Agriculture

EXTENSION
Utah State University

extension.usu.edu

October 2017 AG/Beef/2017-03pr

Understanding the Contributions of Beef Cattle to Greenhouse Gas Emissions

***Elizabeth Stewart*[1], *Eric Thacker*[1], *Matthew Garcia*[2] and *Juan Villalba*[1]**

[1]Department of Wildland Resources, and the [2]Department of Animal, Dairy and Veterinary Science, Utah State University

Current and Projected Beef Consumption in the U.S.

The consumption of beef in the United States has decreased by more than 10% since 2006, and this decrease in consumption has been correlated to the rising price per pound of beef. The average price per pound of beef was $3.97 in 2006 and had risen to $6.29 per pound in 2015 (USDA 2016). However, according to the USDA (2016), decreasing costs of production and a continuous demand from both international and domestic markets are expected to drive an increase in beef production and consumption at a rate of approximately 1% per year over the next decade (USDA, 2017). This rise in beef production is going to increase the concern about environmental impacts from cattle and how to reduce them.

Agricultural activities are responsible for 7.9% of total greenhouse gas (GHG) emissions in the U.S., according to the EPA (2017). Beef cattle are the largest contributor here, primarily due to their sheer numbers (Stackhouse-Lawson, 2015). Of this, the cow-calf phase is responsible for approximately 80% of the GHG emissions from the entire beef production system (Beauchemin, 2010). There are three greenhouse gasses that are produced from the production of beef cattle: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). CH_4 and N_2O emissions are typically less than CO_2 emissions, however they are much more effective as greenhouse gasses so a smaller amount can do more damage (Stackhouse-Lawson, 2015; Figure 2).

Methane

Total methane production from cattle comes from two mains sources, manure and enteric fermentation, with enteric methane being the biggest contributor (Stackhouse-Lawson et al., 2015; Figure 1). When cattle digest their feed, it is subjected to what is called enteric fermentation in the rumen and enteric methane is a by-product of this.

Figure 1. Most methane from cattle is the result of enteric fermentation and is expelled through their nose and mouth.[1]

Methane emissions in the U.S. resulting from enteric fermentation account for about 35% of the total anthropogenic (originating from human activity) CH_4 production and of this, beef cattle are the largest contributors. This is important because methane is approximately 25 times more effective of a greenhouse gas than carbon dioxide (EPA 2017; Figure 2).

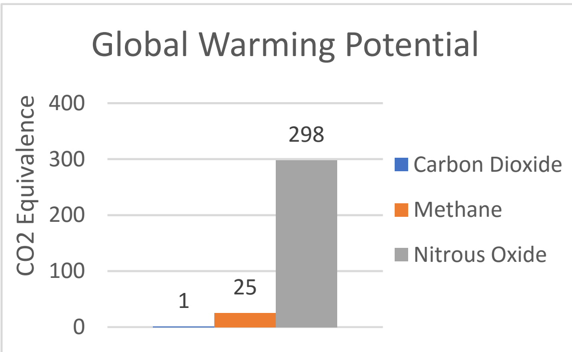

Figure 2. Global warming potentials of the three greenhouse gasses arising from beef production.

Nitrogen

Cattle are not efficient at utilizing the nitrogen that is provided in their feed, which results in large losses through the urine as urea. Once excreted, some of the urea is transformed into ammonia (NH_3) and nitrous oxide.

The primary pathway for nitrous oxide formation is through nitrification and denitrification, which are parts of the normal nitrogen cycle, in the soil following fertilizer application or urine deposition by animals. The continuous input of nitrogen fertilizer and manure make pastures and areas cultivated for crops the main sources of nitrous oxide emission (Stackhouse-Lawson et al., 2015). This is of concern because 27% of GHG emissions from beef production can be attributed to the N_2O in the soil and manure (Beauchemin, 2010) and N_2O is almost 300 times more potent as a greenhouse gas than CO_2 is (EPA, 2017; Figure 2).

