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Effects of Selenium-Yeast on Nutrient Metabolism and Serum Physico-Chemical Parameters in Simmental Steer

LIU Qiang　HUANG Ying-xiang　WANG Cong　DONG Sheng　LIN Wen-ai

(*College of Animal Science and Technology, Shanxi Agricultural University, Taigu* 030801, *China*)

Abstract: To evaluate the effects of Se-yeast on nutrients digestibility, nitrogen balance and serum biochemical parameters, sixteen Simmental steers consuming a corn straw diet were stratified by weight and randomly assigned in a block design to treatments. Treatments were consisted of 0 (control), 0.3, 0.6 or 0.9 mg of supplemental Se (as Se-yeast) per kg diet DM. The results showed that the digestibility of nutrients, the apparent deposit rate of mineral, digestion nitrogen and the utilization of nitrogen in Treatment 1 and Treatment 2 supplemented 0.3 and 0.6 mg Se were higher than other Treatments ($P<0.05$). Serum triglycerides concentration in Treatment 2 supplemented 0.6 mg Se was higher than other Treatments and the control ($P<0.05$). Serum glucose concentrations in all Treatments supplemented Se increased significantly ($P<0.05$). Serum albumin concentrations in Treatment 2 and Treatment 3 supplemented 0.6 and 0.9 mg Se increased ($P<0.05$). Total serum cholesterol, total protein and urine nitrogen concentrations were not affected. The activities of serum GOT and GPT in Treatment 2 and Treatment 3 supplemented 0.6 mg and 0.9 mg Se were higher than other Treatments ($P<0.05$). Serum AKP, ACP and LDH activities were not affected ($P>0.05$). Serum GSH-px activity in Treatment 2 supplemented 0.6 mg Se increased ($P<0.05$). Serum GSH concentration in Treatment 2 supplemented 0.6 mg Se increased ($P<0.05$). Serum MDA and Se concentration in Treatment 2 and Treatment 3 supplemented 0.6 mg and 0.9 mg Se decreased significantly ($P<0.05$). These data indicated that the digestion and utilization of nutrients were improved by Treatment 1 and Treatment 2 0.3～0.6 mg Se per kg diet DM. The activities of serum enzyme increased and MDA concentration decreased by Treatment 2 supplemented 0.6 mg Se per kg diet DM. The optimum Se supplemented dose is 0.6 mg Se per kg diet DM in this experiment.

Key words: Simmental Steer; Se-yeast; Digestibility; Nitrogen balance; Serum biochemical parameters

Selenium, which is an essential element and the composition of GSH-px and the catcher of free radicals, could prevent the cell membrane from the damage of oxidative[1]. When Se is deficiency in animal body, a lot of disease arise, for example, white muscle disease, exhaustion, disease resistance decreased, reproductive performance of adult cow decreased[2]. Now, there have are two methods in adding Se to diet, one is inorganic Se (sodium selenite *et al*.), another is organic Se (Se-yeast). The utilization of sodium selenite decreased by the metabolism of rumen microorganism[3-4]. However, Se in the Se-yeast combined with protein firmly, a lot of Se leaves from rumen by Se-amino acid, and is absorbed in stomach and duodenum, so its utilization is higher[5]. Serum Se content and GSH-px activity could be improved significantly by supplementing Se with Se-yeast in delivered cow[6]. Fisher[7] reported that the milk yield and dry matter intake were not affected by Se-yeast, but milk Se content and Se in erythrocyte increased significantly, and the morbidity of recessive mastitis decreased. In beef cattle, when the cow fed Se-yeast, serum Se con-

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Author information: Liu Qiang (1971-), male, born in Fushan, Shanxi. Associate professor, Ph.D., engaged mainly in ruminant nutrition and feed science research. E-mail: liuqiangabc@163.com

tent of calf increased by 35 percent and 42 percent, serum GSH-px activity of calf increased by 32 percent and 75 percent, respectively[8-9]. Most studies about Se-yeast were in the effects on immunization and productive performance[10-11], but studies about the effects of Se-yeast on nutrients digestion and metabolism were little. Therefore, the aim of this work was to study the effects of Se-yeast on nutrients digestion, nitrogen balance and antioxygenation capacity.

