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Feeding Strategies and Manure Management to Mitigate Green House Gas (GHGs) Emission in Dairy Farms

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Abstract

Basic aims of livestock rearing are production and harvest more and more profit margin. Nutrition (Balanced ration), along with manage mental, gynaecological and medicinal inputs helps to enhance the profitability through livestock rearing. Nutrition is foremost important and significantly higher input cost in livestock rearing and surely influential and deciding factor of profitability. Gaseous loses from overall nutritional inputs is significant lose of input and hazardous to climate safety. Thus, article proposed to elaborate various feeding strategies to minimize the gaseous loses, enhance climate safety and deliver more and more profit towards livestock owners.

Key words: Nutrition, Green house gases, Climate safety.

Introduction

Net GHGs emissions from India in 2007 were 1727.71 MT of CO_2 equivalents, out of this livestock and manure emitted about 212.10 MT of CO_2 eq. GHG (INCCA, 2010). Methane is a potent greenhouse gas and comprises up to 16% of the total GHGs emission (Scheehle and Kruger, 2006). Total GHGs emissions from livestock globally estimated as 7.1 GT (18%) CO_2 eq. (Steinfeld et al., 2006). Global atmospheric CH_4 conc. increased by 150% from 722 ppb in 1750 to 1803 ppb in 2011 (IPCC, 2013). (Fig. 1 and 2)

Thus, we urgently needed to elaborate various plans/strategic measures to overcome such environmental issues, as such things might be catastrophic consequences for upcoming generation and. Scientist and researchers are trying to manipulate conventional feeding system to beneficially affect rumen environment, lower down dietary loses and eco-friendly animal husbandry.

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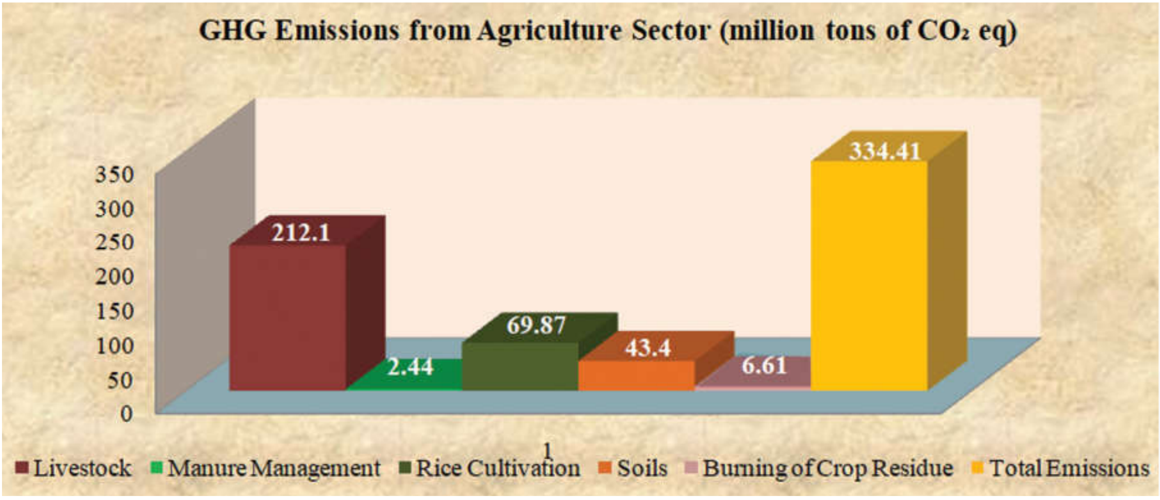

Fig. 1 Partitioning of GHGs from agriculture and its allied sectors. (INCCA, 2010)

