Features

Research Team Tackles Global Warming Using Inedible Grain By-Products

It is mid-July at the Glenlea Research Station, just east of highway 75. The station is home to the U of M Faculty of Agricultural and Food Sciences research, teaching, and outreach facility where the Agricultural Greenhouse Gas Program (AGGP) is underway. AGGP will advance our understanding of how cattle production systems can be better managed to reduce the emission of the greenhouse gases (GHGs) methane (CH_4) and nitrous oxide (N_2O).

U of M master's student Rhea Teranishi is leading the tour of the station where the AGGP research steers are housed. Approaching the pens, the unmistakable scent of cattle farm gently caresses your nostrils, an inextricable concoction of fresh manure, hay, and cattle. It is almost 10 a.m. A concrete platform lies adjacent to the pens; it doubles as a work area and as storage for equipment and dry hay. The roof of the platform provides shade for the cattle at midday, but, farthest from the roofed platform, the pens remain unshaded to allow the cattle to move between the shaded and unshaded areas as they cool off and warm up. There are 24 steers in total, eight per pen. On entering the platform two more silhouettes appear and quickly become visible — they are undergraduate students Kara Fulawka and Melanie Roulin.

Having spent the last few days doing lab work and data analyses at the U of M animal science department, being in the field is one of the best parts of working on the AGGP.

This morning Fulawka and Roulin are emptying uneaten hay from feed bins and replenishing with fresh hay.

Both Fulawka and Roulin, along with a third undergraduate student — Katherine Green — worked with master's student Sidonie Robinson on an earlier part of the project where they sampled rumen from the stomachs of steers.

The rumen is one of the four stomach compartments of ruminant animals like cattle. When they first consume feed, the partially-chewed feed goes to the rumen — the first and largest of the four stomach compartments — for the first round of digestion. In a process unique to ruminant animals, the partially-digested feed is returned to the mouth for further and more thorough chewing. The animal swallows the feed and it returns to the rumen, then the other three stomach compartments for complete digestion. The rumen, also called a fermentation vat, contains acidic digestive fluid and is rich in billions of microbes that help break down feed. One major by-product of the digestion and bacterial activity in the rumen is CH_4 gas — one of the greenhouse gases whose excess in the atmosphere is causing global warming.

In the rumen-sampling phase, the team — led by Kim Ominski, U of M animal science professor — compared different by-products from cereal and oilseed processing to see which ones were most digestible, released the least amount of CH_4, and had the highest efficiency in releasing nutrients to the animals. The AGGP project is now at the "animal trial and selective feed technology" phase where these grain by-products have been compressed into pellets and are being fed to the steers. The steers are then monitored to see which experimental treatments they find most appealing. Their breath will be collected to measure how much CH_4 is released from their rumen during the digestion of the pellets. The hay bedding of the pens is also high in microbial activity. The warmth of the bedding favors the growth of these microbes which naturally help breakdown cattle feces, releasing nutrients into the soil and N_2O, a by-product, into the atmosphere. The hay bedding will also be studied to measure how much N_2O is normally released and how each feed supplement influences the amount released during the microbial breakdown of feces in the bedding. Like in fecal decay, many sources of N_2O are from natural bacterial activity on nitrogen and nitrogenous compounds in the soil. Excess use of nitrogenous fertilizers are a major source of N_2O.

GHGs in moderate amounts provide a protective layer in the earth's atmosphere to trap ultraviolet (UV) radiation from the sun, thereby protecting the earth from damaging effects of UV radiation. In excess amounts, however, these gasses trap excess UV and store it as heat, causing 'global warming' with effects manifesting as 'climate change'. The three GHGs that significantly contribute to global warming are carbon dioxide, CH_4, and N_2O. Methane and N_2O are 23 and 296 times more potent than carbon dioxide in trapping UV radiation. Current agricultural systems in Manitoba are overwhelmingly responsible for the production these two high global-warming-potential gases. But our transport and energy sectors are equal culprits in the total greenhouse gas production, together accounting for more than half of total greenhouse gas emissions.

Ominski and her students are conducting this study to monitor if and how diet changes affect CH_4 emission from cattle and N_2O emission from stockpiled manure.

Back at the station tour with Teranishi, Fulawka and Roulin are almost done replenishing the bins; the steers have not glanced their way. The fresh hay does not interest them; they're distracted. Fulawka and Roulin are unsurprised. At the other side of the pens the sound of hooves shuffling against the hay-bedding betrays the excitement among the herd. The rhythmic opening and shutting of metallic sensor-controlled gates is as audible as the shuffling. The steers have

all rallied around a new piece of technology, the SmartPro feed delivery systems, as it dishes out tasty treats.

