LCA approach to demonstrate how optimizing amino acids dairy cows' diets improves performances and reduces environmental impacts

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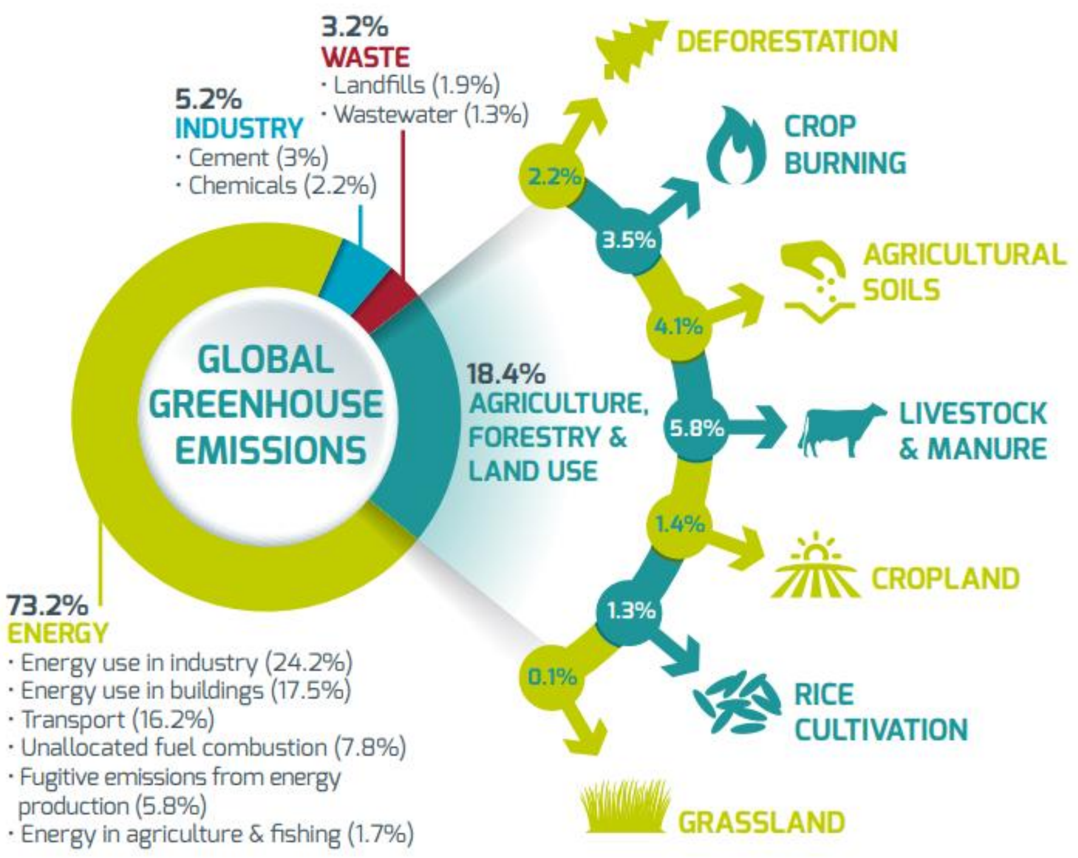
1. INTRODUCTION

- Methionine (Met) and Lysine (Lys) are the first limiting amino acids for dairy cows.
- 5.8% of global greenhouse gasses (GHG) emissions comes from livestock and manure.[1]
- Ruminants use on average 25%[2] (up to 45%)[3] of their dietary nitrogen transformed into animal product while the remaining part is excreted into the environment through feces and urine.
- Rumen-protected amino acids balancing aims to increase the NUE and may reduce environmental impact through better efficiency of feed utilization. So, it is not only necessary for better production, but it is also involved in metabolic pathway.[4]

FIGURE 1. Agriculture's influence on global GHG emissions



Hannah Ritchie and Max Roser (2020) • "CO2 and Greenhouse Gas Emissions." *Published online at OurWorldInData.org.* Retrieved from: "https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions" [Online Resource]

2. OBJECTIVE

Evaluate the cradle-to-farm-gate environmental performance of dairy production using Life Cycle Assessment (LCA) by comparing a standard unbalanced AA diet (Con), a balanced AA diet - 15% of SBM substituted with cereals - (Trt1) and a theoretical optimized Met balanced diet (Trt2).

