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Organic selenium supplementation increases serum selenium levels in healthy Xinjiang brown cattle fed selenised yeast

Z. Li[1,2,*], J. Tang[1,3], J. Li[1,2], D. Ling[1], X. He[1,2], Y. Tang[1,2], P. Yi[1], Y. Yang[1,] H.E. Khoo[4] and Y. Liu[5,*]

[1] Guangxi Academy of Agricultural Sciences, Agro-food Science & Technology Research Institute, 530007 Nanning, China
[2] Guangxi Key Laboratory of Fruits and Vegetables Storage-processing Technology, 530007 Nanning, China
[3] Guangxi Academy of Agricultural Sciences, Technology Transfer Department, 530007 Nanning, China
[4] Guilin University of Technology, College of Chemistry and Bioengineering, 541006 Guilin, China
[5] Guangxi Academy of Agricultural Sciences, Agricultural Resource and Environmental Research Institute, 530007 Nanning, China

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* Corresponding author:
e-mail: lizhichun@gxaas.net; liuyx27@163.com

ABSTRACT. The study aimed to determine the effect of different dietary selenium (Se) doses in the form of selenised yeasts on serum Se levels and serum biochemical indices in Xinjiang brown cattle. The animals were randomly divided into five groups (n = 5): NC (negative control), group A (0.3 mg Se/kg dry matter (DM)), group B (0.6 mg Se/kg DM), group C (0.9 mg Se/kg DM), and group D (1.2 mg Se/kg DM). The animals received a Se-enriched diet with jujube for three months. The results showed that serum Se levels in cattle fed higher doses of selenised yeast were significantly higher than in control cattle. Serum cholesterol, proteins, globulin, uric acid and blood urea nitrogen levels were also significantly different between the experimental and control groups. Serum triglyceride, albumin, creatinine, and total bilirubin levels did not exhibit marked differences between the experimental groups. Moreover, serum alanine transaminase, aspartate transferase, and alkaline phosphatase concentrations in cattle also varied between the experimental groups. While the increased serum Se levels were found to enhance the cellular antioxidant status in cattle, they did not provide protection against cellular oxidative stress. Based on these findings, the addition of a moderate dose of selenised yeast to cattle feed can help maintain cattle health and contribute to the production of high-quality meat.

Introduction

For many years, China has faced a selenium (Se) deficiency crisis due to its uneven food distribution (Li et al., 2007). According to the latest report, 67.8% of daily Se intake in Suzhou (a mid-sized Chinese city) comes from cattle and poultry meats (Gao et al., 2011). An effective strategy to enhance Se intake by people is to add Se into animal diets, thereby obtaining Se-enriched meat (Mehdi and Dufrasne, 2016). Higher Se content in meat products translates into better meat quality. In China, the beef cattle breeding standard permits feed enrichment with Se at a dose range of 0.18–0.31 mg/kg, with a maximum tolerance value of 2 mg/kg. Additionally, the local standard for Se-rich beef in Guangxi is set at 0.15–0.50 mg/kg (Yan et al., 2015).

Se is an antioxidant that improves immunity and reproductive performance of cattle (Mehdi and Dufrasne, 2016). The addition of appropriate amounts

of selenised yeast into animal feed has been proposed to promote animal health. The literature shows that organic Se is superior to inorganic Se in improving animal production performance, antioxidant status and meat quality, as well as increasing Se deposition in muscle tissues (Edens and Sefton, 2016; Li et al., 2021). Dietary supplementation with inorganic (e.g., selenite or selenate) and organic Se (e.g., selenised yeast) was demonstrated to differentially alter Se concentrations in the muscles and internal organs of farm ruminants (Czauderna et al., 2018; Białek et al., 2021).

