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

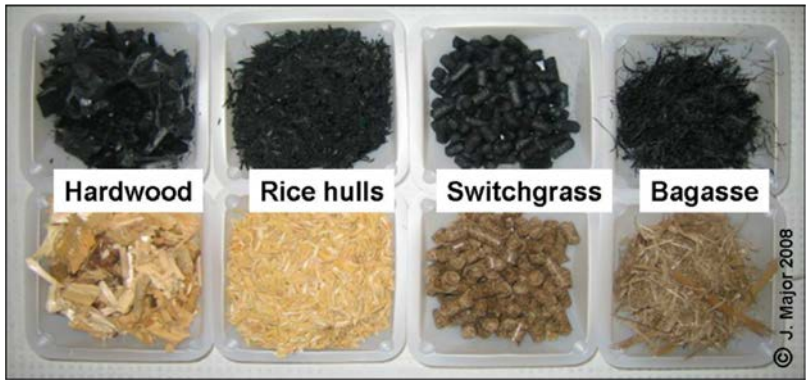


Image credit: International Biochar Initiative

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

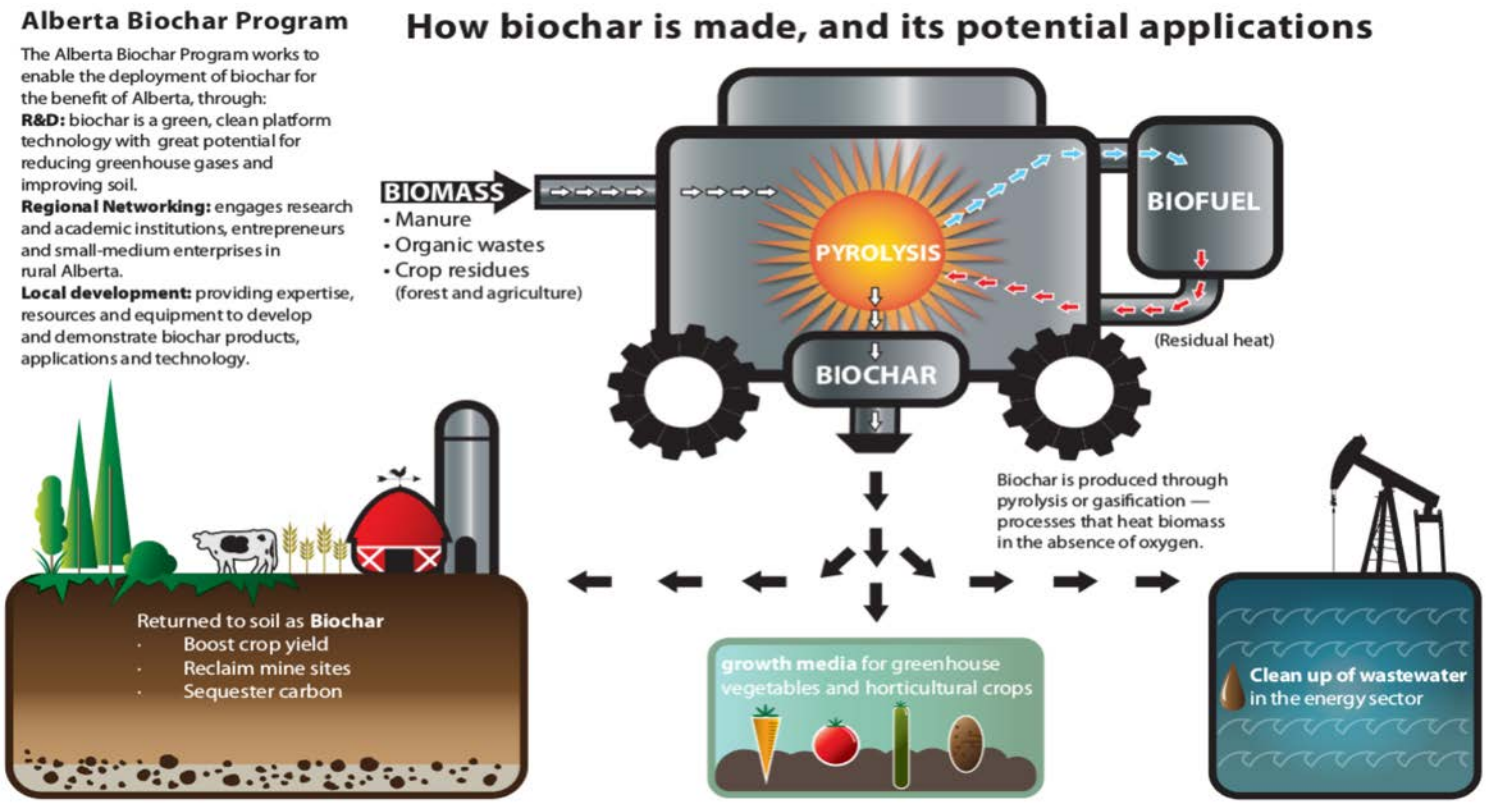
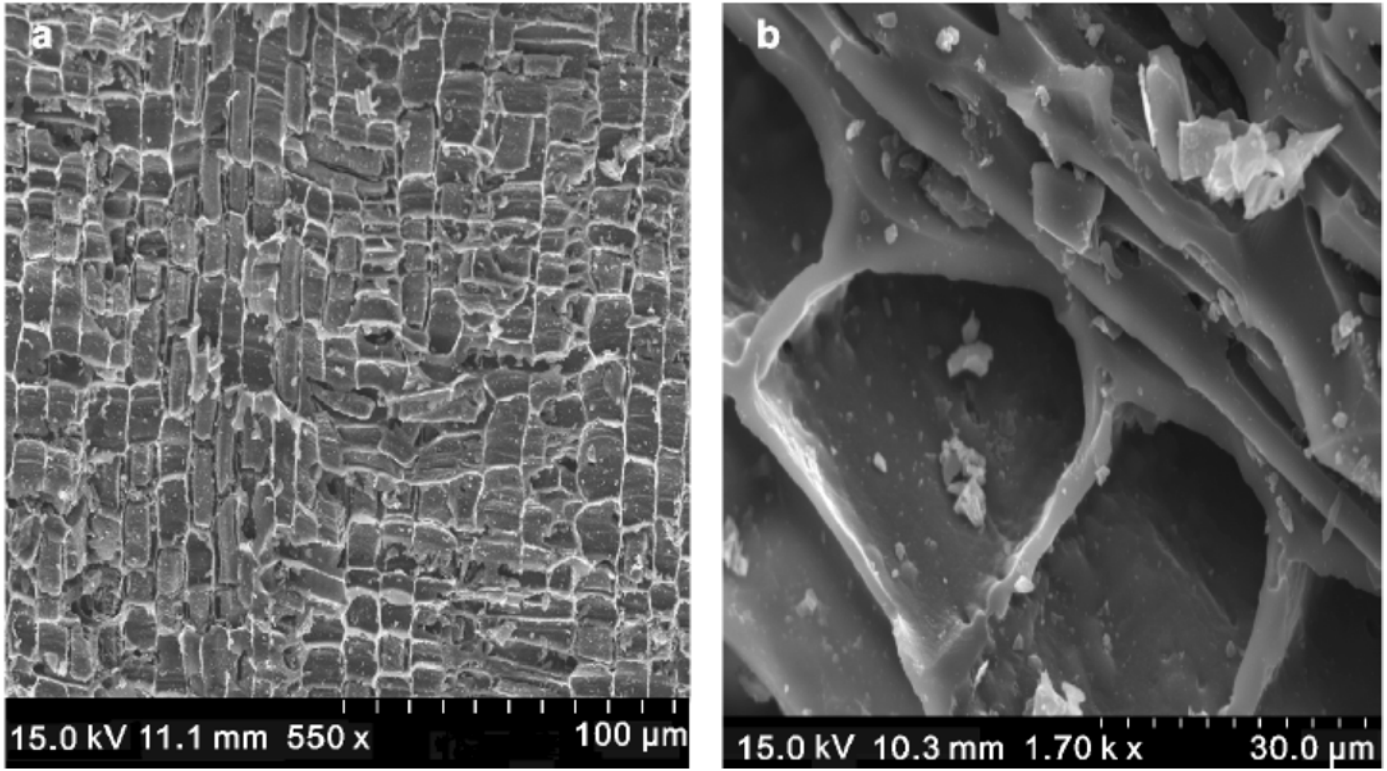