1 Materials and methods

1.1 Animals and expeirmental design

Sixteen Chinese Simmental steers averaging 2.5 years of age and 420 kg of body weight (BW) consuming a corn straw diet were randomly assigned in a block design to four treatments. The treatments were: the control (fed basal diet and no Se supplementation); Treatment 1 (basal diet and supplemented 0.3 mg Se per kg dry matter (DM) with Se-yeast); Treatment 2 (basal diet and supplemented 0.6 mg Se per kg DM with Se-yeast); Treatment 3 (basal diet and supplemented 0.9 mg Se per kg DM with Se-yeast); Se-yeast was obtained from Alltech China, and was stated by the manufacturer to contain 1 000 mg Se per kg. Experimental periods were 20 days with 11 days of adaptation and 10 days of sampling.

1.2 Animal feeding and management

Composition and nutrient levels of basal diet are shown in Table 1. Steers were housed in individual pens (3 m × 3 m) and fed twice daily at 07:00 and 19:00. Each steer was given 3 kg concentrate and 6 kg corn straw per day. The house disinfected timely and fresh water was available during the entire experimental period.

1.3 Sampling and laboratory analyses

Feed intake, orts, feces and urine excretion were recorded daily during the sampling periods. Samples of diets were collected once daily for DM determination. Samples of feces and urine were collected according with 2 percent once daily and divided into two, one for nitrogen and another for DM determination. The samples were dried in an oven at 65℃ for 48 h, and ground to pass a 1 mm screen with a mill (FZ102, Shanghai Hong Ji Instrument Co., Ltd., Shanghai, China) for chemical analysis. Samples were analyzed for DM, OM, CP, CF, Ca and P with the method of Yang and AOAC [12-13], neutral detergent fibre (NDF) and acid detergent fibre (ADF) were analyzed with the method of Van Soest *et al*[14]. Fe, Cu, Zn and Mn concentrations of samples were analyzed by AA-2610 atomic absorption spectroscopy[14], S and Mo were analyzed with the method of AOAC[13].

Table 1 Composition and nutrient levels of basal diet

(%)

Items	Content
Ingredients	
Corn straw	60.0
Corn grain	20.8
Wheat bran	4.0
Soybean meal	6.6
Cottonseed cake	4.8
Rapeseed meal	2.0
Calcium carbonate	0.5
NaCl	0.4
Dicalcium phosphate	0.35
Mineral and vitamin premix*	0.55
Total	100.00
Nutrient levels	
NE of maintain and finish(MJ/kg)	6.54
Crude protein(CP)	10.74
Neutral detergent fibre	56.51
Acid detergent fibre	35.59
Calcium	0.75
Phosphorus	0.52
Sulfur	0.41
Selenium (mg/kg)	0.07
Cuprum (mg/kg)	8.36
Zinc (mg/kg)	45.68
Ferrum (mg/kg)	340.15
Manganese (mg/kg)	41.98
Molybdenum (mg/kg)	1.79

*: The premix provides the following content per kilogram of feed (diet): VA 3 000 IU; VD_3 1 200 IU; VE 15 IU; Fe 30 mg; Cu 8 mg; Zn 30 mg; Mn 40 mg; I 0.25 mg; Co 0.1 mg.

At the end of sampling period, before feeding on the morning, 40 milliliter of blood samples were collected by venipuncture into collection tubes. Blood samples were kept in an ice chest until centrifugation at 3 000 × g for 5 min. Serum samples were protected from light, separated in Eppendorf tubes and stored at -40℃ for the determination of triglycerides, glucose(GLU), cholesterol total, albumin, total protein, serum urine nitrogen, glutamate pyruvate transaminase, glutamate oxaloacetate transaminase, alkaline phosphatase, acid phosphatase, lactate dehydrogenase, ceruloplasmin, superoxide dismutase, glutathione peroxidase, maleic dialdehyde, glutathione, selenium, ferrum, cuprum, zinc and manganese by ultraviolet-visible spectrophotometer UV-2100. All the reagent boxes were obtained from the Nanjing Jiancheng Institute of Biological Engineering. Selenium was determined by fluorispectrometer WFY-28[14].

1.4 Statistical analysis

Experiment data were analyzed as a block design with treatment using the one-way-ANOVA procedures of the SPSS package. If significant treatment effects were observed, means were separated using Duncan test.

