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Effects of inorganic and organic selenium on the fatty acid composition of rumen contents of sheep and the rumen bacteria and ciliated protozoa

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ABSTRACT

The impact of 3 months of daily administration of equimolar doses of inorganic and organic Selenium (Se) on the fatty acid composition of rumen contents and rumen bacteria and protozoa was studied. Twelve sheep were fed a basal diet of meadow hay (1380 g dry matter/sheep) and ground barley grain (450 g dry matter/sheep) containing a background Se concentration of 0.16 mg/kg DM. The sheep were randomly divided into three groups and fed the basal diet only (Control) or identical diets supplemented with inorganic (Na_2SeO_3; ISe) or organic Se (selenized yeast; OSe) in equimolar amounts of Se of 0.4 mg/kg of feed DM. The fatty acid (FA) profile was determined in the total rumen contents (TRC), bacterial fraction (BF) and ciliated protozoal fraction (PF). In the TRC, supplementation with OSe decreased the concentration of $C_{18:2}$ *cis*-9, *trans*-11 ($P<0.05$) and increased the concentration of α-linolenic acid ($C_{18:3}$ n3; LNA; $P<0.01$). In the BF of the ISe group the content of myristic acid ($C_{14:0}$; $P<0.05$), palmitic acid ($P<0.01$) and medium chain fatty acids ($P<0.01$) were lower, and the content of long chain fatty acids ($P<0.05$), stearic acid ($C_{18:0}$; $P<0.01$), arachidic acid ($C_{20:0}$; $P<0.001$) and behenic acid ($C_{22:0}$; $P<0.01$) were increased. The OSe increased the concentration of caprilic acid ($C_{8:0}$; $P<0.001$), eicosatetraenoic acid ($C_{20:4}$ n6; $P<0.01$) and eicosatrienoic acid ($C_{20:3}$ n3; $P<0.01$) in the BF. In the PF the ISe decreased the concentration of docosahexaenoic acid ($C_{22:6}$ n3) and tricosylic acid ($C_{23:0}$; $P<0.05$). The addition of OSe increased the content of LNA ($P<0.01$) and decreased the content of palmitooleic acid ($C_{16:1}$; $P<0.05$) in the PF. Our results point to the probable impact of OSe on the intake of dietary polyunsaturated fatty acids (PUFA) by rumen microbes, especially by rumen ciliates, and on the biohydrogenation of PUFA to more saturated FA.

Abbreviations: BF, bacterial fraction; CLA, conjugated linoleic acid isomers; DM, dry matter; FA, fatty acids; ISe, inorganic selenium; ME, metabolisable energy; OSe, organic selenium; PF, protozoal fraction; PUFA, polyunsaturated fatty acids; SCFA, short fatty acids; TRC, total rumen content; TVA, trans-vaccenic acid (trans11-C18:1); UFA, unsaturated fatty acids.

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Table 1
Chemical composition and intake of the basal diet (g/kg DM).

Item	Grass hay	Ground barley
DM	920	900
Crude protein	118	122
ADF	350	63
NDF	460	176
Ash	83	27
Se	0.22	0.05
Ingredient intake (g DM/sheep)	1380	450
Mineral	*Ad libitum*	

DM, dry matter; ADF, acid detergent fibre; NDF, neutral detergent fibre.

1. Introduction

The role of Se for immunity, reproduction and performance of animals as well as its antioxidant status is well known (Surai, 2006). Slovakia is classified as a low Se area (Chovancová and Lesný, 2006). One way to raise the Se status of animals is the use of Se additives in feedstuffs. Differences exist in the utilisation of dietary selenium from its various chemical forms. Rumen microorganisms have been shown to accumulate dietary Se (Čobanová-Boldižárová et al., 2008; Mynhardt et al., 2006; Van Ryssen and Schroeder, 2003) and incorporate Se from both inorganic and organic forms into their protein and cell wall components (Hidiroglou et al., 1968; Hudman and Glenn, 1984; Hudman and Glenn, 1985; Koenig et al., 1997). Recently, information regarding the effects of Se on the fatty acid composition of ruminant tissues was presented (Czauderna et al., 2004; Gabryszuk et al., 2007; Korniluk et al., 2008; Pechová et al., 2008; Yu et al., 2008). Dietary supplementation with Se, Zn and vitamin E improved the long-chain polyunsaturated fatty acids profile of ruminant tissues.

Fatty acid metabolism in the rumen has a major influence on the fatty acid composition of ruminant meats and milk (Jenkins et al., 2008). Selenate increases the *in vitro* content of isomers of conjugated linoleic acid (CLA) and *trans*-vaccenic acid (TVA) in ovine rumen fluid incubated with linoleic acid (LA), in contrast to selenite (Wasowska et al., 2006). It is known that the rumen ciliates contribute to the concentration of some important long-chain fatty acids in rumen, namely TVA and CLA (Devillard et al., 2006; Yáñez-Ruiz et al., 2006). Supplementation with organic Se was shown to be beneficial to rumen ciliate development in young ruminants (Mihaliková et al., 2005) possibly due to the improved antioxidant status of the rumen environment. However, it cannot be excluded that some other rumen microbial activities might also be influenced. Therefore, the objective of this study was to consider the impact of long-term daily administration of equimolar doses of inorganic and organic Se on the fatty acid profile of sheep rumen contents as well as on the bacterial and ciliate protozoal populations.

2. Materials and methods

2.1. Animals and diet

The experiment was completed in accordance with established standards for the use of experimental animals. The experimental protocol was approved by the Ethical Committee of the Institute of Animal Physiology SAS and State Veterinary and Food Office (Ro-987/08-221). Twelve Valaska sheep (18 month of age; 47 ± 3.4 kg) were housed in individually pens and randomly allocated into three dietary groups. The diets for all treatments were prepared daily and fed in two equal meals per day (Table 1). One group was fed the basal diet which consisted of meadow hay (1380 g DM/sheep) and ground barley grain (450 g DM/sheep). A trace mineral premix without Se was also included in the basal diet (g/kg: Ca 16.2, Na 316, Mg 32, Cu 0.7, Mn 2.5, Zn 3.1, Co 0.06, I 0.02). The Se content of the basal diet fed to the control sheep was 0.16 mg/kg DM. The other two groups were fed the basal diet supplemented with an additional 0.4 mg Se/kg DM either in the form of sodium selenite (ISe, 990 g/kg purity, Sigma-Aldrich, St. Louis, MO, USA) or selenized yeast (OSe, Se-yeast, Sel-Plex, Alltech, Nicholasville, KY, USA,). The aliquots of sodium selenite solution or Se-yeast were mixed with ground barley grain for each feeding. The diets were fed for 3 month. Feed consumption was visually controlled to ensure no refusals. At the end of the experiment, the sheep were slaughtered and samples were collected from the thoroughly mixed rumen contents.

2.2. Fractionation of rumen contents

For each animal 500 ml of rumen content were strained through four layers of cheesecloth to remove large plant fragments and then purged with CO_2. Samples of all rumen contents were microscopically examined for determination of the ciliate population (Eadie, 1967). Samples of total rumen contents (TRC) were prepared by centrifugation of the strained rumen contents for 30 min at $10{,}000 \times g$ at 8 °C with the resulting sediments used as the TRC (Czerkawski, 1976; Váradyová et al., 2008). The remaining strained rumen contents were incubated in large separating funnels at 39 °C for 2 h to allow small feed particles to float and the ciliated protozoal fraction (PF) to sediment to the bottom. The supernatant liquid was centrifuged at $200 \times g$ for 5 min at 23 °C to remove protozoa and food particles. The centrifuged fluid was again centrifuged twice more