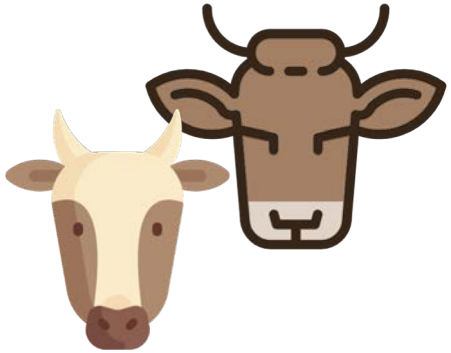
Image credit: Alberta Biochar Initiative

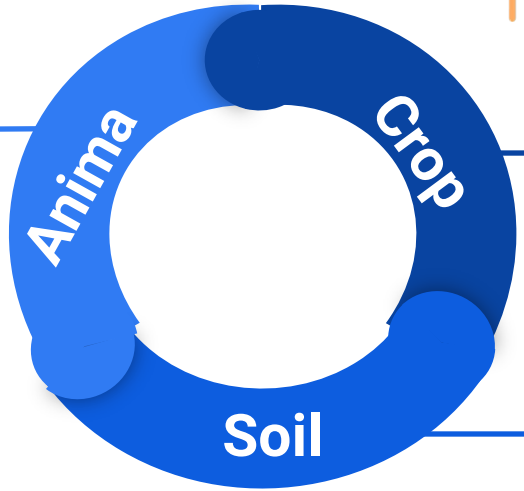


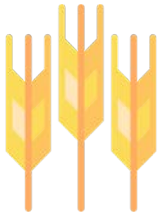
Jarrah wood biochar (SEM). Joseph *et al.* (2015)

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







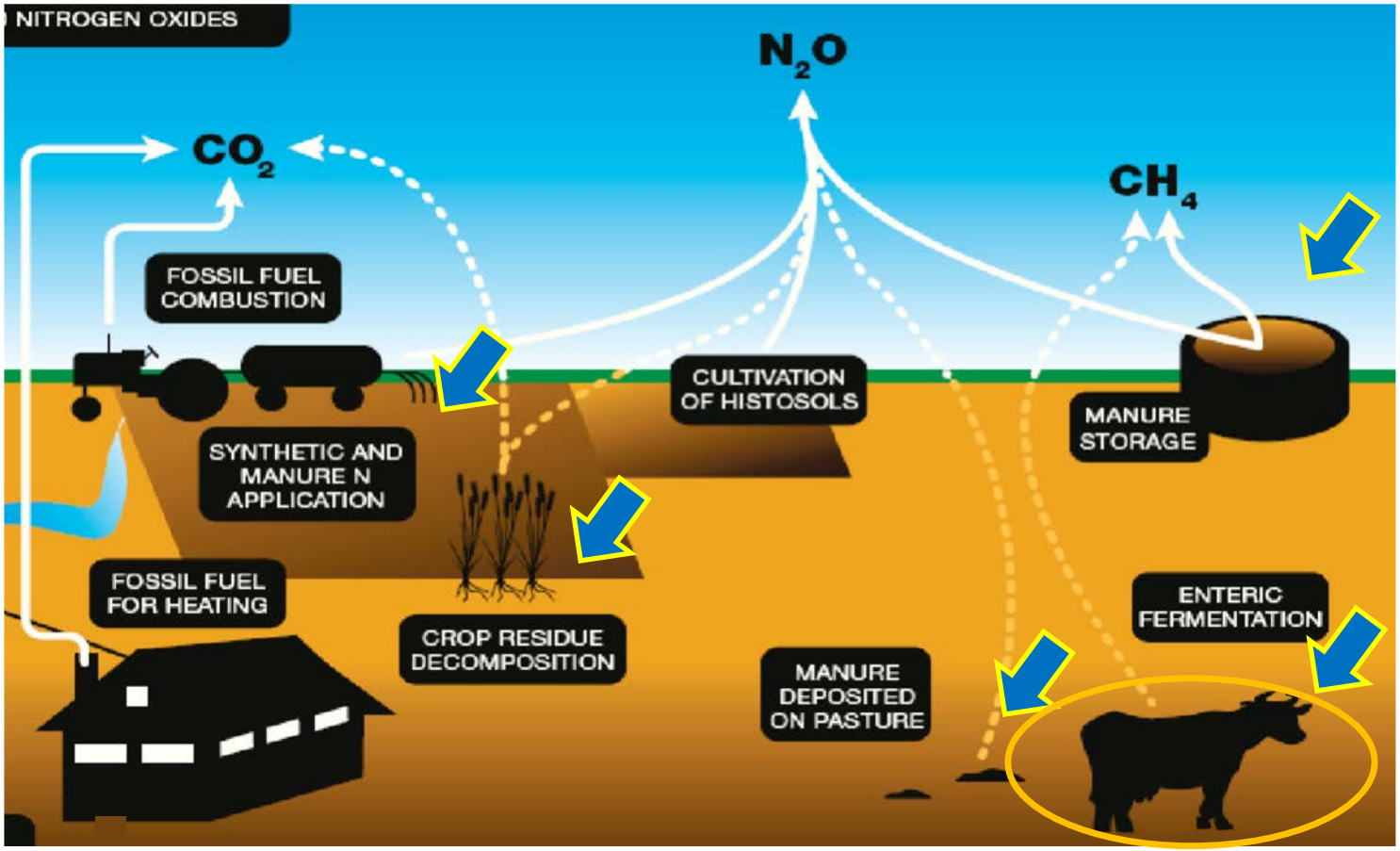
Investigate agronomic values of manure and compost from biochar-fed cattle from crop production