3. MATERIALS AND METHODS

Treatment 1 (Trt1):

- The data refer to SOS Protein (EU Project Dy+ Milk) trial.
- 444 lactating dairy cows from 5 commercial farms in the West region of France (188 DIM and 33 kg/d milk yield).
- The trials were conducted as ABA reversal design lasting 4 months (divided into 3 periods, **Table 1**).
- Dry matter intake (DMI) was measured per period and farm.
- Complete analysis and nutritive values were evaluated (INRA 2007) from samples collected per period.
- Milk yield (MY) and composition were analyzed five times.
- The relative impact of greenhouse gasses (GHG) emissions including CO_2, CH_4 and N_2O were converted to CO_2 eq according to IPPC 2014.
- Emissions as CO_2 eq were evaluated using LCA methodology according to the Product Environmental Footprint Category Rules (PEFCR) and the Joint Research Centre (JRC) approaches with fat and protein corrected milk (FPCM) as functional unit.
- Data were analyzed with ANOVA using Proc Mixed of R software.

TABLE 1. Diets comparison. Control (Con), Treatment 1 (Trt1), Treatment 2 (Trt2)

Composition	Con	Trt1	Trt2
CP (%)	**16.1**	**15.6**	**14.5**
NE_L (Mcal/kg DM)	1.62	1.62	1.66
MP (g/kg DM)	99	96	97
Met (% MP)	1.8	2.4	2.3
Lys (% MP)	6.9	7.2	6.9
kg CO_2 eq/cow/d (from diets)	**19.68**	**17.74**	**13.09**

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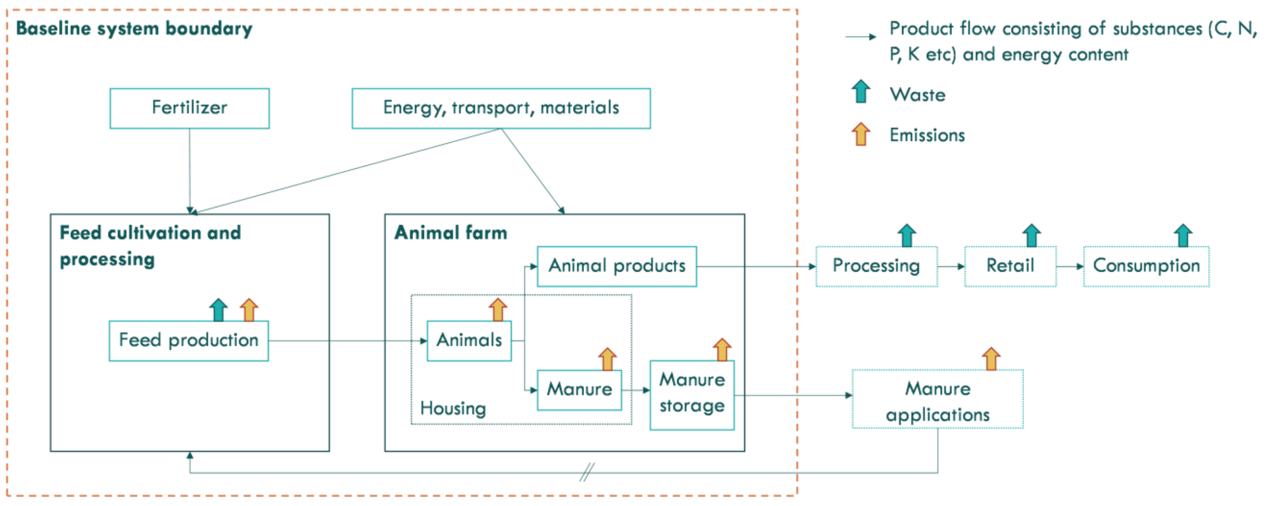
SOS Protein Dy+ UNION EUROPÉENNE Région PAYS de la LOIRE Région BRETAGNE

LCA system boundaries (Treatment 2, Trt2)

The system boundary is summarized in **Figure 2**. The data used represent a typical French dairy system (2019-2020) developed by Blonk in 2021 (using Agri-Footprint database, version 5.0).

