J. Dairy Sci. 92:5512–5522
doi:10.3168/jds.2008-1441

Difference in the nature of tannins on in vitro ruminal methane and volatile fatty acid production and on methanogenic archaea and protozoal populations

R. Bhatta,*[1] Y. Uyeno,† K. Tajima,* A. Takenaka,* Y. Yabumoto,* I. Nonaka,* O. Enishi,* and M. Kurihara*
*National Institute of Livestock and Grassland Science, Tsukuba 305-0901 Japan
†National Institute of Advanced Industrial Science and Technology, Tsukuba 305-0901 Japan

ABSTRACT

Six plant sources of hydrolyzable tannins (HT) or HT and condensed tannins (CT; designated as HT1, HT2, HT3, HT + CT1, HT + CT2, and HT + CT3) were evaluated to determine their effects in vitro on CH_4 production and on ruminal archaeal and protozoa populations, and to assess potential differences in biological activities between sources containing HT only or HT and CT. Samples HT1, HT2, and HT3 contained only HT, whereas samples HT + CT1, HT + CT2, and HT + CT3 contained HT and CT. In experiment 1, in vitro incubations with samples containing HT or HT + CT resulted in a decrease in CH_4 production of 0.6 and 5.5%, respectively, compared with that produced by incubations containing the added tannin binder polyethylene glycol-6000. Tannin also suppressed the population of methanogenic archaea in all incubations except those with HT2, with an average decrease of 11.6% in HT incubations (15.8, 7.09, and 12.0 in HT1, HT2, and HT3) and 28.6% in incubations containing HT + CT (35.0, 40.1, and 10.8 in HT + CT1, HT + CT2, and HT + CT3) when compared with incubations containing added polyethylene glycol-6000. The mean decrease in protozoal counts was 12.3% in HT and 36.2% in HT + CT incubations. Tannins increased in vitro pH, reduced total VFA concentrations, increased propionate concentrations, and decreased concentrations of iso-acids. In experiment 2, when a basal diet was incubated with graded levels of HT + CT1, HT + CT2, and HT + CT3, the total gas and CH_4 production and archaeal and protozoal populations decreased as the concentration of tannins increased. Our results confirm that tannins suppress methanogenesis by reducing methanogenic populations in the rumen either directly or by reducing the protozoal population, thereby reducing methanogens symbiotically associated with the protozoal population. In addition, tannin sources containing both HT and CT were more potent in suppressing methanogenesis than those containing only HT.
Key words: tannin, methane, methanogenic archaea, protozoon

INTRODUCTION

Ruminal methanogenic organisms use hydrogen produced during carbohydrate fermentation to reduce CO_2 to CH_4, thereby maintaining low partial pressures of hydrogen, which allows the oxidation of reduced NAD (Schonhusen et al., 2003). Despite this beneficial role in the rumen microbial ecosystem, the production of CH_4 is an energetically wasteful process to ruminants (Anderson et al., 2003). Methane emission by ruminants has received considerable attention because of its contribution to global warming (Lassey, 2007). Therefore, CH_4 reduction strategies should improve ruminant production efficiency and mitigate global warming.

Direct ruminal intervention is a means to control ruminant CH_4 emissions (Joblin, 1999), because CH_4-producing archaea, known as methanogens, are a distinct group of organisms that form a normal component of the rumen microbial ecosystem (Tavendale et al., 2005). Hydrogen and CO_2 are the major substrates for ruminal methanogens, and compounds that inhibit the activity of methanogens are likely to reduce or eliminate CH_4 production. Based on their structure and chemical properties, tannins are divided into hydrolyzable tannins [**HT**, which have a central carbohydrate core to which number of phenolic carboxylic acids are bound by esters of gallic acid (gallotannin) or ellagic acid (ellagitannins)] and condensed tannins (**CT**, or proanthocyanidines, which have no carbohydrate core and are derived by condensation of flavonoid precursors or polymers of flavonoids; Baker, 1999). Although tannins are generally regarded as antinutritional, certain tannins at low concentrations alter ruminal fermentation (Bhatta et al., 2002) and microbial protein synthesis (Bhatta et al., 2001). Tannins also reduce ruminal CH_4 production when included either as temperate legumes (Waghorn et al., 2002) or as purified tannin extracts

Received June 10, 2008.
Accepted July 29, 2009.
[1]Corresponding author: ragha0209@yahoo.com