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Image: Florian Grandl

Mercator Research Program

Greenhouse gas emissions from dairy production systems based on longevity or high-yield strategies

Most milk production systems focus on a high-yielding strategy with high milk production over just a few years, resource-intensive diets, and frequent calf rearing to replace old animals. This project investigated whether increasing the longevity of cows creates a more sustainable approach for milk production. Researchers found that the longevity approach can help to reduce greenhouse gas emissions and increase economic profits.

Motivation

Many dairy production systems follow a high-yield strategy, using cows with high milk yields over a rather short productive life (often less than three years). By being fed with a resource-intensive high-concentrate diet, these cows efficiently transform nutrients into milk. The strategy also requires rearing a large number of young animals to replace culled cows, which results in high economic and ecological costs. The longevity approach, often promoted in organic farming, aims to extend the productive life of cows and may result in higher yields per day of life with lower environmental and economic costs. However, more research is needed on the effect of cow age on greenhouse gas emissions and yields.

Objective

The overall research objective was to compare the environmental impact and economic performance of longevity and high-yield strategies for dairy production systems. Specifically, the research assessed how a cows age relates to its digestion, greenhouse gas emissions, and profitability.

Research Highlights

Researchers found that digestion, methane emissions, and energy utilization in cows changed at different age. Forty-two Brown Swiss dairy cattle aged between one and ten years were kept in stalls and respiratory chambers to measure digestion patterns and methane emissions. Cows were fed either a forage-only diet or a combined forage-concentrate diet, typically used in higher-yielding dairy strategies. Irrespective of the feeding regime, older cows ingested more organic matter and retained it longer in their gastrointestinal tracts than younger cows. Surprisingly, the longer retention time did not result in an increase in methane emissions. In


Image: Florian Grandl

Doctoral student Florian Grandl conducting an experiment to quantify the changes in digestion and methane emissions with age.

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fact, emissions of methane peaked at the age of around 5.5 years and decreased in older cows. In addition, older cows in the study retained more energy in the body and utilized metabolizable energy more efficiently for milk production than younger cows.

Next, researchers used a life-cycle assessment approach and a full-cost analysis to calculate the greenhouse gas balance and profitability of extending the length of the productive life of dairy cows. The calculations included cow emissions, feed production, rearing of replacement cows, and the potential beef production as sources of greenhouse gases (see figure). Emissions and economic profit per unit of milk were most favorable in cows with longer productive lifetime, although improvement rates became less steep with higher age. In contrast, young cows that had not finished their first lactation were not able to amortize their rearing costs. Emissions per unit of animal protein also decreased with age, when the potential beef production by fattening the offspring of the dairy cows was taking into account.

Relevance to Stakeholders

This project showed that increasing the length of productive life of dairy cows is a valid strategy to make dairy production more sustainable, as it led to a reduction in greenhouse gas emissions and to an increase in profitability of dairy production. In particular, a reduction of the number of cows that leave the herd before finishing their first lactation can help to decrease greenhouse gas emissions per unit of food produced and to increase profitability of dairy herds.

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Food System Challenges Addressed **Sustainable livestock production, greenhouse gas mitigation, economic sustainability**

www.worldfoodsystem.ethz.ch/research/research-programs/MRP/llc.html

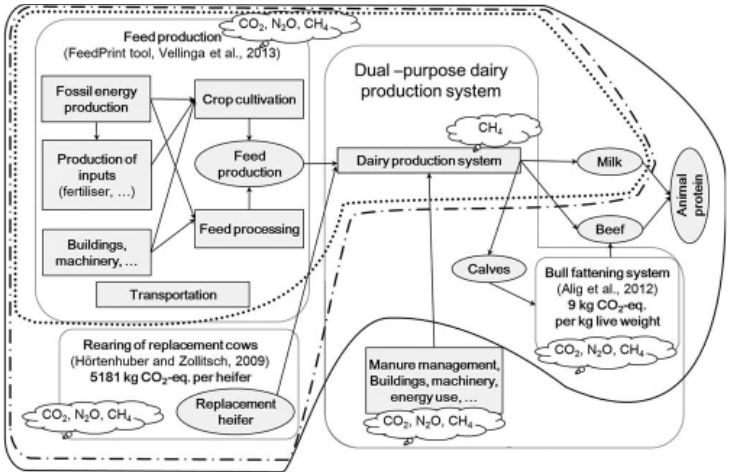

Figure: Inter-relationships of processes and greenhouse gas emissions in the life-cycle analysis of dairy production system (Source: Grandl, Furger et al. 2019).

Selected Publications

Grandl, F.; Luzi, S.P.; et al. Biological implications of longevity in dairy cows: 1. Changes in feed intake, feed behavior, and digestion with age. *J. Dairy Sci.* **2016**, 99 (5), 3457-3471.

Grandl, F.; Amelchanka, S.L.; et al. Biological implications of longevity in dairy cows: 2. Changes in methane emissions and efficiency with age. *J. Dairy Sci.* **2016**, 99 (5), 3472-3485.

Grandl, F.; Schwarm, A.; et al. Kinetics of solutes and particles of different size in the digestive tract of cattle of 0.5–10 years of age, and relationships with methane production. *J. Anim. Physiol.Anim. Nutr.* **2018**, 102, 639-651.

Grandl, F.; Zeitz, J. O.; et al. Evidence for increasing digestive and metabolic efficiency of energy utilization with age of dairy cattle as determined in two feeding regimes. *Animal.* **2018**, 12 (3), 515–527.

Grandl, F.; Furger, M.; et al. Impact of longevity on greenhouse gas emissions and profitability of individual dairy cows analysed with different system boundaries. *Animal.* **2019**, 13 (1), 198-208.

Media

Project Video: Fighting the other greenhouse gas

Koch. C; Misteli, S. Pioniere im Stall. *NZZ Folio*, July 2016, 38-43.

Meier, S. Plantahofkühe im Dienst der Forscher. *Schweizer Bauer*, Jan 25, 2014.

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