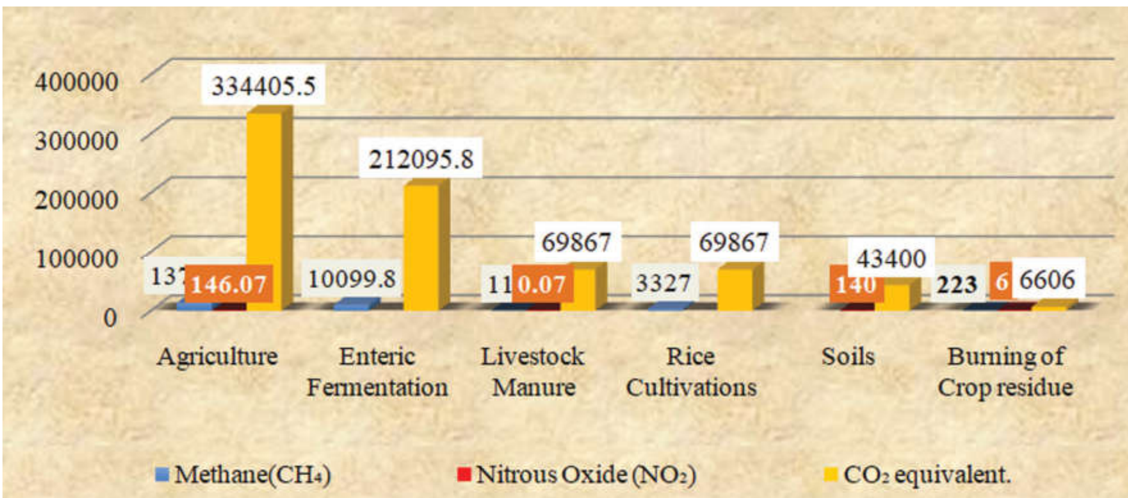

Fig. 2 Greenhouse Gas Emissions by Sources and Removal by Sinks from India in 2007 (Thousand tons). (INCCA, 2010)

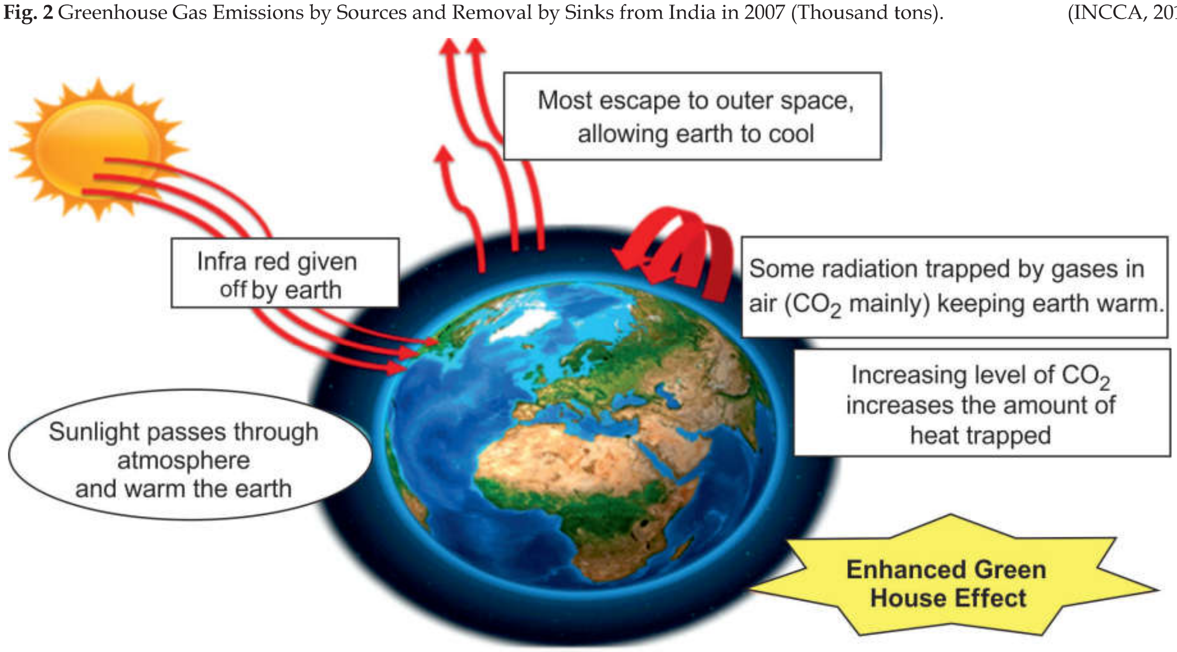

Fig. 3 Green House Effect on Earth. (INCCA, 2010)

Table 1: Major Green house gases and its contribution

Gas	Current Conc. (ppm)	Rate of increase (%/yr)	Half Life (yr)	GHG Contribution (%)
CO_2	391	0.5	150	55 – 60
CH_4	1.8	0.7	7-10	15 – 20
N_2O	0.32	0.2	150	5

