Relationships of genetic composition and carcass grades with ruminal parameters and methane emissions in grain-fed bison

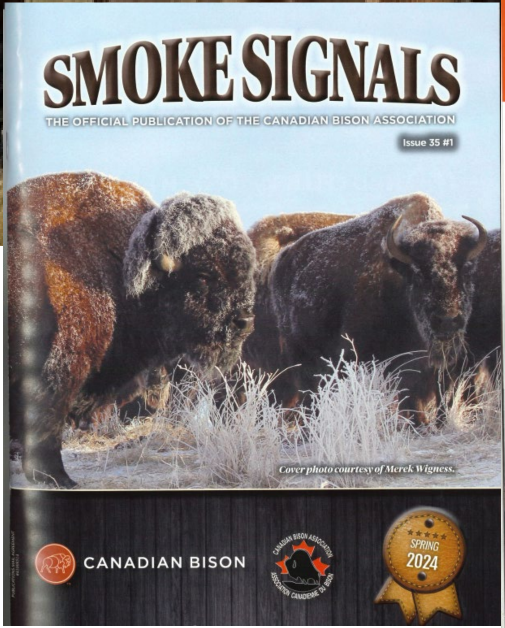
S. Poothong, B. Thomas, X. Wu, D. K. Yaa, L. Guan, C. Nuengjamnong and Y. Montanholi

OUTLINE

01 Introduction

Life cycle assessment of bison production

Cow-calf, backgrounding, finishing operation



Sustainable bison production chain for our planet

By Saranporn Poothong and Yuri Montanholi

In this century, climate change has become an urgent issue. The release of greenhouse gases into the atmosphere by human-made processes in sectors such as agriculture and manufacturing are a major player. The term "carbon footprint" is commonly used and refers to the overall amount of greenhouse gas emissions given to a specific activity (i.e., driving a car to the grocery store). Regular human activities release carbon into the atmosphere, as has been known for several decades. Fortunately, scientists have found a method to compensate for these emissions. Carbon neutrality means balancing out the carbon dioxide (CO_2) and other greenhouse gases with the equivalent carbon absorption from the atmosphere, also known as carbon sequestration. Additionally, absorption tactics can be modified according to the needs of enterprises or farms if there is an awareness about the volume of emissions from the given production system. For this reason, before developing a sequestration strategy to compensate for, and achieve zero CO_2 emissions across the bison production cycle, it is necessary to estimate the carbon footprint throughout the bison production chain. The common "currency" of estimating a carbon footprint is called CO_2 equivalent, which is an accepted unit of measurement to measure the global warming potential of different greenhouse gas emissions such as methane (CH_4) and nitrous oxide (N_2O).

Enteric fermentation in the rumen by microorganisms results in feed degradation and the release of greenhouse gases (i.e., CO_2, CH_4 and N_2O) into the air. Notably, enteric fermentation in ruminant production is responsible for a fraction of global warming, particularly due to CH_4. Furthermore, CH_4 is responsible for 6-7% of the feed energy loss that negatively impacts the productive performance of bison. The World Food Organization estimates that 44.3% of all livestock emissions in 2018 came from enteric fermentation by

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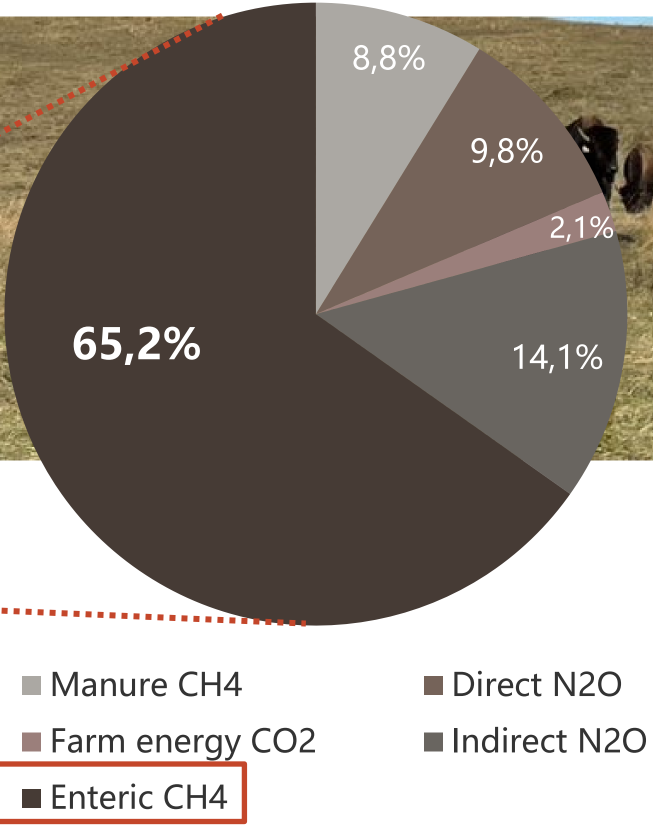
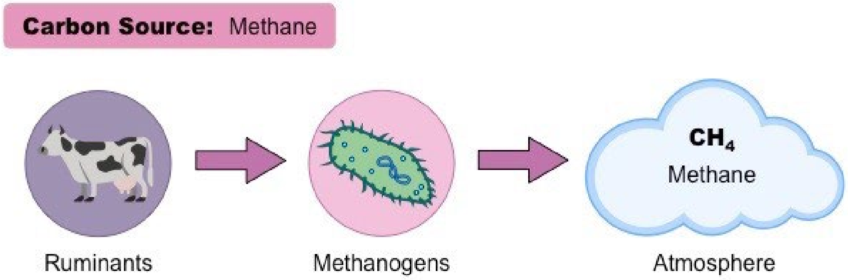
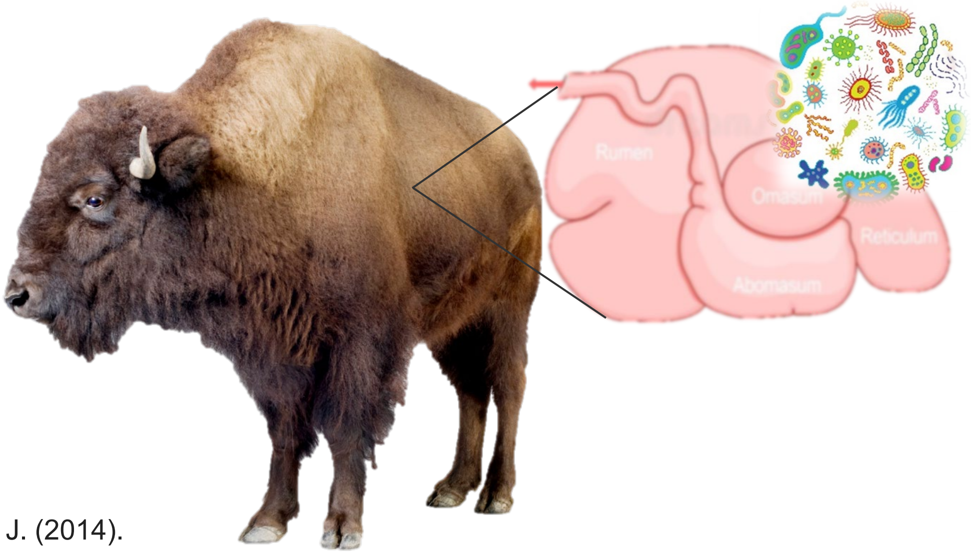


Enteric methane production





Genetics

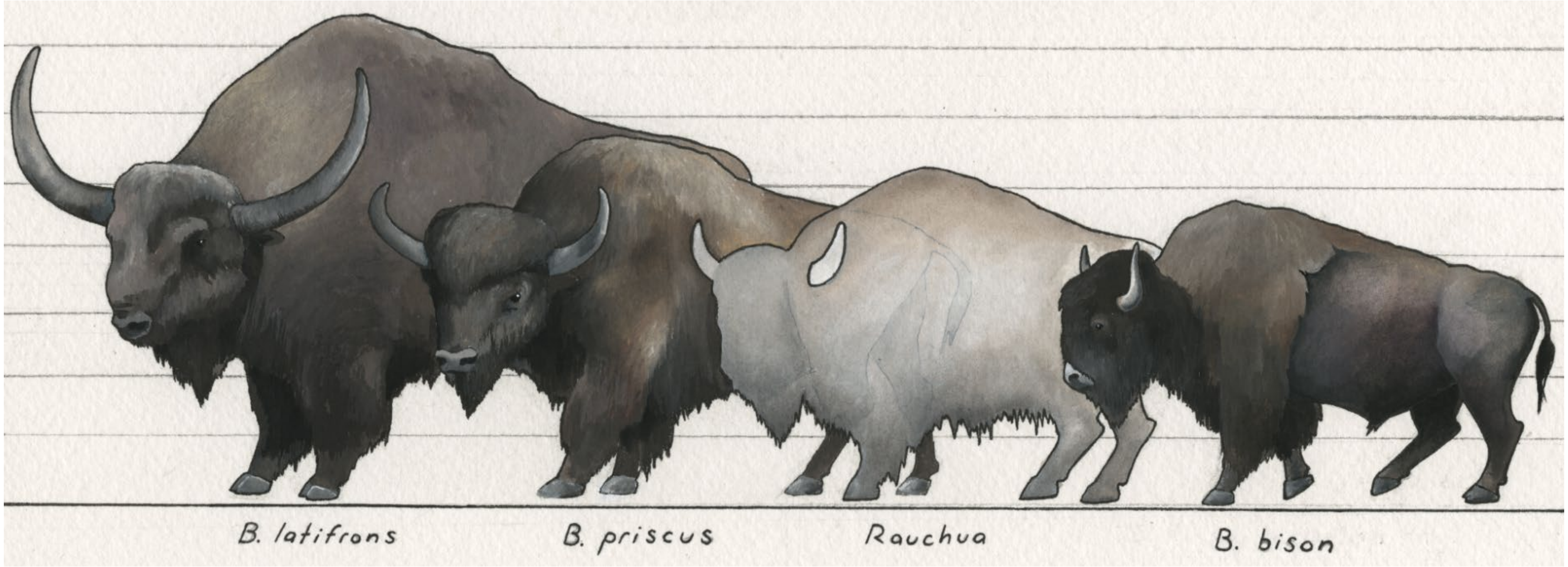
- Animal size
- Growth rate
- Microbiome

Nutrition

- Feed intake
- Type and quality of feed

Broucek, J. (2014).

