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Effect of dietary quebracho tannin extract on milk fatty acid composition in cows

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ABSTRACT

The aim of this study was to examine the capacity of quebracho tannin extract (QTE) to modulate the fatty acid (FA) profile in the milk fat of cows. Fifty Holstein cows yielding 33.2 ± 8.2 kg/d of milk were divided into 2 groups. The cows were fed a basal diet with a forage-concentrate ratio of 66:34 on a dry matter (DM) basis. Diets tested were control (CON, basal diet without QTE) and basal diet plus 15 or 30 g of QTE/kg of DM (QTE_{15} and QTE_{30}, respectively). Two treatments could be tested simultaneously and were arranged along 6 periods. The milk FA profile was characterized by increments in the proportion of linoleic (LA) and α-linolenic acid (α-LNA) (QTE_{15} = 10 and 6.1%; QTE_{30} = 28 and 25%, respectively) compared to CON, which might indicate reduced ruminal biohydrogenation (BH) of both dietary LA and α-LNA. Vaccenic acid (VA) in the milk fat was reduced (QTE_{15} 8.9% and QTE_{30} 12%) compared to CON, which may be linked to inhibited BH of LA and α-LNA. Rumenic acid (RA), a conjugated LA (*cis*-9,*trans*-11 conjugated linoleic acid) and an important human health promoter, was unfortunately decreased (QTE_{15} 8.3% and QTE_{30} 16%) in the milk compared with CON, probably because of inhibited ruminal BH of LA. However, reduced RA in the milk was probably due to reduced availability of VA produced in the rumen and the consequently low VA available to be desaturated to RA in the mammary gland by Δ^9-desaturase. The proportions of total polyunsaturated FA were increased with QTE_{15} and QTE_{30} by 4.7 and 15% compared to CON, respectively, and the long-chain FA proportions were also increased (QTE_{15} 2.0% and QTE_{30} 8.2%). Moreover, myristic and palmitic acid were reduced by QTE_{30} (9.6 and 3.3%, respectively) compared to CON, which also contributed to increasing the nutritional quality of milk because they are recognized to increase high-density lipoprotein in humans. Branched-chain FA in milk was reduced with QTE treatments, which indicates inhibited ruminal BH and microbial activity. In general, our findings suggest that dietary QTE have the potential to modulate FA profile of milk fat, and this effect is dosage dependent. Because QTE influenced the FA profile of milk fat both positively and negatively, further research is needed before concluding that QTE may improve the nutritional quality of cow milk fat in human diets.
Key words: condensed tannin, biohydrogenation, fatty acid profile, α-linolenic acid

INTRODUCTION

Triacylglycerides with more than 400 different fatty acids (**FA**) (Månsson, 2008) are the main components of milk fat in cows. The FA are either synthesized de novo in the mammary gland or taken up from the blood (Chilliard et al., 2000), which contains FA that originate mainly from the diet, lipid metabolism of rumen microbes, and mobilized body fat (Stoop et al., 2009).

Microbial biohydrogenation (**BH**) of PUFA decisively influences the composition of milk fat. During ruminal BH, linoleic acid (**LA**, *cis*-9,*cis*-12 C18:2), α-linolenic acid (**α-LNA**, *cis*-9,*cis*-12,*cis*-15 C18:3), and oleic acid (**OA**, *cis*-9 C18:1), as the main substrates of this process, are successively isomerized and hydrogenated to C18:2 and C18:1 isomers that may in turn be further saturated to stearic acid (**SA**, C18:0) (Shingfield et al., 2010). Condensed tannins may bind to rumen microbes or to their enzymes and may thereby also inhibit growth and activity of rumen microbes responsible for BH (Min et al., 2003). For instance, Buccioni et al. (2015) showed that condensed tannins from the heartwood of

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the quebracho tree (*Schinopsis lorentzii* and *Schinopsis balansae*) inhibit *Butyrivibrio proteoclasticus*, one of the bacterial species involved in ruminal BH. The effects of condensed tannins on ruminal BH have been linked to an accumulation of the substrates LA, α-LNA, or OA or their corresponding intermediates, as well as a corresponding increase in the proportions of PUFA, in the milk (Buccioni et al., 2015).

