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The use of feed additive to reduce methane in greenhouse gas

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Abstract

Ruminant produces GHGs primarily CH4 and so cattle and sheep contribute significantly to the carbon footprint of farming. The Climate Change sets ambitious emission reduction targets, requiring all sectors, including agriculture to reduce GHG emissions to mitigate anthropogenic climate change. Globally, 50-60% of methane emissions are from the agricultural sector, specifically from livestock production operations; the principal source of methane is from ruminant animals. Digestive processes happen mainly in anaerobic conditions, and microorganisms have a huge role in these processes. Enteric fermentation from livestock is a large source of methane, which has a global warming potential 23 times of carbon dioxide. Feed additives classified as CH_4 inhibitors directly act on the methanogens pathway that can disrupt the process and reduce CH_4 production (g/day). Methanogens prevent H_2 accumulation in the rumen, which otherwise may lead to adverse effects on fibre degradability and animal performance. The rumen environment can be modified with feed additives to limit the growth of methanogens and to suppress CH_4 production, without targeting the specific methanogens pathway. The factors influencing CH_4 production include those involved in H_2 and carbohydrate metabolism. Understanding rumen metabolic processes that affect CH_4 formation is still advancing; however, feed additives were used to modify the rumen environment to reduce CH_4 production without compromising animal health or productivity.

Keywords

feed additive,
rumen,
mitigation and
methane

1. Introduction

Methane (CH4), as an atmospheric greenhouse gas, has climatic importance because it contributes to global warming. Methane is produced mainly by reducing carbon dioxide with hydrogen (CO2+4H2→ CH2+ 2H2O) [3] from enteric fermentation during the normal digestive process of ruminants. Additionally, methane is one of the most important sources of energy loss in ruminants(Science, 2021). Ruminant production produces GHGs primarily CH4and so cattle and sheep contribute significantly to the carbon footprint of farming. The Climate Change sets ambitious emission reduction targets, requiring all sectors, including agriculture to reduce GHG emissions to mitigate anthropogenic climate change. Globally, 50-60% of methane emissions are from the agricultural sector, specifically from livestock production operations; the principal source of methane is from ruminant animals. Digestive processes happen mainly in anaerobic conditions, and microorganisms have a huge role in these processes(Grange, 2021). Enteric fermentation from livestock is a large source of methane, which has a global warming potential 23 times of carbon dioxide. The ruminant stomach consists of 4 compartments and the rumen is the main place of methane production. Approximately 90% of the whole methane are produced there Rest of it is produced in the large intestines. Almost all methane (89%) emitted from ruminants is produced in the rumen and exhaled through the mouth and nose. One way of decreasing GHG is to use a specific methane inhibitor3NOP (3-nitrooxypropanol) that has no significant impact on cows: feed intake, fibre digestibility and milk production. Researchers have also noticed the increase in milk protein and lactose level in milk. The emitted methane was reduced by30%. In other studies, researchers reached the methane reduction by 20%, at the same time, the weight gain increased by additional 75g/day, and milk yield increased by 1l/day in dairy cattle. It means that with a significant reduction of CH_4 emission the animal productivity can be improved, but we need to find the optimal feeding recipe which would be compatible with conditions and available feed sources in Latvia, taking into account economic factors and the obtained production. The other way to decrease GHG is to reduce the use of dairy cattle for beef production(December, 2017). Therefore, it is advisable to slaughter those calves which are not used for herd reproduction before they have become full ruminants, that is - before the emission of gases from the rumen into the surrounding environment has not significantly increased. However, producers in order to get more valuable production from one animal grow animals longer till they reach a higher live weight. We consider that shorter animal growing periods can be achieved by making corrections in the animal feeding strategy and by using natural feed supplements which can promote animal interior body reserve usage. Prebiotics can increase daily weight gain in calves and are used along with nitrate, probiotics, and yeasts and have a potential to reduce methane production(Jaihindcollege, 2012). Such prebiotics as fructo-oligosaccharides (FOS), inulin and galacto-oligosaccharides (GOS) can be used to reduce methane production in ruminants. But there are fewer studies done about FOS and inulin and their impact on methane reduction in ruminants, therefore we used inulin. In the previous study by, milk supplementation with inulin had very promising results regarding weight gain when animals reached 90kg weight3 weeks earlier than the control group; also the live weight gain was higher in calves fed with additional supplement of inulin(Kataria, 2015).