2 Results

Effects of Se-yeast on apparent digestibility of nutrient in Simmental steer are shown in Table 2. The apparent digestibility of OM, EE, CP, NFE, NDF and ADF in Treatment 1 and Treatment 2 supplemented 0.3 mg Se per kg DM and 0.6 mg Se per kg DM with Se-yeast were higher than that of Treatment 3 supplemented 0.9 mg Se per kg DM and the control significantly ($P<0.05$).

Table 2 Effects of Se-yeast on nutrient apparent digestibility in Simmental steers (%)

Items	Control	Treatment 1	Treatment 2	Treatment 3
OM	59.68 ± 1.60^{b}	65.74 ± 0.50^{a}	67.59 ± 1.11^{a}	59.99 ± 1.32^{b}
CP	55.13 ± 1.04^{b}	59.62 ± 0.74^{a}	60.76 ± 0.84^{a}	56.30 ± 1.51^{b}
EE	50.09 ± 2.45^{b}	59.03 ± 2.63^{a}	60.25 ± 1.56^{a}	53.30 ± 4.14^{b}
NFE	63.72 ± 2.26^{b}	69.43 ± 0.72^{a}	70.71 ± 0.91^{a}	65.19 ± 2.89^{b}
NDF	46.15 ± 1.18^{b}	56.75 ± 1.58^{a}	58.71 ± 1.38^{a}	49.39 ± 2.58^{b}
ADF	44.37 ± 1.98^{b}	56.44 ± 1.52^{a}	57.53 ± 2.13^{a}	46.04 ± 3.36^{b}

Values in the same row with different superscripts letters are significantly different ($P<0.05$). The same as below.

Effects of Se-yeast on nitrogen balance in Simmental steer are shown in Table 3. Nitrogen intake was not affected ($P>0.05$). Feces nitrogen in Treatment 1 and Treatment 2 supplemented 0.3 mg Se per kg DM and 0.6 mg Se per kg DM with Se-yeast were lower than that of Treatment 3 0.9 mg Se per kg DM and the control significantly ($P<0.05$). Digestible nitrogen in Treatment 1 and Treatment 2 supplemented 0.3 mg Se per kg DM and 0.6 mg Se per kg DM with Se-yeast were higher than that of Treatment 3 0.9 mg Se per kg DM and the control significantly ($P<0.05$). Urine nitrogen in Treatment 1 and Treatment 2 supplemented 0.3 mg Se per kg DM and 0.6 mg Se per kg DM with Se-yeast were lower than that of the control significantly ($P<0.05$). Retention nitrogen and the ratio of digestible nitrogen to retention nitrogen of Treatments were higher than the control ($P<0.05$), which in Treatment 2 supplemented 0.6 mg Se per kg DM with Se-yeast were higher than that of Treatment 1 and Treatment 3 0.3 mg Se per kg DM and 0.9 mg Se per kg DM ($P<0.05$).

Effects of Se-yeast on the apparent deposit rate of mineral in Simmental steer are shown in Table 4. The apparent deposit rate of Se, Cu, Fe

and Mn in treatments was higher than the control significantly ($P<0.05$), but no significance between treatments ($P>0.05$). The apparent deposit rate of Ca in Treatment 2 supplemented 0.6 mg Se per kg DM with Se-yeast was higher than the control significantly ($P<0.05$). The apparent deposit rate of Zn in Treatment 1 supplemented 0.3 mg Se per kg DM with Se-yeast was higher than other treatments and the control significantly ($P<0.05$). The apparent deposit rate of Mo in Treatment 1 supplemented 0.3 mg Se per kg DM with Se-yeast was higher than that of Treatment 3 supplemented 0.9 mg Se per kg DM and the control significantly ($P<0.05$). The apparent deposit rate of S and P were not affected ($P>0.05$) significantly.