Evolution



- Bison *bonasus*
- Bison *bison*
  - Bison *bison bison (plains)*
  - Bison *bison athabascae (woods)*
- Bison *latifrons*

Bison genetics

Bison bison athabascae (woods)

Bison bison bison (Plains)

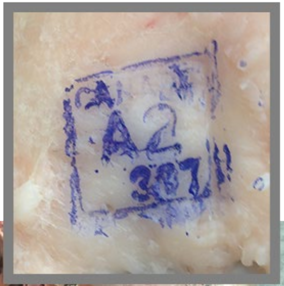
Plains Score	Category
93.75% - 100%	Plains
81.25% - 93.74%	7/8 Plains 1/8 Wood
68.75% - 81.24%	3/4 Plains 1/4 Wood
56.25% - 68.74%	5/8 Plains 3/8 Wood
43.75%-56.24%	1/2 Plains 1/2 Wood
31.25%-43.74%	3/8 Plains 5/8 Wood
18.75%-31.24%	1/4 Plains 3/4 Wood
8.75%-18.74	1/8 Plains 7/8 Wood
0.0% -8.74%	Wood

Cattle introgression

COSEWIC. (2013)

Carcass grades

GRADE DESIGNATION	MATURITY CLASS	MUSCLING	FAT COLOUR	MEAT COLOUR	FAT MEASURE
A1	CLASS I (youthful) CAPS OSSIFIED 80% OR LESS	excellent to good	white to amber & firm	bright red & firm	2 to 6 mm
A2		excellent to good	white to amber & firm	bright red & firm	7 to 12 mm
A3		excellent to good	white to amber & firm	bright red & firm	13 to 18 mm
A4		excellent to good	white to amber & firm	bright red & firm	>18 mm
B1	CLASS I (youthful) CAPS OSSIFIED 80% OR LESS	excellent to good	white to amber & firm	bright red & firm	< 2 mm
B2		excellent to medium	white to yellow	bright to dark red	
B3		deficient to point of emaciation	no requirements	no requirements	no requirements
D1	CLASS II (mature) CAPS OSSIFIED OVER 80%	excellent to medium	no requirements	no requirements	2 to 6 mm
D2		excellent to medium	no requirements	no requirements	>6 mm
D3		< medium	no requirements	no requirements	< 1 mm



02 Objectives

Objectives

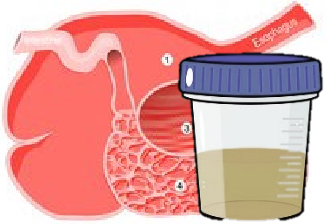
- Genetic composition
  - Carcass traits
  - Microbial diversity
  - Volatile fatty acids
    - Methane emission
- Carcass grades
  - Carcass traits
  - Microbial diversity
  - Volatile fatty acids
    - Methane emission