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

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)

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Government of Canada invests 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

University of Lethbridge

Principal Investigator: **Erasmus Okine**

University of Manitoba

University of Alberta

Agriculture and Agri-Food Canada

Alberta Agriculture and Forestry

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

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

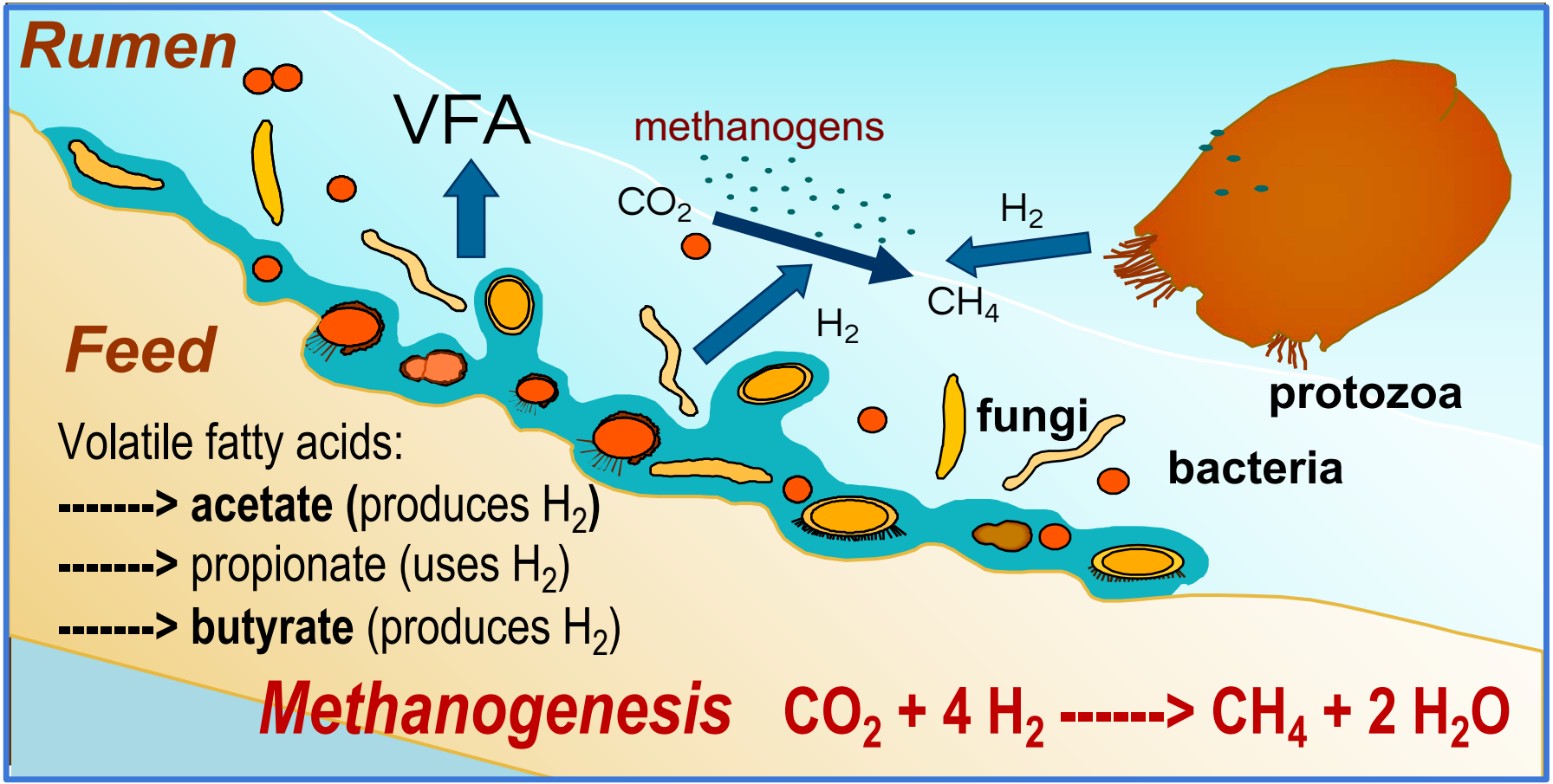
Small intestine
- Nutrient absorption
- Viscosity reduction
- Immune stimulation

