IECN 2024 Conference
The 4th International Electronic Conference on Nutrients
16–18 October 2024 | Online
MDPI

Dietary β-hydroxybutyric acid alters rumen microbiome and nutrient metabolism in the rumen epithelium of pre-weaned goats

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INTRODUCTION & AIM

The role of β-hydroxybutyric acid (BHBA) includes providing energy, regulating signaling pathways, and ameliorating the gut microbiota in the host. The ketogenic capacity of the ruminal epithelium, one of the most important parameters, that represents the maturation of rumen functions, is important and less studied.

Rumen VFAs could diffuse into rumen epithelial cells and are metabolized into ketones which provide energy and facilitate signals for the host gene transcription and the regulation of metabolism. The process in which acetyl-CoA from butyrate is converted to the ketone body (e.g., β-hydroxybutyric acid (BHBA and acetoacetic acid) is called ketogenesis. BHBA, the major ketones from the metabolism of VFA in rumen epithelium, might be the biomarkers for the maturation of rumen functions and microbiota as well as VFA utilization ability.

We hypothesized that BHBA supplementation could partially act via the rumen microbiota and improve the rumen development and host growth. Next-generation sequencing technology was performed to identify the microbial biomarkers.

METHOD

Animals, treatments, and sampling collection

Sixty-four goat kids were assigned to four treatments in a completely randomized design (eight replicates per treatment). The solid diet (starter) supplemented with 0 (control, C), 3 (low dose, L), 6 (medium dose, M), or 9 (high dose, H) g/d per animal; β-hydroxybutyric acid (BHBA) was provided to the experimental goat kids from 30 to 90 days (d) of age. At d 90, blood samples were collected, and six goat kids from each treatment were slaughtered for the rumen sample collection, resulting in four groups, namely, C90, L90, M90, and H90..

The body weight was recorded at d30 and d90. At the end of the trial, blood samples were collected. Then, goat kids were slaughtered at the abattoir of the goat farm to collect the rumen content samples for VFA and microbial measurement.

Serum and rumen BHBA determination

The biochemical analyses of BHB were performed at the laboratory of Beijing Jinhai Keyu Biotechnology Development Co., Ltd., Beijing, China.

Measurement of rumen VFAs

The GCwas used bases on previous methods.

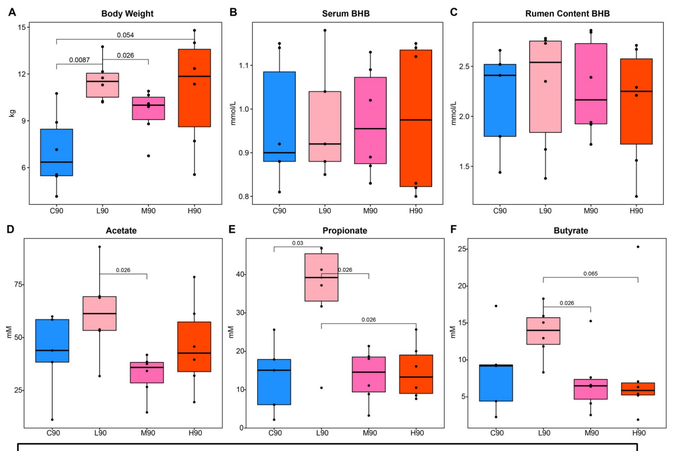
Rumen microbial sequencing

The total genomic DNA of rumen content samples was extracted and V3–V4 region of bacterial DNA was amplified. An Illumina Miseq PE250 platform (Realbio Technology Genomics Institute, Shanghai, China) was used to sequence the prepared amplicon library.

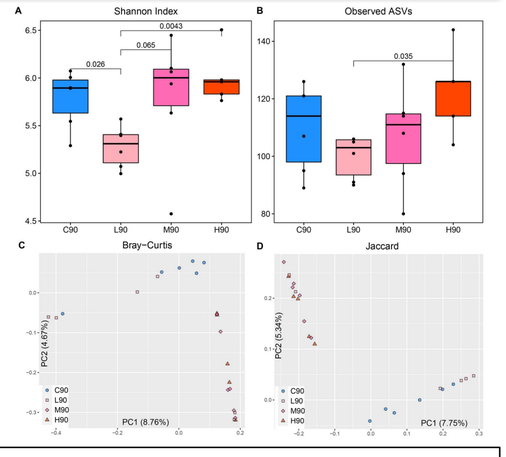
Bioinformatics and statistics

QIIME2 platform was used to process sequencing data. The alpha and beta diversity, network analysis and random forest were conducted in R.

