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Combatting the Effects of Greenhouse Gas Emissions by Cattle to Decrease Global Warming

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Abstract

Greenhouse gases (GHG), specifically methane, carbon dioxide, and nitrous oxide, contribute to eutrophication and global warming. Large amounts of these gases are released by beef and dairy farms. The misconception is how and why greenhouse gases are emitted from cows. It is hypothesized that greenhouse gas emissions from cattle can be reduced through mitigation strategies in beef and dairy production along with farmers' contributions to their livestock's emissions. The reduction of emissions and increase in milk production comes from increased activity and care of the cows, including medicating lesions and diseases. It is also concluded that waste management and records of emissions support the general public in renewable energy, better quality beef and dairy for sale, and a reduced progression of global warming. These results can add to future methods for climate control, alternatives to beef and dairy, and farm maintenance of all livestock.

Keywords: mitigation, enteric fermentation, methanogens, biogas, cattle lameness, carbon footprint

Introduction

Greenhouse gases (GHG) contribute to climate change by depleting the ozone layer and changing the planet's environment. Some of these gases are emitted from dairy and beef farms due to biological functions of the cattle. Methane, nitrous oxide, and carbon dioxide are the most common greenhouse gases released from cows[1]; methane comes from the release of gas during digestion while carbon dioxide and nitrous oxide are found in manure[1]. Cows contribute to GHG emissions in the agricultural industry due to rumination. They digest complex starches with a natural process of fermentation in their rumen called enteric fermentation[2], resulting in the highest impact on methane production in the gastrointestinal tract. Problems also arise in the lactation process of dairy cows[3] and the intensive growth of muscle in beef cattle[1]. Cattle in farms that are fed a main diet of grain increase emissions from rumination and lead to reduced muscle production[4]. While this diet may be cheaper and easier for the farmer, it leads to health issues and lack of activity for the cows, resulting in conditions like subclinical mastitis and foot lesions. These health issues in the cows increase GHG emissions and impact global warming and the environment overall.

The future of the atmosphere, temperature, and water conditions on this planet depend on reduced greenhouse gas emissions and a reduction in the environmental hazards of mass production of beef and dairy[5]. Almost 40% of carbon dioxide emissions in Latin America are due to their cow pastures[1]. Some solutions to mitigate these

emissions are available for farmers, including a carbon footprint calculator and milk recording. These tools can help current farmers understand their own impact to GHG emissions and assist scientists' future research developments of more useful mitigation strategies and possible ways to raise cattle with reduced GHG emissions. The future of this research can also include developing alternatives to beef and dairy that may reduce the demand for cows and result in a healthier lifestyle for the livestock. There are gaps in the field regarding the measured GHG in the atmosphere, along with the recorded emissions from the farms themselves. The technology to study cattle emissions is limited, and thus prevents accurate studies of GHG emitted worldwide. It is essential to reduce these emissions to prevent a higher concentration of GHG in the atmosphere.

Source of the Gases

Of all greenhouse gases emitted by dairy cows on farms, 62-65% of emissions are reported to be methane from digestion[1]. Cows have a complex digestive system which involves their rumen, the first compartment of their stomach where enteric fermentation occurs, as seen in Figure 1. Methanogens, a species of microbial gut bacteria, live in the rumen and are responsible for fermenting plant material and producing methane[6]. While many farmers find it cost-effective to use a grain-based diet, it is more harmful to the cows and the environment. A diet consisting of primarily grains or complex carbohydrates increases methane release. A cow's digestive system is built to break down omega-3 fatty acids and simple starches in grass, but the

introduction of grain, including corn and soy, to their diet has only lengthened the process of digestion and led to an increase in the release of methane[7]. Due to increased digestion time, beef cattle experience a reduction in muscle production since most of their diet is broken down to methane[4]. The methanogens impact the digestion process, which limits the food contribution to muscle growth and an increase in methane release.