Objective

To discuss the use of feed additives to reduce methane

2. The use of feed additive to reduce methane in greenhouse gas

The level of methane production from the rumen is inversely related to the quantity (energy value) and quality (digestibility) of the feed an animal consumes(Jaihindcollege, 2012). As the amount of feed consumed increases, the energy available for conversion to methane also increases. There is a relationship between Methane emissions and feed digestibility. Therefore, if the efficiency with which the animal digests its feed is increased, the amount of energy released in the form of Methane gas by rumen can be reduced. From5-15% of the digestible energy in feed Lost as methane gas. So, if we could reduce the amount of methane produced by cattle, we could significantly reduce the amount of feed they need and also protect the environment from the hazards of greenhouse effect. The most promising approach for reducing methane emissions from livestock is by improving the productivity and efficiency of livestock production. Increasing animal productivity will generally reduce methane emissions per kg of product. Because of the improvement in production efficiency, a greater proportion of the energy in the animal feed is directed towards production of useful products and hence a methane emission per unit product is reduced. This will also lead to a reduction in herd size to produce the given level of product. In the developed countries of the world, ruminant livestock are kept in well managed production systems and generally fed diets that are very high indigestibility and nutrients. The result is very efficient production (milk or meat) relative amount of methane emitted(Kataria, 2015). Unfortunately, ruminants in developing countries are kept on diets that are low in both digestibility and nutrient content. This leads not only to greatly increased methane emissions, but also much diminished productivity relative to the animals' genetic potential. This in efficient productivity has global implications. Which rumen fermentation will be optimized requires an understanding of the nutrient requirements of the mixed microbial population. Growth of rumen microbes is influenced by chemical, physiological and nutritional components. The major chemical and physic-logical modifiers of rumen fermentation are rumen pH and turnover rate and both of these are affected by diet and other nutritionally related characteristics such as level of intake, feeding strategies, forage length and quality and forage: concentrate ratios. Recent research has suggested that interventions in early life of the animal can trigger differential microbial rumen colonization and development, which may result in differential rumen CH_4 production. This interesting concept may offer new opportunities for mitigating CH_4 emission in ruminants but needs to be further tested and verified. Since methane represents a loss of carbon from the rumen and therefore an unproductive use of dietary energy, scientists have been looking for ways to suppress its production(Jaihindcollege, 2012).

2.1 Rumen methanogens

Methane production can be substantial in ruminants, representing upto12% of gross energy intake that could potentially be utilized for physiological processes, but instead is released into the atmosphere through eructation(Jaihindcollege, 2012). However, CH_4 synthesis represents a significant metabolic sink for reducing equivalents (hydrogen, H_2) that would otherwise accumulate in the rumen and create an unfavourable environment for fermentative digestion processes. Hydrogen itself does not accumulate due to methanogen activity; instead, methanogens participate in interspecies H_2transfer, and dispose of the reducing equivalents from other metabolic processes(Honan et al., 2017). Hydrogen synthesis is a self-limiting process that relies on separate and distinct reducing equivalent consumption pathways so as to continue production. Cellulose-degrading activity in both bacteria and fungi increases in the presence of methanogens, which contributes to the principle of rumen syntrophic relationships. Rumen methanogens is performed strictly by archaea. A methanogens pathway is presented in a simplified diagram (Fig. 1), which includes the convergence of pathways known to occur in a *Methanosarcina* spp. categorized methanogens on the basis of their metabolic path ways, as follows: hydrogen trophic, aceto clastic and methyl trophic that can yield CH_4 in the rumen from *Methanosarcina* spp. Methanogens reduce CO_2 with H_2 (hydrogenotrophic), source a methyl group from acetate (acetoclastic), or a methyl group from compounds such as methanol, methylthiol, dimethylamine and mono-,di-,tri- methylamine. Formate contributes to methanogens is as an electron donor(Honan et al., 2017).