(IPCC, 2013)

Table 2: Methane Production by Dairy Animals

Species	Enteric Fermentation Emission (Tg)	Manure Management Emission (Tg)	Total Emission (Tg)
Dairy Cattle Indigenous	2.32	0.289	2.61
Cross-bred	0.84	0.074	0.92
Total	3.16	0.363	3.53
Non Dairy Cattle Indigenous	2.12	0.208	2.33
Cross – bred	0.11	0.01	0.12
Total	2.23	0.218	2.45
Dairy Buffaloes	4.06	0.371	4.441
Non dairy Buffaloes	0.44	0.055	0.490

(Chhabra et al., 2009)

Strategies to Mitigate Enteric Methane Emission

1. Inhibitors
2. Electro receptors
3. Ionophores
4. Dietary lipids
5. Exogenus enzymes
6. Direct fed microbial
7. Defaunation
8. Feed intake
9. Concentrate inclusion
10. Forage quality
11. Feed processing and feeding frequency
12. Plant bio-active compounds

Inhibitors

Bromoethanesulphonate (BES) is a potent inhibitor of methanogenesis because it is a structural analogue of the cofactor mercaptoethanesulfonic acid (coenzyme M), used by methanogenic bacteria (Mathison et al., 1998). BES depressed CH4 production by 71% without significantly affecting organic matter digestibility and VFA concentrations

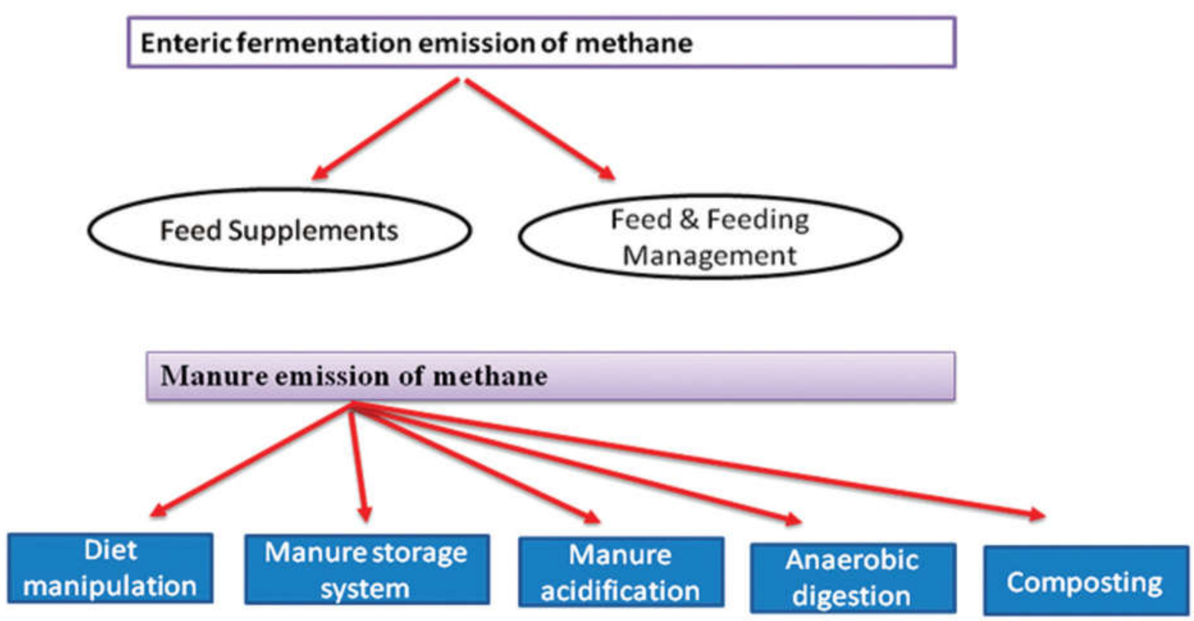

Fig 4. Enteric and Manure Emission of GHGs.

(Source: Personal)

in the artificial rumen (Dong et al., 1997). Bromochloromethane (BCM) and Cyclodextrin reduce 50% of CH_4 production (Mitsumori et al., 2011). (Fig. 4 and 5)

Table 3: Concentrate Roughage Ratio

Concentrate	Roughage	Propionate (%)
25	75	23.33
50	50	30
75	25	35.66

(Singh & Mohini.,1993).