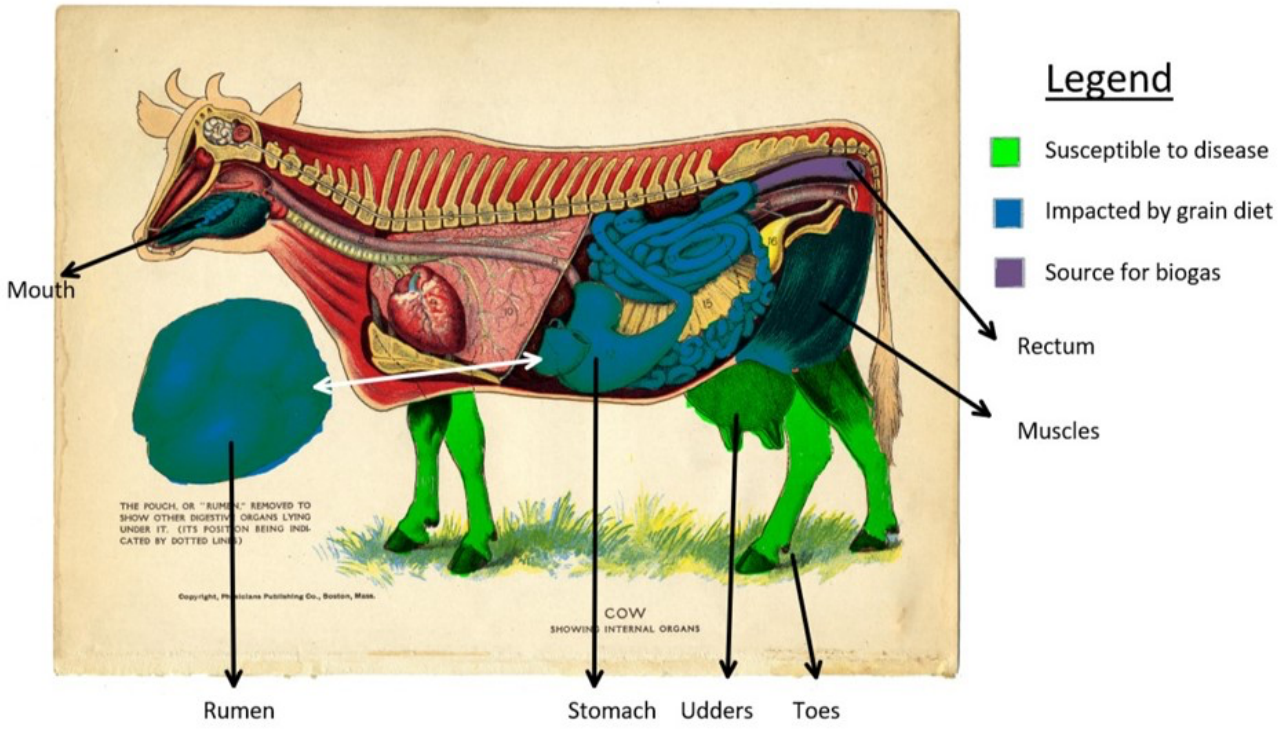

Figure 1. Anatomical Description of GHG Release. This diagram accentuates the major areas of the cow's anatomy that are directly affected or contribute to GHG emissions. The utters and toes indicate diseases and medical treatment for milk production and lameness, shown in green. The mouth explains the strain of a grain diet

and complex carbohydrates which lead to the rumen/stomach, which shows the enteric fermentation that produces methane[7] shown in blue. The muscles depict the effects of complex starches and the vital production of muscles for profitable beef[1]. The last section of the cow is its rectum, the source of manure and release of methane through gas expulsion[2] shown in purple. The sections of the cow's anatomy have been segmented based on their impact in GHG emission. Image altered from https://commons.wikimedia.org/wiki/File:Interior_of_a_cow_from_The_Household_Physician,_1905_(14147237759).jpg

One solution offered was isolating the genome sequence in methanogens and working on modifying it to release less methane during enteric fermentation[6]. Through modification, this would allow for cows to continue to eat grains and release less methane while digesting. Another solution is for farmers to treat their cows in an ethical way. This is crucial in order to ensure comfort in the cows, increase their physical health[8], and abide by worldwide policies on livestock treatment[9]. Ethical treatment involves a proper diet and land for cows to be active. If farmers could provide more grassy land for their cows to roam and eat, the release of methane for the farm overall would reduce.

Cow manure breaks down into carbon dioxide and nitrous oxide in the soil[10], which contribute to pollution by runoff. This leads to eutrophication in the local water and releases greenhouse gases from the algae produced by pollution[11]. One solution to

reducing the amount of manure in the soil is to utilize biogas. Biogas has emerged as a popular process on dairy farms that can be a renewable energy source through the collection and burning of manure[2, 12]. Not only is it a cheaper form of energy, but it was found to mitigate 60% of GHG emissions annually in two cities in northern Italy[13]. Burning the manure instead of allowing it to infiltrate the soil will reduce the carbon dioxide and nitrous oxide present while providing a new form of renewable energy. If the gases never make it to the ground, then there will be a reduction in pollution and eutrophication of local water.

