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RESEARCHES CONCERNING THE USE OF FEED INGREDIENTS TO REDUCE GREENHOUSE GAS EMISSIONS IN DAIRY COWS FARMS

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Abstract

From the multitude of solutions proposed to reduce greenhouse gas emissions, the strategies based on feed solutions are the most effective in the ruminant breeding sector. In most cases, the benefit is twofold, namely limiting the greenhouse effect and improving animal production. In practice, a reduction in gas emissions in the future is possible provided that farmers are aware of the need to invest in order to ensure this food adaptation to the new recommendations of researchers in the field. One way to reduce methane emissions is to increase the proportion of concentrated feed in the ration, which has been found to reduce CH_4 emissions per unit of ingested dry matter and liter of milk, as production remains the same or increases. Experiments performed on lactating cows indicated linear decreases in CH_4 emissions with an increase in the proportion of concentrated feed in the ration. Concentrated feeds also generally provide more digestible nutrients compared to bulky feeds, which could increase animal productivity. As a result, the decrease in fiber content and the faster passage of leguminous through the digestive tract of cows decrease the production of CH_4.

Key words:*dairy cows, feed, methane gas.*

INTRODUCTION

Gas emissions have increased by about 20% in recent years, which has exacerbated the greenhouse effect. This situation is also due to the emissions of polluting gases that ruminants produce.
The amount of greenhouse gas (GHG) that human activities release into the atmosphere each year is the equivalent of 49 billion tons of CO_2, and from this value the livestock sector, namely the amount of methane gas eliminated by ruminants, is equal to 13.5%, lying behindthe energy sector (25.9%), industrial (19.4%), forestry (17.4%), but ahead the transport sector (13.1%) (Lesschen et al. , 2011). The situation of gaseous emissions from the agricultural sector thus becomes one of the targets of the fight against global warming. CO_2 emissions exceeded the carbon-absorbing capacity of terrestrial and ocean vegetation almost a century ago.
Greenhouse gas (GHG) emissions associated with animal production contribute with an equivalent of 7.1 gigatonnes of carbon dioxide per year (14.5% of the total emissions from human activities), according to the Food and Agriculture Organization of the United Nations (FAO, 2014).
Globally, ruminants are estimated to produce 5.7 gigatonnes of CO_2 equivalent per year, accounting for about 80% of emissions in the livestock sector. In the case of dairy cows, emissions account for 35%,respectively 30% of emissions in the animal sector (equivalent to 4.6 gigatonnes of CO_2).
The average emission intensity corresponding to the products obtained from ruminants was estimated at 2.8, 3.4 and 6.5 kg CO_2 equivalent/kg milk corrected according to fat and protein corrected milk (FPCM) for milk from cattle (FAO, 2014).
It is estimated that a cow can emit more than 100 kg of methane each year during rumination. Methane is an important factor in the greenhouse effect, whose heating potential is twenty times higher than that of carbon dioxide (Euractiv, 2019).
The main sources of emissions are: production, processing and transport of feed (45% of the total); digestion of ruminants (39%); manure decomposition (10%). The rest is attributed to

the processing and transport of animal products (post-slaughter transport, refrigeration and packaging of animal products) (Dunca et al., 2011).

By carefully analyzing how these emissions occur, the significant reduction in emissions is within the reach of animal producers. Adopting current best practices and technologies for feeding, raising and ensuring animal health, manure management, and greater use of technologies for biogas generators and energy-saving devices would help the global livestock sector reduce greenhouse gases by almost 30%.

In this paper, the objectives are to analyze methods to reduce greenhouse gas (GHG) emissions in dairy farms.

MATERIALS AND METHODS

In animal production systems there is a strong link between resource efficiency and the intensity of GHG emissions.

Many of the actions recommended by FAO (2014) to improve efficiency and reduce greenhouse gas emissions also improve the production process, resulting in a quantitative and qualitative increase in food and higher incomes, with benefits for food security. and poverty reduction.

