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Garlic: A potential alternative for monensin as a rumen modifier

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ABSTRACT

The effects of supplementing a basal diet (CTR) with raw garlic (GAR) or garlic oil (GO) on rumen fermentation were evaluated. Monensin (MON, 33 mg/kg DM) was used as positive control. Four ruminally fistulated sheep were used in three experiments arranged as 4×4 Latin squares with a 28-day period. Experiments 1 and 2 differed in the dose of GAR (75 versus 100 g/kg DM) and GO (500 versus 750 mg/kg DM) included in the basal diet while experiment 3 was designed to compare the two doses of each additive. The results revealed that dry matter intake and rumen fluid pH were not affected by additives although organic matter (OM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibility were slightly depressed by GO but not by GAR supplementation. MON had a similar depressing effect but was restricted mainly to ADF digestibility. Ruminal protozoa population was reduced by MON supplementation and to lesser extent by GAR100 and GO in a dose-independent manner. This effect was reflected in a lower rumen ammonia concentration. Total volatile fatty acid concentrations were not affected by any of the additives. However, individual VFAs were significantly altered by MON and to lesser extent by GAR and GO ($P<0.05$), enhancing the concentration of propionate and the propionate to acetate ratio ($P<0.05$). Although the capability of GAR and GO is lower than MON in decreasing the acetate to propionate ratio, they can be considered as potential alternatives to MON.

1. Introduction

Ionophores have been used as feed additives to increase feed conversion efficiency in ruminants. The effect of monensin on ruminal fermentation has been widely studied (Russell and Strobel, 1989). Monensin is highly effective against gram positive bacteria but exhibits limited or no activity against gram negative bacteria (Chen and Wolin, 1979). Ionophores alter rumen microbial fermentation and much of their benefits are attributed to the improved energy status through increasing production of propionic acid production and a concurrent reduction in the proportion of acetate and butyrate as well as methane production. Due to the beneficial effects on energy status, monensin has been used extensively as a growth promoter in beef cattle industry (Goodrich et al., 1984) and for improving energy metabolism and milk production efficiency in dairy cows (Radostits et al., 2007).

However, use of antimicrobial agents as feed additives can contribute to antimicrobial resistance both in animals and humans (Chesson, 2006), posing a serious risk to the public health. More and more regulations are getting in place to ban their usage (OJEU, 2003; Regulation (EC) 1831/2003). In recent years, there has been a growing interest in the potential use of plant extracts as alternatives for antimicrobial feed additives in ruminants. Recent reviews on secondary plant metabolites (Benchaar et al., 2008; Calsamiglia et al., 2007) have described the ability of some essential oils to promote rumen microbial fermentation. However, most of the studies to date have been laboratory-based research (i.e., in vitro) and of short-term

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nature (Benchaar et al., 2007a; Busquet et al., 2006; Fraser et al., 2007; Hristov et al., 2008). The essential oil of garlic has been shown to possess a special feature of having unique compounds which do not exist in the original plant and are produced from thiosulfates during the steam treatment (Pentz and Siegers, 1996). They are very active against a wide range of gram-positive and gram-negative bacteria, fungi, parasites, and viruses (Reuter et al., 1996). Few studies have so far investigated the effects of essential oils and their components on feed intake, digestion, ruminal fermentation, and milk performance in ruminants (Benchaar et al., 2006b, 2007b; Yang et al., 2007). Moreover, to our knowledge, no research has simultaneously compared the effects of garlic oil and raw garlic on digestion and ruminal fermentation. The objective of this study was to evaluate the effects of raw garlic bulb (GAR) and garlic oil (GO) on ruminal fermentation characteristics and to assess their usefulness as an alternative to monensin in a sheep model.

2. Materials and methods

2.1. Animals

Four 3 year old ruminally fistulated Iranian Makoui male sheep (average body weight 55 ± 3 kg) were used in this study. The overall health of the sheep was monitored prior to and throughout the study. The animals were housed in a ventilated barn in the individual metabolic cages and were acclimatized to the experimental conditions for 10 days. All experimental procedures were approved by the Advisory Committee of Urmia University Research Council.