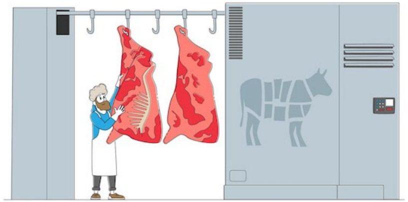
03 Materials and Methods

Materials and Methods

Sample collection

37 Bull calves fed with barley-based diet
Age: less than 30 months

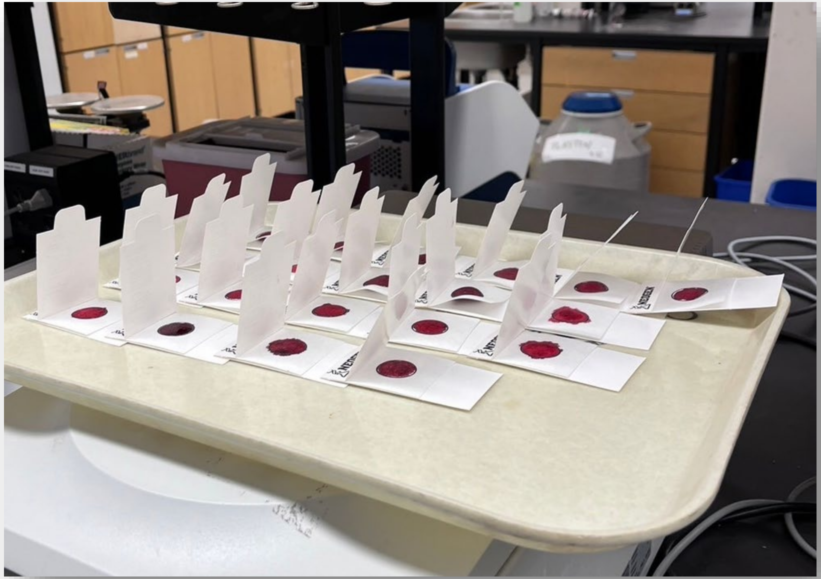




Animal ID → **Blood sample** → **Rumen content** → **Carcass quality**

Materials and Methods

Blood sample



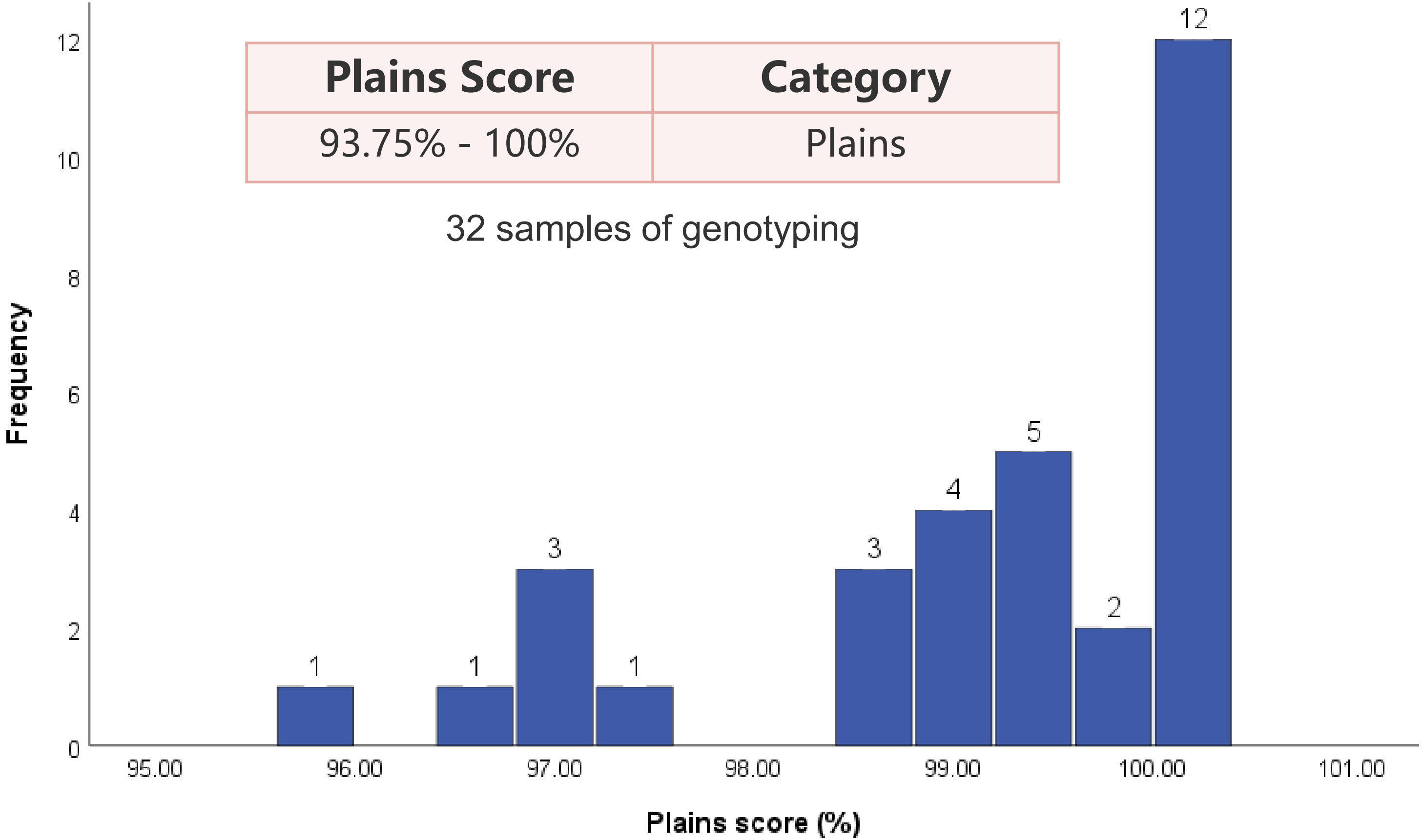
Whole blood sample
Spot on blood card

- Subsp. genotyping
- Cattle introgression

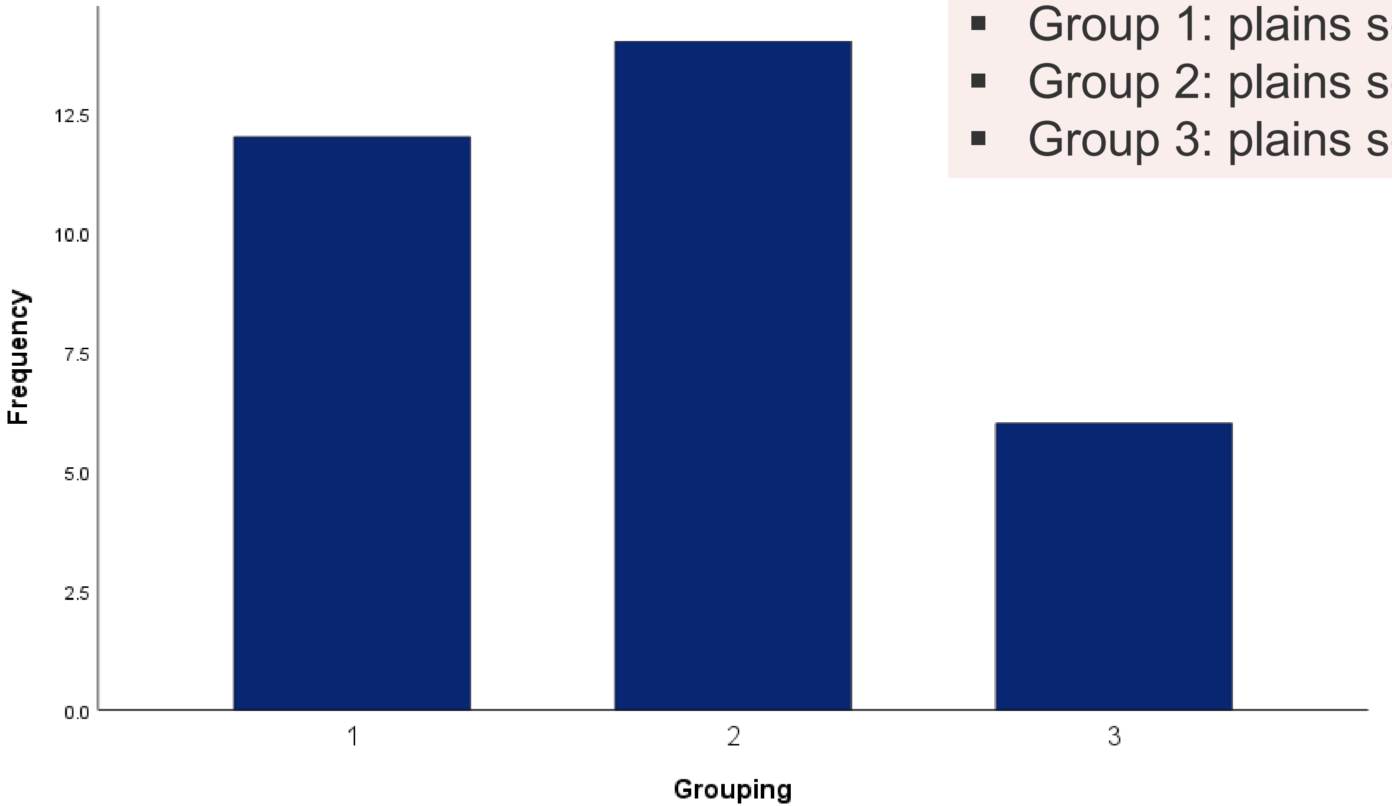
Bison genotyping

Plains Score	Category
93.75% - 100%	Plains

32 samples of genotyping

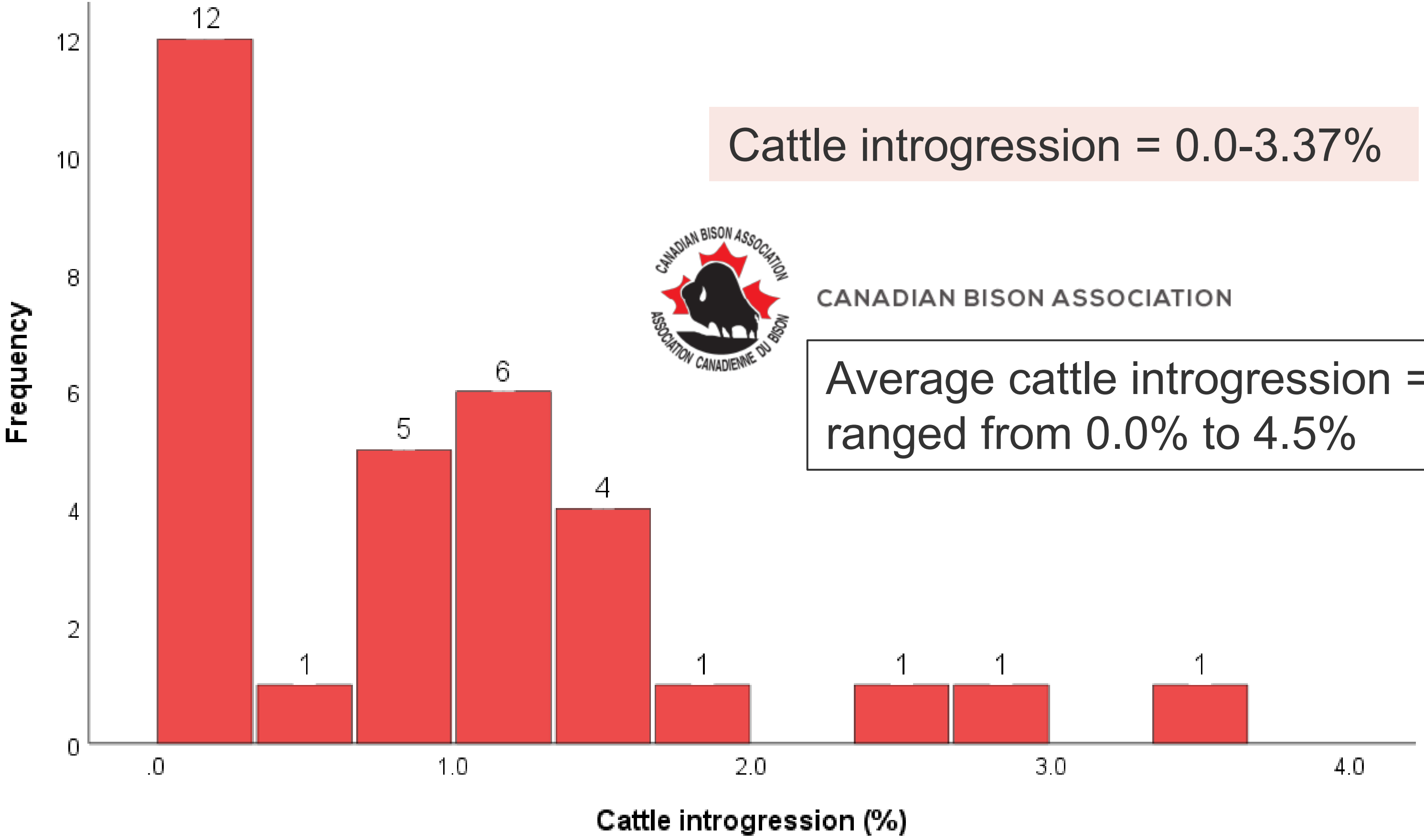


Genotype groups



- Group 1: plains score 100 %
- Group 2: plains score 97.5-99%
- Group 3: plains score < 97.5%

Cattle introgression



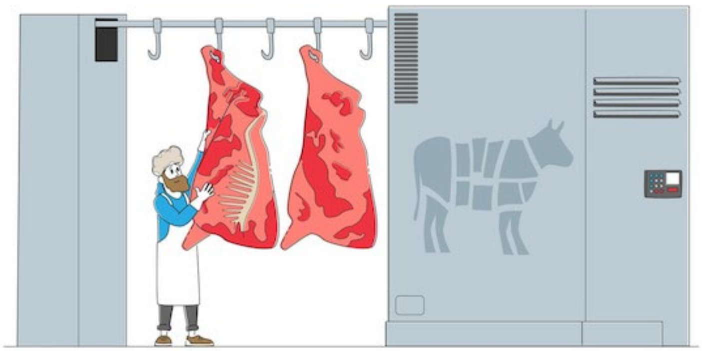
Cattle introgression = 0.0-3.37%

CANADIAN BISON ASSOCIATION

Average cattle introgression = 0.8% ranged from 0.0% to 4.5%

Materials and Methods

Carcass traits



Grading	No.
A1	4
A2	11
A3	13
A4	9
Total	37
BW: 500±56 kg	

Live weight (kg)

Hot weight (kg)

Grading

Yield (%)