"What each [steer] has is a Radio Frequency Identification (RFID) tag," began Teranishi, as she showed the research setup. "In the smart feed system there is a sensor in there that will read the tag, see if it is that certain animal, and will let them into the feeder."

The SmartPro is a programmable feeding system loaded with grain pellets and programmed to allow each steer 1 kg of grain pellets per day. The steers are, however, allowed unlimited access to regular hay. There are three feed systems, one per pen, and each has a set of automated gates that allows only one steer access at a time. The RFID tag on the left ear of each steer keeps track of this allotment. When a steer approaches the system, sensors around the gates read the RFID tags and the gates instantaneously slide open to allow access. Each steer will return to the feed system multiple times.

"It is like they have an internal clock. They will recognize at 10:00 [every morning] that it is time to eat again," explained Kara Fulawka. "All eight [steers] per pen would have eaten their [1 kg feed pellet allotment] in 20 minutes." This is quite fast, given that they spend the rest of their day chewing their food a second time after it has been partially-digested in the rumen.

The system is so accurate it can keep track how much the steers eat over multiple feeding attempts, shutting it out once it has reached its 1 kg limit — only allowing steers that have yet to reach their daily allotment. Nevertheless, they will try a few more times after they are denied access.

At the start of the summer, all three undergraduate students started working with U of M master's student Brandon Hanson to track the health and vitals of the steers and to monitor their feed intake and weight progress using another system called GrowSafe. This system works in tandem with the SmartPro. The system has feed bins where hay is replenished regularly. Like the SmartPro, each feed bin also has a sensor which reads the RFID tags of the steers. Their daily intake and weight progress are tracked. The bins also have load cells that measure the amount of hay consumed by the steers based on the weight changes of the bins. The combination of the SmartPro feed, GrowSafe systems, and the frequent vitals and blood work helps to keep track of the health and wellbeing of the steers.

Manitoba is responsible for up to 90% of Canada's annual sunflower seed production, up to 75% of faba beans, 20% of flaxseed crop, 15% of wheat, 10% of barley, 20% of rye, and 25% of Canada's oats crop production. Manitoba also processes many of these grains and oilseeds.

These crops are processed into, for example, flour, pasta, bread, cooking oil, and malt to support domestic food production. Many of these cereal and oil seeds also generate export revenue. In 2017, exports from grain and oilseed milling in Manitoba generated revenue of over $1 billion, accounting for 38% of the total revenue from the exports of processed food and beverage products from Manitoba.

By 2020, the $400 million Roquette pea processing plant will begin operations in Portage la Prairie. The project will further strengthen Canada's position as one of the global leading pea producers and will increase the availability of by-products from processed grains. Some by-products cannot be consumed by humans but they can be used to supplement livestock diets. Processing of grains and oilseeds in Manitoba has made low-cost, by-products readily available to supplement cattle nutrition.

Some of these by-products are low quality while others are high quality. Ominksi's project is also exploring the digestibility of these different quality by-products as well as the amount of CH_4 produced during the digestion of different types of by-product. The potential of these grain by-products to be used to supplement cattle diet is being monitored with the aim of reducing the amount of CH_4 and N_2O that our current cattle production systems produce.

Cattle production systems are complex, often involving ever-changing management strategies in order to enhance beef production, animal health, and the health of the soil. However, the impact of these changes on GHG emissions is not entirely known. The AGGP project will measure net emission of CH_4 and N_2O from beef cow-calf production systems by tightly monitoring the feed intake and manure production of the steers.

In the next phase of Teranishi's project, the by-products that performed the best in the *in vitro* studies will be fed to the steers. The CH_4 released by the steers will then be measured using a technique called the sulphur hexafluoride (SF6) technique. A fingertip-sized permeation tube, filled with the SF6 gas, is placed in the rumen of the cattle; the rate of release of the SF6 is determined prior. A halter with a negative pressure vacuum collection canister is placed around the steer's head and this canister is connected to a tube passing over the bridge of the steer's nose and slightly protudes in front of the mouth. The tube collects air from the steer's mouth when they belch; the air will contain a mixture of the SF6 from the permeation tube and the CH_4 released during the digestion of food in the rumen. The quantity of CH_4 present can be determined based on its ratio to SF6 in the canister.

