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Effect of tea saponins on milk performance, milk fatty acids, and immune function in dairy cow

B. Wang,*† Y. Tu,* S. P. Zhao,† Y. H. Hao,† J. X. Liu,‡ F. H. Liu,† B. H. Xiong,§[1] and L. S. Jiang†[1]
*Feed Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China
†Beijing Key Laboratory for Dairy Cow Nutrition, College of Animal Science and Technology, Beijing University of Agriculture, Beijing 102206, China
‡Institute of Dairy Science, MoE Key Laboratory of Molecular Animal Nutrition, College of Animal Sciences, Zhejiang University, Hangzhou 310058, China
§State Key Laboratory of Animal Nutrition, Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing, 100193, China

ABSTRACT

This study investigated the effects of tea saponins (TSP) on milk performance, milk fatty acids, and blood immune function in dairy cows. A total of 20 early-lactation Holstein cows (days in milk = 66.4 ± 16.8 d; parity = 1.75 ± 0.91; and milk yield = 36.3 ± 7.32 kg/d; mean ± standard deviation) were randomly divided into 4 homogeneous treatment groups, with TSP added at 0, 20, 30, and 40 g/d per head, respectively. All cows had 2 wk of adaptation and 6 wk of treatments. Feed, milk, and blood were sampled and analyzed weekly. At the end of the experimental period (wk 6), the dry matter intake and yields of energy-corrected milk, milk, and milk protein, fat, and lactose in the cows fed TSP showed a quadratic response, with the lowest values in cows fed TSP at 40 g/d. The milk fat content of cows fed TSP increased linearly. Significant interactions for treatment by week were found in milk C16:1 *cis*-9 and C18:1 *cis*-9, with the highest values at wk 2, 3, and 4 in the cows fed TSP at 40 g/d. The levels declined quickly after 4 wk of feeding to values similar to those for other TSP treatments and the control at wk 5 and 6. Plasma malondialdehyde concentration decreased as the supplement level of TSP increased. The concentration of superoxide dismutase increased as the supplement level of TSP increased. The plasma concentration of tumor necrosis factor-α increased as the supplement level of TSP increased. In summary, this study showed that an intermediate dose of TSP (20 and 30 g/d) had no significant effect on feed intake, but the supplementation of 40 g/d TSP decreased feed intake, resulting in a lower milk yield. The energy-corrected milk of cows fed 40 g/d TSP declined at first but increased after 3 wk of feeding, indicating the potential adaptation to high doses of TSP supplements in dairy cows. The supplementation of TSP could reduce oxidative stress in cows and improve the immunity of dairy cows during 6 wk of feeding.
Key words: fatty acids, immune function, milk quality, tea saponins

INTRODUCTION

Tea saponins (**TSP**), which mainly consist of triterpenoid saponins, have been reported to have antimicrobial effects, decrease methane emission, and alter rumen fermentation by killing protozoa and increasing microbial protein synthesis (Hu et al., 2006; Guo et al., 2008; Wang et al., 2012). The decreased methane emission accompanied by increased ruminal microbial protein synthesis might be an indicator that the rumen fermentative environment is good for animal production (Wang et al., 2012). Decreased methane emissions were reported in some trials (Wang et al., 2012), but several other studies found inconsistent results. Some studies indicated that the methane emissions could not be changed (Guyader et al., 2015; Ramírez-Restrepo et al., 2016), and others showed that the growth of lambs changed little (Mao et al., 2010) after they were fed TSP. Such mixed results indicate that more research on TSP is needed.

In addition, TSP has been shown to have antioxidant capacity as well as antifungal, antiviral, and anti-inflammatory activities (Francis et al., 2002; Zhou et al., 2012; Li et al., 2015). In general, the antioxidant effect of TSP is mainly due to the reducing function of acyl and hydroxyl group of saponins, which can directly remove free radicals or inhibit the initiation of the free radical chain reaction (Guyader et al., 2015). The antifungal effect is through the invasion of microbial cell membrane structure, leading to cell membrane disintegration caused by ion loss (Wanapat et al., 2012).

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[1]Corresponding authors: jls@bac.edu.cn and bhxiong@iascaas.net.cn

Therefore, TSP has been proposed as a potential substitute for antibiotics in animal feed (Francis et al., 2002).

