Slovak J. Anim. Sci., 39, 2006 (1-2): 51 - 54

Selenium content and antioxidant status in tissues of veal calves fed a diet supplemented with selenium yeast

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ABSTRACT

Two groups of 6 calves each were fed a milk replacer and a starter concentrate for 125 days. Control diet contained 0.13 mg selenium (Se) per kg of feed dry matter, on average. Experimental diet was supplemented with Se-enriched yeast to increase Se concentration to 0.50 mg/kg. Weight gain, feed intake, chemical composition of meat (*m. longissimus thoracis et lumborum*) and meat colour were not affected by Se supplementation ($P > 0.05$). Feeding Se-yeast resulted in two-fold higher ($P < 0.05$) concentration of Se in meat (0.69 mg/kg), faeces (2.13 mg/kg) and hair (3.09 mg/kg). Hepatic and renal concentrations of Se were non-significantly increased by 19.1 and 5.6%, respectively. Glutathione peroxidase activity was significantly increased in the liver tissue of Se-supplemented calves, but not in the muscle. No treatment effect on catalase activity was observed. In meat of treated animals the formation of thiobarbituric acid-reactive substances was non-significantly reduced. It can be concluded on basis of these results that the enrichment of meat with Se is the main benefit of Se supplementation of diets of veal calves.

Key words: calves; meat; selenium; oxidative stability

INTRODUCTION

Selenium (Se) is a trace element essential for animals and humans, which is required in small amounts and is toxic at high concentrations. Se forms the active centre for various selenoenzymes such as glutathione peroxidase (GSH-Px), thioredoxin reductase and thyroid hormone deiodinases (Behne and Kyriakopoulos, 2001). In the majority of European countries the Se intake in humans is not adequate for full activity of these enzymes, and consequently for prevention of several metabolic diseases. Increased consumption of meat enriched with Se may provide a means for improving the Se status in the general population. For this reason, feedstuffs are supplemented with organic or inorganic Se sources at 0.2 - 0.3 mg per kg of dry matter (DM). In past, inorganic forms of Se have been mostly used. Feeding organic Se, however, resulted in higher Se retention than when Se was added to the same diet in the form of sodium selenite (Leng et al., 2003). The main Se species in cereals, forage crops and commercially available Se-yeast is selenomethionine. Animal tissues readily incorporate selenomethionine into protein in competition with methionine (Deagen et al., 1987; Behne et al., 1991).

The antioxidant properties of selenoproteins help prevent cellular damage from free radicals. The antioxidant status of animal tissues is very important because the oxidation of muscle lipids after slaughter can adversely affect the flavour and nutritive value of meat and meat products. A correlation exists between the GSH-Px activity and Se content of tissues of cattle (Scholz et al., 1981; Gatellier et al., 2004), pigs (Daun et al., 2001) and poultry (Daun and Ĺkesson, 2004). Thus, the supplementation of diets with Se may increase the oxidative stability of meat, which is very important when animal diets contain unsaturated lipids. The effect of dietary Se on performance and meat quality was studied in our experiments with calves fed a diet with or without supplemental linseed. In this paper we present results of the latter experiment.

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MATERIALS AND METHODS

Animals and diets

Twelve Holstein bulls, 3 to 4 weeks of age at the start of the experiment were fed a milk replacer Telasan V (Bodit Tachov, Czech Republic) and a starter concentrate Telstar (Zea Sedmihorky, Czech Republic). The composition of the feeds is presented in Table 1.

Table 1: Composition of feeds of calves (per 1 kg)

	Milk replacer [1]	Starter concentrate [2]
Dry matter (g)	930	860
Crude protein (g)	220	200
Fat (g)	190	29
Fibre (g)	13	42
Ash (g)	70	62
Se (mg)	0.034	0.15

[1]Telasan V contained milk, plant oils, oilseeds, yeast, soybean meal, cereal products, vitamin and mineral supplements.

[2]Telstar contained cereals, cereal by-products, oilseed cake, by-products of the sugar industry, antioxidant, vitamin and mineral supplements.