Quebracho tannin extract (**QTE**) as a commercial source of condensed tannins has been widely investigated in ruminant feeding. Overall, agreement exists that high levels of quebracho tannins have negative effects on rumen microbial activity. For instance, recent studies of Ahnert et al. (2015) and Henke et al. (2017) evaluated the effects of increasing levels of QTE on digestibility, nitrogen partitioning, microbial crude protein synthesis, and milk yield and composition. Both studies found that QTE inclusion of 15 and 30 g/kg of DM in the diets of Holstein dairy cows (Henke et al., 2017) and 40 and 60 g/kg of DM in the diets of rumen-cannulated heifers (Ahnert et al., 2015) decreases apparent total-tract digestibility of the fiber fractions and reduces urinary purine derivatives excretion. Fermentation in the rumen and microbial growth, activity, or both were suggested as probably being impaired by QTE. Although condensed tannins such as those in QTE are well known for these antinutritional effects at high doses in ruminants (Mueller-Harvey, 2006), they may increase PUFA content in the milk, which is considered positive from a human health point of view (Dewhurst et al., 2006). However, results in literature on the effects of QTE on FA profile in milk or rumen fluid of ruminants are inconclusive and quite limited (Kronberg et al., 2007; Toral et al., 2013; Buccioni et al., 2015). Although in vitro experiments show positive effects on rumen α-ALA accumulation, in vivo studies seem to suggest no significant effect (Kronberg et al., 2007; Benchaar and Chouinard, 2009). Furthermore, one in vivo study with dairy ewes showed positive effects on milk vaccenic acid (**VA**, *trans*-11 C18:1) proportion (~53 g of QTE/kg of DM; Buccioni et al., 2015), but in another study, QTE did not affect milk VA (20 g of QTE/kg of DM; Toral et al., 2013). Owing to the potential of quebracho tannins to positively modulate the FA profile of milk fat and the limited and contradictory information on the use of QTE to alter the BH process, further and more specific characterization of this additive through feeding trials under field conditions is required. Therefore, the aim of the present study was to examine the capacity of quebracho tannin (i.e., 15 g vs. 30 g of QTE/kg of diet DM) to modulate the milk FA profile of cows with a special focus on the FA related to ruminal BH: LA, α-LNA, rumenic acid (**RA**, a CLA, *cis*-9,*trans*-11 C18:2), VA, SA, and OA.

MATERIALS AND METHODS

The animal study reported herein was performed in accordance with the animal welfare legislation and approved by the Animal Welfare Commission of the Ministry of Energy, Agriculture, Environment, and Rural Affairs of the federal state of Schleswig-Holstein in Germany (V312-72241.123-5). A special permit for feeding QTE to dairy cows in this experiment was granted by the competent authority for feed control, Landeslabor Schleswig-Holstein (LSH3212, dated April 9, 2012).

Animals, Diets, and Experimental Design

The data were derived from the trial described by Henke et al. (2017), which was conducted at the experimental farm Schädtbek of the Max Rubner-Institute (Dobersdorf, Germany). Fifty Holstein dairy cows, divided into 2 groups of 25 cows each, were used for this feeding trial. The average milk yield, BW, DIM, and number of lactations of the cows at the start of the experiment were 33.2 ± 8.2 kg/d, 637 ± 58 kg, 114 ± 73 d, and 2.3 ± 1.6 lactations, respectively. The cows were housed in a freestall barn, had free access to drinking water, and were offered the diets once a day at approximately 0600 h for ad libitum consumption. The cows were fed a basal diet of total mixed ration that contained (on DM basis) 34% grass silage, 32% maize silage, and 34% concentrate mixture (Table 1), and a mineral premix was added. The QTE (*S. lorentzii*, Silvafeed ByPro; Silvateam S.p.a., San Michele Mondovì, Italy) was a fine, red powder, containing 705 g/kg total phenols (tannic acid equivalents) according to the Folin-Ciocalteu method, and 157 g/kg condensed tannins (leucocyanidin equivalents) determined with the HCl–butanol method described by Porter et al. (1986). Every morning before feeding, the extract was added to a mixer wagon and thoroughly mixed into the basal diet at levels of 15 or 30 g/kg of DM. Hence, we created 3 dietary treatments: the control (**CON**, basal diet without QTE), the basal diet + 15 g of QTE/kg of DM (**QTE_{15}**), and the basal + 30 g of QTE/kg of DM (**QTE_{30}**). Because of technical limitations only 2 treatments could be tested simultaneously. Therefore, the 3 treatments were tested across 6 experimental periods. Details on experimental design are described in detail by Henke et al. (2017). Each period comprised 21 d with a 13-d adaptation phase followed by an 8-d sampling phase, and cows were the experimental unit.

Sample Collection, Preparation, and Analysis

Diets. Details on diet sampling and analysis of crude ash, ether extract, CP, NDF, ADF, ADL, and starch

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