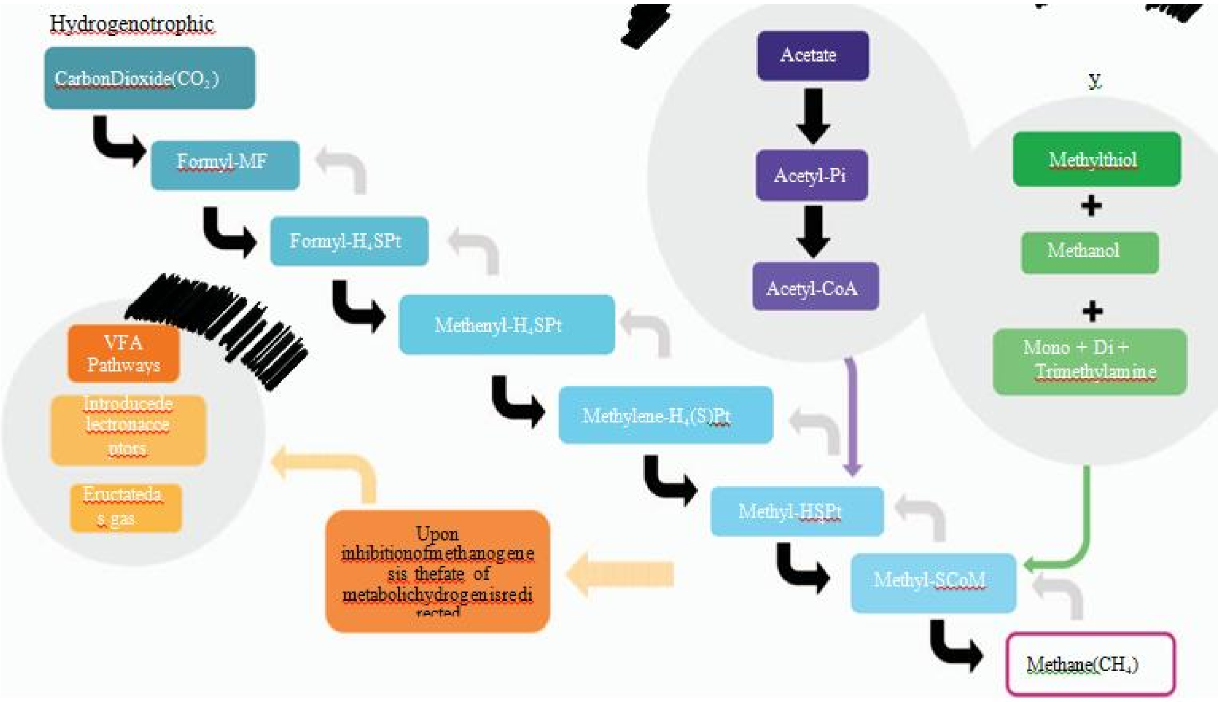


Figure 1 methane formation in the rumen

Coenzyme requires a methyl group for the reduction to CH_4, which is provided through each of these pathways. Methane mitigation could be achieved by directly targeting methanogens or modifying the rumen environment to shift the metabolic pathways away from methanogens or reduce substrates for the archaea(Honan et al., 2017).

2.2 Rumen inhibitors to reduce methane

Feed additives classified as CH_4 inhibitors directly act on the methanogens pathway (Fig. 1) In a way that can disrupt the process and reduce CH_4 production (g/day)(Honan et al., 2017). Methanogens prevent H_2 accumulation in the rumen, which otherwise may lead to adverse effects on fibre degradability and animal performance. Given the importance of efficient fibre digestion, the use of CH_4 inhibitors must balance between reducing CH_4 production and avoiding negative impacts on animal performance and welfare. Inhibition of methanogens requires are direction of reducing equivalents, H_2 in this case, to alternative sinks, instead of CO_2, unless the inhibitor’s mode of action is a highly competitive electron acceptor. Several of these alternative sinks reviewed here in and may also be implemented as independent feed additives or with an inhibitor. Studies have shown a decrease in CH_4 emissions paired with an increase in H_2 emissions without the addition. More than 15 studies have been conducted using 3NOP, showing a marked reduction of enteric CH_4emissions with a range of effectiveness. 3NOP added to ruminant diets in small quantities has been shown to persistently reduce enteric CH_4emissions by inhibiting an important step in the methanogens metabolic pathway, without apparent negative side effects(Honan et al., 2017). The effect sizes of a mean difference between the control and treatment-group mean CH_4production. For example,m0.2 g 3NOP/kg dry-matter(DM) supplementation, CH_4 production in back grounding and finishing beef cattle reduced 37.6% and84.3% compared with the control group, whereas using the same amount of supplementation in background phase (0.2 g/kg DM) of beef cattle, found a54.1% reduction in CH_4 production. These reduced the level of supplementation of 3NOP to 0.125g/kgDM during the finishing phase and reported 53.8% reduction in CH_4 production.

There was also an improvement in gain-to-feed ratio during treatment, with a 7% drop in DM intake. Similarly, another report shows a decrease in CH_4 production of 38% and daily weight gain of 0.571kg/day compared with the control in steers supplemented with 0.30g3NOP/kg DM. Methane (CH_4) production in lactating cows was reduced by 30% by feeding 3NOP at 0.04–0.08 g/kg DM without affecting feed intake and milk production. It shows 31% decrease CH_4 production in lactating dairy cattle fed diets supplemented with 0.06 g/kg DM. In a meta-analysis of the anti-methanogen effects of 3NOP, reported that enteric CH_4 production was reduced 39% in dairy and 22% in beef cattle at a mean dose of 0.123g/kg DM. Additive dose and the neutral detergent fibre (NDF) content of diet had a significant impact on the effectiveness of 3NOP in reducing CH_4 emissions. Furthermore, an increase in 3NOP dose of 0.010g/kg DM from the mean dose further reduced CH_4 production by 2.560.55%. Similarly, the methanogen archaea population was reduced through 3NOP supplementation and the magnitude of reduction was positively correlated with 3NOP dose in small and large ruminants(Honan et al., 2017). Addition of 3NOP is also associated with shifting H_2production in the rumen and results in an increase in molar proportion for propionate and decreases acetate production. There are no known adverse effects of supplementing 3NOP on the animal or the subsequent product. The feed additive 3NOP continues to be studied and, after approval by regulatory bodies, it is expected to be on the market in the near future(Honan et al., 2017).