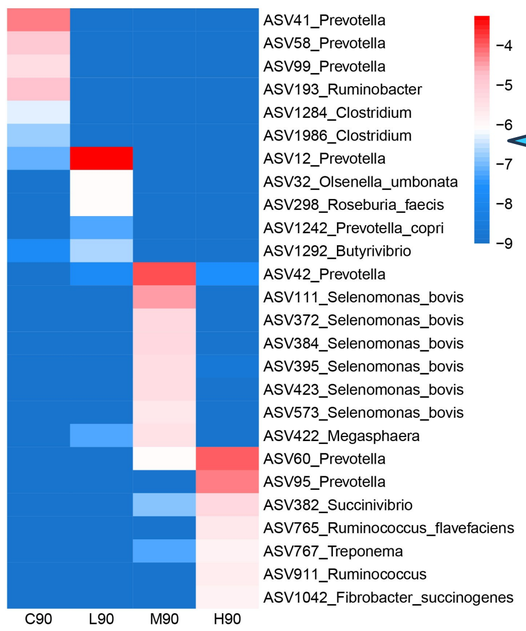
RESULTS & DISCUSSION



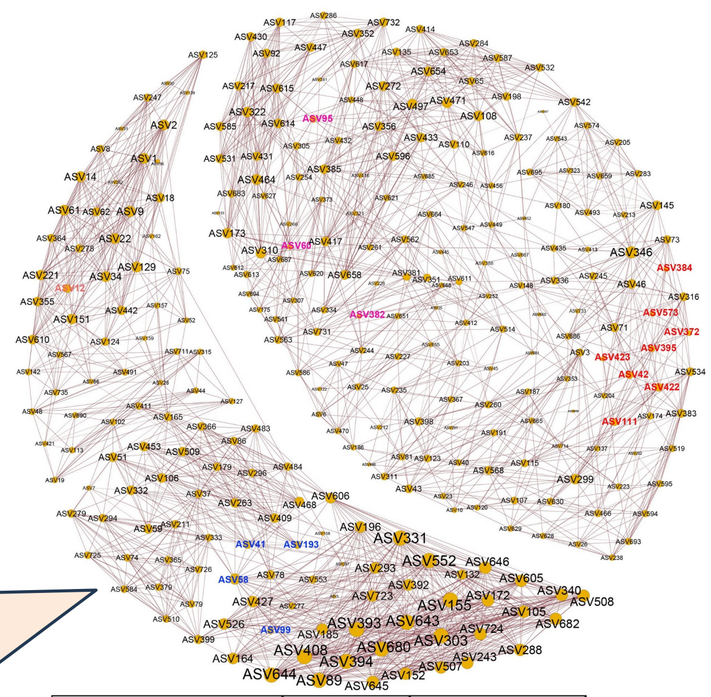
Dietary β-hydroxybutyric acid (BHBA) improved growth and rumen environment in goat kids



Dietary BHBA altered the diversity and structure of the rumen microbiota



The bacterial ASVs identified by LEfSe analyses were associated with dietary β-hydroxybutyric acid (BHBA)



Co-occurrence patterns of rumen bacterial interactions associating with the levels of dietary β-hydroxybutyric acid (BHBA)

C90	L90	H90
Prevotella (ASV41, ASV58, ASV99)	Prevotella (ASV12)	Prevotella (ASV60, ASV95)
Ruminobacter (ASV193)		Succinivibrio (ASV382)

M90
Prevotella (ASV42)
Selenomonas bovis (ASV111, ASV372, ASV384, ASV395, ASV423, ASV573)
Megasphaera (ASV422)

CONCLUSION

Our results revealed the beneficial effects of dietary BHBA on the rumen microbiota, host transcriptome and metabolomics and validated the roles of BHBA in regulating the development of rumen epithelium.

FUTURE WORK / REFERENCES

Our lab uses interdisciplinary approaches such as multi-omics (e.g. metagenomics, metatranscriptomics, metabolomics, culturomics), bioinformatics, statistics, and machine learning to understand the roles that animal and human microbiome play in nutrient metabolism, health and different diseases.