2.2. Additives

Raw garlic bulb (*Allium sativum*) was harvested from Hamadan County, Iran. Garlic oil was prepared according to Clevenger (1928). In brief, the cloves of garlic were sliced and crushed and then subjected to hydro distillation for 3 h using a Clevenger type apparatus. The oil was transferred into dark glass bottles, capped and stored at 4 °C in a lab refrigerator. Monensin was purchased from Behroodatrak Company (Iran), which produces this product under a license by Elanco Division, Eli Lilly Canada Inc.

2.3. Experimental design and treatments

The study was conducted in three experiments with a resting interval of 4 weeks between them. Each experiment was conducted as a four treatment cross-over trial with four 21 day periods. In the first experiment each of the four sheep was randomly assigned to one of four diets: control diet (basal total mixed ration with no additive = CTR), (Table 1), control diet with GAR (75 g/kg DM = GAR75), control diet with GO (500 mg/kg DM = GO500), and control diet with MON (33 mg/kg DM). In the second experiment the diets were similar to experiment 1, however, the dose of GAR and GO were increased to 100 g/kg DM (GAR100) and 750 mg/kg DM (GO750), respectively. In the third experiment each of the four sheep was fed the basal diet with GAR 75 g/kg DM (GAR75), GAR 100 g/kg DM (GAR100), GO 500 mg/kg DM (GO500) and GO 750 mg/kg DM (GO750). In the first 7 days of each period, the animals were allowed to adapt to their new diets and rumen fluid collection were carried out on days 7, 14 and 21 of each period. Within each experiment there was a one week washout interval between periods, during which the sheep were fed basal diet with no additives. The basal diet was calculated to meet the maintenance energy and protein requirements (AFRC, 1992 and NRC, 1985). The basal diet was provided daily as a total mixed ratio in two equal portions at 08:00 and 16:00. Water was freely available through individual drinking fountains. Additives were administered into the rumen through the rumen fistula before their morning feeding. Raw garlic bulb was sliced; garlic oil and monensin were mixed with distilled water immediately before administration. The level of raw garlic supplementation (Table 2) was adjusted according to the previous studies (Bampidis et al., 2005; Wanapat et al., 2008). The amount of garlic oil administration (Table 3) was calculated based on a study in adult lactating dairy cow (Yang et al., 2007). The apparent digestibility was measured by the differences in the quantity of fed and refused for each animal.

Table 1
Ingredients and chemical composition of the basal diet (control).

Item	Amount
Ingredient, (g/kg DM)	
Alfalfa hay	381.4
Corn silage	396.9
Soy bean meal	85.0
Barley grain	109.9
Wheat bran	26.8
Chemical composition	
DM, (g/kg of feed)	719.5
OM, (g/kg DM)	908.2
ME, (MJ/kg DM)	10.50
FME, (MJ/kg DM)	9.60
MP, (g/kg DM)	86.0
ERDP, (g/kg DM)	112
UDP, (g/kg DM)	20
CP, (g/kg DM)	165
NDF, (g/kg DM)	397.3
ADF, (g/kg DM)	209.3
EE, (g/kg DM)	17.6
Calcium, (g/kg DM)	5.8
Phosphorus, (g/kg DM)	2.8

DM = dry matter. OM = organic matter. CP = crude protein. NDF = neutral detergent fiber. ADF = acid detergent fiber. EE = ether extract. ME = metabolisable energy. FME = fermentable metabolisable energy. MP = metabolisable proteins. ERDP = effective rumen degradable protein. UDP = undegradable protein.

Table 2
Chemical composition of the raw garlic, (g/kg DM).

Composition	Raw garlic
DM, g/kg	371.3
OM	958.1
Crude protein	96.2
Ether extract	7.1
aNDF	67.9
ADF	52.1
Calcium	0.5
Phosphorus	0.3

DM = dry matter. OM = organic matter. CP = crude protein. NDF = neutral detergent fiber. ADF = acid detergent fiber. EE = ether extract. aNDF = neutral detergent fiber assayed with a heat stable alpha amylase.