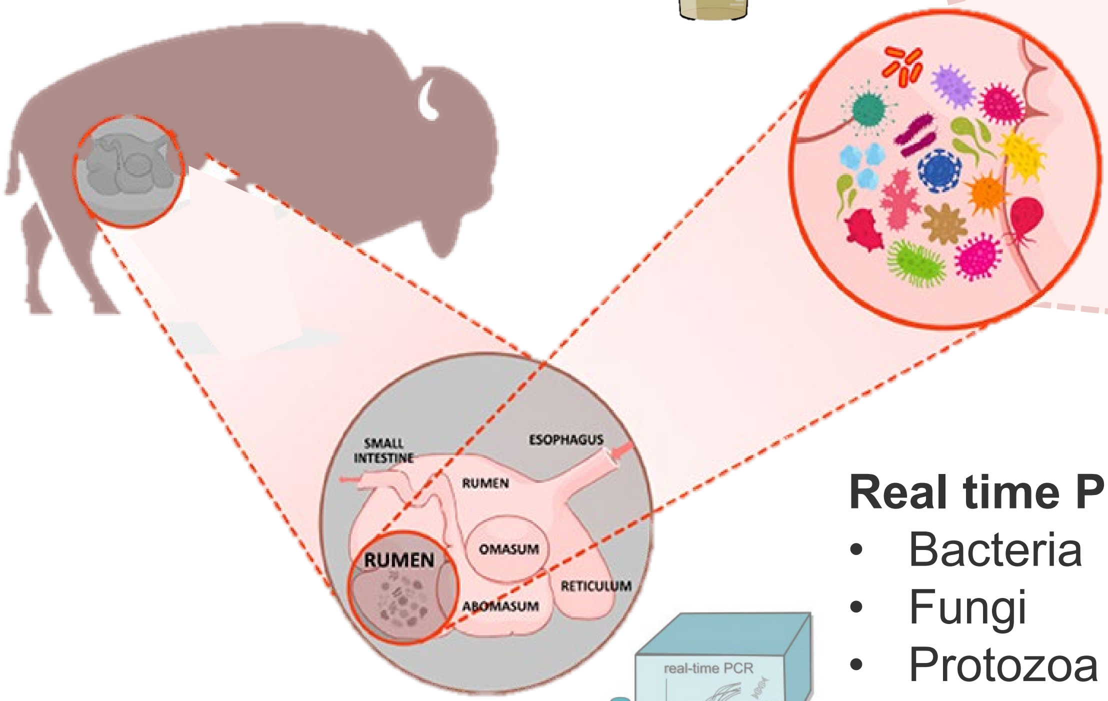
Materials and Methods

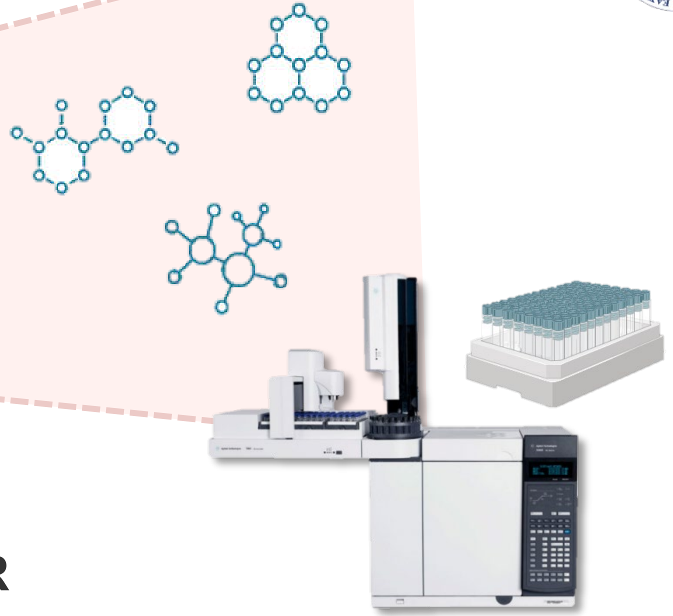
Rumen sample

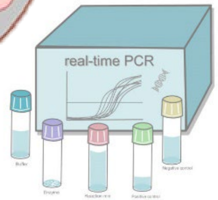
Volume: 50 mL/animal

Materials and Methods

Rumen sample







Real time PCR

- Bacteria
- Fungi
- Protozoa
- Archaea

Gas chromatography

- Volatile fatty acids

Methane

- Calculated

$CH_4 = 0.45C_2 - 0.275C_3 + 0.40C_4$ (Moss et al., 2000)

