博 士 論 文 の 内 容 の 要 旨

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学位授与年月日	令和 2 年 9 月 30 日
論文題目	Establishment of procedures for integrative mitigation of greenhouse gases relating to ruminant production: effects of feeding fruits by-products （反芻家畜生産に関連した温室効果ガスの複合的緩和手法の確立：果物副産物給餌の効果）

（博士論文の内容の要旨）

The ruminant production system is facing two main challenges; first is to comply increasing production demand regardless of feed scarcity particularly in the developing countries. Second is the challenge being posed by climate change due to ruminant greenhouse gas (GHG) emission. Several GHG mitigation approaches have been evaluated, however, the strategy that can fill the gap between feed production and to simultaneously decrease the GHG emission is not sufficiently explored. Recently, attention has been turned on the use of alternative, unconventional feed ingredients that are locally available and inexpensive. Fruit by-products (FBs) offer available and attractive sources as livestock feed because of their richness in many nutrients and high contents of plant secondary metabolites (PSM). Plant secondary metabolites can modulate the rumen ecosystem and is considered promising enteric methane mitigation strategy. Persimmon skin (PS) is a PSM-rich byproduct (e.g., tannin) which generated from dried persimmon production prevalent in Nagano prefecture, however, its use as a sustainable feed is limited due to seasonal production, high soluble carbohydrate, and high moisture content. Ensiling offers the appropriate technique to enable PS annual use but the high moisture remains an obstacle in the silage preparation.

In the first study, three kinds of FBs (grape pomace, wild grape pomace, and PS) were compared in view of plausibility for feed use. Those materials were ensiled for four-week anaerobic fermentation by Lactobacillus buchneri inoculant and subjected for in vitro test at level 30% of DM. Two consecutive in vitro experiments were conducted; Experiment 1 showed that the inclusion of FBs decreased methane production and increased propionate proportion. Also, lower levels of Archaea 16S rRNA genes and a higher level of Fibrobacter succinogenes were noted in the bottles containing FBs than in the control. In Experiment 2, FBs failed to exhibit a significant difference in methane production with or without polyethylene glycol, suggesting that tannins in the FBs were not responsible for the mitigation of methane generation. Unlike non-ensiled ones, ensiled FBs possibly affected the rumen fermentation patterns and consecutive methane generation, mainly due to the changes in the carbohydrate forms during fermentation.

The second study aimed to overcome the main obstacles militating against the usage and preparation of PS silage (PSS). Three experiments were undertaken to reveal the effect of the dry absorbents on PSS quality, rumen fermentation kinetics, and ingestive behavior. A table-scale silages were prepared (Experiment 1), and five different mixtures were evaluated: PS without additive (CONT), PS + L. buchneri inoculum (1%, Lb), Lb plus either of kraft pulp (KP), wheat bran (WB), or beet pulp (BP). The dry absorbent treated groups showed a favorable fermentation profile with a lower volume of effluent ($p < 0.001$). Further, with an in vitro batch culture study (Experiment 2), the fermentation pattern of PS with a mixture of two absorbents (KP and WB) was evaluated either raw or ensiled. In vitro fermentation profile and methane reduction degree observed in the first study were maintained by the absorbent inclusion. Finally, a feeding trial was conducted using six Suffolk ewes in a crossover design of two periods. The ewes in the control group were fed a basal diet comprising tall fescue hay and concentrate mixture without PSS, while in PSS group were fed on the basal diet and tall fescue hay was partially replaced (20% on dry matter basis) with PSS ensiled for three weeks with KP as a sole absorbent. Persimmon skin silage inclusion in sheep had suitable palatability along with improved digestibility and without adverse effect on the rumen fermentation parameters.

This study could indicate the potential use of ensiled FBs as a ruminant feedstuff and its efficiency

in methane mitigation. On the other hand, anticipation of the total GHG reduction resulted from using local FBs in animal feed, which includes the decrease of the environmental load both of CO2 by the feed transportation and of N2O by decomposition of the material, has not yet been determined. Therefore further comprehensive studies are required to establish this integrative strategy for GHG mitigation.