An integrated research program for the assessment of the potential of engineered biocarbon added to beef cattle diets to reduce greenhouse gas emissions in agriculture

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University of Lethbridge

USBI Biochar 2018
August 20-23 2018
Wilmington, DE
Biochar/engineered biocarbon

Charcoal-rich product obtained by pyrolysis of biomass (varies between 300°C-700°C)

It may have potential to increase digestive efficiency, reduce methane production, and increase N retention in cattle
**Alberta Biochar Program**

The Alberta Biochar Program works to enable the deployment of biochar for the benefit of Alberta, through:

- **R&D**: biochar is a green, clean platform technology with great potential for reducing greenhouse gases and improving soil.
- **Regional Networking**: engages research and academic institutions, entrepreneurs and small-medium enterprises in rural Alberta.
- **Local Development**: providing expertise, resources and equipment to develop and demonstrate biochar products, applications and technology.

**How biochar is made, and its potential applications**

- **Biomass**: Manure, Organic wastes, Crop residues (forest and agriculture)

- **Biochar**: Returned to soil as Biochar
  - Boost crop yield
  - Reclain mine sites
  - Sequester carbon

- **Biofuel**: Clean up of wastewater in the energy sector

- **Pyrolysis**: Processes that heat biomass in the absence of oxygen

**Image credit**: Alberta Biochar Initiative
Assessment of the potential of the addition of engineered biocarbon to beef cattle diets in the mitigation of GHG

Evaluate engineered biocarbon for GHG mitigation and increased efficiency

Investigate agronomic values of manure and compost from biochar-fed cattle from crop production

Yield
Nutrient uptake
Utilization efficiency

Evaluate impact of biocarbon-loaded manure with respect to soil properties

Water
Holding capacity
Nutrient cycling
Microbial activity
Carbon sequestration

Anim

Soil

Crop
Greenhouse gas emissions from agricultural systems


**Previous work**

- Reduced ruminal methane emissions
  - 17% *in vitro* (Hansen, 2012)
  - 22% *in beef cattle* (Leng *et al.*, 2012)
- Improved average daily gains by 25% (Leng *et al.*, 2012)
- Increased nutrient content in feces (Joseph *et al.*, 2015)
- Improved net returns to producers (Joseph *et al.*, 2015)

*Cassava root biochar* (Leng *et al.*, 2012)  
*Dung beetles, dung, and biochar* (Joseph *et al.*, 2015)
Government of Canada investing in Research to Reduce Methane Gas Emissions in Cattle

From: Agriculture and Agri-Food Canada

News Release

July 11, 2017 – Lethbridge, Alberta – Agriculture and Agri-Food Canada

Farmers know the importance of keeping the land, water and air healthy to sustain their farms from one generation to the next. They also know that a clean environment and a strong economy go hand-in-hand.

Minister of Veterans Affairs and Associate Minister of National Defence and Member of Parliament (Calgary Centre) Kent Hehr today announced a $1.1 million investment with the University of Lethbridge to study ways to reduce methane gas emissions in cattle.

This project with the University of Lethbridge is one of 20 new research projects supported by the $27 million Agricultural Greenhouse Gases Program (AGGP), a partnership with universities and conservation groups across Canada. The program supports research into greenhouse gas mitigation practices and technologies that can be adopted on the farm.

Quotes

“Canadian farmers are great stewards of the land and the environment. These new investments are part of the government’s commitment to addressing climate change and ensuring our farmers are world leaders in the use and development of clean and sustainable technology and processes.”

- Lawrence MacAulay, Minister of Agriculture and Agri-Food

Project officially announced by the federal government and highlighted by Canada’s Prime Minister in Parliament
Agricultural Greenhouse Gases Program

Principal Investigator: Erasmus Okine

University of Lethbridge

University of Manitoba

Agriculture and Agri-Food Canada

Alberta Agriculture and Forestry

InnoTech Alberta

Blue Rock Animal Nutrition Ltd.
Biochar: possible modes of action

**Rumen**
- Modulate fermentation
- Enhanced feed digestion
- Microbiome enhancement
- Mitigation of methanogens
- Bind toxins

**Small intestine**
- Nutrient absorption
- Viscosity reduction
- Immune stimulation

**Large intestine**
- Enhanced fermentation
- Mineral absorption

*Biochar consumption*
Methane Production is a Microbial Driven Process

Methanogenesis

CO$_2$ + 4 H$_2$ $\rightarrow$ CH$_4$ + 2 H$_2$O
Animal Analysis of engineered biocarbon samples

Meeting CFIA guidelines

Nutrient disappearance

Total gas production

Methane and carbon dioxide concentration

pH, VFA, NH$_3$-N

In vitro batch cultures and RUSITEC

In vivo rumen fermentation

Apparent total tract digestion

Nutrient excretion

Feed intake

Weight gains

Feed efficiency

Nutrient excretion

Liver scores

Ataullah Khan

Emma McGeough

Kim Ominski

Paul Tamayao

University of Manitoba thesis

Karen Beauchemin

Stephanie Terry

Wenzhu Yang

Agriculture and Agri-Food Canada
Analysis of engineered biocarbon samples

- Plant-based biomass derived engineered biocarbon (wood and/or nuts)
- Toxicity and safety evaluation performed
- Samples were found to be free of metal and dioxin contaminants and are considered safe
- Project was granted authorization by CFIA to use engineered biocarbon in the animal studies
In vitro batch cultures
Effect of engineered biocarbon on rumen fermentation, microbial protein synthesis, and methane production in an artificial rumen (RUSITEC) fed a high forage diet

Atef M Saleem, Gabriel O Ribeiro, Jr, Wenzhu Z Yang, Tao Ran, Karen A Beauchemin, Emma J McGeough, Kim H Ominski, Erasmus K Okine, Tim A McAllister


Published: 14 June 2018

Article history
Summary

• Addition of AC to a high forage diet up to 20 g/kg of diet DM improved in vitro ruminal fermentation, nutrient degradability, and microbial protein synthesis, and reduced CH$_4$ production.

• The lowest CH$_4$ production was achieved 5 g/kg of diet DM, but higher AC inclusion levels promoted higher DMD, VFA, and microbial N production.
Metabolism study
Feedlot experiment
Manure - Soil

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University of Lethbridge

Chunli Li
Carlos Romero
Paul Hazendonk

Agriculture and Agri-Food Canada

Xiying Hao

University of Alberta

Derek MacKenzie
Manure management practices

Direct land application of raw manure

Stockpiling

Composting
Two types of soil

Six treatments

Four crop systems (corn, barley, broom grass, alfalfa)

Four growth cycles

Crop yield and quality

Soil, C, N and P levels

Soil properties

Water holding capacity

Structure

Nutrient cycling

Microbial activity

Carbon sequestration

Greenhouse manure experiment

Manure / compost field application

Nine treatments (combinations of manure/composting, fertilizer, biochar)

Two locations: Lethbridge and Vauxhall

Two crops: barley and corn

Chunli Li
Carlos Romero

Xiying Hao

Derek MacKenzie
Manure application – Crop production
Benefits to the industry

Economic evaluation of adding Biochar to feedlot rations

How will producers benefit?

• Average daily gain
• Feed conversion efficiency
• Days on feed
• Yardage costs
• Extra costs (i.e. storage)
• Potential carbon credits
• Enhanced fertilizer value
• Improved soil health and crop production
Extension program

- Reaching out to the industry and the community
- We have received considerable attention from stakeholders
- Barry Yaremcio
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Contacts

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Thank you!