Statistical analysis

Software: SPSS 22.0

Kruskal-Wallis test

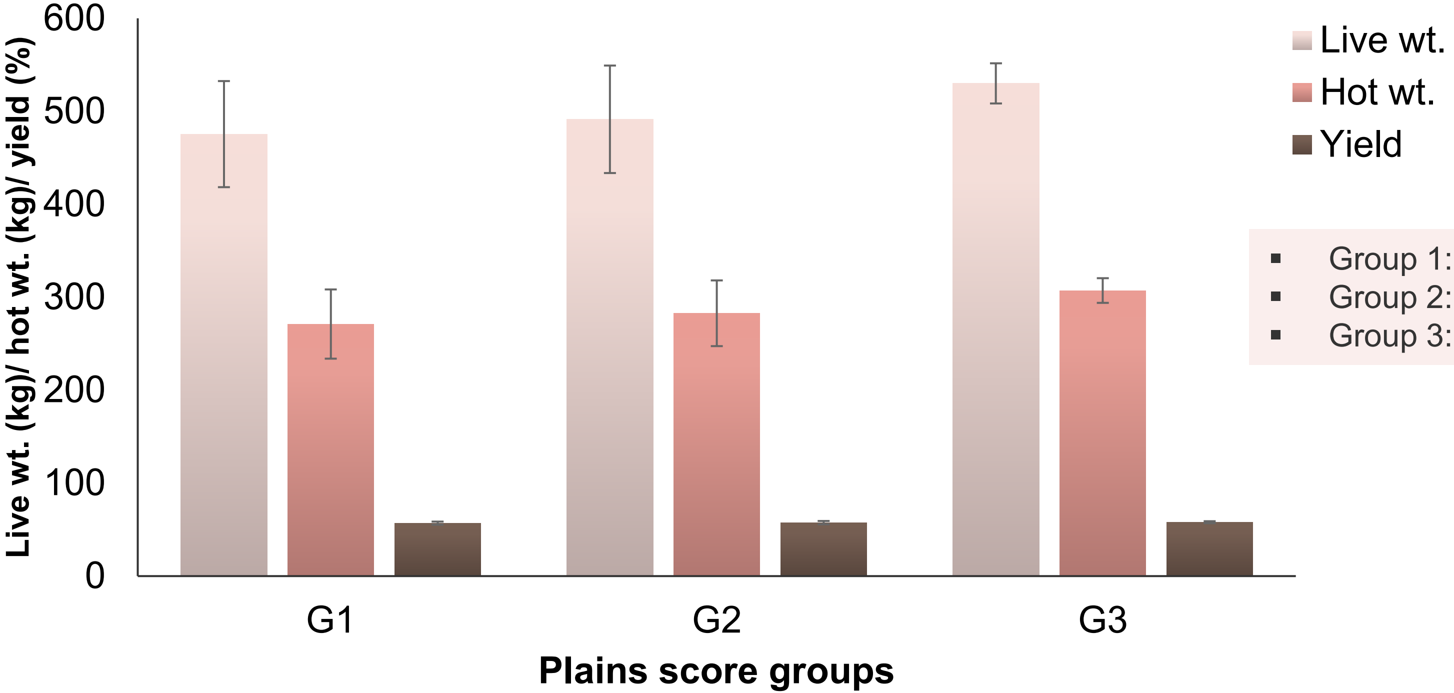
Pairwise comparison

*p-value of ≤ 0.05

Mean ± SEM

04 Results and Discussion

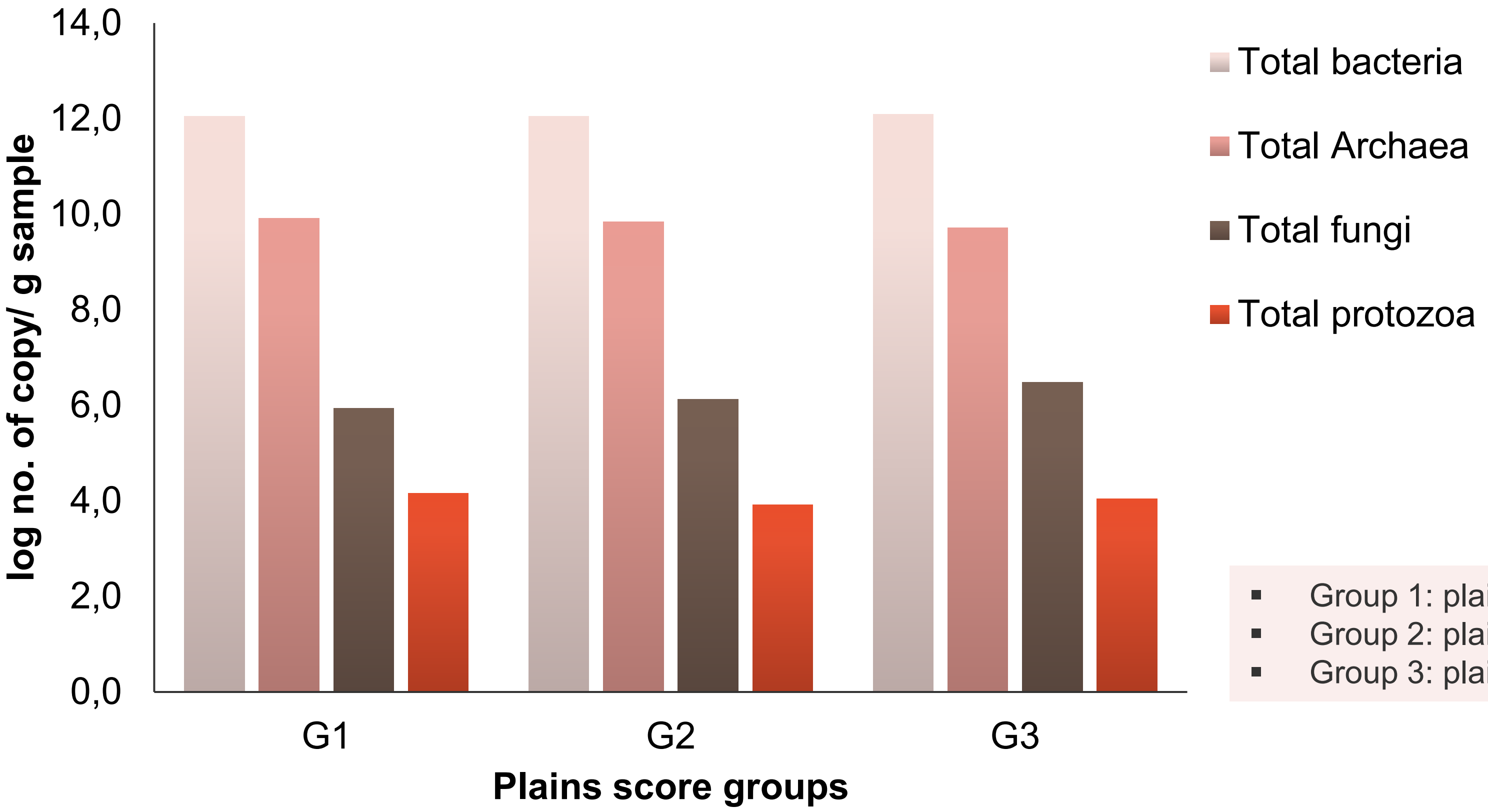
Genetics and Carcass traits



- Group 1: plains score 100 %
- Group 2: plains score 97.5-99%
- Group 3: plains score < 97.5%

Note: The different letter indicated the significant different at $p<0.05$

Genetics and Microbial diversity



- Group 1: plains score 100 %
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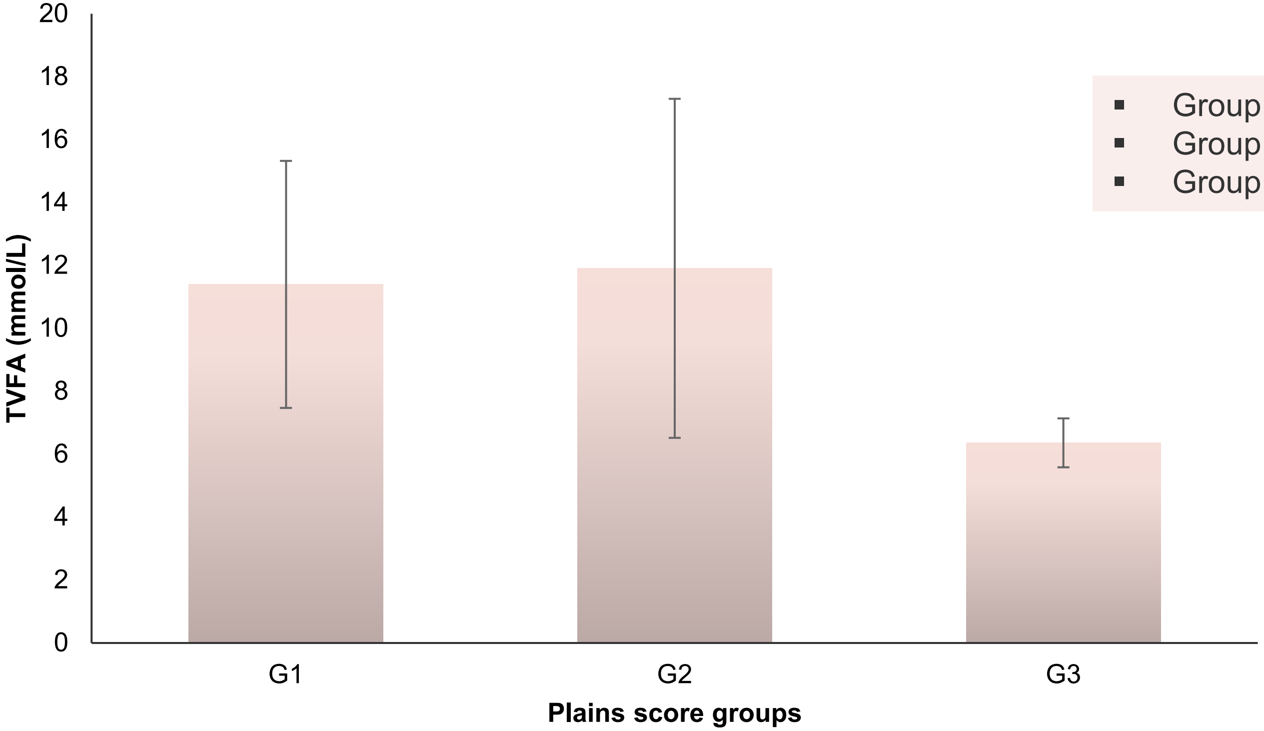
Genetics and TVFAs



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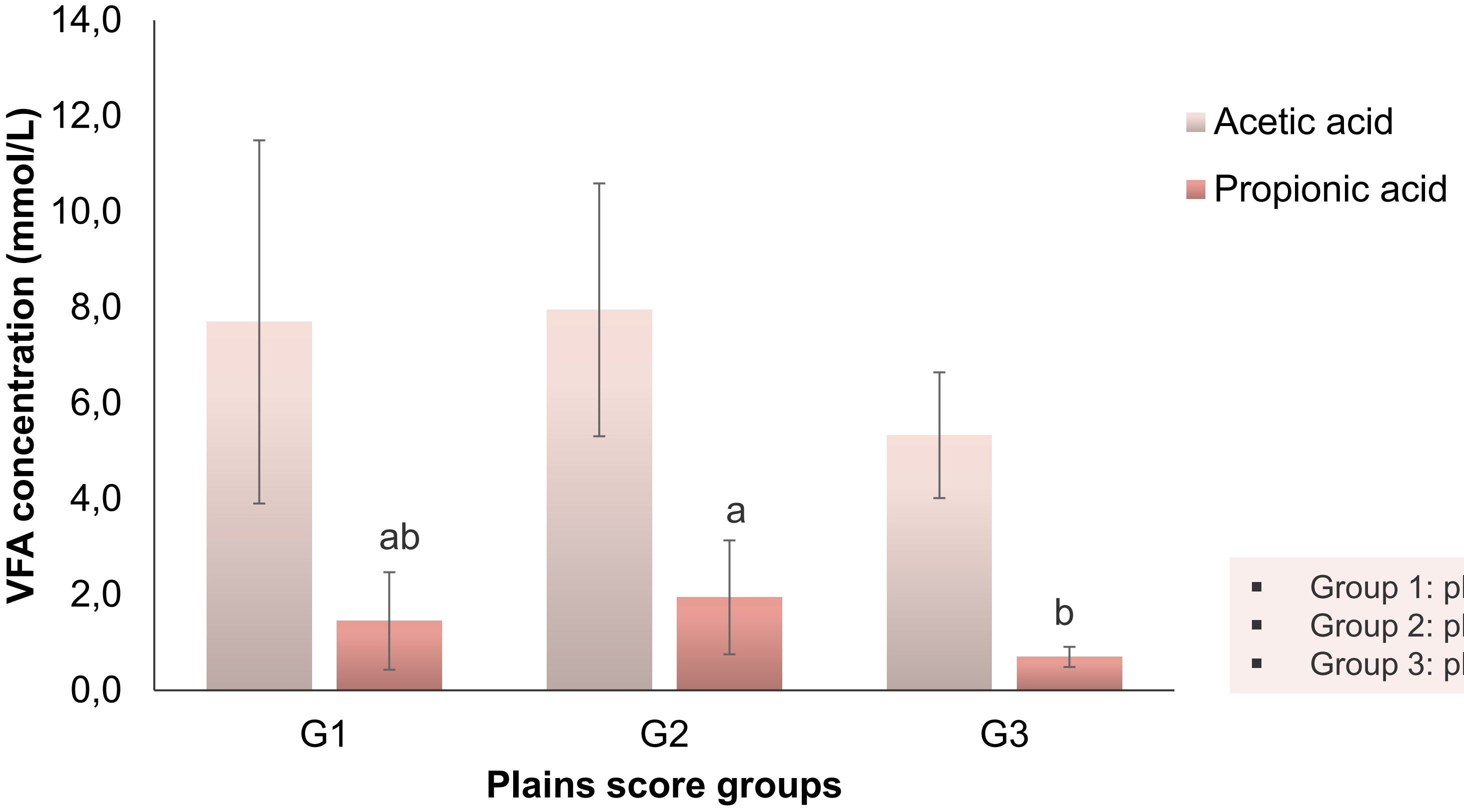
Genetics and VFAs