Table 3 Effects of Se-yeast on nitrogen balance in Simmental steers (g/d)

Items	Control	Treatment 1	Treatment 2	Treatment 3
N intake	153.25 ± 2.53^{a}	152.61 ± 1.94^{a}	153.02 ± 1.83^{a}	151.34 ± 2.17^{a}
Feces N	68.76 ± 1.24^{a}	61.64 ± 1.31^{b}	60.05 ± 1.18^{b}	66.14 ± 0.94^{a}
Digestible N	84.49 ± 1.52^{b}	90.97 ± 1.76^{a}	92.97 ± 1.69^{a}	85.20 ± 1.74^{b}
Urine N	54.83 ± 1.65^{a}	49.51 ± 0.79^{ab}	42.47 ± 1.36^{b}	45.95 ± 1.23^{b}
Retention N	29.66 ± 1.18^{c}	41.46 ± 1.51^{b}	50.50 ± 0.82^{a}	39.25 ± 0.75^{b}
RN/DN	35.10 ± 1.54^{c}	45.58 ± 1.63^{b}	54.32 ± 1.71^{a}	46.07 ± 1.37^{b}

Table 4 Effects of Se-yeast on the apparent deposit rate of mineral in Simmental steers (%)

Items	Control	Treatment 1	Treatment 2	Treatment 3
Se	22.29 ± 2.35^{b}	52.61 ± 2.68^{a}	47.32 ± 8.84^{a}	48.87 ± 8.14^{a}
Ca	16.32 ± 2.25^{b}	20.74 ± 3.59^{ab}	27.27 ± 3.38^{a}	25.77 ± 3.48^{ab}
P	18.35 ± 1.35^{a}	22.82 ± 5.29^{a}	25.53 ± 1.14^{a}	26.35 ± 4.01^{a}
Cu	31.16 ± 2.78^{b}	49.99 ± 2.82^{a}	42.37 ± 9.30^{a}	48.89 ± 3.34^{a}
Fe	10.76 ± 1.61^{b}	20.34 ± 2.45^{a}	20.46 ± 2.40^{a}	21.02 ± 1.74^{a}
Zn	53.98 ± 1.84^{b}	67.02 ± 1.59^{a}	53.28 ± 9.44^{b}	53.16 ± 1.98^{b}
Mn	10.37 ± 1.34^{b}	26.83 ± 4.43^{a}	26.79 ± 6.77^{a}	29.26 ± 6.50^{a}
Mo	25.29 ± 2.26^{b}	38.48 ± 2.37^{a}	30.22 ± 5.88^{ab}	27.53 ± 2.56^{b}
S	24.32 ± 1.39^{a}	22.73 ± 1.92^{a}	22.93 ± 2.50^{a}	26.11 ± 1.93^{a}

Effects of Se-yeast on serum physico-chemical parameters in Simmental steer are shown in Table 5. Serum triglycerides content in Treatment 2 of 0.6 mg/kg increased significantly than control ($P<0.05$). Serum GLU content in treatments increased significantly than control ($P<0.05$). Serum total cholesterol(TC) and serum urine nitrogen content decreased, but no significance ($P>0.05$). Serum albumin content in Treatment 2 and Treatment 3 of 0.6 mg/kg and 0.9 mg/kg increased significantly than control ($P<0.05$). Serum total protein content increased, but no significance ($P>0.05$). Serum glutamate pyruvate transaminase (GPT) and glutamate oxaloacetate transaminase (GOT) activity in Treatment 2 and Treatment 3 of 0.6 mg/kg and 0.9 mg/kg were higher than the control ($P<0.05$). Serum alkaline phosphatase (AKP), acid phosphatase (ACP) and lactate dehydrogenase (LDH) activity were not affected significantly ($P<0.05$). Serum glutathione peroxidase (GSH-px) activity in treatments was higher than control ($P<0.05$). Serum maleic dialdehyde (MDA) content decreased, 0.6 mg/kg and 0.9 mg/kg was lower than control ($P<0.05$). Serum glutathione (GSH) content increased significantly than control ($P<0.05$). Serum Se content increased, 0.6 mg/kg and 0.9 mg/kg were higher than control ($P<0.05$).

Table 5 Effects of Se-yeast on serum physico-chemical parameters in Simmental steers

