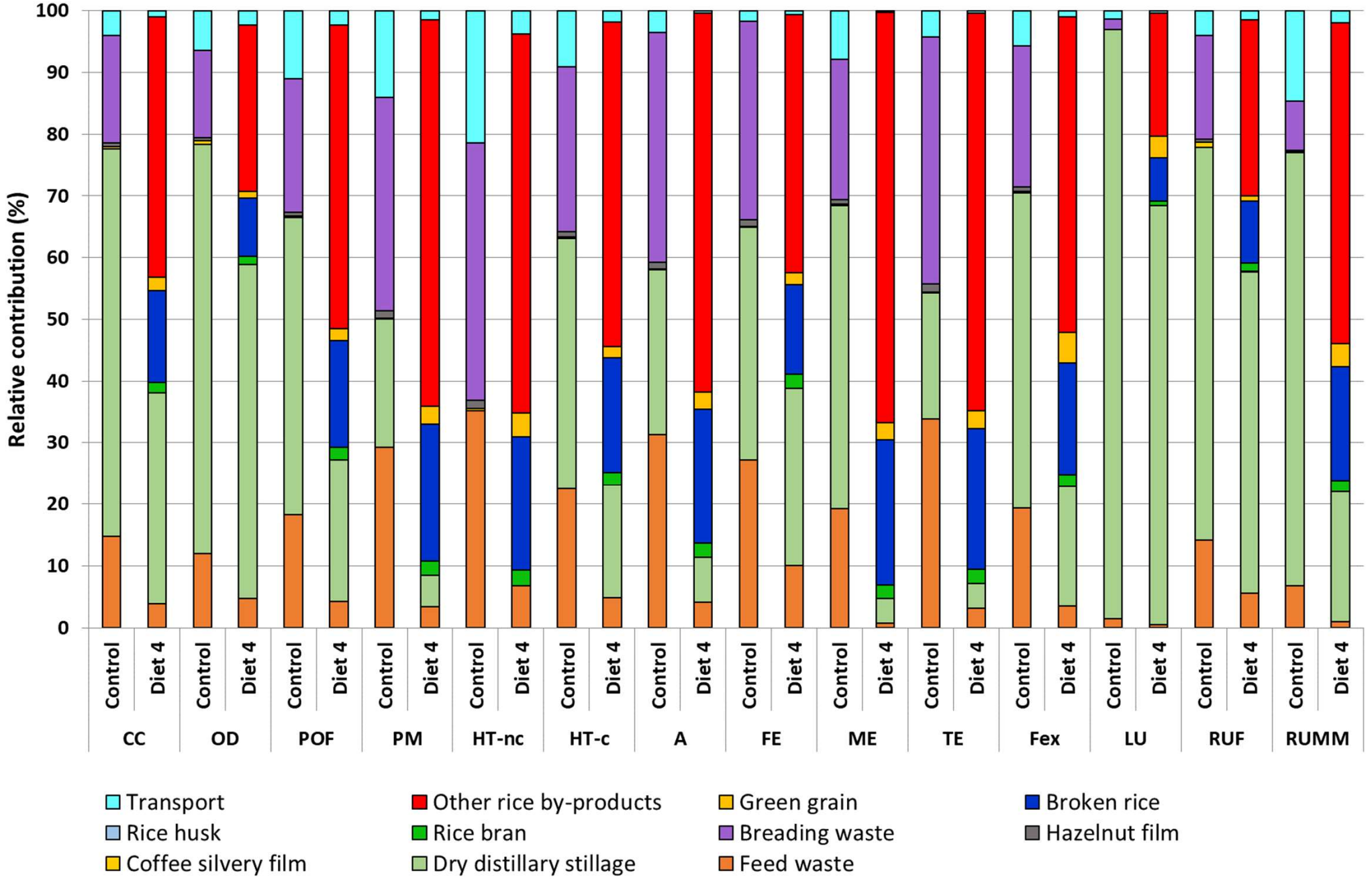
LCA application – Environmental hotspot



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- Focus on **climate change**

- Baseline

	Control	Substrate 1	Substrate 2	Substrate 3	Substrate 4
Kg CO_2 eq	0.098	0.108	0.232	0.122	0.408

- AS: Transport from 30km to → 100km

	Control	Substrate 1	Substrate 2	Substrate 3	Substrate 4
Δ	+9%	+8%	+10%	+8%	+2%
Kg CO_2 eq	0.107	0.118	0.241	0.132	0.417

- AS: Avoided waste management

	Control	Substrate 1	Substrate 2	Substrate 3	Substrate 4
Δ	-18%	-43%	-10%	-36%	-9%
Kg CO_2 eq	0.080	0.061	0.197	0.078	0.384