2.2.1 Halogens to reduce methane

Plant species that accumulate halogenic compounds in their tissues have been investigated for their potential to reduce enteric CH_4 emissions(Honan et al., 2017). Halogens are elements that hold a large, negative electron affinity and seek to combine with other compounds to reach stability through satisfaction of the valence shell in the rumen environment. Bromoform and chloroform are halogens that have been found to interfere directly with the methanogens path way by serving as competitive inhibitors, preventing the final catalysis step. The mode of action is through reacting with reduced vitamin B12 and inhibiting the cobamide-dependent methyl-transferase step of methanogens. The B12-dependent methyl-transferases also play an important role in one carbon metabolism in acetogenic bacteria and therefore, halogenated compounds may have an effect on reductive acetogenesis. At supplementation level of 1.50–1.59 g/kg DM (2.6 g/100 kg live weight; mean live weight=288kg) of chloroform–cyclodextrin, steers have demonstrated a30–35% reduction in enteric CH_4production, with no detectable differences in rumen ferment ability. Steers dosed daily with 0.267 g/kg DM of chloroform were shown to decrease 94–95% of CH_4 production with in4–5days of treatment. However, CH_4production has been shown to slowly recover to 62% of the pre-treatment levels byDay42 of treatment. The macro algae species *Asparagopsistaxiformis* and *A.armata* have been evaluated for their mitigation potential both *in vitro* and *in vivo*. *Asparagopsis*spp.contain relatively high concentrations of bromoform and other halogenated compounds such as bromochloromethane. An *in vitro* trial analysing effectiveness across sea weed species found *A. taxiformis* to be the most effective species among 20 freshwater and marine macro algae in reducing CH_4output (98.9%), but also reduced total gas production (62%), likely indicating inhibition of digestion(Honan et al., 2017). Increasing the dose to 5% *in vitro*, reported a 95% reduction in the level of CH_4 production. Three papers have been published so far, reporting the effect of *Asparagopsis* spp. in sheep, dairy and beef cattle *in vivo*. Supplemented *A. taxiformis*at67.5g/kg DM (30g/kg of organic matter, OM) in sheep diets and reported a reduction of upto 80% in enteric CH_4 production(Honan et al., 2017). However, rumen volatile fatty acid(VFA) concentrations in the 0%,0.5%,1.0%,2.0% and 3.0% macro algae inclusion groups declined from92.0,to86.5,74.9,69.1 and 65.4m M respectively. Reductions in VFA concentrations are not desirable as they provide energy to the ruminant. In lactating dairy cattle, observed up to

67.2% reduction in CH_4 intensity (g/kg milk produced) using *A. armata* at an inclusion rate of 18.3 g/kg DM (10 g/kg of OM). In Brangus beef cattle, reported a reduction of enteric CH_4production of up to98% by supplementing a feedlot diet with *A. taxi formis* at 3.26g/kg DM(2g/kg of OM). In addition, there was an improvement of 42% in average daily gain with a supplementation level of 1.63g/kg DM(1.0g/kg of OM) and it went up to 53% a tan inclusion rate of 3.26g/kg DM(2.0g/kg of OM). The study by reported a greater effectiveness at a lower dose than did, which was likely due to the large differences in the bromoform concentration in *A. taxi formis* and *A. armata*, while also acknowledging the inclusion of monensin in the experimental diets(Honan et al., 2017). The bromoform concentration in study was 1.32 mg/g compared with 6.55mg/g in the study. Sourcing naturally occurring halogens circumvents the need to use synthetic halogens. Historically, these synthetics have had detrimental effects on the environment. the tested for residual bromoform content in meat (or edible offal) and milk respectively. In both cases, concentration of bromoform were either undetectable or not significantly different from the control, suggesting no safety issues arising from the active ingredient. At present, *A. taxiform* is not produced commercially; so accessibility is an issue. The use of macro algae also needs to be approved by regulatory agencies before wide spread use by producers.

