学位論文内容の要旨

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学位論文題名

Functional evaluation of bean husk as a new feed ingredient for monogastric animals

（単胃動物のための新規飼料素材としてのマメ外皮の機能評価）

Bean husk is an agricultural by-product that is generated from the processing of bean for human consumption. Since the total husk constitutes about 10-11 % of the whole seed, it can be abundantly available. Bean husk is rich in dietary fiber and phytochemicals such as polyphenols and considered a new feed source candidate for various animals, but still underutilized. Bean husk fiber is reported to selectively stimulate the growth of fiber-degrading bacteria in the gastrointestinal tract of herbivorous livestock animals such as ruminants. Therefore, bean husk has gained attention as a new possible source of functional fiber for other animals, in particular monogastrics. The objective of the present study was to evaluate effect of bean husk on blood parameters, cecal fermentation and microbial community in rats and dogs. The results are expected to provide insights into the future development of functional foods for monogastric animals.

1. Function of chickpea husk in rats

For evaluation of chickpea (*Cicer arietinum*) husk, feeding study using 15 male SD rats (5 weeks of age) was conducted. Rats were divided into three groups; they were fed one of the following diets for 3 weeks: purified diet (AIN 93G) containing 5% cellulose (CEL), an identical diet in which cellulose was replaced by corn starch (Starch) or by chickpea husk (CPH). Chickpea husk contained high polyphenolic content and significant superoxide dismutase and 2,2-diphenyl-picrylhydrazyl scavenging activities. In a feeding experiment, CPH showed lowered cholesterol levels and improved antioxidant activity represented by reduced thiobarbituric acid reactive substances in blood. CPH showed increased cecal levels of total short-chain fatty acids and butyrate. CPH presented with lowered cecal indole and skatole concentrations, as did CEL. Cecal bacterial changes were notable in CPH, evidenced by differences in denaturing gradient gel electrophoresis banding patterns. These results indicate that chickpea husk feeding

can improve the antioxidative status of rats through its polyphenolic components and modulate the hindgut environment by its fibrous components.

2. Function of lablab bean husk and soybean husk in rats

For evaluation of lablab bean (*Dolichos lablab*) husk and soybean (*Glycine max*) husk, a feeding study using twenty male SD rats (5 weeks of age) was conducted. Rats were divided into 4 groups and fed one of the following diets for 3 weeks: purified diet (AIN 93G) containing 5% cellulose (CEL), or the same diet in which cellulose was replaced by corn starch (STA), lablab bean husk (LBH), or soybean husk (SBH). Feed intake, body weight, anatomical parameters, and cecal ammonia level did not differ significantly among diets. Rats on LBH and SBH showed higher concentrations of cecal short-chain fatty acid and lactate than those on CEL. Rats on CEL, SBH, and LBH exhibited decreased cecal indole and skatole levels. LBH yielded increased cecal abundance of beneficial bacteria such as *Akkermansia muciniphila*, bifidobacteria, and *Oscillibacter* relatives, as demonstrated by either qPCR, MiSeq, or clone library analysis. SBH favoured the growth of lactobacilli as assessed by both qPCR and MiSeq, and favoured the growth of bifidobacteria as assessed by MiSeq. In comparison with STA, LBH and SBH yielded decreased cecal abundance of bacteria related to *Dorea massiliensis*, as demonstrated by qPCR, MiSeq, and clone library analysis. Both types of bean husk were found to contain oligosaccharides that might selectively stimulate the growth of beneficial bacteria. Based on these results, the two species of bean husk tested are considered functional for promoting the gut health of monogastric animals.

3. Function of soybean husk in dogs

For the confirmation of the functionality of soybean husk, a feeding study using four Shiba dogs (7–48 months in age and 7.5 ± 1.7 kg in body weight) was conducted. Dogs fed a commercial diet supplemented with 5.6% soybean husk after feeding control cellulose diet, showed an increase in short-chain fatty acids, such as acetate and butyrate, and lactate, and a decrease in indole and skatole in the feces compared to those fed a 5.6% cellulose diet. The qPCR assay showed that soybean husk supplementation stimulated the growth of lactobacilli, *Clostridium* cluster IV including *Faecalibacterium prausnitzii*, *Clostridium* cluster XIVa, *Bacteroides-Prevotella-Porphyromonas* group but inhibited the growth of *Clostridium* cluster XI. Therefore, soybean husk is suggested to be applicable as a functional fiber in the formulation of canine diets.