Large intestine
- Enhanced fermentation
- Mineral absorption

Biochar consumption

Increased fertilizer value

Methane Production is a Microbial Driven Process



Animal

Analysis of engineered biocarbon samples	*In vitro* batch cultures and RUSITEC	Metabolism study	Feedlot trial
Meeting CFIA guidelines	Nutrient disappearance	***In vivo*** rumen fermentation	Feed intake
	Total gas production		Weight gains
	Methane and carbon dioxide concentration	Apparent total tract digestion	Feed efficiency
		Nutrient excretion	Liver scores
	pH, VFA, NH_3-N		
Ataullah Khan	**Emma McGeough** **Kim Ominski** **Paul Tamayao**	**Karen Beauchemin** **Stephanie Terry** **Wenzhu Yang**	

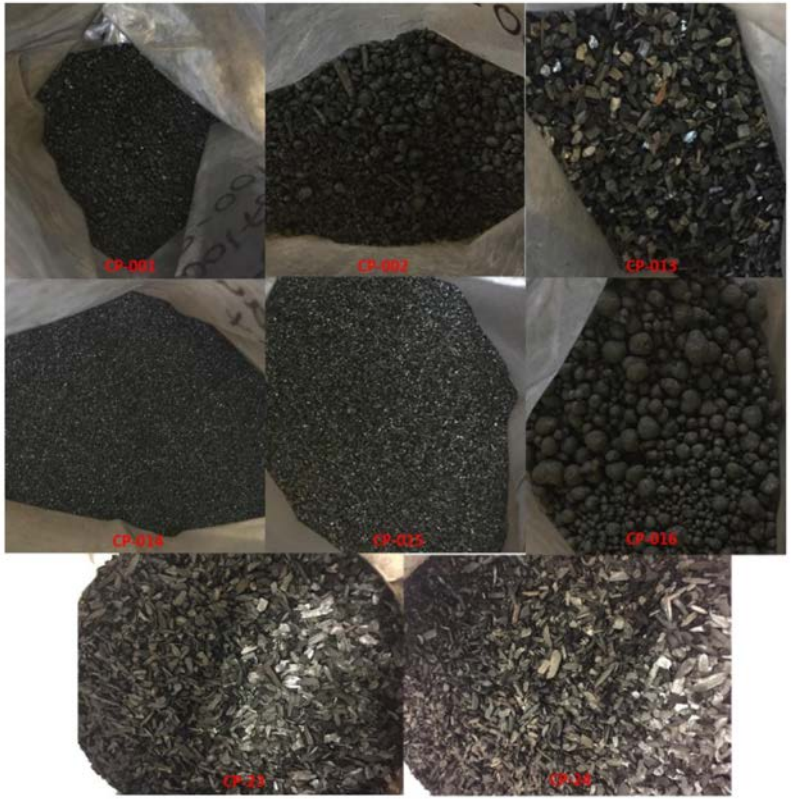
InnoTech Alberta — A subsidiary of Alberta Innovates