For animal production systems, emissions of nitrogen oxide, methane gas and carbon dioxide are losses of nitrogen, energy and organic matter which reduce their efficiency and productivity. Possible interventions to reduce emissions are therefore largely based on technologies and practices that improve production efficiency at the animal and livestock level.

Although the ways to reduce greenhouse gas emissions need to be adapted to specific local targets and conditions, currently available limitation options include:

- the use of feed and feeding techniques that take into account the digestibility, quality and composition of the feed ration, which can reduce the methane generated during digestion, as well as the amount of nitrogen and methane released by the decomposition of manure;
- improving the genetics and health of animals which contributes to a better conversion of feed into animal products, further reducing the intensity of emissions of animals;
- improving breeding strategies (replacement rate, age at first calving), reducing the number of non-productive animals in the herd and, therefore, emissions per unit of product generated in the herd;
- the modality of crop management on land surfaces, respectively the extension of pastures, is an important factor of emissions management, improving productivity;
- the application of current manure management techniques influences the release of methane and nitrogen oxide, ensuring the recovery and recycling of nutrients and energy, as well as the use of energy saving devices.

RESULTS AND DISCUSSIONS

For ruminants, the processes preceding the absorption of nutrients take place in a completely different way from that of animal species with a single-cavity stomach.

The digestive peculiarities of ruminants are determined by the existence of a gastric complex consisting of 4 compartments, the most important being the fact that it has a microflora and microfauna that allows the feeding of ruminants to be mostly fibrous, even if a single feed is used.

While the ruminant consumes fodder, certain microorganisms in the prestomacal cavity extract hydrogen. Hydrogen is used by other methanogenic bacteria to reduce carbon dioxide (created after digestion) into methane (Constantin, 2006). This process consumes between 2 and 15% of the energy provided by food. The synthesis of methane in the rumen environment is facilitated by the activity of methanoforming bacteria, such as *Methanobacterium ruminantium*. It is very sensitive to environmental conditions (Ellis et al., 2008). When these conditions are not favorable, methane production is reduced, which can lead to the switching of metabolic pathways of catabolism of pyruvic acid in the direction of propionic acid formation. The main conditions that determine the inhibition of the activity of methanoforming bacteria are: a high level of ingestion; finely processed fodder; their high starch content. Under these conditions, the rate of methane production is reduced, decreasing the production of acetic