Se requirements of animals can vary based on the type of livestock and their growth stages. Xinjiang brown cattle struggle to adapt to the hot and humid environment in Southern China, which differ from the dry climate of Xinjiang. Therefore, there is a need to improve the physical health of Xinjiang brown cattle grazing in hot and humid regions. The concentration of Se in the diet of ruminants is another crucial factor in maintaining healthy cattle in such environments. Beef cattle require lower Se levels (0.10 mg/kg diet) than dairy cattle (0.30 mg/kg diet), while egg-laying hens need even lower amounts of Se (0.05–0.07 mg/kg diet) in the diet (Saha et al., 2016). Insufficient cellular Se can lead to an increase in hepatic glutathione levels and a reduction in cellular cysteine levels (Celi, 2011).

This study was designed to assess the effect of different Se concentrations and jujube supplementation on serum Se levels and serum biochemical parameters in Xinjiang brown cattle fed a diet enriched with selenised yeast and jujube. The objective of this study was to investigate the serum Se levels and protective effects of selenised yeast against oxidative damage in Xinjiang brown cattle. We hypothesised that adding selenised yeast and jujube to cattle feed would increase Se levels in cattle serum. The diets might alter serum biochemical parameters of these experimental cattle. Also, high cellular Se level may exert a protective effect against oxidative damage in cattle. Therefore, the findings from this experiment could contribute to the production of premium beef, while potentially reducing feeding costs.

Material and methods

Animal experimentation

Ethical approval for the use of animals in this study (approval number: GXAAS/AEEIF/00002) was obtained from the Animal Care and Use Committee (ACUC) of the Guangxi Academy of Agricultural Sciences. All procedures involving the animals, including their handling and care, were conducted in accordance with the guidelines and regulations of the ACUC.

The experimental cattle, known as Xinjiang brown cattle (*Bos taurus*), were obtained from a local farm. A total of 40 bulls, approximately 30 months old, were selected based on similar body weight (BW), which ranged between 400 kg and 450 kg. The bulls were acclimatised for one week on the farm before the feeding experiment. During the acclimatisation period, some of the animals fell ill and were subsequently excluded from the study. As a result, the final number of cattle included in the study was 25 heads. Body measurements, including body weight, length, height and chest circumference were determined (Table 1). The initial values of the above parameters of the cattle did not show significant differences between the experimental groups ($P > 0.05$).

Table 1. Body measurements of Xinjiang brown cattle

Group (n = 5)	Weight, kg	Length, cm	Height, cm	Chest circumference, cm
NC	385.6 ± 33.78	141 ± 0.57	118 ± 4.00	194 ± 7.93
A	378.1 ± 32.67	144 ± 3.61	117 ± 4.36	194 ± 10.69
B	386.5 ± 29.91	146 ± 2.31	128 ± 6.43	184 ± 4.62
C	363.5 ± 21.68	141 ± 2.52	126 ± 5.29	190 ± 5.69
D	370.5 ± 44.58	140 ± 6.08	119 ± 5.57	184 ± 3.06

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; data are presented as the mean value ± SEM (standard error of the mean); $P > 0.05$

All animals were further acclimatised for one week in a cattle barn before being given the experimental diet. They were randomly divided into five groups, which included negative control (NC) and four treatment groups with varying Se supplementation levels in the form of selenised yeasts. The supplementation groups were as follows: group A (0.3 mg Se/kg DM), group B (0.6 mg Se/kg DM), group C (0.9 mg Se/kg DM), and group D (1.2 mg Se/kg DM). Each group consisted of five cattle heads, whose ears were labelled with ear tags.

The standard cattle diet was prepared based on the nutritional requirements for beef cattle recommended by the industry-standard "Beef Feeding Standards" (NY/T 815-2004) of the People's Republic of China (CAFS, 2004). The dosage of yeast Se was based on the 'Code for Safe Use of Feed Additives' formulated by the Ministry of Agriculture of the People's Republic of China. Organic Se, in the form of selenised yeast, was purchased from Angel

Yeast Co., Ltd. (Yichang, HB, China), where each kg of selenised yeast contained 2000 mg organic Se. This selenised yeast product was manufactured by mixing sodium selenite with brewer's yeast.