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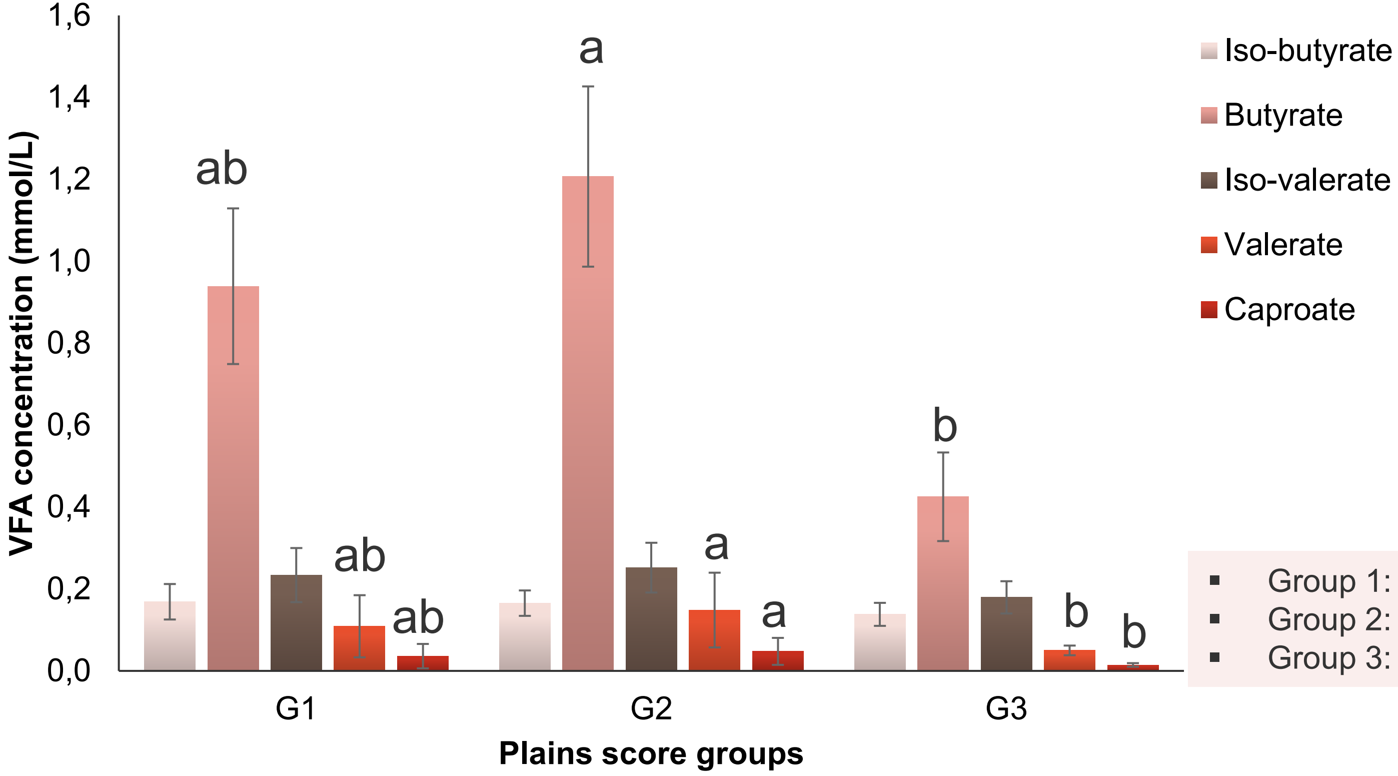
Genetics and VFAs



- Group 1: plains score 100 %
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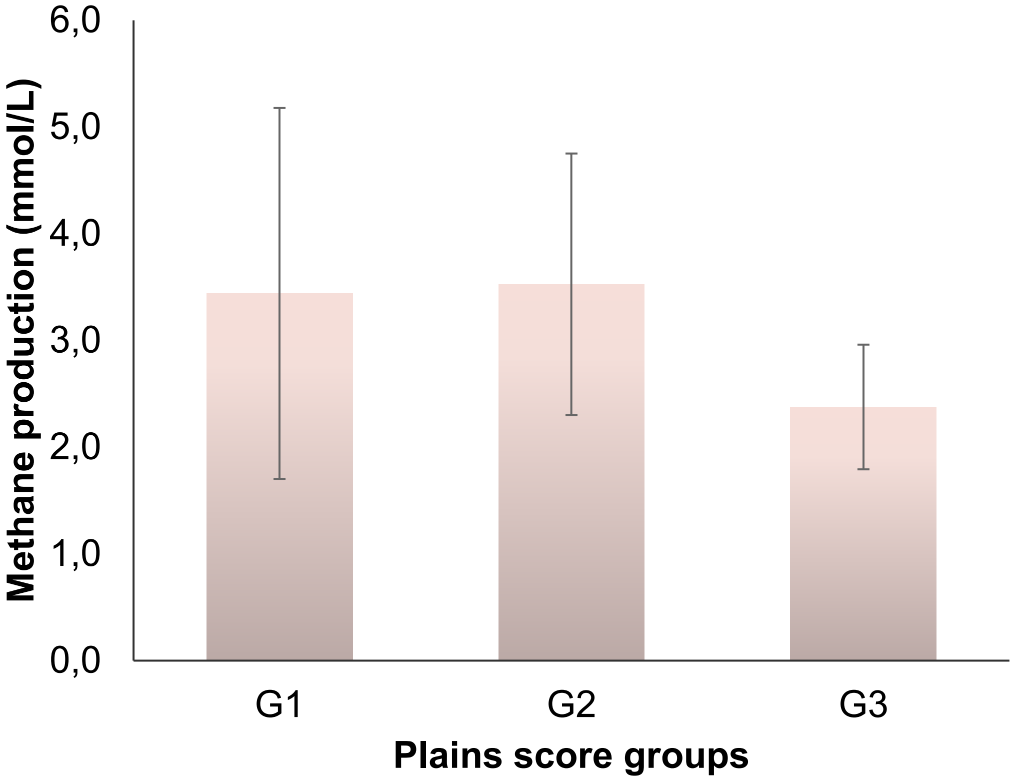
Genetics and Methane emission



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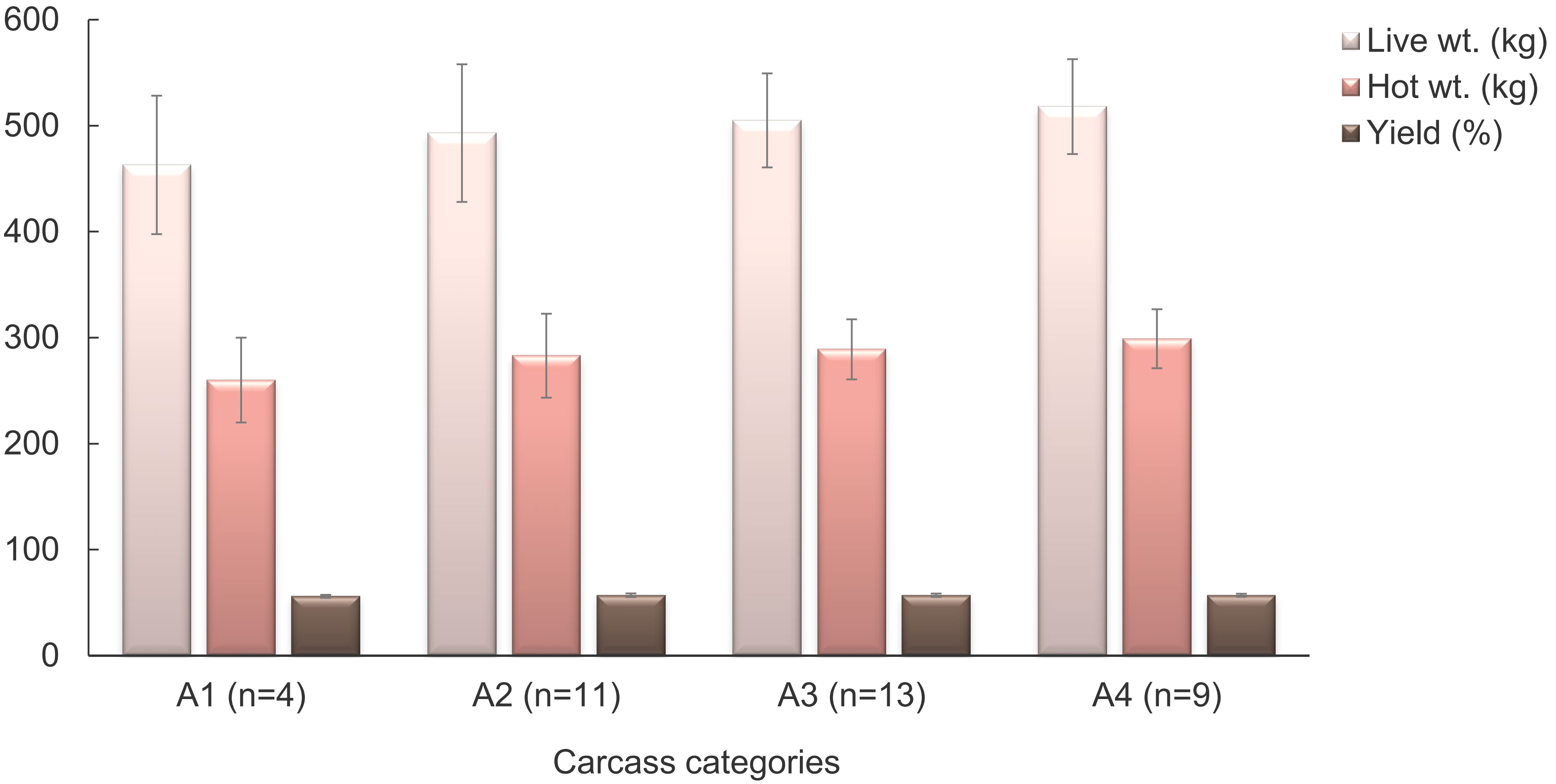
Carcass grades and carcass traits