The milk replacer was supplied twice a day at 0.4 kg in 3 l of water. The starter was available ad libitum and its consumption was measured. Calves were divided at random into 2 groups. Calves of the control group received the basal diet without the Se supplement. Calves of the experimental group received the basal diet supplemented with Se-yeast (Sel-Plex, Alltech) to achieve a final Se concentration of 0.50 mg/kg. Water was available ad libitum. After 125 days of treatment the animals were slaughtered in the Institute abattoir.

Sampling and analyses

Faeces were collected for 5 days, 3 weeks before the slaughter. After slaughter, samples of liver and kidney were taken and immediately frozen. Samples of hair were taken as well. The carcasses were rapidly chilled and m. longissimus thoracis et lumborum (MLT) samples were obtained 24 h postmortem and stored at -40°C, or at -70°C for enzyme assays. The pH of MLT was measured at the time of sampling. Estimation of the drip loss was performed during the period 24-48 h after slaughter, by weighing the drip collected from approximately 100 g of the MLT during hanging in a plastic bag at 4°C.

Feeds and samples of MLT were air-dried at 105°C to constant weight to determine the DM content. Crude protein and fat were determined using Kjeltec AUTO 1030 Analyser and Soxtec 1043 instruments (Tecator, Comp., Sweden), ash after ashing at 550°C. Petrol ether was used for fat extraction. Content of fibre in feeds was determined employing Fibertec 2010 from the same firm. Feeds, tissues, hair and faeces were mineralized using the microwave digestion technique in a closed system (Milestone Ethos TC, Italy), in the presence of HNO3 and H2O2. Se in processed samples was measured by the atomic absorption spectrometry (Solaar M-6 instrument, TJA Solutions, U.K.). The analytical procedure was validated by the analysis of a certified reference material RM 8414 Bovine Muscle (NIST).

The colour parameters of meat (L*, a*, b*) were measured using a Minolta CR-300 colourimeter (Osaka, Japan). Lipid oxidation in minced MLT samples was measured by the thiobarbituric acid method of Piette and Raymond (1999) and results were expressed as thiobarbituric acid reactive-substances (TBARS) in mg of malondialdehyde/kg muscle. The activity of GSH-Px was measured with tert-butyl hydroperoxide as a substrate by a coupled assay recording the oxidation of NADPH by the decrease in absorbance at 340 nm and was expressed as mmol NADPH oxidised min-1 g-1 meat or liver tissue (DeVore and Greene, 1982; Hernández et al., 2004). Catalase activity was measured by the rate of disappearance of H2O2 at 240 nm following the method of Aebi (1983), and was expressed as mmol H2O2 decomposed min-1 g-1 meat or liver tissue.

The t-test was used to assess the significance of differences between both groups.

RESULTS AND DISCUSSION

Calves fed the Se-supplemented diet gained more (+2.9 kg) and consumed more starter concentrate (+12.1 kg) than control calves. The differences, however, were not statistically significant (Table 2).

Table 2: Performance and feed intake in calves[1] fed a control diet and diet supplemented with Se

	Control	Se
Initial weight (kg)	57.5 ± 5.7	58.6 ± 6.1
Final weight (kg)[2]	173.0 ± 15.0	177.0 ± 13.9
Weight gain (kg)	115.5 ± 9.8	118.4 ± 9.0
Intake (kg)		
Milk replacer	100	100
Starter	232.6 ± 22.2	244.7 ± 24.1

Means ± S.D.; [1]6 calves per group; [2]Experiment lasted for 125 days

There was no effect of diet on pH post mortem, drip loss, chemical composition of meat and its colour (Table 3). Supplementation with Se non-significantly increased hepatic and renal concentrations of Se by 19.1 and 5.6%, respectively (Table 4).