University of Manitoba — thesis

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

Journal of ANIMAL SCIENCE

Volume 96, Issue 8
August 2018

< Previous Next >

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

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https://doi.org/10.1093/jas/sky204
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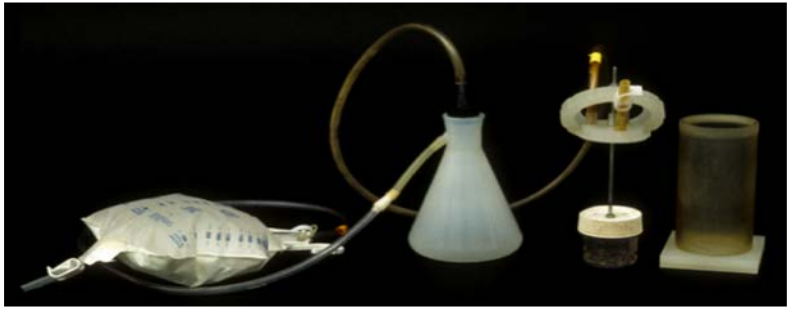
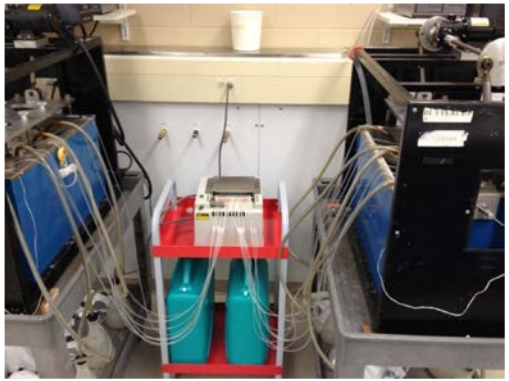
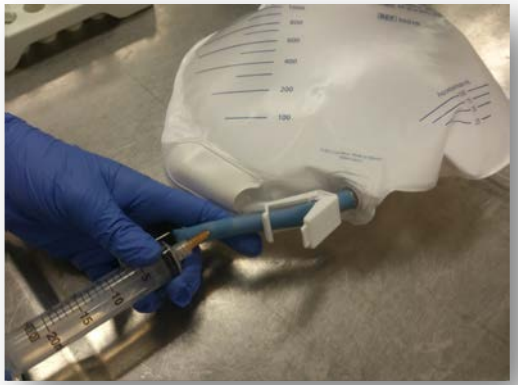
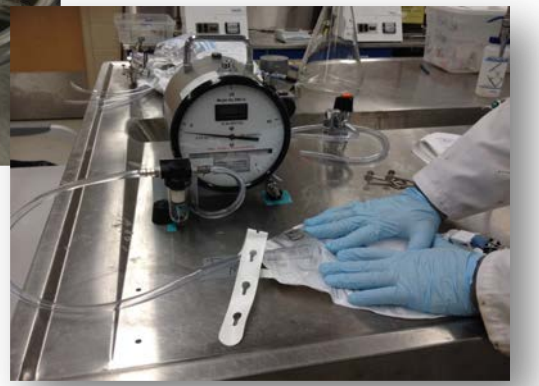
RUSITEC