The fresh grass and silage contained 0.08 ± 0.02 mg Se per kg fresh weight. The standard diet contained 42% maize starch, 28% soybean meal, 20% jujube powder, 5% wheat powder and 5% premix. Each kg of the premix contained vitamin D_3 (100000 IU), powdered vitamin E (700 mg), vitamin A (224000 IU), zinc (1900 mg), manganese (1200 mg), sodium chloride (160 g), calcium (200 g), and phosphorus (40 g). It is important to note that the standard diet was Se-free. After mixing the standard diet with selenised yeast, it was packaged and stored in a ventilated dark place before being fed to the cattle.

The health status of all animals was checked and confirmed by a veterinarian, and the barn was sterilised before the experiment. Observations of cattle grazing behaviour were carried out during the acclimatisation period. The duration of the experiment was 90 days. Cattle were fed twice daily at 8:00 and 15:30, with additional silage supplementation. Each group of cattle was provided with specific feed formulations, as outlined in Table 2. The barn was cleaned daily by hired workers. Daily food intake and body measurements of the animals were also obtained.

Table 2. Monthly feed intake of Xinjiang brown cattle per group

Group (n = 5)	Experimental diet, kg	Fresh grass, kg	Silage, kg
NC	371 ± 1.21	2039 ± 41.89^{a}	202 ± 3.42^{b}
A	371 ± 1.32	1965 ± 35.32^{b}	205 ± 2.68^{b}
B	371 ± 1.01	2052 ± 50.07^{a}	203 ± 4.78^{b}
C	371 ± 1.14	2057 ± 57.51^{a}	208 ± 3.39^{b}
D	371 ± 1.51	2052 ± 54.93^{a}	216 ± 5.77^{a}

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; data are presented as the mean value ± SEM (standard error of the mean); ^{ab} – means within a column with different superscripts are significantly different at $P < 0.05$

Blood sample collection

At the end of the study, the bulls were fasted for 12 h before blood was drawn for analysis. A blood sample (5 ml) was collected from each experimental animal via the cervical vein using a plain tube. These collected blood samples were kept in a foam box containing ice packs and immediately sent to the laboratory for centrifugation. Blood samples were centrifuged at 3500 rpm (10 cm radius) for 15 min at 4 °C. The collected blood serum was transferred to a new centrifuge tube for subsequent determination of serum Se level and other serum biochemical parameters.

Serum Se content

The analysis was performed based on the method described by Jing (2015), with slight modifications. Before acid hydrolysis, serum samples were digested with nitric acid and perchloric acid at a ratio of 9:1. After digestion, the solution was allowed to cool to room temperature, and 2.5 ml of hydrochloric acid solution (6 M) was added. Subsequently, Se analysis was performed using an atomic fluorescence spectrophotometer. Se analysis was performed using an AFS-9700 atomic fluorescence spectrophotometer (Beijing Kechuang Haiguang Instrument Co., Beijing, China). For the purpose of standard calibration, a 1000 ppm of Se was prepared, and Se powder was purchased from Sigma-Aldrich Trading Co., Ltd. (Shanghai, China). Se concentration in serum samples was expressed as μg/ml.

Serum biochemical parameters

The analysis of various serum parameters, including total cholesterol, triglycerides, total protein, globulin, albumin, uric acid, blood urea nitrogen (BUN), creatinine, total bilirubin, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transpeptidase (GGT) (GGT), and alkaline phosphatase (ALP) was performed using appropriate assay kits according to the provided protocols. These assay kits were purchased from ZhongSheng BeiKong Biotechnology Co., Ltd. (Beijing, China) (Luo et al., 2020). The detection instrument used was a Hitachi 7020 automatic biochemistry analyzer (Tokyo, Japan).