acid and increasing the one of propionic acid (Morgavi et al., 2010).
Rumen fermentation is also influenced by the order of administration of feed assortments; it is more appropriate to administer the hay beforehand, followed by succulents and finally concentrates.
The administration of fibrous 90 minutes before the concentrates achieves a better digestion of cellulose in the rumen, maintains a wider ratio between acetic acid and propionic acid, increases the rate of bacterial protein formation, factors that contribute to maintaining normal limits within 24 hours for the rumen physiological value. Thus, there is a direct relationship between acetic acid production and methane production: the increase in the amount of pyruvic acid directed through the synthesis of acetic acid determines the increase in methane production (Ellis et al., 2008).
There is also a relationship between methane and propionic acid production: as the pathways of pyruvate metabolism are directed through propionic acid synthesis, methane production decreases (Miresan et al., 2003).
One way for farmers to reduce greenhouse gases in dairy farms is to choose the type and quality of feed that make up the rations of ruminants.
An important characteristic of feed that can have an impact on the production of enteric CH_4 is the ***quality of the feed***, especially its digestibility. Increased intake of poor quality feed with lower digestibility may have an insignificant effect on CH_4 production (Garg et al., 2018; de Vries et al., 2019). On the contrary, the increase in the ration intake of fodder with a higher digestibility causes a decrease in the amount of CH_4/kg of fodder consumed.
A number of factors, such as plant species, variety, crop maturity and preservation, can affect feed quality and digestibility. As the plant matures, the content of structural carbohydrates increases and that of fermentable carbohydrates decreases. Feeding at the right time is important to increase the amount and digestibility of nutrients in feed (Hristov et al., 2013b). Also, the different processes used for preserving feed (hay, silage, etc.) can negatively influence the nutritional value, if not done correctly.
Drehmel (2017) observed that the decrease in fiber content and the faster passage of legumes through the digestive tract of cows decrease the production of CH_4.
A substantial effort has also been made to ***develop varieties of fodder rich in important nutrients*** (proteins, lipids, carbohydrates) to ensure a mitigation of greenhouse gas emissions.
Hristov et al. (2013b) propose several options for reducing the amount of methane removed by ruminants by improving feed quality, including the correct management of pastures. As a result of these measures, which will ensure the quality green fodder with a high nutrient digestibility for dairy cows, increases in the efficiency of milk production will be obtained, which will probably lead to a decrease in CH_4 emissions.
Pasture management practices to reduce gaseous emissions from ruminants include shortening the grazing time, moving the animals from the pasture to time intervals to prevent the emission of N_2O or CH_4 into the soil. These measures will improve production efficiency and reduce GHG emissions per unit of production.
Keady et al. (2012) analyzed the effects of ***forage silage*** on the productive performance of animals and showed that a 10 g/kg increase in the concentration of digestible organic matter in the dry matter of the grass silo could increase the daily yield of milk obtained from cows with 0.37 kg. They also highlighted the unfavorable effect of silage on some plants that exceeded the optimal harvesting period. At the grass silo they found that the delay in harvesting the plants reduced digestibility by 3 to 3.5%. The same team of researchers pointed out that the use of bacterial inoculants in silage, with the addition of formic acid, especially in difficult silage conditions, can increase the performance of animals, which will reduce CH_4.
The inclusion of corn and alfalfa pickled fodder in lactating cow rations can also improve animal production (Groff and Wu, 2005) and the efficiency of nitrogen metabolism (Wattiaux and Karg, 2004), which could lead to a decrease in nitrogen in the urine and N_2O emissions from the application of manure.

The ***use of probiotics*** (lactic acid bacteria, Bacillus, yeasts) as a way to reduce ruminal methane gas can be used in ruminants to improve ruminal fermentation, dry matter intake and milk yield (Beauchemin et al., 2008). Due to the low prices and their wide use in feeding ruminants, the acceptance of probiotics in order to reduce CH_4 has a high probability.

Weinberg et al. (2003) and Huyen et al. (2020) indicated that probiotics based on lactic acid bacteria added to silage can positively influence fermentation by buffering rumen pH and oxygen consumption, improve nitrogen utilization and increase microbial protein synthesis in rumen. Another way to influence the composition of the ruminal microflora was to use as a probiotic the bacterium *Lactobacillus plantarum* in silage alfalfa (Mohammed et al., 2012) or *Enterococcus faecium* which increased the concentration of volatile fatty acids but decreased the concentration of methane (Mamuad et al., 2019).

There are also studies that have not shown any difference in methane levels in the case of consumption of pickled fodder with *Lactobacillus fermentum* or *Enterococcus faecium* (Jalč et al., 2004).

To reduce ruminant emissions, researchers at the University of Davis in California have experimented with ***alternative ways of feeding***, namely a combination of cow feed made from hay mixed with 1% natural red algae, *Asparagopsis armata*. To improve the palatability of the ration and mask the salty taste and specific smell, molasses was added (Searby, 2019).The conclusion was that the animals that consumed the ration containing algae had a significant reduction in methane gas. During experiments lasting two or three weeks, in which the concentration of algae was different, it was observed that the cows that consumed the highest content of algae eliminated half of the initial amount of gas.At the beginning of the experiment, it was assumed that algae could influence the taste and aroma of milk, but the sensory analysis of milk obtained from 25 people showed that the taste is normal. The only disadvantage was the decrease in milk production. An impediment to the use of algae, however, is the taste of the algae and the difficulties in obtaining large amounts of algae.