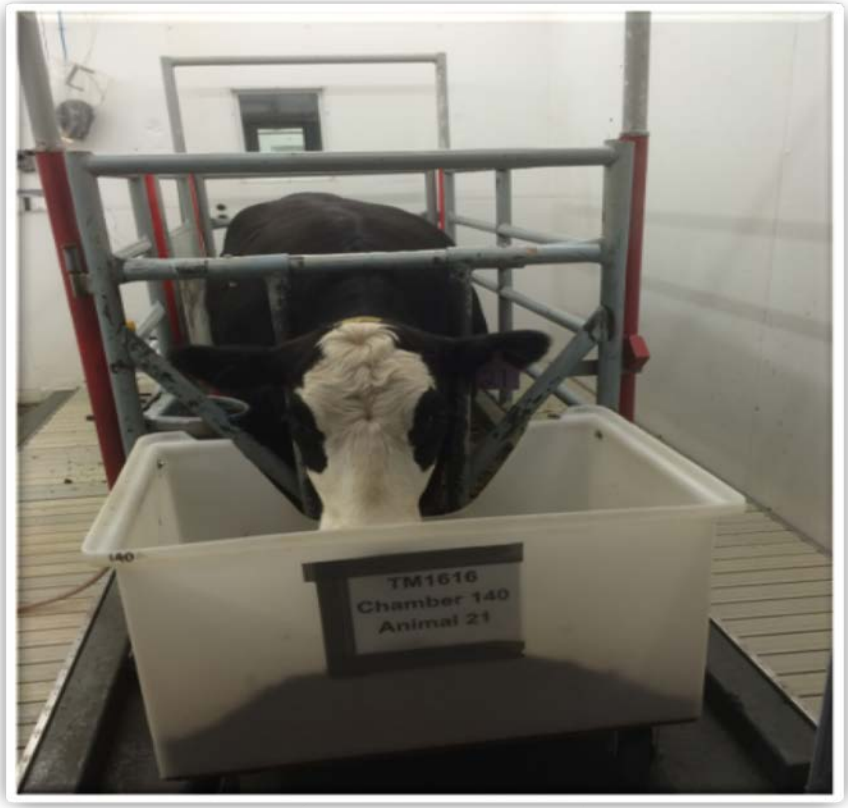
Summary

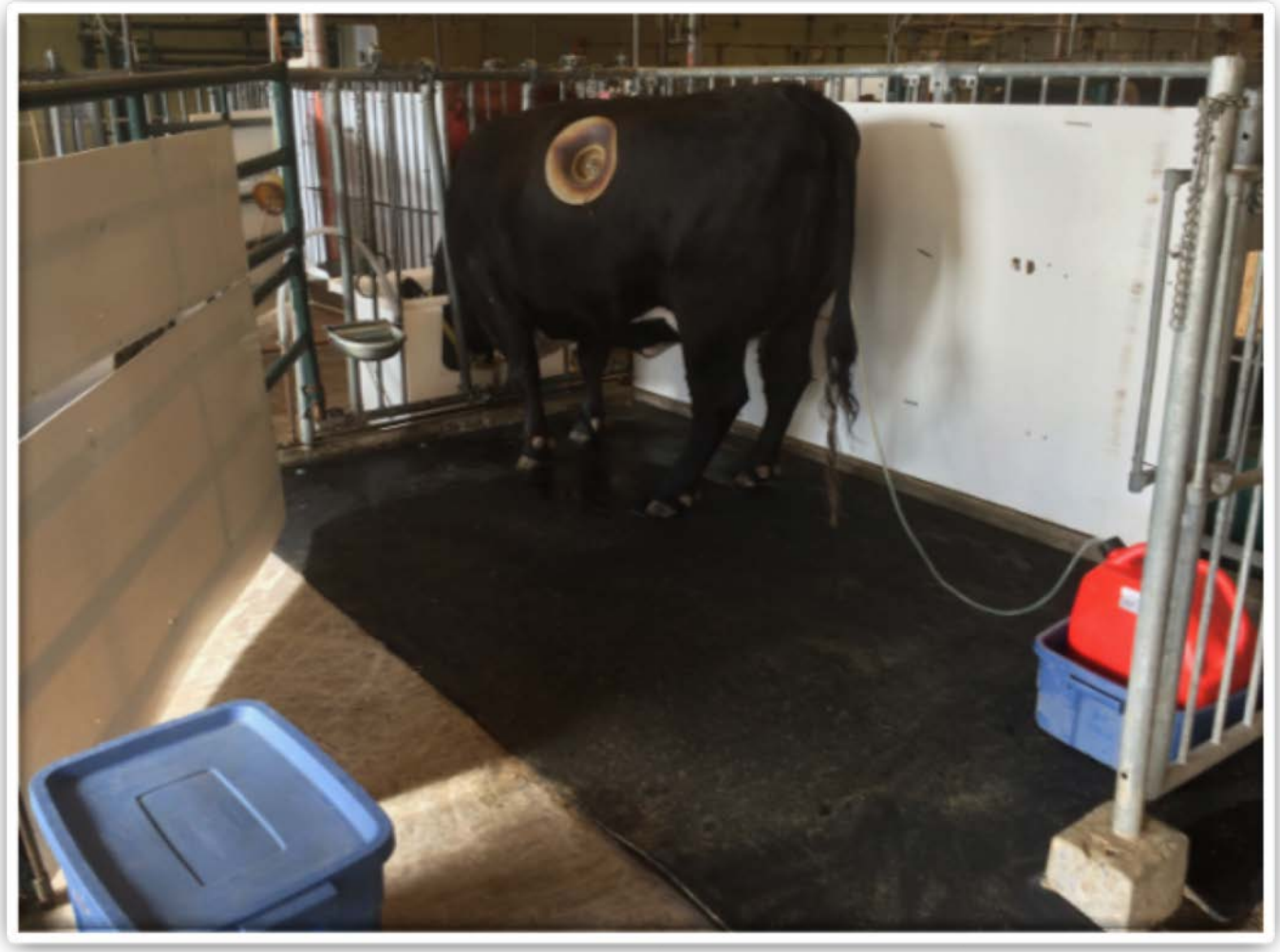
- Addition of AC to a high forage diet up to 20 g/kg of diet DM improved in vitro ruminal fermentation, nutrient degradability, and microbial protein synthesis, and reduced CH_4 production.