Monitoring the amount of N_2O produced in hay bedding, another phase in this multi-level diet and manure management study, will involve a collaboration between Ominki's lab and the lab of Mario Tenuta, U of M soil science professor. A technique called Fourier transform in-

frared (FTIR) spectroscopy will be used to measure N_2O released from the bedding during the decay of manure.

Working with beef cattle has been a fun, but vastly different, experience for Roulin, who grew up on a dairy farm.

"Dairy, I know it and I can do it so easily. Beef, I was thinking was going to be similar [...] but the temperament, how you manage them was very different," she added. "I realized [on the first day] that this is not going to be like on my farm where I can just think 'oh I need this animal, I'll just go over and get them'. You have to respect their flight zone and their area," Roulin warned.

Initially looking to see whether doing a master's program was a good next step after her undergraduate degree, Roulin decided it was a good idea to shadow a master's student first.

"I didn't want to jump into a master's [program] without having done any research, not knowing what it's going to be like. So, this way I could shadow other master's students to see if it is something I want to lead into for the future."

Roulin received the Natural Sciences and Engineering Research Council of Canada (NSERC) Undergraduate Student Research Award (USRA) to work on the AGGP this summer. Through this project she has enjoyed a mixture of office work, lab work, and farm work over the summer. She is currently completing her entomology and biology minor degrees, in addition to her animal science degree. She plans to continue with a master's program afterwards.

Having lived in the city all her life, Green is getting her first experience with large animal research. She also received the USRA to work on the AGGP this summer.

"My biggest challenge was getting comfortable around cattle. I have not spent much time around cattle before," said Green. "They are huge animals and it's kind of scary at first when they are running around you, but you get used to it and you learn how to handle them," she added.

Working on the AGGP project has been an invaluable experience. It provided Green the research requirement that helped her get accepted into the veterinary medicine program at the Western College of Veterinary Medicine, University of Saskatchewan, this 2018 fall.

"It's like you are in the lab for a class [...] you use the micropipettes like you use in your biochemistry class, but you're actually doing [applied work]," Green added.

Fulawka is a second-year pre-med student in the U of M Faculty of Kinesiology and has been involved with beef research since Grade 9. Last summer she trained Hank, one of the steers used at the Bruce D. Campbell Farm and Food Discovery Centre for demonstrations. Located at the Glenlea Research Station, the Centre is a hands-on interactive facility where people can go the see the ways in which food is produced in Canada.

"He was two months old when we got him. He was tiny, and he was the best little guy ever," said Fulawka, recounting how halter-training Hank was her favourite experience. "You call his name and he would come running to the side of the pen, he would walk beside you [...] when the seniors came they would have a ball of a time because he was like a big dog," she added.

One of the greatest benefits that the students draw from the research project is developing their problem-solving skills. The team is constantly troubleshooting problems that arise during their study. From controlling rogue steer to monitoring data collected by the GrowSafe Systems for inconsistencies, the challenges are ceaseless, and the students are thrilled with each one they surmount.

"The SmartPro system we are using has not gone smoothly, to begin with," said Green, explaining one of the ways the project has challenged them.

"The animals were figuring out that they could stand on their tippy toes and reach the feed when they were not supposed to," Green continued. "We had to work with moving the gates around to make sure they are not accessing the feed when they are not supposed to," she said.

Fulawka also explained that consistent check and balancing is required to adequately monitor the behavior of the steers and to measure their intake.

"If animals are getting more than a kilo, 'Why?'. If animals are not showing up, 'is it because the system is not recording them properly or is it because they are really not interested?'" explained Fulawka.

When the steers are not recorded in the system it could be that they have eaten too much hay and are too full to eat pellets, or there is a system malfunction. Sometimes the cattle are not feeling well. Unwell cattle can be identified early because they will often have reduced appetite days before they fall sick. This helps the research team, and cattle owners, catch illnesses or disease breakouts before they happen.

The goal at this point of the project was to see whether the steers preferred the grain pellets to regular hay, and to monitor their daily intake. The team also want to see whether caramel-flavored grain pellets will be consumed more preferably over the unflavored ones.

So far, the tasty pellets dished out by the SmartPro is the clear favorite over hay, but the flavoring does not make a difference. The steers in all three treatment pens consume the pellets in about the same amount of time.

Back at the pens, it is now calm as the excitement has slowly come to an end — most steers have had their 1 kg treat. It won't be until 10 a.m. tomorrow before the party begins again. In the meantime, they will have to munch on regular hay as they casually ruminate over how grain by-products could save the planet from over-heating.

— *David Zirangey*