The total amounts of NH_3 and N_2O produced can depend on the type of production system used. The high protein content and quality of the diet fed in a feedlot system results in higher losses of nitrogen since the cattle are not able to efficiently utilize it. Thus, ammonia and nitrous oxide emissions resulting from beef cattle are decreased when animals are kept on pasture to graze rather than being finished on a high grain diet in a feedlot system (Stackhouse-Lawson et al., 2015).

Beef Cattle Production

Rangeland Grazing

In the western portion of the U.S, a large portion of beef production takes place on rangeland for most of the year (Figure 3). Cattle grazing rangeland are typically consuming a diet that consists of mainly (if not entirely) roughage. Consequently, they will produce more enteric methane than cattle in feedlots that are consuming a concentrate based diet (Stackhouse-Lawson et al., 2015). This is because, in general, methane producing bacteria are not as numerous in the rumens of cattle consuming high concentrate diets so there will be less opportunity for the production of CH_4. Additionally, the lower the quality of the feed the more CH_4 produced (Van Soest, 1994). On the other hand, lower quality feed is likely to be lower in protein. Less protein in the feed will likely result in less nitrogen that is excreted as urea in the urine.

Figure 3. In the west, a large portion of beef production takes place on rangelands.[3]

Grass Finished Beef

Grass finished beef is a niche market that keeps cattle on forage during the last stage of production rather than the more conventional option of moving them to a feedlot to finish on a high concentrate diet. One of the main reasons driving the demand for grass finished beef is health concerns (McCluskey et al., 2005) and the perceived benefit of grass finished over grain finished beef because the meat from grass finished beef is lower in total saturated fatty acids (Daley et al., 2010). From an environmental standpoint, however, this might not be the best option. Grass finished production systems have been shown to produce more methane and require more land than conventional beef finishing systems (Capper, 2012). However, as mentioned above, cattle consuming low quality forage will produce less urinary urea than those consuming high concentrate diets.

Conventional Beef Production System

The conventional beef production system in the United States consists of a cow-calf phase which lasts for about a year. This is followed by a finishing phase lasting for about 4 months (Figure 4).

Figure 4. In the U.S. most weaned calves are finished on a high concentrate diet before being harvested.

During the finishing phase, the animals are fed a high concentrate diet in order to put as much weight on them as quickly as possible before harvest. This diet is very easily digested by the animal which reduces the amount of methane produced (Van Soest, 1994), but also increases the amount of nitrogen wasted and excreted as urea in the urine (Gay, 2009).

Possibilities for More Sustainable Beef Production

Diet is key in reducing the GHG emissions from cattle and it can be very difficult to control or manipulate the diet of cattle in a rangeland situation. Furthermore, it is not a win all or lose all situation. The same diet that could limit the amount of methane produced by cattle could also increase the amount of nitrogen excreted as urea in the urine.

For grass fed operations, consideration should be given to the type and quality of the forage that is being fed, since giving cattle access to higher quality roughage would help to decrease the amount of enteric methane produced (Van Soest, 1994). Another option to reduce methane would be to feed forage that contain certain plant secondary compounds. For example, tannins have been shown to reduce populations of CH_4 producing bacteria in the rumen, thus reducing the amount of CH_4 produced (Tan et al., 2011). Tannins can also bind with proteins in the rumen, resulting in less nitrogen lost as urea in the urine (Grainger et al., 2009).

Additionally, to decrease the amount of nitrogen excreted in the urine and feces, attention would need to be given to the nitrogen content of the feed and how much nitrogen fertilizer is applied to the pastures. Feeding hay or grazing pastures with lower nitrogen would decrease fecal and urinary nitrogen excretion, thus reducing the amount of N_2O produced (Dijkstra et al., 2013).