Items	Control	Treatment 1	Treatment 2	Treatment 3
TG (mmol/L)	0.36 ± 0.06^{b}	0.45 ± 0.04^{ab}	0.63 ± 0.07^{a}	0.59 ± 0.03^{ab}
GLU (mmol/L)	3.34 ± 0.04^{b}	3.53 ± 0.07^{a}	3.61 ± 0.09^{a}	3.57 ± 0.14^{a}
TC (mmol/L)	3.46 ± 0.10^{a}	3.31 ± 0.13^{a}	3.42 ± 0.11^{a}	3.26 ± 0.09^{a}
ALB (g/L)	34.38 ± 4.66^{b}	38.45 ± 4.04^{ab}	40.99 ± 0.81^{a}	42.91 ± 1.41^{a}
TP (g/L)	56.65 ± 1.27^{a}	58.27 ± 2.41^{a}	58.38 ± 2.15^{a}	61.62 ± 1.65^{a}
SUN (mmol/L)	3.96 ± 0.46^{a}	3.74 ± 0.57^{a}	3.66 ± 0.12^{a}	3.77 ± 0.28^{a}
GPT (IU/L)	4.75 ± 1.92^{b}	6.86 ± 1.08^{ab}	8.93 ± 1.97^{a}	10.06 ± 1.23^{a}
GOT (IU/L)	8.63 ± 1.81^{b}	14.00 ± 3.17^{b}	15.23 ± 1.26^{a}	15.99 ± 1.15^{a}
AKP (U/dL)	12.44 ± 1.91^{a}	12.94 ± 1.26^{a}	12.15 ± 0.88^{a}	10.67 ± 1.09^{a}
ACP (U/dL)	2.21 ± 0.43^{a}	2.49 ± 0.49^{a}	2.79 ± 0.20^{a}	1.56 ± 0.37^{a}
LDH (U/L)	7.96 ± 0.48^{a}	8.07 ± 0.26^{a}	7.82 ± 0.45^{a}	8.33 ± 0.22^{a}
GSH-px (U/mL)	52.86 ± 8.23^{b}	123.36 ± 9.91^{a}	161.73 ± 9.04^{a}	127.11 ± 9.32^{a}
MDA (nmol/L)	4.57 ± 0.72^{a}	4.20 ± 1.33^{a}	1.96 ± 0.77^{b}	1.76 ± 0.77^{b}
GSH (mg/L)	85.86 ± 5.69^{b}	94.85 ± 4.98^{ab}	108.57 ± 2.71^{a}	91.07 ± 8.34^{ab}
Se (μg/dL)	0.16 ± 0.03^{b}	0.30 ± 0.06^{ab}	0.39 ± 0.05^{a}	0.42 ± 0.07^{a}

3 Discussion

Feed conversion efficiency is improved by supplemented 0.25 mg/kg Se-yeast[15]. In this experiment, the digestion of nutrients and the utilization of nitrogen were improved by supplemented 0.3～0.6 mg Se per kg diet DM with Se-yeast, because Se could stimul ate the growth and reproduction of rumen microorganism and enhance the activity of rumen microorganism[16], or improve the digestion and utilization of nutrients due to the enhanced activity of rumen microorganism. When supplemented Se 0.9 mg/kg with Se-yeast, the digestion of nutrients and the utilization of nitrogen decreased, perhaps because Se inhabit the growth and reproduction of rumen microorganism due to the digestion of nutrients decreased, and it is necessary that the results should be verified further. In normal circumstance, Se apparent deposit rate of ruminant is 20%～25%[17]. In this trail, Se apparent deposit rate increased than control significantly, because Se in the Se-yeast combined with protein firmly, a lot of Se leave from rumen by Se-amino acid, and absorbed in stomach and duodenum, so its utilization is higher[5].

Serum TG and TC content are the primary parameter of fat metabolism and liver function. Serum TG content in Treatment 2 of 0.6 mg/kg increased significantly and Serum TC content no apparent significance, the result showed that the metabolism of diet fat is improved by Se-yeast. Serum GLU, ALB, TP and SUN content are the primary parameter of sugar and protein metabolism. Serum ALB content in Treatment 2 and Treatment 3 of 0.6 mg/kg and 0.9 mg/kg increased significantly, serum GLU content in treatments increased significantly, serum UN and TP content no apparent significance, the result showed that the metabolism of diet protein and carbohydrate is improved by Se-yeast. During the transform of amino acid, protein, fat and sugar, transaminase activities are the primary parameter, especially the activity of GPT and GOT are the parameter of liver and heart function. In normal circumstance, the activity of GPT and GOT are stable, it suggested that liver and heart function were damaged when its activity increasing or decreasing. In this trial, serum GOT and GPT activities in Treatment 2 and Treatment 3 of 0.6 mg/kg and 0.9 mg/kg increased significantly, but in normal range, the result showed that the transform of amino acid, protein, fat and sugar is improved by Se-yeast.