Statistical analysis

All data obtained were analysed using SPSS software version 21. Comparisons between individual experimental groups was performed based on analysis of variance (ANOVA) coupled with Duncan's multiple comparison methods, and the level of significance was assumed at $P < 0.05$. The results are presented as mean ± standard deviation of five replicates.

Results

Body measurements

After feeding the Se-enriched diet for 90 days, all cattle from the control group, group B and group C showed similar percentages of body weight gain (13–16%). As shown in Figure 1, group A cattle

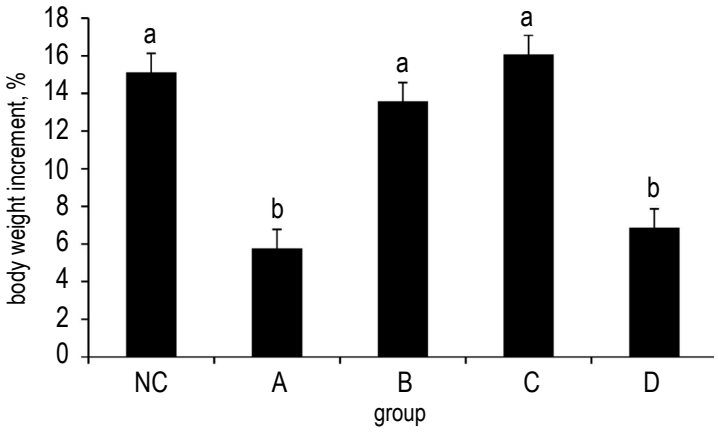

Figure 1. Percentage body weight gain of Xinjiang brown cattle (n = 5)

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; [ab] – means in a column with different superscripts are significantly different at $P < 0.05$

exhibited the lowest increment in body weight percentage (5.79%), followed by group D (6.88%). The reduction in body weight in group A could mainly be attributed to the reduced daily consumption of fresh grass compared to the other supplementation groups. It was therefore hypothesised that the reduction in body weight was due to a high dose of organic Se supplementation.

Serum Se content

Serum Se levels in the experimental cattle showed an increase corresponding to the dosage of organic supplementation (Figure 2). Serum Se concentration in the animals from all supplementation groups was significantly higher than in the control group (NC), except for group A. A dose-dependent effect was observed for Se supplementation, with serum Se concentrations increasing linearly with raising doses of selenised yeasts ($R^2 = 0.97$).

Serum total cholesterol and triglyceride levels

Serum total cholesterol and triglyceride concentrations in cattle from all experimental groups are shown in Table 3. The result showed that serum total cholesterol levels in animals from groups A and B increased ($P < 0.05$), whereas those from groups C and D were reduced ($P < 0.05$). Additionally, there were no significant differences in serum triglyceride levels among any of the experimental animals ($P > 0.05$).

Serum proteins

As shown in Table 3, total serum protein and globulin levels in cattle from experimental groups A and B were significantly higher compared to the control group ($P < 0.05$). Serum protein and globulin levels in cattle from groups C and D were similar to the control group. Group B animals also had

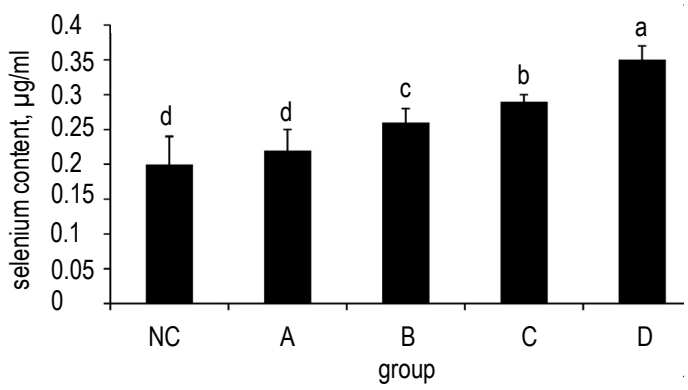

Figure 2. Serum selenium levels of Xinjiang brown cattle (n = 5)