- 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.


18

Metabolism study





Control

Biochar

Feedlot experiment

Manure - Soil

Manure lab incubation

Two types of soil and six treatments

GHG flux rates over time

Soil NO_3, NH_4 and PO_4 levels

Soluble pH, C and N level changes

Potentially mineralizable N and P in relation to type of soil and manure used

University of Lethbridge

Chunli Li
Carlos Romero
Paul Hazendonk

Evaluate impact of biochar loaded manure

Soil properties

Water holding capacity

Structure

Nutrient cycling

Microbial activity

Carbon sequestration

Manure stockpiling and composting

Manure management

Open windrow composting/stockpiling for 14 weeks

Compost windrow turned 3 times (2, 5, and 10 weeks or when center windrow drops below 55℃)

Agriculture and Agri-Food Canada

Xiying Hao

Manure / compost field application

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

Two locations: Lethbridge and Vauxhall

Two crops: **barley and corn**

UNIVERSITY OF ALBERTA

Derek MacKenzie

Manure management practices

Direct land application of raw manure

Stockpiling

Composting

Crop

Greenhouse manure experiment

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

University of Lethbridge

Chunli Li
Carlos Romero

Agronomic values of manure and compost

Soil properties

Water holding capacity

Structure

Nutrient cycling

Microbial activity

Carbon sequestration

Agriculture and Agri-Food Canada

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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**

  barry.yaremcio@gov.ab.ca

Contacts

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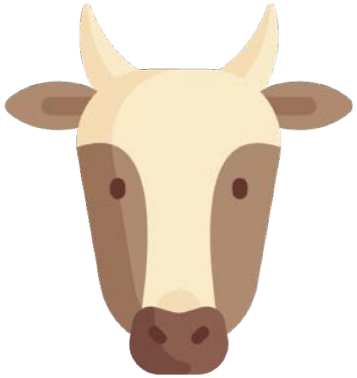
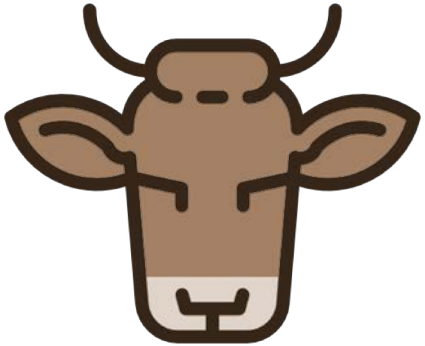
Thank you!





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