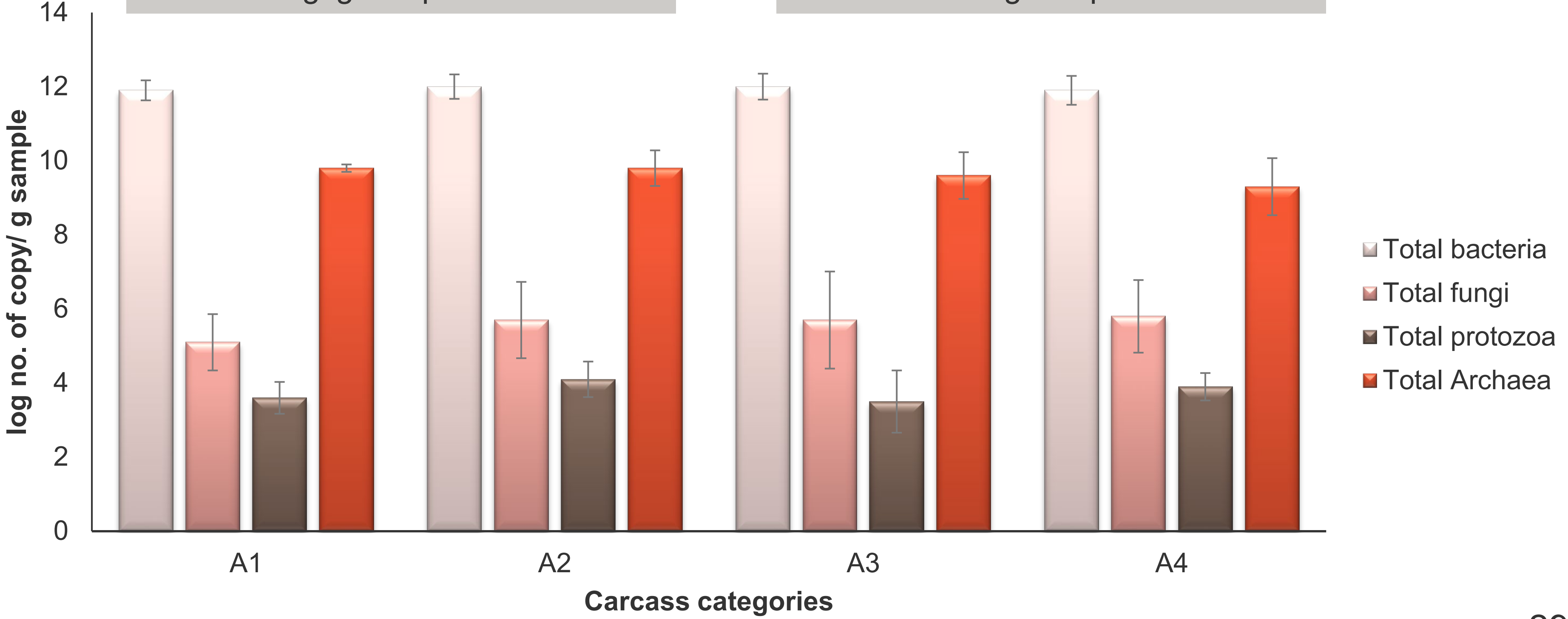
Carcass grades and microbial diversity

Total bacteria/g sample: 10^{11} to 10^{12}

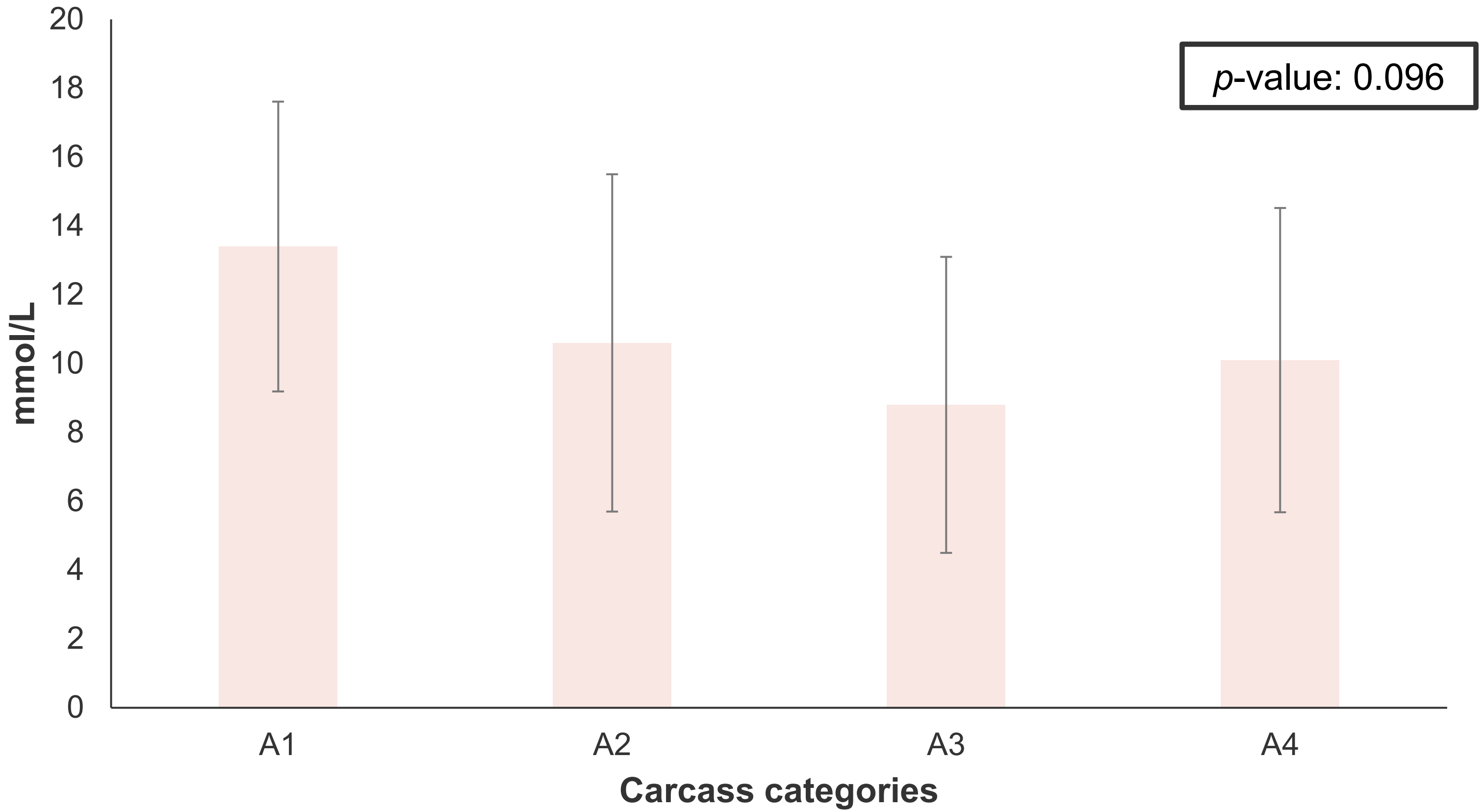
Total protozoa/g sample: 10^{3} to 10^{4}

Total fungi/g sample: 10^{5} to 10^{6}

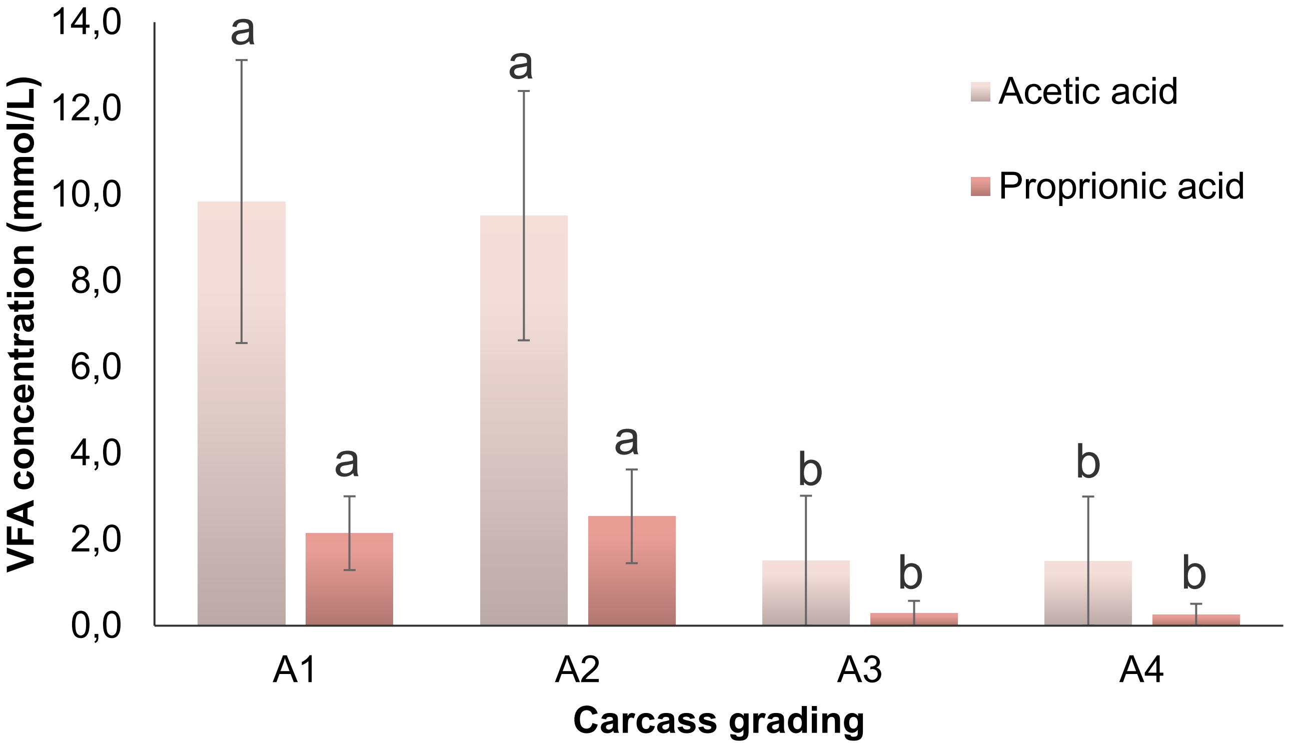
Total Archaea/g sample: 10^{9} to 10^{10}