Table 3: Quality parameters of m. longissimus thoracis et lumborum (MLT) of calves fed a control diet and diet supplemented with Se

	Control	Se
pH 24 h	5.5 ± 0.1	5.6 ± 0.3
Drip loss 24 h (%)	1.9 ± 0.7	1.2 ± 13.9
Dry matter (g/kg)	228 ± 3	227 ± 7
Protein (g/kg)	200 ± 3	202 ± 4
Fat (g/kg)	5.1 ± 1.6	5.7 ± 2.2
Ash (g/kg)	10.2 ± 0.3	10.4 ± 0.4
Cholesterol (g/kg)	0.75 ± 0.07	0.68 ± 0.05
Lightness (L*)	39.9 ± 2.1	36.7 ± 4.5
Redness (a*)	14.9 ± 2.0	13.4 ± 1.8
Yellowness (b*)	3.6 ± 2.5	2.5 ± 0.9

Means ± S.D.

Table 4: Concentration of Se (mg/kg) in m. longissimus thoracis et lumborum (MLT), liver, kidney, faeces and hair of calves fed a control diet and diet supplemented with Se

	Control	Se
MLT	0.35 ± 0.08	0.69 ± 0.10 *
Liver	1.57 ± 0.68	1.87 ± 0.46
Kidney	2.51 ± 0.26	2.65 ± 0.30
Faeces	0.94 ± 0.28	2.13 ± 0.69 *
Hair	1.62 ± 0.29	3.09 ± 0.57 *

Means ± S.D.; *Significantly different from the control value ($P < 0.05$)

Se concentrations in MLT, faeces and hair were doubled ($P < 0.05$). Hepatic activities of GSH-Px and catalase were much higher than those assayed in MLT (Table 5).

Table 5: Activity of glutathione peroxidase (GSH-Px) and catalase in meat and liver, and production of thio-barbituric acid-reactive substances (TBARS) in m. longissimus thoracis et lumborum (MLT) of calves fed a control diet and diet supplemented with Se

	Control	Se
GSH - Px in MLT[1]	0.41 ± 0.13	0.42 ± 0.11
GSH - Px in liver[1]	2.89 ± 0.33	5.61 ± 0.63 *
Catalase in MLT[2]	48.3 ± 4.3	48.0 ± 5.1
Catalase in liver[2]	3380 ± 490	3481 ± 206
TBARS (mg MDA/kg)		
Day 0	0.07 ± 0.04	0.09 ± 0.05
Day 3	0.38 ± 0.24	0.18 ± 0.06
Day 6	0.95 ± 0.59	0.41 ± 0.21

Means ± S.D.; [1]expressed as mmol NADPH oxidised min-1 g-1 meat or liver tissue; [2]expressed as mmol H_2O_2 decomposed min-1 g-1 meat or liver tissue; MDA, malondialdehyde; *Significantly different from the control value ($P < 0.05$)

The activity of GSH-Px was significantly higher in livers of Se-supplemented animals, however in MLT was not influenced. No treatment effect on activity of catalase was observed. Dietary Se tended to reduce formation of TBARS in meat stored for 3 and 6 days at 4°C.

Control diet contained 0.13 mg Se per kg of feed DM, on average. Nutritional requirement of cattle for Se is lower (0.10 mg per kg of feed DM, according to NRC 1971ab), thus no effect of supranutritional Se on performance of calves occurred. Se-supplementation increased Se concentration in meat, but several other meat quality parameters were not influenced. Se concentration in veal in this experiment was higher than that reported in meat of milk-fed calves by Scholz et al. (1981). Comparable concentration of Se in meat was reported in lambs on a Se-supplemented diet (Molnár et al., 1998). Surprisingly, the deposition of Se in the livers and kidney of calves fed Se-yeast was only marginally increased. In experiment of Scholz et al. (1981) the Se concentrations in livers positively correlated with those in the feed. As observed also by other authors (Scholz et al., 1981; Daun and Åkesson, 2004), the activity of GSH-Px in the livers responded well to dietary Se supplementation in the present experiment. The GSH-Px activities in meat of control and experimental calves were almost the same. The oxidative stability of meat, however, was non-significantly improved in latter animals. Thus, the enrichment of meat with Se is the main benefit of supplementation of diets of veal calves with this element. Consumption of 80 g of meat of treated calves would supply 55 µg Se, which is current recommended daily intake in EU countries (EC Scientific Committee on Food, 2003).

Acknowledgement

The study was financed by the Ministry of Agriculture of the Czech Republic (project MZE 0002701403).

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