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# DIETARY MANIPULATION TO COMBAT RUMINANT METHANE PRODUCTION

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## ABSTRACT

Mitigating methane ($CH_4$) losses from ruminants is generally required to minimize global greenhouse gas emissions and to enhance animal performance by improving feed conversion efficiency. The production of $CH_4$ has been reduced using various techniques which affect the metabolism, microbial population and/or animal digestive physiology. These technologies can be broadly classified into improved nutrition and fermentation modification strategies. The nutritional approaches include dietary manipulation and feed additive supplementation. This paper presents some promising methane mitigation options with special consideration to ruminant dietary modification.

**Keywords:** Methane, forages, concentrate, lipid, mitigation.

## INTRODUCTION

Methane ($CH_4$) is the second most important greenhouse gas after carbon dioxide and contributes for 16% of the total greenhouse gas emissions globally (Scheehle and Kruger, 2006). The global warming potential of methane is 21 times more than carbon dioxide (EPA, 2008). Methane production from ruminants has been considered as the single largest source of anthropogenic $CH_4$ (Mathison *et al*., 1998). Livestock release methane as part of their natural digestive processes. The rumen serves as the habitat of billions of microbes, including bacteria, methanogens, protozoa and fungi which breakdown feed to produce volatile fatty acids (VFAs), carbon dioxide, ammonia and methane. The VFAs are utilized by animal as energy source whereas gases are emitted by eructation.

According to FAO, the world livestock population in 2011 comprised 1,400 million cattle, 195 million buffaloes,1,044 million sheep and 876 million goats. Globally, about 80 million tonnes of $CH_4$ is produced annually from enteric fermentation mainly from ruminants (Patra, 2012).

Cattle can produce 250–500 liter of methane per day per animal (Johnson and Johnson 1995) and generally lose 2–15% of their ingested energy as eructated methane (Giger-Reverdin and Sauvant, 2000). Nevertheless, controlling methane losses from ruminants has environmental as well as economical benefits. Less methane means a lower concentration of greenhouse gases in the atmosphere. Also, less methane means increased efficiency of livestock production and increased income for farmers. A greater amount of methane production can be controlled by modifying the composition of the animal feed. Changing the feed composition, either to reduce the percentage which is converted into methane or to enhance the meat and milk yield has been considered as the most efficient methane reduction strategy. Enhancement in the overall quality of animal feed may prove helpful in maintaining meat and dairy production at the same level with fewer animals and so less total methane emission.

### Dietary manipulation

**Roughages (Forage type and quality):** The composition and quality of forage along with level of intake significantly influences the rumen fermentation (Johnson and Johnson, 1995). Ruminants fed low quality roughages could release large amount of methane. Feeding crop residues to ruminants is a common practice in many Asian countries due to which methane emission from ruminants especially cattle is significant. Benchaar *et al*. (2001) speculated 15% reduction in methane production by increasing the digestibility of forages and 7% by increasing feed intake. Grinding and pelleting operations of roughages decrease methane production by improving passage rate and reducing time of feed (Eckard, 2001). The shifting of animals from low to high digestible pasture significantly reduced methane production per gram of live weight gain (Hegarty, 1999). The use of forages meant for improving animal performance can reduce methane emissions per unit of feed intake. Importantly, pasture improvement can be a good choice if fewer animals are used (Patra, 2012).

**Concentrates:** A negative correlation between proportion of concentrate and methanogenesis has been reported in the literature (Holter and Yong, 1992; Yan *et al*., 2000). Beauchemin and McGinn (2005) found methane reduction due to high levels of starch-based concentrate (grains). Sauvant and Giger-Reverdin (2007) observed a curvilinear relationship between concentrate proportion in the diet and methane production. A significant reduction in methane production was reported in young bullsfed the diet containing more than 40% starch (Martin *et al*.,2007). A diet comprising 45% starch decreased methane production by 56% compared to diets containing 30% starch without affecting animal health. Inclusion of starch in the diet has a significant impact on changing ruminal pH and microbial populations (Patra, 2012). As concentrate contains more soluble substances, the addition of concentrate in animal diet changes the composition of partial short chain fatty acids (SCFA) from higher to lower acetate production and more propionate (Johnson and Johnson, 1995). Similarly, milk quality is negatively affected if concentrates exceed 50% which limits the use of concentrates to lower methane emissions in the dairy sector. Moreover, the increased dietary concentrate may proliferate total net emissions as more grain must be grown, processed and transported, resulting inmore use of pesticides, fertilizers, and additional supplementary sources of emissions associated with production and transportation infrastructure (Beauchemin *et al*., 2008). Forage processing like chopping, grinding and pelleting can further decrease methane production. Increase rate of passage of the processed forage likely contributes to the reduced methane production (Johnson and Ward, 1996).

**Lipids:** Lipids and lipid-rich feeds are among the most efficient and emerging options for methane mitigation. Lipid inclusion in the diet reduces methaneemissions by decreasing fermentation (Johnson and Johnson, 1995). Saturated medium chain fatty acids, C10-C14, also lead to methane reduction. At ruminal temperature, an increasing chain length of medium chain fatty acids seems to reduce their efficiency in inhibiting methanogens and methane formation due to lower solubility (Bucher *et al*., 2008; Patra, 2012). Beauchemin *et al*. (2008) reviewed the practical application of lipids to reduce methanogenesis. Oil supplementation to diet decreased methane emission by upto 80% *in vitro* (Fievez *et al*., 2003) and about 25% *in vivo* (Machmu¨ller *et al*., 2000). The toxic effects of certain oils on rumen protozoa contributed to reduced methane production (Machmu¨ller *et al*., 1998). The addition of canola oil at 0%, 3.5% or 7% to the diets of sheep reduced the number of rumen protozoa by 88–97% (Machmu¨ller *et al*., 1998).The detrimental impact of unsaturated fatty acids has also been reported (Henderson,1973). Machmulleur *et al*. (1998) observed coconut oil as more effective inhibitor followed by rapeseed, sunflower seed, and linseed oil. Coconut oil comprises medium chain fatty acids. Dong *et al*. (1997) compared canola oil to coconut oil and demonstrated coconut oil as more effective methane inhibitor. Coconut oil controlled rumen methanogens by changing the metabolic activity and composition (Machmu¨ller *et al*., 2003). The inclusion of sunflower oil to the diet of cattle resulted in 22% decrease of methane emissions (McGinn *et al*., 2004). However, fats and oils may pose numerous negative impacts to the animals. Dietary oil supplementation caused lower fiber digestibility (McGinn *et al*., 2004). Jordan *et al*. (2006) estimated that feeding copra meal containing coconut oil to animals takes a longer time to reach a common carcass weight and decrease the effects on total methane emissions. High cost and the negative impact on milk fat concentration are some of the limitations of oil supplementation (Zheng *et al*., 2005).

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