2.2.2 Nitrate to reduce methane

Adding nitrate to ruminant diets can be an effective CH_4 mitigation strategy because nitrate competes with methanogens for H_2 in the rumen(Honan et al., 2017). Nitrate (NO_3^{-}) is reduced to nitrite ($NO_2^{-}NO3^{-}+H_2NO_2^{-}+H_2O$) and further to ammonia ($NH^{+};NO^{-}+3H+2H^{+}NH^{+}+2HO$) by rumen microbes. However, small quantities of nitrous oxide may also be produced. This pathway is highly competitive with methanogens for H_2 utilization in the rumen due to greater changes in Gibbs energy than with methanogens ($CO_2+4H_2CH_4+2H_2O$) pathway. The result is a redirection of H^{+}flow from $CO_2$to nitrate reduction, thereby reducing the generation of CH_4, about 24 *in vivo* studies showed that the efficacy of nitrate additives varied widely, ranging from +1.25% to29.8%, and may be affected by several factors. A meta-analysis conducted by investigated the potential explanatory variables for anti-methanogenic effects of *in vivo* nitrate supplementation in cattle. These included DMI, roughage proportion, NDF content, crude protein content, body weight, nitrate dose, cattle type, and CH_4 measurement methods. The authors reported that nitrate significantly reduced CH_4 emissions in a dose–response manner and the mitigating effect increased with the level of nitrate inclusion. Methane production reduced 14.6% in cattle supplemented with nitrate at 17.7 g/kg DM. The nitrate supplementation increased ammonia-nitrogen concentrations in the rumen by 34%, decreased propionate concentrations by 16%, but did not affect the total VFA concentrations. Persistency of nitrate was tested by including 21g/kg DM during four successive 24-day periods and a consistent 16% reduction in daily CH_4 production (g/day) and yield (gCH_4/kg DMI) was demonstrated(Honan et al., 2017). An additive effect of nitrate and linseed oil was reported by multiparous, non-lactating dairy cattle. These authors reported that adding 4% linseed oil to 3% calcium nitrate further reduced CH_4 production from 22.8% (nitrate only) to 33.0%. Concerns about the toxicity of the intermediate product of nitrate, namely nitrite, to ruminants necessitate management, as animal poisoning may occur via methaemoglobinemia. Nitrite is toxic in blood because it converts hemoglobin to methaemoglobin, which is in capable of carrying oxygen. Blood methaemoglobin concentrations in ruminants increase with a greater nitrate consumption and could cause nitrate poisoning. Apparent nitrate-poisoning symptoms such as depressed feed intake, slow or no weight gain, reproduction failure, respiratory distress and death have been reported in previous studies with methaemoglobin concentrations of 30–40% of total hemoglobin. It discussed several critical factors related to nitrate toxicity, including the dietary nitrate concentrations, nitrate consumption rate, incomplete reduction of nitrate and nitrite to ammonia, and rumen outflow rates(Honan et al., 2017). Toxic effects of nitrite on the populations of main cellulolytic bacteria, which may be caused by the negative effects of nitrate/nitrite on cellulolytic and xylanolytic activity, have also been observed. However, the risk of nitrate toxicity can be reduced by gradual acclimation of ruminants to dietary nitrate or utilization of encapsulated nitrate. Currently, nitrate inclusion may not be advisable in commercial operations due to its potential toxicity. However, a denitrifying probiotic, *Paenibacillus fortis*, that can enhance nitrite detoxification in nitrate treated ruminants, has been identified. If successful, nitrate and the probiotic might be a practical mitigation strategy to reduce CH_4 production from ruminants(Honan et al., 2017).

2.3 Rumen modifiers to reduce methane

The rumen environment can be modified with feed additives to limit the growth of methanogens and to suppress CH_4 production, without targeting the specific methanogens pathway(Honan et al., 2017). The factors influencing CH_4 production include those involved in H_2 and carbohydrate metabolism. Understanding rumen metabolic processes that affect CH_4 formation is still advancing; however, feed additives were used to modify the rumen environment to reduce CH_4 production without compromising animal health or productivity. This section discusses feed additives that can potentially reduce CH_4 production by modifying the rumen environment.

2.3.1 Dietary lipids

Dietary lipids modify the rumen environment in several ways, including(1) toxic characteristics on methanogens and protozoa,(2) hydrogenation of unsaturated fatty acids(alternative H_2sink) and (3) shifts to propionic production, leading to reduction of enteric CH_4 production (Jaihindcollege, 2012). Efficacy of lipids to reduce CH_4 emissions are dependent on the form and level of supplementation, as well as the source and fatty acid profile. For example, evaluated 17 studies in sheep, beef and dairy cattle and reported a5.6% reduction in CH_4 production for every 1% additional inclusion of supplemental fat. In dairy cattle, reported a decrease of 9% through lipid-supplementation (average 6.4%) compared with control diets (average 2.5%), mostly as a consequence of reduced DMI. Similarly, reported 3.77% decline in CH_4 emissions for each percentage inclusion of lipid in dairy cattle diets. Prediction in consistencies by the inclusion of supplemental lipid is likely to be due to differences in lipid source and diet composition. In a review, reported that the most effective fatty acid profiles that reduce CH_4 production were medium-chain(8–16 carbon chains; MCFA) and polyunsaturated (PUFA) fatty acids. However, reductions in DMI due to high levels of dietary lipids are well characterized and ration formulation programs often are set not to exceed6–7% of total DMI(Jaihindcollege, 2012).

2.3.2 Medium-chain fatty acids

These include lauric, meristic, capric and caprylic acids. *In vitro* studies have reported coconutoil, which contains 75% of MCFA, to reduce CH_4 production by43–85%. Application of coconut oil in *in vivo* trials also showed similar patterns in CH_4 reduction(Honan et al., 2017). Ruminants fed diets containing13,27 and 33g coconut oil/kg DM had 3%, 37% and 45% reduction in CH_4 output compared with the control respectively. DMI, solids-corrected milk yield and milk fat yield decreased linearly with an increase in coconut oil application. Inclusion of meristic acid at a rate of 50.0 g/kg DM in dairy cattle diets reduced CH_4 production by 36%, but also reduced milk fat by 2.4%, with a tendency to reduce DMI. Lauric acid had no negating effects on methanogens in dairy cattle when they received it at 10.0 g/kgDM.With in the same trial, the treatment group receiving21.6g/kg DM of coconut oil reduced their CH_4 production by 61% compared with the control(Honan et al., 2017).