Medical Impacts on GHG Emissions/ Treatment

One component of farm-raised cattle is promoting active lifestyles for the cows to ensure prime health. Dairy cows who are not as active or do not have accessibility to roam are more likely to suffer medical ailments, produce less milk, and have higher GHG emissions[14-15]. The largest problem in cattle lameness is informing the farmers; 8-25% of cattle lameness goes undetected due to farmers overestimating the activity of their cows[16]. Two specific diseases caused by cattle lameness are subclinical mastitis[15] and foot lesions[14].

Subclinical mastitis is a bacterial infection of the udders from the staphylococci pathogen[17]. It clogs the milk ducts, reduces milk released, and causes an increase of methane due to higher somatic cell counts in the infected areas[15]. One issue with

subclinical mastitis is its ability to be resistant to antimicrobials, especially when a large number of the herd has the disease[17]. The most effective solution to treat subclinical mastitis is medicating with alternating antibiotics[18] and udder injections[17]. This medication method treats the infections, prevents the spread to more of the herd, and allows for a larger supply of milk per cow.

Digital dermatitis, or foot lesions, are ulcers that appear on the bottom of the toes when the cows are inactive for long periods of time[14, 19]. As seen in Figure 1, the toes are hidden under the hooves and are highly susceptible to injury due to exposure. In an experiment of 204 herds, 96.7% of the herds were affected by digital dermatitis[19]. When the cattle are in pain, they produce less milk and release more methane in times of bodily stress[14]. The solutions to foot lesions are treating them medically and increasing activity of the cows by access to pastures or open land[16]. This will reduce the stress, allow for a healthier lifestyle, and overall reduce GHG emissions.

Methods for Efficient Farming

One component of these farms is their carbon footprint, a number recorded per unit, that collects every environmental impact from the farm, including GHG emissions, and pollution of the world's air and water. This number per farm is usually not known, which puts farmers at risk for releasing more GHG than they are aware of. One mitigation strategy offered is a carbon footprint calculator, which calculates the

footprint based on these direct and indirect GHG emissions from farms[20]. This calculator allows farmers to see the actual number of GHG being released and use other mitigation strategies to reduce this number. For example, the average carbon footprint for milk in New Zealand dropped from 0.81 to 0.75 kg of carbon dioxide equivalent from the years 2010 to 2018 once limitations on farms were enacted[10]. This calculator will allow all farmers to record their GHG emissions and modify their personal mitigation strategies on their farms.

Another sustainable farming solution is a process called milk recording. This is a use of a machine commonly in agriculture that measures milk through samples and provides records of quality and properties[21]. This technique allows farmers to evaluate their milk samples and make changes based on the health of their livestock. For example, a milk record from an Irish farm predicted a 9% increase in GHG emissions based on the production of milk per cow and the quality of the milk[21]. Milk recording can provide accurate data on the quality of milk and its contribution to GHG emissions. It was found that organic milk has 40% less GHG emissions than mass-produced milk on other farms[22]. This method of milk recording can allow all farmers to see a report of their milk quality and production and alter their mitigation strategies to farm effectively and sustainably.

Conclusion

Raising cows for beef and dairy in mass numbers results in some of the largest emissions of greenhouse gases in agriculture. Cows experience high methane emissions due to enteric fermentation and a diet with prolonged digestion. Solutions include a primarily grass diet for the cattle or gene modification of the methanogens. A solution to soil saturated with carbon dioxide and nitrous oxide from cow manure is to increase popularity of biogas beyond farms.

Many health problems in beef and dairy cows go unnoticed and tend to lead to higher emissions and a reduced production of milk[15], which can be solved with consistent records, prevention of lameness, and medical attention to diseases. Routine veterinarian exams and sufficient room for cattle activity can prevent subclinical mastitis and foot lesions in the herd. The demand for beef and dairy creates a struggle for farmers trying to profit off of their farm while still maintaining proper treatment of their animals and the environment. A method for monitoring GHG emissions is an official recording of their carbon footprint and milk recording while also practicing mitigation strategies and avoiding mass production of beef and dairy.

Future research in GHG emissions from cattle can branch off into environmental sustainability or alternates to dairy and beef in the food industry. There can be more research into solutions of raising cattle to reduce methane emissions along with more

research in proper waste management[12]. Research can also advance in substitutes for dairy and beef demand, including synthetic meat, to introduce the general population to more plant-based lifestyles. This would allow for farmers to avoid mass production and offer more ethical ways to raise cattle. These advancements in research can lead to greater reduction of greenhouse gas emissions, a healthier environment for all, and the reduced production of cattle for the beef and dairy industry.

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