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; [a–d] – means in a column with different superscripts are significantly different at $P < 0.05$

Table 3. Serum lipid marker and protein levels of Xinjiang brown cattle

Group (n = 5)	Total cholesterol, mmol/l	Triglyceride, mmol/l	Total protein, g/l	Globulin, g/l	Albumin, g/l
NC	1.68 ± 0.48^{b}	5.50 ± .00	78.57 ± 2.60^{b}	54.57 ± 2.50^{b}	24.00 ± 2.01
A	2.03 ± 0.16^{a}	5.47 ± 0.06	84.7 ± 6.00^{a}	59.07 ± 3.01^{a}	25.63 ± 3.01
B	2.01 ± 0.27^{a}	5.53 ± 0.06	86.8 ± 5.44^{a}	63.73 ± 7.36^{a}	23.07 ± 3.81
C	1.40 ± 0.17^{c}	5.53 ± 0.06	79.37 ± 6.27^{b}	55.60 ± 4.65^{b}	23.77 ± 1.63
D	1.14 ± 0.17^{d}	5.53 ± 0.06	77.5 ± 9.81^{b}	55.30 ± 8.40^{b}	22.20 ± 2.07

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; data are presented as the mean value ± SEM (standard error of the mean); $^{a–d}$ – means in a column with different superscripts are significantly different at $P < 0.05$

the highest serum total protein and globulin levels, followed by group A cattle. Moreover, serum total protein levels in cattle from all experimental groups were higher than those in the control group, except for group D.

Similarly, cattle from group B had the highest serum total protein and globulin levels, although there was no significant difference in serum albumin content. This shows that supplementation with a moderate dosage of selenised yeast to Xinjiang brown cattle improved their serum protein levels. Conversely, there were no significant differences determined in serum albumin levels. In conclusion, supplementing selenised yeast to the cattle did not affect serum albumin content.

Renal function tests

The renal function parameters of Xinjiang brown cattle supplemented with selenised yeast are presented in Table 4. The results indicate that supplementation of selenised yeast in Xinjiang brown cattle led to a minor increase in renal function indices. However, organic yeast did not significantly affect serum creatinine and total bilirubin levels in the experimental cattle. The animals supplemented with the highest dose of selenised yeast (1.2 mg/kg BW) had uric acid levels similar to the control group. This suggests that the intake of a high dose of selenised yeast by the experimental cattle caused no adverse effects on their renal function. Further research is needed to elucidate the metabolic pathways responsible for the observed increase in serum uric acid and BUN levels in cattle supplemented with a moderate concentration of selenised yeast.

Liver enzyme activity

The impact of selenised yeast supplementation on serum ALT, AST, ALP, and GGT levels in Xinjiang brown cattle is presented in Table 5. Supplementation of selenised yeast significantly influenced serum ALT, AST, and ALP levels, but had no significant effect on GGT levels. Cattle from group C exhibited a markedly lower ALT level (19.33 U/l) compared to animals from other supplementation groups (>24 U/l; $P < 0.05$). Serum AST levels in cattle from all supplementation groups (>70 U/l) was significantly higher than those determined in the control group (61.67 U/l). The highest serum ALP level was observed in cattle from group B (72.33 U/l), followed by group C (66.03 U/l). Interestingly, cattle receiving the highest dosage of selenised yeast (group D) displayed the highest blood ALT activity, while AST and ALP activities were reduced. Dietary addition of selenised yeast did not alter GGT levels in any of the experimental cattle. Moreover, supplementation of moderate doses of organic yeast to Xinjiang brown cattle only affected blood AST and ALP activities.

