How can we use nutritional strategies to mitigate methane emissions from ruminants?

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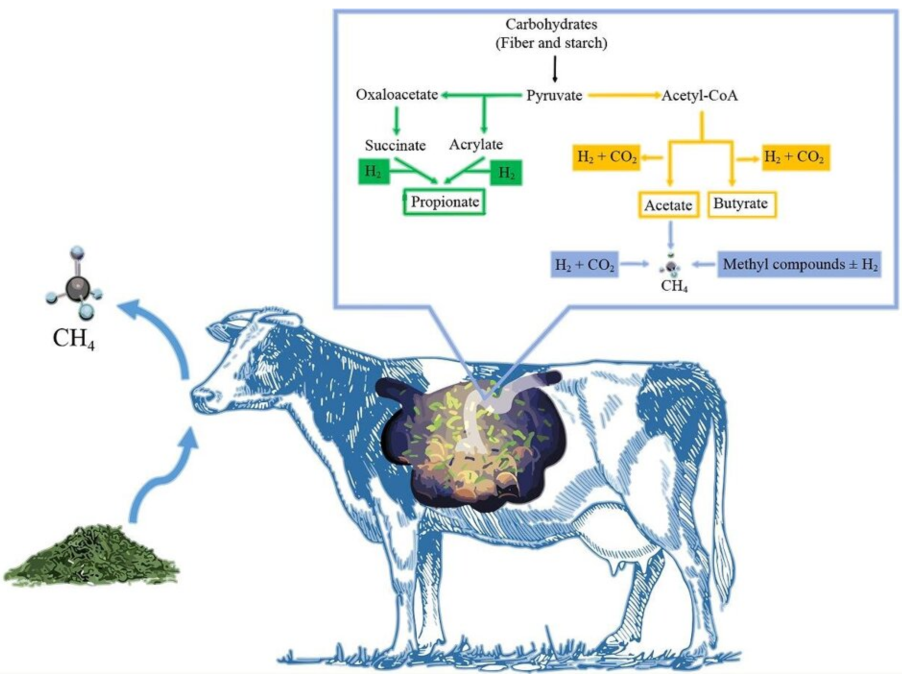

Credit: *Frontiers of Agricultural Science and Engineering* (2023). DOI: 10.15302/J-FASE-2023504

Methane concentrations have increased rapidly and have doubled in the atmosphere compared to preindustrial levels. Within the agricultural sector, animal production contributes to 14.5% of global anthropogenic greenhouse gas (GHG) emissions and produces around 37% of global emissions of CH_4. Microbial fermentation in the rumen produces 6% of global anthropogenic GHG emissions representing around 40% of total livestock emissions.

The atmospheric lifetime of CH_4 is 8–11 years, which is much less than that of carbon dioxide. However, CH_4 is more than 25 times as potent as carbon dioxide at trapping atmospheric heat. Therefore, decreasing CH_4 emissions from ruminants will be more significant in controlling GHG in the livestock production system.

Nutritional strategies, such as inhibiting substrate levels, regulating ruminal microbial compositions, and manipulating nutrient metabolic pathways, have been investigated to decrease methanogenesis. However, different strategies under in vivo and in vitro conditions might be inconsistent regarding prescriptions or potentials. Meanwhile, it is necessary to develop a suitable strategy without affecting the performance of animal production and food safety.

Associate Professor Mengmeng Li and Professor Guangyong Zhao from China Agricultural University systemically described the mechanisms of CH_4 production and reviewed nutritional strategies to mitigate CH_4 emissions. For each mitigation strategy, their work discusses effectiveness for decreasing CH_4 emissions, application prescription, and feed safety based on results from in vitro and in vivo studies.

In addition, the study summarizes different nutritional strategies to mitigate CH_4 emissions and proposes comprehensive approaches for future feeding interventions and applications in the livestock industry. The work is published in the journal *Frontiers of Agricultural Science and Engineering*.

The research suggests that the composition and proportion of methanogens have a significant impact on CH_4 production. As shown in the work, the CH_4 production pathways are: (1) hydrogenotrophic pathway; (2) acetoclastic pathway; (3) methyl dismutation pathway; and (4) methyl-reducing pathway. The CH_4 production pathways usually utilize the decomposition of low carbon organics. Although CH_4-producing pathways in methanogens are complex, almost all CH_4-producing reactions require minerals (cobalt, iron and nickel) as cofactors.

Hydrogen is required in most of the methanogenesis pathways. The majority of hydrogen used by methanogens is dissolved hydrogen and gaseous hydrogen only accounts for 2.7% of hydrogen used in the methanogenesis pathways.

To determine the potential of nutritional strategies to mitigate CH_4 production, changing feeding management and feed composition, modifying microbial community in the rumen, and adding chemical additives into diets, have been widely investigated in ruminants. Changing dietary nutrient compositions, especially the content of non-fiber carbohydrate (NFC) and neutral detergent fiber (NDF), has been proven to be an effective strategy to decrease methanogens abundance and CH_4 emissions by manipulating H_2 production, dry matter intake (DMI), rumen nutrient outflows, and nutrient digestibility.

Methanogen inhibitors are typically used as substrates or analogs of enzymatic factors to inhibit the enzymatic reaction in the methanogenesis pathways, such as polyhalogen compounds that can inhibit CH_4 emissions by inhibiting the generation of methyl-coenzyme M. Taking bromochloromethane as an example, bromochloromethane can maintain its activity in the rumen for a long time after being wrapped by α-cyclodextrin.

Using plant secondary metabolites as feed additives to mitigate CH_4 emissions is continuously increasing. Tannins and gallic acid could selectively inhibit CH_4 related bacteria. Given that gallic acid can bind to surface proteins in methanogens and form phenol-hydroxyl compounds, hydrolyzed tannins exhibit a more potent effect in decreasing CH_4 emissions than condensed tannins.

This work concludes that using nutritional strategies to regulate CH_4 emissions is becoming increasingly possible. These strategies are developed based on mechanisms that decrease H_2 production, promoting propionic acid fermentation, lower protozoa abundance and inhibited methanogen activity. Optimizing nutrient supply to animals according to their requirements can contribute to decreasing CH_4 emissions and allow for more efficient animal production.

It is important to mention that CH_4 production cannot be decreased to a sufficient degree through dietary adjustments, as there are conflicts with animal production efficiency, rumen environmental health, and economic benefits. Therefore, mitigation practices must be evaluated in an integrated animal production system instead of as isolated components. Also, some strategies might have impacts on microbial adaptation, chemical residues in tissue, and the spread of antibiotic resistant genes and microbes.

These research gaps need further exploration. Although the effect of chemical materials is highly efficient, the main issue lies in the difference between the in vitro studies and the actual process in vivo. The complex digestion process in vivo is generally inconsistent with the results obtained by in vitro fermentation.

Some chemicals have great potential to decrease CH_4 emissions, which require further investigation in animal studies before they can be used as reliable tools. Consequently, dietary supplementation with 3-NOP, probiotics, organic acids or plant secondary metabolites, such as tannins and seaweed polyphenols, is recommended to decrease CH_4 emissions. Also, the combined use of probiotics and appropriate supplements can optimize the properties of probiotics.

Overall, combined nutritional strategies and continuous technological innovations are greatly needed to accommodate the wide variation in the livestock production systems.

More information: Jian Sun et al, Using Nutritional Strategies To Mitigate Ruminal Methane Emissions From Ruminants, *Frontiers of Agricultural Science and Engineering* (2023). DOI: 10.15302/J-FASE-2023504

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