- Thevenot et al. (2018), a mealworm flour LCA study, it can be deduced an impact of **1.14 kg CO_2** eq per kg of insect diet
- Oonincx et al. (2012) reported an impact of the diet of **0.68 kg CO_2** eq/kg of substrate (*Tenebrio Molitor*)

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LCA application – One literature case study

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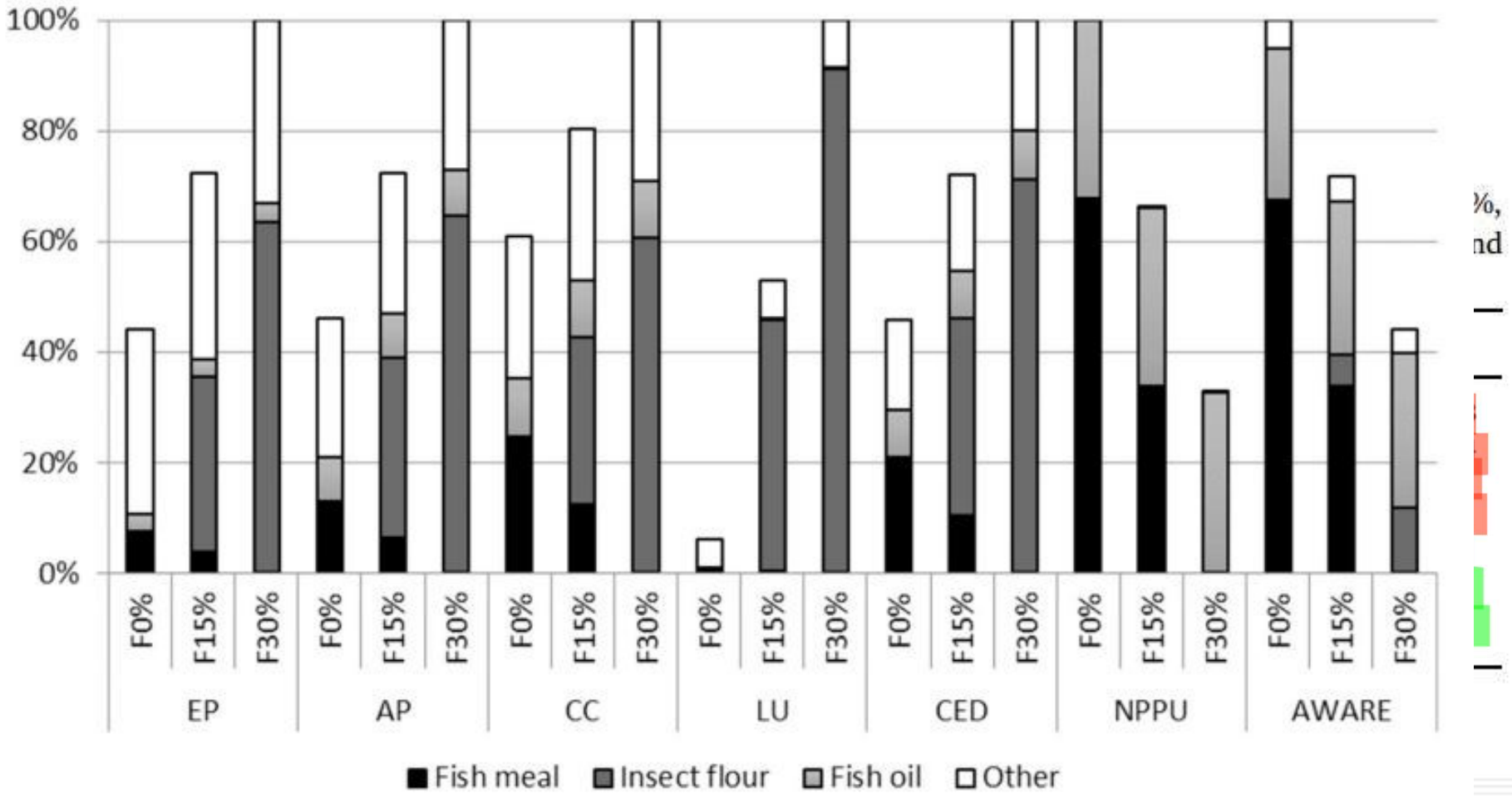

- Rice by product are the ingredients with the highest environmental impact due to their economic values;
- However they seems good for their chemical and nutrient composition and they can leas to better insect growth;
- Next steps will be the evaluation of the entire new supply chain;

……

- To date, the few LCAs studies in aquaculture with insect meal report higher impact than fishmeal with equal or slightly lower fish growth performance;
- Utilisation of food/feed waste and avoidance of waste management can decrease the impact of insect meal
- What about scale of production?

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Thank you

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