Electron Receptor

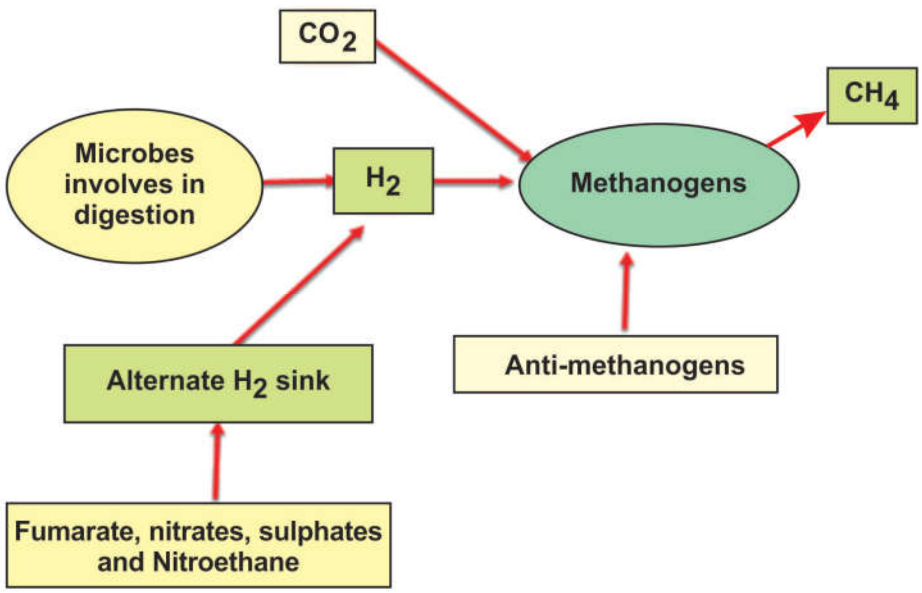

Fig. 5: Influences of Electron Receptors on GFGs Emission.

(Source: Personal)

Ionophores

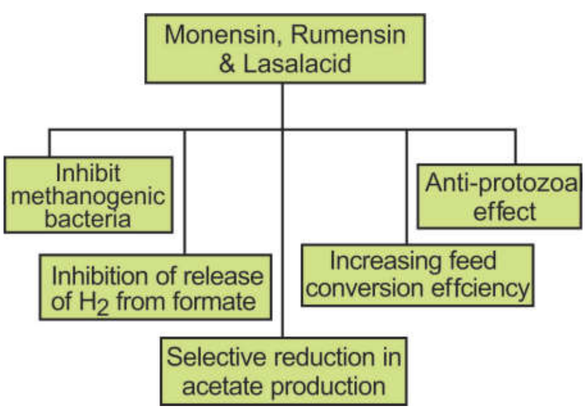

Fig. 6: Different Pathways to Control GHGs.

(Source: Personal)

Methane production reduced from 40.9 to 28.0 lit/Kg DM due to the increase of concentrate mixture from 25% to 75% in wheat straw based diet (Singh & Mohini.,1993). (Table 3 and Fig 6)

Dietary Manipulation

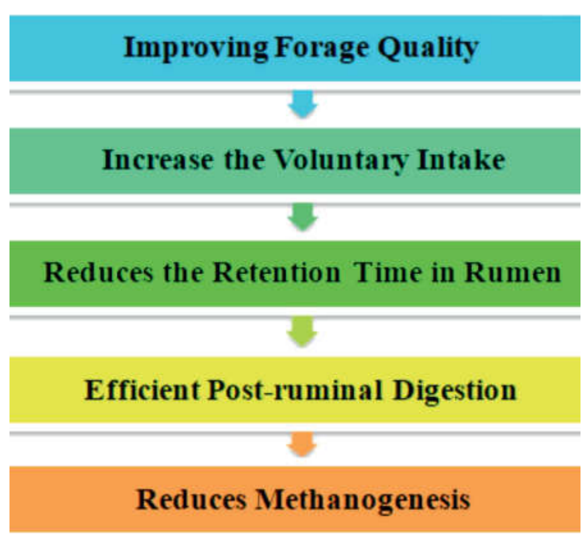

Fig. 7: Influences of dietary quality on GHGs emission

(Hess et al., 2011)

Plant Bioactive Compounds (PBAC)

This category includes a variety of plant secondary compounds, specifically tannins, saponins, essential oils and their active ingredients.