2.3.3 Polyunsaturated fatty acids

Polyunsaturated fatty acids have also been shown to reduce CH_4 production. For example, it found that enteric CH_4 production reduced by 29.5% with supplementation of 60 g/kg DM of camelina oil, but other parameters such as milk yield and milk components were compromised(Honan et al., 2017). In contrast, did not find significant differences in enteric CH_4production in steers fed increasing amounts of dietary lipid sourced from maized is tillers dark grains, which increased diet ether extract from24to37 g/kg DM for 17 weeks. Supplementation of diets with cottonseed oil has been shown to decrease enteric CH_4 production by ~42%.These authors suggested that bio-hydrogenation of lipids served as an alternative H_2sink, and with each percentage point of lipid added to the diet, CH_4 production was reduced by 8%. Further characterization and understanding of the impact and longevity of dietary lipid inclusion on methanogens would be valuable in selecting plant sources and estimating their impact. Dietary lipid additives show substantial decreases in CH_4 production with a wider range of effectiveness compared with other feed additives(Honan et al., 2017).

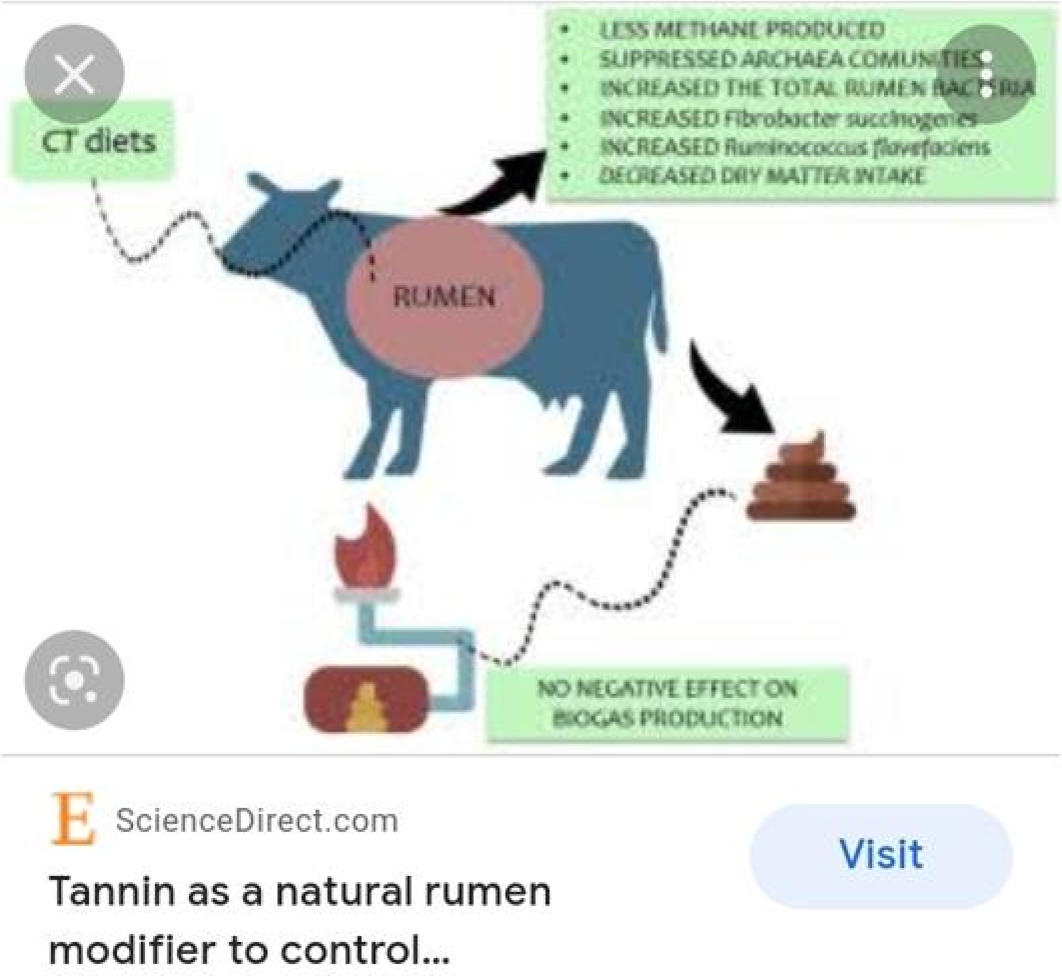
2.3.4 Ionophores to reduce methane

Ionophores, such as monensin, alter rumen microbial populations to improve digestive efficiency by depriving methanogens of substrates that are typically provided by Gram-positive bacterial and ciliate protozoal populations(Jaihindcollege, 2012). This fermentation shift favours the production of propionate over acetate, which reduces the amount of H_2 available for methanogens. A meta-analysis by quantitatively determined the impact of monensin in cattle. In beef cattle supplemented with monensin at an average dose of 0.032 g/kg DM, CH_4 production was reduced by 19 g/day, which was further reduced as the NDF content of the diet increased. In dairy cattle, CH_4 production was reduced by 6 g/day at the same average dose and was further reduced as the dietary lipid content increased. Stated that although there were reductions in CH_4 production through supplementation with monensin, the effect was transient, lasting ~6weeks. In contrast, reported no suppression effect of monensin on CH_4 output when it was administered to dairy cattle (0.024 g/kg DM), but there was an increase in the proportion of a bio hydrogenation intermediate, thus altering rumen metabolism patterns. The anti-microbial nature of ionophores has caused a concern to human health. Long-term use of ionophores is limited due to a low efficacy, transient nature and safety concerns(*Animals-11-02871-V294*, n.d.).

