TOOLS TO OPTIMISE THE CARBON FOOTPRINT OF MILK PRODUCTION

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Conclusions

- The productivity of dairy cows has increased significantly over the past decades due to significant improvements in terms of genetics, animal health, and nutrition, and information retrieved from milk samples has played a key role
- Dairy herd improvement (DHI) testing programmes, meaning monthly collection and analysis of milk samples from individual cows, represent a practical and inexpensive tool for milk porducers to manage and optimise herd health and nutrition and thus productivity and profitability of their cows
- Our findings using real-life data sets from Denmark and Germany revealed that there is still potential to optimise productivity of cows and greenhouse gas (GHG) emission per kg milk produced with respect to mastitis, ketosis, and nutrition amounting to up to 96.4 t CO_2e per 100.000 cows and day
- Animal productivity and longevity as well as precision nutrition are key in lowering the carbon footprint of milk production and data-driven solutions such as dairy herd improvement programmes can clearly help to support these aspects

Objective

The objective of this study was to investigate the effect of DHI testing programmes on GHG emission of dairy farms.

Facts and figures about dairy farming in Denmark and Germany

Table 1. Overview briefly describing dairy farming in Denmark and Germany

	Country	
	Denmark	Germany[1]
Dairy farms	2,014	289
Cows	550,667	97,604
Enrolled in DHI (%)	91.6	95.8
Herd size (cows/herd)	250.5	337.7
Average annual performance		
Milk weight (kg)	10,543	9,721

[1]Numbers refer to federal state Thuringia only

- Regular DHI results from Denmark (n = 193,321) and Germany, federal state Thuringia only (n = 399,428) were available for data analysis using linear mixed models as described in detail elsewhere (https://doi.org/10.1016/j.prevetmed.2020.105123).
- ICAR guidelines (https://www.icar.org/index.php/icar-recording-guidelines/) were followed in terms of milk sample collection and analysis

Introduction

- Global greenhouse gas emissions:
  - 26% from food production
  - 14% from global livestock alone
  - 4.2% from dairy farming alone

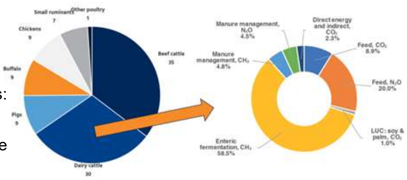

Figure 1. Split of greenhouse gas emissions from livestock (left) and sources of emissions from the global dairy cattle systems in 2015 (right), source: FAO, 2019 (www.fao.org/3/CA2929EN/ca2929en.pdf)

- Increasing animal productivity is considered the single most effective mitigation strategy and optimising animal health (e.g. reducing prevalence of diseases) and nutrition (e.g. increasing feed efficiency) are key focus areas (FAO, 2019 www.fao.org/3/CA2929EN/ca2929en.pdf)

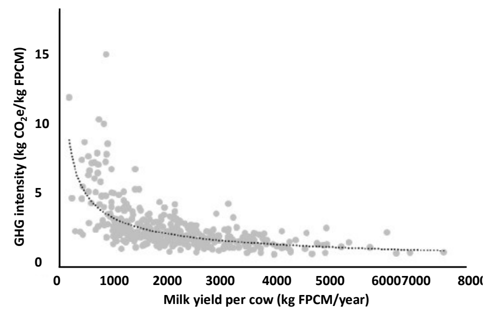

Figure 2. GHG intensity in g CO_2e/kg fat- and protein-corrected milk depending on annual production per cow, source: https://doi.org/10.1016/j.jclepro.2020.121780

- Dairy herd improvement (DHI) testing (or milk recording) is broadly used for herd health, nutrition, and management purposes around the globe. An estimated number of 632 million milk samples is available per year (**https://my.icar.org/stats/list**).

Dairy herd improvement testing and potential for improvements of GHG emission

Animal health and welfare

Mastitis – The most prevalent and costliest disease

Proxy: Somatic cell count (SCC, differential SCC)

Background: Mastitis is defined as the infection of the cow's udder. In such a situation, immune cells from the blood stream are recruited to fight the invading bacteria and SCC increases. The DSCC parameter (i.e. combined proportion of the PMN (polymorphonuclear neutrophils) and lymphocytes as a percentage of SCC) in combination with SCC provides a more detailed picture of the actual health status of the mammary gland (Table 2).