The animal system was modelled to represent the average French dairy production system including all substance flows and typical management practices. It consists of Holstein Friesian breed with typical herd composition of dairy cows and youngstock for replacement.

FIGURE 2. Boundaries of the animal system: cradle-to-farm-gate



LCA functional unit

In line with the dairy PEFCR, one kilogram of FPCM was used as the functional unit for analysis, calculated according to the equation below:

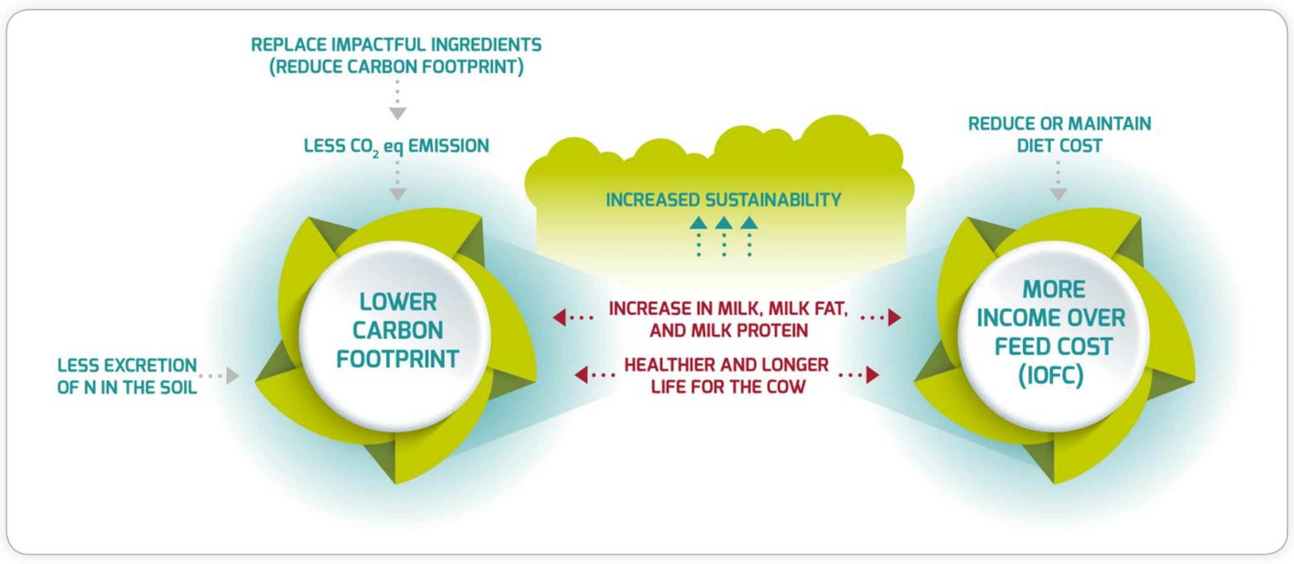
$$FPCM\ (kg) = milk\ (kg) * (0.1226 * True\ Fat\% + 0.0776 * True\ Protein\% + 0.2534)$$

4. RESULTS

TABLE 2. AA impact in dairy farms

	Con→Trt1	Con→Trt2[5]
Milk yield	+0.6 kg/cow/d	+0.5 kg/cow/d
Milk protein content	+0.5 g/kg	+1.1 g/kg
Milk protein yield	+39 g/cow/d	+43 g/cow/d
Gross MP efficiency	+4%	+6.5%
NUE	+9%	+14%
IOFC	+5%	+9.7%
Diet (CO_2 eq)	-10%	-26%
Fertility	-8 days calving interval	
Reduced illness	-21% mastitis proxy	
LCA Climate change - land use and transform. (CO_2 eq)	n.a.	**-49%**
LCA Climate change (CO_2 eq)	**-11%**	**-14%**

FIGURE 3. Overall result



5. CONCLUSIONS

These results demonstrated that a better amino acids balancing improved cow performances and reduced environmental impacts. Furthermore, with the reduction of expensive raw materials, the economical sustainability was positively impacted too.

By taking into consideration the long-term effects of better health, better reproductive function and less nitrogen release with amino acid-balanced rations, the environmental benefits, shown by the LCA, are even more significant.

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