Tannins

Condensed tannin form complexes with dietary proteins and carbohydrates in the rumen (pH = 7.0). Thus, reducing digestibility of DM and organic matter (OM) and the release of H2 (indirect effect) (Jayanegara et al., 2011) (Fig. 8)

- Two forma of tannin occurs, naturally

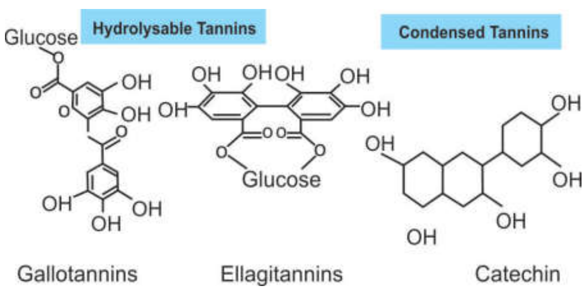

Fig. 8: Chemical Structures of Tannin.

(Patra et al., 2010)

Saponin

Suppress enteric CH_4 production due to their ability to reduce Protozoal numbers and modify fermentation patterns in the rumen (Meale et al., 2012). 54% decrease in protozoa counts and a 20% decline in in vitro CH_4 production when supplementing saponins at 12 mg/g DM (Rejil et al., 2008). Singh et al. (2017) investigated blend of saponin rource, Sapindus mukorosii alongwith Ficus bengalensis and Eucalyptus globus essential oil under In vitro environmental conditions and reported significantly (P<0.001) reduced methane emission in treatment group, as compared with control group. They suggested influenced beneficial microbial population, enhanced propionate production and suppressed ruminal degradability of feed might be the cause of methane inhibition. Singh et al. (2018) In vitro examined natural saponin from Sapindus mukorosii in various cumulative dose regimens and reported significantly reduced methane production, as compared with control group. They suggested enhanced propionate production leads to methane inhibition.

Essential Oils

Anti-microbial activities against Gram-positive and Gram-negative bacteria, attributed to a number of terpenoid and phenolic compound (Sivropoulou et al.,1996). Singh et al., (2018), investigated Cymbopogon citratus essential oil for its effect on methane inhibition and various other ruminal parameters and reported highly inhibition of methane production, even though very low dose incubation (@10µl/40ml of rumen fluid) (Fig. 9)

Defaunation

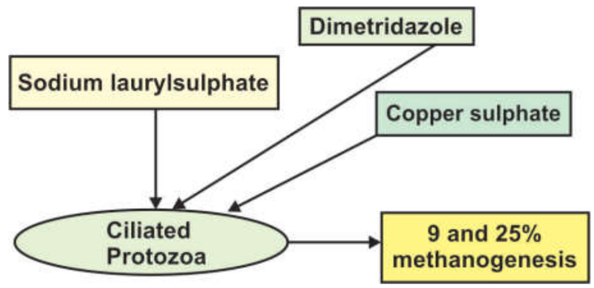

Fig.9 Influences of defaunation on GHGs emission.

(Boadi et al., 2004)

Immunization

Methanogenic specific vaccine 1st developed by Australian researchers reduce 7.7% methane emission (Wright et al., 2004). Canadian researchers prepared IgY antibodies in chicken eggs against three species of methanogens (Cook et al., 2008). Identified several gene targets to inhibit CH_4 in M.ruminantium via chemogenomic and vaccine is prepared (Leahy et al., 2010).

Use of Bacteriocin

Bovicin HC_5, a bacteriocin produced by Streptococcus species from the rumen, was reported to suppress CH_4 production in vitro by 50% (Lee et al., 2002)

Use of Probiotics

Probiotics are 'live microorganisms' which when administered in adequate amounts confer a health benefit on the host. (Saccharomyces cerevisiae & Aspergillus oryzae) (Lascano & Cardenas, 2010).

Mitigation of manure (CH_4 and NO_2) Emission

Dietary Manipulation

Feeding dairy cows low-protein diets dramatically reduces the proportion of urinary, particularly urinary urea N (> 50 %) in animal excreta (Misselbrook et al., 2005).(Fig. 7)

Manure Acidification

Moderate decrease in manure pH through acidification significantly reduces NH_3 volatilization and CH_4 losses from stored manure (Petersen and Sommer, 2011).

