LCA unveils positive contribution from traditional sheep-farming

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1. INTRODUCTION

Ruminants, including sheep, contribute significantly to methane emissions, thus resulting in high emissions per kg of product. However, they can utilise plant material unsuitable for human consumption, thereby transforming it into valuable, protein-rich food. Grazing also preserves cultural landscapes and can contribute to carbon sequestration. Understanding the balance between these factors within the climate change context is crucial. This study investigates the environmental impact of meat, milk, and wool production from sheep farming in Norway and Slovenia.

2. METHODS

Data regarding inputs and production were sourced from eight sheep farms in central Norway and one farm in the south-west of Slovenia, (Table 1). LCA-calculations were undertaken using the LCA software Umberto©, with assess to the ecoinvent© database for incorporating emissions related to purchased inputs. On-farm emissions were modelled in line with ISO standards and IPCC (2007, 2021) guidelines. Feed demand for animal groups was determined for winter barn feeding and for the grazing period, based on energy requirements for maintenance, activity, lactation, pregnancy, growth, and wool. Allocation was biological based on energy demand for meat, milk, and wool. Carbon sequestration estimates for grasslands were adapted from Chang et al. (2015). An uncertainty analysis was conducted using Monte Carlo simulations for all input variables and emission factors to ascertain their effect on the results.

3. RESULTS AND DISCUSSION

Norway's longer winters limit the grazing period to 163 days, compared to Slovenia's 240 days in (Table 1). This results in increased demand for winter feed, thereby elevating emissions from e.g. machinery use and diesel combustion. Moreover, Norwegian farmers purchased more concentrates. Climate gas emissions, calculated as GWP_{100} (IPCC 2007), were comparable in both countries with 19.2 kg CO_2-equivalents and 19.6 kg CO_2-eq per kg slaughter-weight, which is lower than the world average (Clune et al. 2017). Emissions related to the production of edible energy from both meat and milk, were less in Slovenia, producing both milk and meat as well as wool, at 1.00 kg CO_2-eq/MJ, compared to 1.45 kg CO_2-eq/MJ in Norway. Using GTP as the matrix, as suggested by IPCC for the discussion to limit global warming (IPCC 2021), emissions were lower, and when including sequestration values (Chang et al. 2015) for both countries, the Norwegian production sequestered more CO_2 than they emitted (-0.57 kg CO_2-eq/MJ), and Slovenian production was about carbon neutral (-0.02 kg CO_2-eq/MJ). The high uncertainty of carbon sequestration significantly influenced the calculated GTP_{100} emissions per MJ edible energy.

4. CONCLUSIONS

This study offers insights into the balance between methane emissions, the ability to utilise areas not suitable for direct food production by grazing to produce meat, milk, and wool, while sequestering carbon. Despite climatic differences, both countries showed comparable greenhouse gas emissions as GWP_{100} per kg meat. Slovenian farms, producing both milk and meat in addition to wool, demonstrate lower emissions per MJ of edible energy. The GTP_{100} results emphasise that grazed areas can sequester carbon in an amount that can offset emissions from sheep production, highlighting the potential of sustainable and responsible sheep farming in climate change mitigating and emphasising the need for more knowledge on carbon sequestration in agricultural soils. The positive effects from ruminants are only attainable when winter feed is produced with low emissions, and areas are grazed predominantly where no industrial inputs are used, and carbon can be sequestered in the soil.

5. ACKNOWLEDGEMENTS

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Table 1: Main data for the farms and LCA-results

	Unit	Commercial farms	Vremščica ICSR
Country		Norway (NO)	Slovenia (SI)
Number	n	8	1
Data	year	2018-2020	2023
Altitude	m above sea	50-600	800-1000
Farm area	ha	29.4	260
Meadows	ha	29.4	90
Grazing period	days/year	163	240
Winter feed, main		silages	hey
Concentrates	kg/year	16,531	15,000
	kg/ewe	115.6	35.7
Diesel	l/year	2715	5000
	l/ha meadow	92.3	55,6
Animals			
Breed		Norsk kvit sau and Old Norwegian Short Tail Landrace	Istrian pramenka
Ewes	n	143	420
Liveweight	kg/ewe	85	75
Lambs, born	n/ewe	2.2	1.2
Breeding, replacement	n/farm	55	75
Rams	n/farm	included in n. ewes	5
Production, annual			
Lambs for slaughter	n/farm	256	429
Sheep-milk	litre/farm	no milking	24,000
LCA-results			
GWP_{100} (IPCC 2007)			
allocated to milk	kg CO_2/kg milk	no milking	2.27 ± 0.18
allocated to meat	kg CO_2/kg meat[1]	19.2 ± 1.3	19.6 ± 1.9
allocated to wool	kg CO_2/kg wool	42.2 ± 3.7	28.7 ± 3.7
all edible energy	kg CO_2/MJ	1.45 ± 0.1	1.00 ± 0.08
all edible energy	kg CO_2/MJ, sequestr. incl.	0.12 ± 0.03	0.63 ± 0.14
GTP_{100} (IPCC 2021)			
allocated to milk	kg CO_2/kg milk	no milking	0.78 ± 0.06
allocated to meat	kg CO_2/kg meat[1]	10.11 ± 0.6	5.70 ± 0.6
allocated to wool	kg CO_2/kg wool	21.8 ± 1.7	10.9 ± 1.5
all edible energy	kg CO_2/MJ	0.77 ± 0.04	0.34 ± 0.03
all edible energy	kg CO_2/MJ, sequestr. incl.	-0.57 ± 2.8	-0.02 ± 0.11

[1] Slaughter-weight is used as weight of meat.