Another way to reduce methane emissions is to ***increase the proportion of concentrated feed in the ration***, which has been found to reduce CH_4 emissions per unit of ingested dry matter and animal product, as production remains the same or increases (Ferris et al. 1999; Sauvant and Giger-Reverdin, 2009; Aguerre et al., 2011).

Use of feed additives

Nitrates and sulfates have been studied as CH_4 emission mitigation agents (Yáñez-Ruiz et al., 2017; Brown et al., 2011). The potential problems with these compounds stem from the fact that the adaptation of the rumen microflora of the ruminant is not sufficiently known.

Plant extracts can be a natural and effective solution in limiting, as much as possible, greenhouse gases from ruminant breeding. Herbal extracts refer to phytonutrients or phytobiotics, such as phenolic compounds, saponins or terpenoids present in plant essential oils.

Munteanu et al. (2016) highlighted the importance of garlic polyphenols, and Gligor et al. (2017) identified and characterized these compounds in order to investigate their effect in the ration of dairy cows on productive performance, health, and ruminal fermentation.

Busquet et al. (2005), Benchaar and Greathead (2011) have observed that garlic essential oil reduced the proportion of acetic acid and volatile fatty acids with branched chain, and increased the proportion of propionic and butyric acid, as well as the concentration of nitrogen. These changes are consistent with the inhibition of methane in ruminal fermentations and bring beneficial changes in the rumen microbial activity.

Garlic inhibits methanogenesis and increases the acetate/propionate ratio (Blanch et al., 2016), as well as the concentration of butyric acid in ruminal fluid (Klevenhusen et al., 2011). Foskolos et al. (2015), Patra and Yu (2015) showed that dairy cow rations, supplemented with garlic phytonutrients, had antimicrobial action on a broad spectrum of bacteria, reduced nitrogen and increased propionic and butyric acid levels, highlighting in vivo the favorable effects of the use of active garlic compounds introduced in the feed of dairy cows.

Kolling et al. (2018) have observed that the use of essential oils extracted from oregano and green tea administered to feed lactating cows during 28-87 days of lactation reduced methane gas emissions during the first third of lactation and have the potential to be used as additives for cows.

Other studies have been conducted by researchers at Aarhus University in Denmark, who found that oregano essential oils do not have the ability to reduce gas emissions from digestion in ruminants (Olijhoek et al., 2019).

Other plant compounds with potential for greenhouse gas emissions produced by ruminants are tannins that are active both as inhibitors of methane and as modulators of NH_3 emissions from excretions (Woodward et al., 2001).

Methane gas emissions can be reduced by using tannin and saponin extracts in vitro, accompanied by a reduction in dry matter digestibility, organic matter digestibility and ammonia (Yogianto et al., 2014).

The addition of fat to the ration of ruminants has been used to reduce CH_4 emissions. The addition of fats reduces the fermentation of organic matter, the direct inhibition of methanogens in the rumen by the hydrogenation of unsaturated fatty acids. The greatest reduction is determined by unsaturated fatty acids, which act on the hydrogen in the rumen by dehydrogenation (Boadi et al., 2004).

Of the medium-chain fatty acids, caproic (C6), caprylic (C8) and myristic (C14) acids in coconut or palm oil are the most effective in attenuating CH_4 emissions. Moreover, fats are not metabolized in the rumen and therefore do not contribute to methanogenesis.

According to the studies conducted by researchers at the National Institute for Agricultural Research in Clermond-Ferrand, the use of flaxseed oil in the diet of dairy cows has led to a reduction in methane emissions, respectively cows that received flaxseed oil, 6% of them have reduced their methane emissions by 27 to 37% (Md Najmul, 2018).

CONCLUSIONS

From the multitude of solutions proposed to reduce greenhouse gas emissions, the strategies based on feed solutions are the most effective in the ruminant breeding sector.

In most cases, the benefit is twofold, namely limiting the greenhouse effect and improving animal production.

In practice, a reduction in gas emissions in the future is possible provided that farmers are aware of the need to invest in order to ensure this food adaptation to the new recommendations of researchers in the field.

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