Overall, the sustainability of beef production is going to be heavily dependent on learning how to better manage the diets of animal raised for beef production. We will be able to manage this by finding ways to incorporate better quality forage into their diets. Furthermore, as we gain a better understanding of plant secondary compounds, such as tannins, they may become an important tool in reducing greenhouse gas emissions.

Sources

[1]Image courtesy of Yvette de Haas (https://www.wur.nl/en/show/Mitigating-methane-emission-from-ruminants-at-European-level.htm)
[3]Image courtesy of Shawn Regan (https://www.perc.org/articles/managing-conflicts-over-rangelands_fraser_ranching-realities)

Beauchemin, K. A., Janzen, H. H., Little, S. M., McAllister, T. A., and McGinn, S. M. (2010). Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. *Agricultural Systems, 103*(6), 371-379.

Capper, J. (2012). Is the grass always greener? Comparing the environmental impact of conventional, natural and grass-fed beef production systems. *Animals, 2*(2), 127-143.

Daley, C. A., Abbott, A., Doyle, P. S., Nader, G. A., and Larson, S. (2010). A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. *Nutrition Journal, 9*(10). Retrieved from: https://nutritionj.biomedcentral.com/articles/10.1186/1475-2891-9-10.

Dijkstra, J., Oenema, O., van Groenigen, J. W., Spek, J. W., van Vuuren, A. M., and Bannink, A. (2013). Diet effects on urine composition of cattle and N_2O emissions. *Animal, 7*(2), 292-302.

EPA. (2017). Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2015. Retrieved from: https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf

EPA. (2017). Overview of Greenhouse Gasses: Methane Emissions. Retrieved from: https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane

EPA. (2017). Overview of Greenhouse Gasses: Nitrous Oxide Emissions. Retrieved from: https://www.epa.gov/ghgemissions/overview-greenhouse-gases#nitrous-oxide

Gay, S. W. (2009). Ammonia Emissions and Animal Agriculture. Retrieved from: https://pubs.ext.vt.edu/442/442-110/442-110_pdf.pdf

Grainger, C., Clarke, T., Auldist, M. J., Beauchemin, K. A., McGinn, S. M., Waghorn, G. C., and Eckard, R. J. (2009). Potential use of Acacia mearnsii condensed tannins to reduce methane emissions and nitrogen excretion from grazing dairy cows. *Canadian Journal of Animal Science,* 89(2), 241-251.

McCluskey, J. J., Wahl, T. I., Li, Q., and Wandschneider, P. R. (2005). US grass-fed beef: marketing health benefits. *Journal of Food Distribution Research, 36*(3). Retrieved from: http://ageconsearch.umn.edu/bitstream/27758/1/36030001.pdf.

Stackhouse-Lawson, K. R., Rotz, C. A., Oltjen, J. W., and Mitloehner, F. M. (2015). Carbon footprint and ammonia emissions of California beef production systems. *Journal of Animal Science, 90*(12), 4641-4655.

Tan, H. Y., Sieo, C. C., Abdullah, N., Liang, J. B., Huang, X. D., and Ho, Y. W. (2011). Effects of condensed tannins from Leucaena on methane production, rumen fermentation and populations of methanogens and protozoa in vitro. *Animal Feed Science and Technology, 169*(3-4), 185-193.

USDA. (2017). USDA Agricultural Projections to 2026. Retrieved from: https://www.ers.usda.gov/webdocs/publications/oce20171/oce-2017-1.pdf?v=42788

USDA. (2016). Statistics & Information. Retrieved from: https://www.ers.usda.gov/topics/animal-products/cattle-beef/statistics-information.aspx

USDA. (2016). U.S. Beef and Pork Consumption Projected to Rebound. Retrieved from: https://www.ers.usda.gov/amber-waves/2016/september/us-beef-and-pork-consumption-projected-to-rebound/

Van Soest, P. J. (1994). *Nutritional Ecology of the Ruminant, second edition.* Ithaca, NY: Cornell University Press.