Table 4. Renal function indices of Xinjiang brown cattle

Group (n = 5)	Uric acid, µmol/l	BUN, mmol/l	Creatinine, µmol/l	Total bilirubin, µmol/l
NC	47.27 ± 8.06^{bc}	5.33 ± 0.58^{c}	44.67 ± 8.14^{a}	1.00 ± 0.0
A	45.70 ± 12.23^{b}	7.33 ± 1.15^{a}	42.33 ± 12.10^{a}	1.03 ± 0.0
B	57.37 ± 8.84^{a}	7.00 ± 0.00^{b}	45.67 ± 10.69^{a}	1.03 ± 0.0
C	54.90 ± 6.34^{ac}	7.67 ± 0.58^{a}	44.67 ± 12.74^{a}	1.03 ± 0.0
D	44.83 ± 13.41^{b}	6.33 ± 1.15^{b}	42.00 ± 3.00^{a}	1.50 ± 0.58

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; BUN – blood urea nitrogen; data are presented as the mean value ± SEM (standard error of the mean); ^{abc} – means in a column with different superscripts are significantly different at $P < 0.05$

Table 5. Liver function indices of Xinjiang brown cattle

Group (n = 5)	ALT, U/l	AST, U/l	GGT, U/l	ALP, U/l
NC	23.33 ± 1.15^{ac}	61.67 ± 8.96^{c}	11.00 ± 5.00	58.33 ± 14.07^{bc}
A	25.33 ± 4.04^{a}	87.33 ± 7.51^{a}	14.53 ± 5.00	55.33 ± 14.05^{bc}
B	24.67 ± 5.69^{a}	79.33 ± 8.33^{ab}	14.03 ± 6.01	72.33 ± 13.02^{a}
C	19.33 ± 3.06^{bc}	74.67 ± 8.02^{b}	12.33 ± 5.05	66.03 ± 15.02^{ab}
D	26.33 ± 4.62^{a}	70.67 ± 6.51^{b}	11.00 ± 6.00	48.30 ± 7.05^{c}

NC – negative control, Group A – 0.3 mg Se/kg dry matter (DM), Group B – 0.6 mg Se/kg DM, Group C – 0.9 mg Se/kg DM, Group D –1.2 mg Se/kg DM; ALT – alanine aminotransferase, AST – aspartate aminotransferase, GGT – gamma-glutamyl transpeptidase, ALP – alkaline phosphatase; data are presented as the mean value ± SEM (standard error of the mean); ^{abc} – means in a column with different superscripts are significantly different at $P < 0.05$

Discussion

In this study, Se supplementation significantly increased serum Se levels in healthy Xinjiang brown cattle in a dose-dependent manner. The findings of our earlier study supported this observation (Li et al., 2021), as did a previous study, where Se supplementation to cattle for three months significantly increased serum Se concentration (Bengoumi et al., 1998). Notably, the use of selenised yeast as a supplement also resulted in a dose-dependent rise in blood Se concentration in cattle, as reported in previous studies (Juniper et al., 2006).

In contrast, supplementation of selenised yeast (0.3 and 0.45 mg/kg DM) to dairy cows also significantly increased blood Se concentration compared to baseline levels, whereas sodium selenite supplementation did not produce the same effect (Phipps et al., 2008). Similarly, in a study of Juniper et al. (2006), sodium selenite supplementation (0.25 mg/kg DM) did not elevate blood Se levels in dairy cattle. The available literature shows that dietary inorganic Se-forms, such as selenite or selenate, and Se-methionine (Se-Met) derived from dietary supplemented selenised-yeast, become incorporated into body proteins. This can be attributed to the fact that tRNA Met (methionine transfer RNA) does not discriminate between Se-Met and methionine (Białek et al., 2021; 2022).

The elevated serum Se concentration in male Xinjiang brown cattle did not necessarily translate into improved slaughter performance. Cattle from the supplementation groups that received high doses of selenised yeast for 90 days had reduced weight gain, especially in group D (1.2 mg Se/kg DM). Previous studies documented that dietary selenised yeast (0.35 mg Se/kg basal diet) reduced body weight gain compared to the control diet and the experimental diet supplemented with selenate (Białek et al., 2021; 2022). The literature also showed that cattle supplemented with selenised yeast did not exhibit significant increases in their body weight (Slavík et al., 2008).