AKP, as a distinctive enzyme about cartilage

cell synthetizing and secreting, in clinical, serum AKP activity reflects reconstruction function activity of bone, its activity show a tendency of calcification capacity of tissue and cell changing to maturity bone cell[18]. In this trail, the activity of AKP was not affected significantly by supplemented Se-yeast. LDH is a primary metabolism enzyme within the body, LDH into blood and the activity in blood raise when part of tissue necrosis. In this trial, the activity of LDH was not affected significantly. This indicated the liver function was not damaged by supplemented Se-yeast.

Serum GSH-px activity and MDA content is the primary antioxidation function parameter. GSH-px catalyses the lipid hydroperoxides into less-reactive products. MDA, as a product of lipid peroxidation, an indicator of free radicals in body, is treated as a parameter of damaged body by all kinds of oxygen free radicals[10]. In this trial, serum GSH-px activity in Treatment 1 and Treatment 2 of 0.3 mg/kg and 0.6 mg/kg increased significantly, the result is consistent with other studies[6,10]. Serum MDA content decreased, the Treatment 2 and Treatment 3 of 0.6 mg/kg and 0.9 mg/kg were lower than Treatment 1 of 0.3 mg/kg and the control, this indicated the activity of GSH-px and SOD enhanced, and free radicals decreased, then oxidative stress and lipid peroxidation reduced when supplemented Se with Se-yeast.

Serum Se concentration show the metabolism of Se and availability of feed Se. Serum Se concentration increased with the diet Se increasing, this indicated the absorption of feed Se increased, and body's Se metabolism enhanced. In this trial, serum Se concentration in Treatment 2 and Treatment 3 of 0.6 mg/kg and 0.9 mg/kg increased significantly, it is consistent with other studies[8-9].

4 Conclusion

Either the apparent digestibility of OM, CP, NFE, NDF and ADF, or the digestible nitrogen, retention nitrogen and the ratio of digestible nitrogen to retention nitrogen, and the apparent deposit rate of mineral, were improved by supplemented 0.3～0.6 mg Se per kg diet DM with Se-yeast. The activities of serum enzyme increased and MDA concentration decreased by supplemented 0.6 mg Se per kg diet DM. The optimum Se supplemented dose is 0.6 mg Se per kg diet DM in this experiment.

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硒酵母对西门塔尔牛日粮养分消化代谢和血清生化指标的影响

刘　强　黄应祥　王　聪　董　升　蔺文爱

（山西农业大学动物科技学院，太谷 030801）

摘　要：本试验旨在研究硒酵母对西门塔尔牛营养物质消化代谢和血清生化指标的影响。选用 16 头平均体重 420 kg，年龄 2.5 岁的西门塔尔牛阉牛，采用随机区组设计分为 4 组，以硒酵母为硒源，分别在日粮中添加硒 0、0.3、0.6 和 0.9 mg/kg。结果表明：日粮养分表观消化率、矿物元素表观存留率、消化氮和沉积氮/消化氮比例均以 0.3 mg/kg 与 0.6 mg/kg 组较高（$P<0.05$）；0.6 mg/kg 组甘油三酯显著提高，处理组血糖显著增加，0.6 mg/kg 和 0.9 mg/kg 组白蛋白增加（$P<0.05$），总胆固醇、总蛋白和尿素氮差异不显著（$P>0.05$）；0.6 mg/kg 和 0.9 mg/kg 组血清 GOT 和 GPT 含量显著提高（$P<0.05$），AKP、ACP 和 LDH 差异均不显著（$P>0.05$）；处理组 GSH-px 活性显著提高（$P<0.05$），以 0.6 mg/kg 组最高；0.6 mg/kg 和 0.9 mg/kg 组 MDA 显著降低（$P<0.05$）；0.6 mg/kg 组 GSH 含量显著增加（$P<0.05$）；0.6 mg/kg 和 0.9 mg/kg 组血清硒含量显著增加（$P<0.05$）。日粮以硒酵母为硒源时，添加硒 0.6 mg/kg 显著促进营养物质消化代谢和提高机体抗氧化能力，建议日粮加硒为 0.6 mg/kg。[动物营养学报，2007，19(4)：379-385]

关键词：西门塔尔牛；硒酵母；消化率；氮平衡；血清生化指标

作者简介：刘　强，副教授，E-mail：liuqiangabc@163.com

（编辑　胡晓蕾）