2.3.5 Tannins to reduce methane

In plants, tannins exist as polyphenols of varying molecular size and complexity and are of two types: hydrolysable and condensed tannins(Kataria, 2015). The condensed tannins also called as proanthocyanidins, has a characteristic influence on proteins and carbohydrates. Tannins have both bactericidal and bacteriostatic effect and canal so inactivate ruminal enzymes. Tannins suppress methanogenesis directly through their anti methanogenic and defaunation property. Tannins, as feed supplements or as tanniferous plants have a potential for reducing CH_4 emission by up to 20% has observed that there is a decrease initro methane production with methanol extract at the level of 0.25/30 mL of incubation medium. He also observed a complete inhibition at double this level. Sources containing both hydrolysable and condensed tannins were shown to be more potent than those containing only hydrolysable tannins. According to the anti-methanogen effect of tannins depends on the dietary concentration and is positively related to the number of hydroxyl groups in their structure. Which stated that hydrolysable tannins tend to act by directly inhibiting rumen methanogens, where as the effect of condensed tannins on CH_4 production is more through inhibition of fiber digestion(Kataria, 2015).

Figure 2 tannins to reduce methane in greenhouse gas



Tannin as a natural rumen modifier to control...

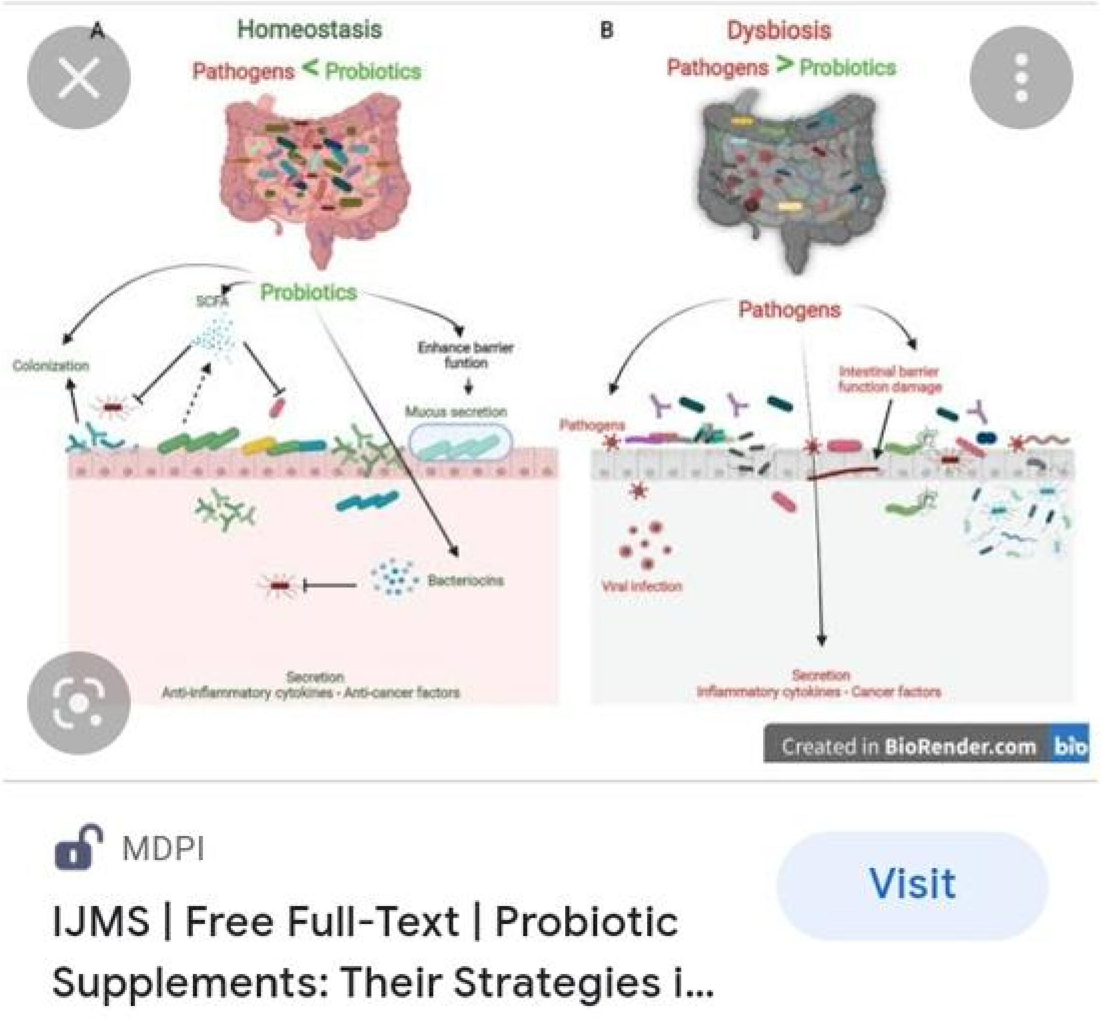
2.3.6 Saponin to reduce methane

Saponins are complex compounds that are composed of a saccharide attached to a steroid or triterpene and have a soapy character due to their surface and properties(Jaihindcollege, 2012). Several studies with saponins reported decreased CH_4 production from about 6 to 27% by reducing the protozoa population. Saponins cause defaunation through their binding with sterols present on the protozoal surface. It found that 5 herbal products such as pulp powder of reetha (*Sapindusmukorossi*), shikakai (*Acaciaconcinna),* mahua (*Madhuca indica) cake,* albezia leaves *(Albizia lebbek)* and yucca (*Yucca schiagera)* reduces methane production *initro*. Inhibition of methane production up to 96%was reported with the ethanol and methanol extracts of soap nut (*Sapindus mukorossi*). The studied focus on the effect of different concentrations of saponin where in 60% of methane reduction was observed as the concentration increased from 1.2 to 3.2 g/L fermentation medium. Studies from China have reported decreased CH_4in ruminants treated with teatriterpenoid saponins but also substantial changes in microbial populations, including a reduction in protozoal counts. Combination of saponin and nitrate may have practical application in mitigating methane emission from ruminants. In a study saponin and nitrate in combination at low dose inhibited methanogens is substantially while increasing feed degradability (Jaihindcollege, 2012).υ

2.3.7 Probiotics to reduce methane