Carcass grades and total VFAs

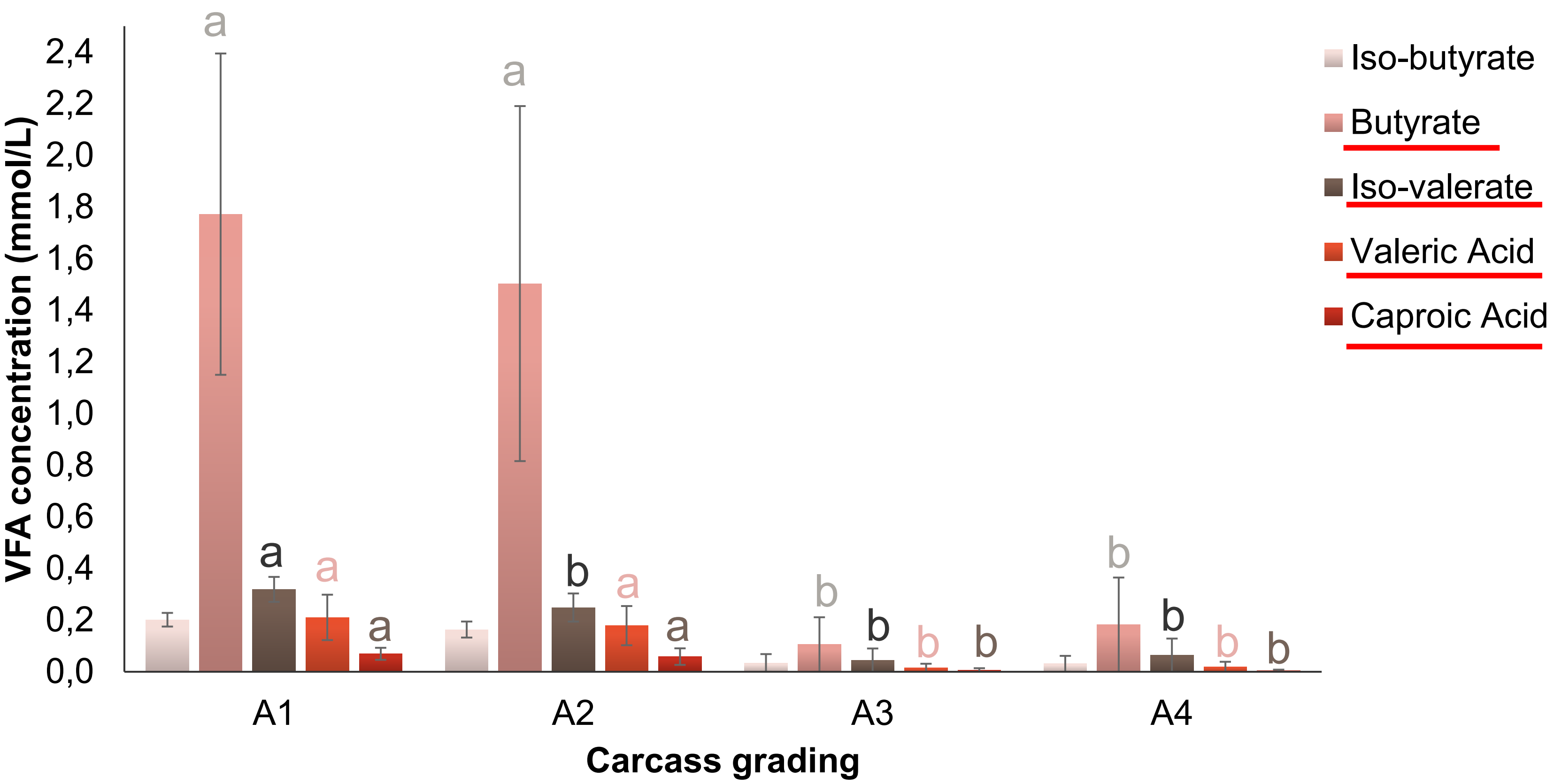


Carcass grading and VFAs



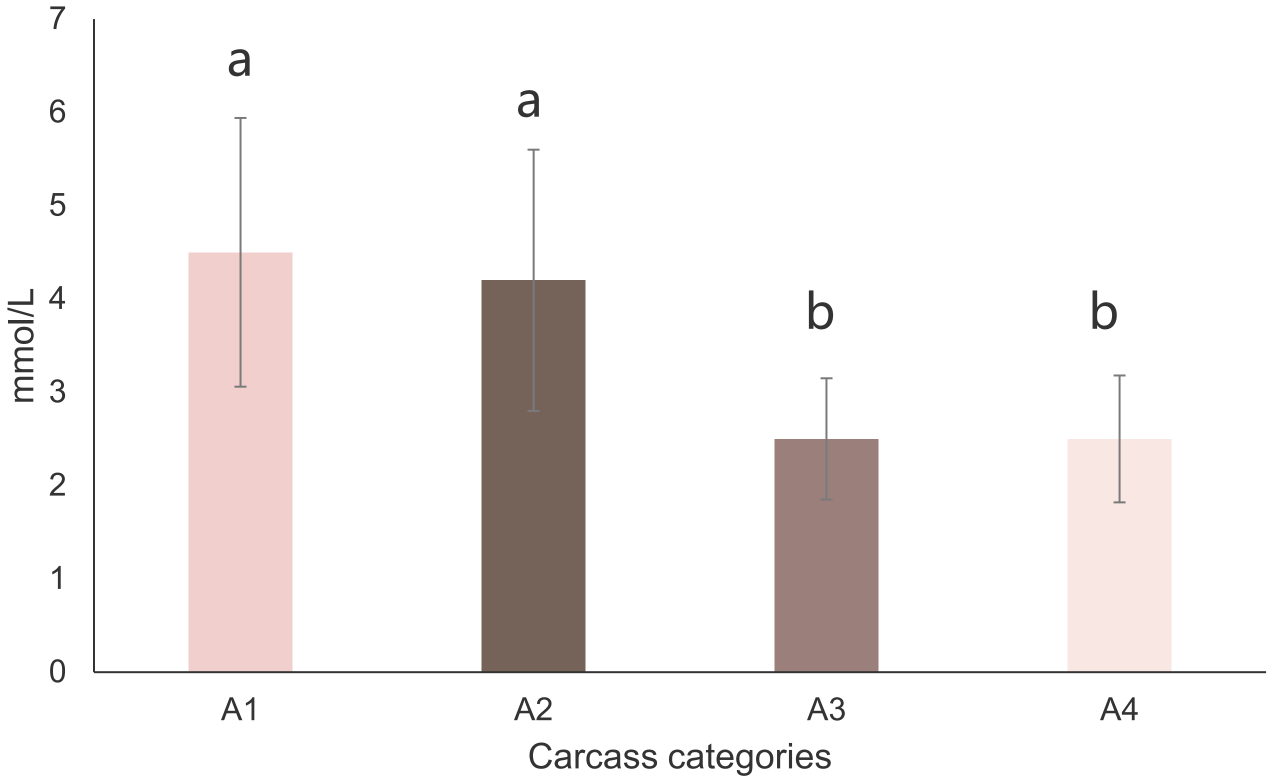
Note: The different letter indicated the significant different at p<0.05

Carcass grading and VFAs



Note: The different letter indicated the significant different at p<0.05

Carcass grades and methane emission



Note: The different letter indicated the significant different at $p<0.05$

Discussion

Methane production

Acetic acid → Methane and Carbon Dioxide
($CH_3COO^- + H^+ \rightarrow CH_4 + CO_2$)

Karakashev et al. (2006)

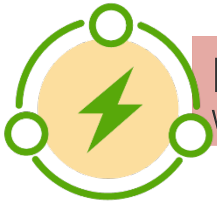
Acetic acid

Propionic acid

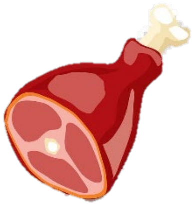
Iso-butyric acid

Valeric acid

Iso-valeric acid



Energy source
Wang et al. (2023)



Branched-chain VFA

- Feed protein degradation
- Microbial protein

Ribeiro et al. (2017)

A1 and A2
Protein, energy supply, methane emission

Conclusions

Plains/Woods genetic composition

The genetic make-up between subspecies did not affect carcass traits, microbial composition and CH_4 emissions. However, some differences were observed on the VFAs

Carcass grades

Carcass grade did not affect carcass traits and microbial composition. However, the concentration of VFAs and CH_4 emissions varied across grades, especially when looking at the 2 most and 2 least grades

Acknowledgements

Lakeland COLLEGE

Alberta Government

NAIT

ALBERTA INNOVATES

Mitacs

สกสว TSRI

RRi

BISON PRODUCERS OF ALBERTA

NSERC CRSNG

CANADIAN BISON ASSOCIATION ASSOCIATION CANADIENNE DU BISON

Chula Chulalongkorn University

IRISH CREEK BISON

AgSights

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