Table 2. Udder Health Groups to categorise udder health status based on SCC and DSCC

Group	Status	Definition	SCC (cell/mL)	DSCC (%)
A	Healthy/normal	No indication for IMI based on SCC and DSCC	≤ 200,000	≤ 65%
B	Suspicious/onset of mastitis	Elevated proportions of DSCC (i.e. PMN) as indication for IMI, although SCC is still low	≤ 200,000	> 65%
C	Mastitis	Indication for IMI, based on SCC and DSCC	> 200,000	> 65%
D	Chronic/persistent mastitis	A constellation of the immune response often seen in connection with chronic IMI	> 200,000	≤ 65%

Findings

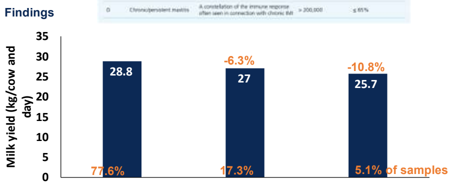

Figure 3. Average daily milk yield depending on SCC category (k cells/mL, data from Germany)

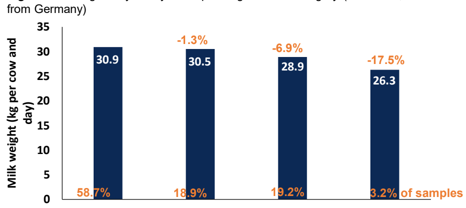

Figure 4. Average daily milk yield depending on Udder Health Group (data from Germany)

GHG potential: The estimated emission associated with mastitis is 60.2 t CO_2e per 100.000 cows and day using SCC only and 77.7 t CO_2e per 100.000 cows and day using the combination of SCC and DSCC (i.e. UHG) assuming that the CO_2e per kg milk is 1.28 kg. In addition, significant amounts of antibiotics for mastitis treatment could be saved if the disease prevalence was lower.

Ketosis – A common metabolic disorder

Proxy: β-hydroxybutyrate (BHB)

Background: Ketosis is a metabolic imbalance that can occur after calving because of the so-called negative energy balance (i.e. energy consumption exceeds energy intake). To compensate for the lack of energy, the cow metabolises body fat, causing an increased production of ketones (acetone and β-hydroxybutyrate (BHB)).

Findings

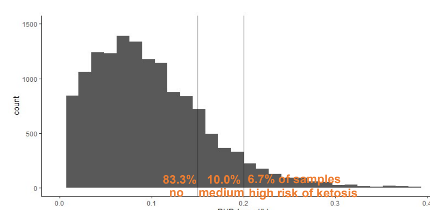

Figure 5. Prevalence of fresh lactating cows having no, medium, or high risk of ketosis as estimated based on milk BHB level (data from Denmark)

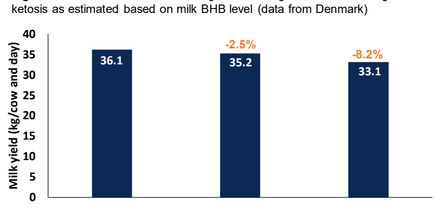

Figure 6. Average daily milk yield of fresh lactating cows depending on the milk BHB level (mmol/L, data from Denmark)

GHG potential: The estimated emission associated with ketosis is 3.1 t CO_2e per 100.000 cows and day assuming that the CO_2e per kg milk is 1.28 kg. Moreover, mastitis and ketosis impair longevity of cows.

Nutrition

Proxies: Urea and milk fatty acid profile

Background: Milk urea is an indicator of the amount of crude protein in a cow's diet because it is formed from the metabolism of absorbed amino acids. The milk fatty acid profile serves as an indicator of rumen health and feeding management including information about the diet's energy level.

Findings (urea only)

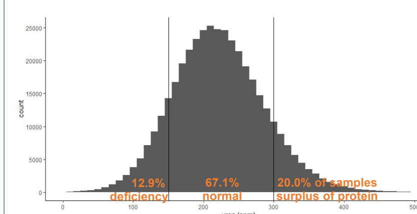

Figure 7. Prevalence of cows having protein deficiency, normal levels, or protein surplus as estimated based on milk urea levels (data from Germany)

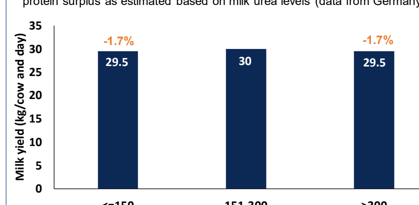

Figure 8. Average daily milk yield of cows depending on milk urea levels (ppm, data from Germany)

GHG potential: The estimated emission associated with inbalanced protein feeding is 15.6 t CO_2e per 100.000 cows and day assuming that the CO_2e per kg milk is 1.28 kg. Beyond that, unused protein (e.g. due to overfeeding) is excreted in urine and feces and thus has a negative environmental effect (e.g. ammonia (NH_3) and nitrous oxide (N_2O).

Acknowledgements and further reading

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