Direct-fed microbial (DFM), in one form or another, are commonly used as supplements in animal production(Kataria, 2015). The most widely used microbial feed additives are based on *Saccharomyces cereisiae* (SC) and *Aspergillus-oryzae* (AO). Their effect on rumen fermentation and animal productivity are wide ranging and this has been carried out by suggesting that live yeast cells can stimulate the use of hydrogen by acetogenic strains of ruminal bacteria there by enhancing the formation of acetate and decreasing the formation of methane. These effects are variable and short-term, diminishing2-4hour after feeding. Other DFM interventions of ruminal fermentation include inoculation with lactate producing and lactate utilizing bacteria to promote more desirable intestinal microflora and stabilize pH and promote rumen health, respectively. There have also been other attempts to inoculate the rumen with fungi (*Candida kefyr*) and lactic acid bacteria (*Lactococcus lactis*) along with nitrate supplementation to control methanogenesis, but no consistent animal data have been reported.

Figure 3 Probiotics to reduce methane in greenhouse gas



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2.3.8 Prebiotics to reduce methane

The prebiotics or oligosaccharides are non-digestible carbohydrates normally used in the non-ruminants for better gut health and feed utilization(Jaihindcollege, 2012). They are used in rumen manipulation along with nitrates, probiotics and yeast to have reduced methane production. The increase in cellulolytic rumen bacteria is provided by using prebiotic compounds such as mannan-oligo-saccharide(MOS), fructo-oligo-saccharide(FOS), and galacto-oligosaccharide-ride. The administrations of galacto-oligo-saccharides have brought about reduction of methane production upto11% (Jaihind college, 2012).

Conclusion

Several feed additives provide a promising option that could increase the sustainability of animal-sourced foods by substantially reducing enteric CH_4 emissions. Methane production can be substantial in ruminants, representing upto12% of gross energy intake that could potentially be utilized for physiological processes, but instead is released into the atmosphere through eructation. However, CH_4 synthesis represents a significant metabolic sink for reducing equivalents (hydrogen, H_2) that would otherwise accumulate in the rumen and create an unfavorable environment for fermentative digestion processes. Rumen inhibitors have shown potential of up to 98% reduction in enteric CH_4 production, although they differ in accessibility and risk to animal welfare. Although none of the inhibitors are currently on the market, on the basis of the volume of available literature, 3NOP may be offered to producers. The rumen environment can be modified with feed additives to limit the growth of methanogens and to suppress CH_4 production, without targeting the specific methanogens pathway. The factors influencing CH_4 production include those involved in H_2 and carbohydrate metabolism. Understanding rumen metabolic processes that affect CH_4 formation is still advancing; however, feed additives were used to modify the rumen environment to reduce CH_4 production without compromising animal health or productivity. The rumens microbes specially the methanogens get adapted to some of these feed additives and initial adverse effect observed on inhibition of methanogenesis are lost. In addition to these, most of the feed additives tested *in vitro* and found effective in inhibiting methanogens, have not been tested and therefore, their exact potential for practical use is still not known. The use of any method for methane reduction can only be justified if there is a beneficial effect larger than the cost of the product. This ratio will depend on the cost of feed additive, the dose required and the resulting improvement in the animal performance.

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