In addition, ruminal acetate and butyrate (the milk fat precursor) and their proportions were reduced by increasing TSP supplementation (Guyader et al., 2017). This finding indicated that the milk fatty acid (**FA**) profile might be altered by TSP supplementation. However, the influence of TSP on dairy cow milk production and milk FA profile has received limited research attention. We hypothesize that milk production and milk FA profile could be changed by feeding TSP to lactating cows. Our goal was to perform a dose–response study on TSP supplementation in dairy cows and its effect on their lactation performance, milk FA profile, antioxidative status, and immune response.

MATERIALS AND METHODS

Tea Saponins

Tea saponins (≥56% purity of triterpenoid saponins) in powder form were provided by the Zhejiang Orient Tea Industry (Shaoxing, China). The proportion of CP, NDF, ether extract, and ash in TSP were 4.12, 2.78, 9.60, and 9.88% of DM, respectively.

Animals, Diets, and Experimental Design

A total of 8 primiparous and 12 multiparous lactating Holstein dairy cows were blocked based on parity and milk production and were randomly assigned to 1 of 4 dietary groups, with 5 cows in each group (2 primiparous and 3 multiparous cows). No initial differences existed between the groups in terms of milk yield (36.3 ± 7.32 kg/d; $P = 0.88$), DIM (66.4 ± 16.8 d; $P = 0.38$), parity (1.75 ± 0.91; $P = 0.81$), and BW (550 ± 30 kg; $P = 0.27$). The cows were fed the same basal diet with TSP supplementation of 0 (control), 20, 30, or 40 g/d per head. The TSP dose for dairy cows in this study was calculated based on the predicted rumen volume and extrapolations from an in vitro study and an in vivo study in goats (Hu et al., 2006; Zhou et al., 2012). The dietary ingredients and nutrient composition of the basal TMR are presented in Table 1. The cows were housed in individual tiestalls, with feed available for ad libitum consumption and free access to water. Feeding and milking occurred 3 times per day (0730, 1430, and 2130 h). The experiment lasted for 8 wk, with a 2-wk adaption period and a 6-wk sampling period. Animals selected in this study were provided by the Beijing Sanyuan Lvhe Dairy Farming Center (Beijing, China), and the experimental procedures were approved by the Animal Care Committee, Beijing Agriculture University (Beijing, China).

Feed and Milk Sampling and Analysis

Daily milk production and DMI were recorded for the first 3 consecutive days of each sampling week throughout the duration of the trial. Milk samples were collected on the third day of each week using milk-sampling devices (Waikato Milking Systems NZ Ltd., Hamilton, New Zealand). Feed and orts samples were collected once per day during the 3 consecutive days to determine the DMI. The amount of feed offered was recorded daily and adjusted to yield 5 to 10% orts; the feed intake was calculated based on the feed of-

Table 1. Ingredients and nutrient composition (% of DM, unless otherwise specified) of basal diet used in the experiment

Item	Content
Ingredient	
Corn silage	46.3
Alfalfa hay	6.90
Oat grass	2.40
Ground corn	9.88
Soybean meal	5.10
Steam-flaked corn	4.40
DDGS[1]	4.40
Corn bran	3.70
Extruded soybean	3.00
Barley	2.66
Wheat bran	2.66
Sodium cyclamate	2.40
Oat	1.50
Canola meal	1.07
Cottonseed meal	1.07
Megalac[2]	0.90
$NaHCO_3$	0.59
Limestone	0.48
NaCl	0.27
MT-BOND[3]	0.02
Premix[4]	0.30
Nutrient composition[5]	
CP	17.4
NDF	31.1
ADF	16.6
Ether extract	5.00
Ca	0.78
P	0.44
NE_L,[6] Mcal/kg	1.76

[1]DDGS = dried distillers grains with solubles.

[2]Church and Dwight Co. Inc., Princeton, NJ.

[3]MT-BOND = Matt mold rubber element (MinTech International Inc., Bloomington, IN).

[4]Formulated to provide (per kg of DM) 4,560 mg of Cu, 3,000 mg of Fe, 12,100 mg of Zn, 4,590 mg of Mn, 60 mg of Co, 200 mg of Se, 270 mg of I, 10,000 IU of vitamin E, 450,000 IU of vitamin D, 2,000,000 IU of vitamin A, and 3,000 mg of nicotinic acid.

[5]Chemical composition is based on chemical analysis of the TMR as described.

[6]Calculated based on individual feedstuffs by the MOA (2004).