Composting

Composting is an exothermic, aerobic process of microbial decomposition of organic matter. It influences significant loss of CO_2, N and reduce CH_4 emission (Husfeldt et al., 2012).

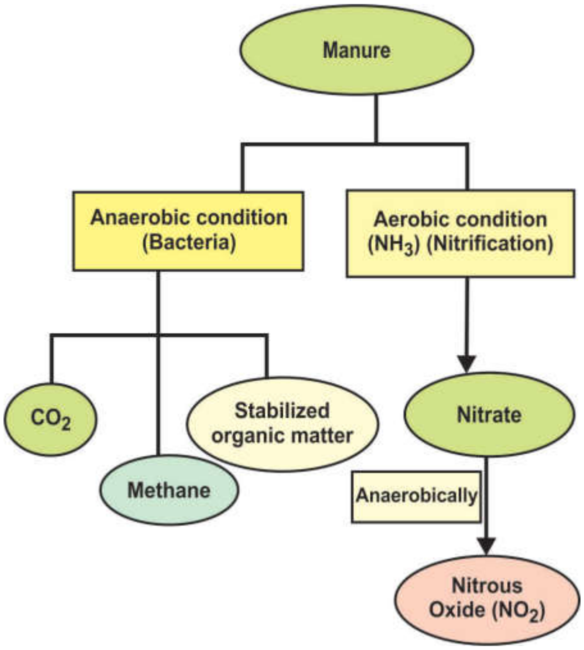

Fig.10 GHG_S mitigation through manuring.
(Source: Personal).

Nitrification Inhibitors

Nitrification inhibitors are chemical compounds that inhibit the oxidation of ammonia to nitrate in soils and thus reduce N_2O emissions from NH_4 (Di and Cameron, 2002). eg. Nitrapyrin, Hippuric acid and Dicyandiamide (DCD)

Anaerobic Digestion

Mechanism of Biogas production

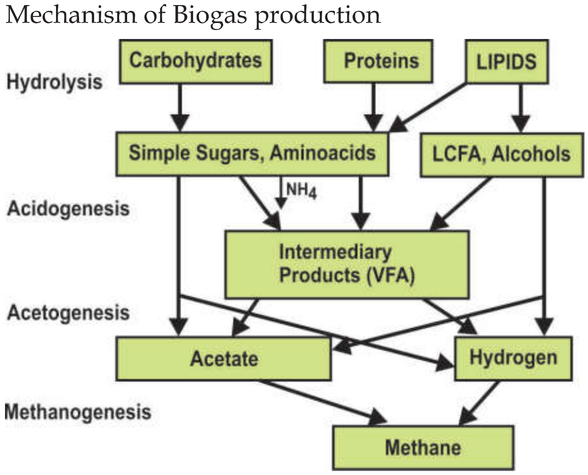

Fig.11 Mechanism of Bio-gas Production.
(Gujer and Zehnder, 1983)

Manure Applications

- Lowering the concentration of N in manure
- preventing anaerobic conditions or reducing concentration of degradable manure C
- Timing of the manure application and maintaining soil pH above 6.5 may decrease N_2O emissions
- Subsurface injection of manure slurries into the soil can result in localized anaerobic
- Conditions surrounding the buried liquid manure, higher CH_4 emissions than with surface applied manure

(Amon et al., 2002)

Grazing Management

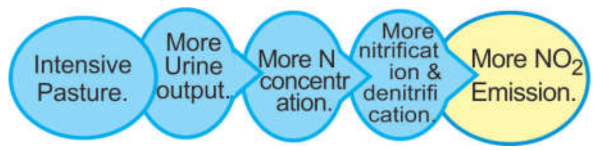

Fig. 12 Pathway of GHGs emission through improper grazing management.
(FAO, 2013)

Conclusions

- Mitigation of CH_4 emissions can be effectively achieved by strategies that improve the efficiency of animal production, reduce feed fermented per unit of product, or change the fermentation pattern in the rumen.
- Strategies that are cost effective improve productivity and have no potential negative effects on livestock production hold a greater chance of being adopted by producers.
- These new strategies are promising, but more research is needed to validate these approaches and to assess in vivo their effectiveness in reducing CH_4 production by dairy cows.
- Adjustment of manure storage systems involves high investment cost and high cost per unit of emission reduction and may not be adopted easily.

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