Higher Se concentrations (0.6, 0.9, and 1.2 mg Se/kg DM as selenised yeast) in the experimental diets (groups B, C, and D) stimulated the passage of Se unmetabolised by the ruminal microbiota to further sections of the digestive tract. Therefore, diets containing 0.6 mg Se/kg DM or 0.9 mg Se/kg DM (groups B and C) improved body weight gain (%) compared to group A. This phenomenon, where dietary Se is transferred into cattle tissues, promotes protein biosynthesis and exhibits lipogenic effects in the bodies of ruminants (Białek et al., 2022).

Elevated blood Se levels can be toxic to cattle, affecting blood protein metabolism. A previous study showed that diets supplemented with selenised yeast (0.35 mg Se/kg basal diet) reduced ruminant performance by increasing rumen concentrations of methane (CH_4) and carbon dioxide (Miltko et al., 2016). CH_4 is a high-energy compound that is eliminated as a waste product in ruminants, leading to a loss of feed energy (Shibata and Terada, 2010). On the other hand, the low bioaccumulation of Se by ruminants could be attributed to their poor health. The compound is then metabolised by rumen microorganisms and becomes insoluble or unavailable as an elemental Se (Białek and Czauderna, 2019). Excessive dietary Se intake by cattle is detrimental to their health.

The literature shows that Se supplementation in phenylketonuria human subjects can affect thyroid hormone metabolism (Calomme et al., 1995). Globulin is an essential type of protein involved in thyroid hormone metabolism. We hypothesised that an increase in blood Se levels could enhance selenoprotein biosynthesis, a physiological process that involves thyroid hormone turnover (Schomburg and Köhrle, 2008). This, in turn, could lead to a reduction in weight gain of cattle supplemented with high doses of selenised yeast. Moreover, cattle fed a high dose of selenised yeast had lower levels of total proteins and globulin (Table 3).

The elevated serum Se levels were attributed to a reduction in total cholesterol concentrations. Se is known for its cardioprotective properties, and supplementing selenised yeast (52.5 g once a week) to postpartum dairy cows for up to 14 days was shown previously to significantly reduce serum cholesterol levels in cows compared to the control group (Hall et al., 2014). Increasing the intake of Se-rich Brazilian nuts was also demonstrated to reduce the atherogenic risk in obese human subjects (Cominetti et al., 2012). Moreover, diabetes patients who received Se supplementation had slightly reduced total cholesterol levels, whereas no reduction in triglyceride levels was found (Faghihi et al., 2014).

In this study, organic Se supplementation significantly increased serum albumin levels. However, our study showed that the concentration of serum albumin in these experimental cattle were not significantly different between the supplemented groups and the control group. This could be explained by the fact that albumin level in the blood is regulated by the liver of a healthy animal (Peavy et al., 1978). Additionally, different Se concentrations determined in human plasma did not significantly affect its distribution in the albumin fraction (Deagen et al., 1993).

The level of total serum protein mainly reflects the overall status of protein absorption, synthesis, and degradation by the body. Serum protein status is an indicator of animal health (Spurlock, 1997). To some extent, it can represent the nutritional level of dietary protein and the degree of protein digestion and utilisation by Xinjiang brown cattle. The inclusion of jujube in the diet can also enhance immunity and reduce inflammation as it contains antioxidant phytochemicals (Li et al., 2005).

ALT is primarily located in the hepatic tissue of both animals and humans, and its activity increases during hepatic inflammation. AST is also an essential enzyme in the liver, whereas GGT is typically found in various organs, including the kidney, pancreas, liver, spleen, intestine, brain, lung, skeletal muscle and myocardial tissues. GGT is mainly present in the liver cytoplasm and intrahepatic bile duct epithelium. ALP is another enzyme widely distributed in bones, liver, bowel, placenta, and other animal tissues. Serum ALP activity is increasing in conditions like liver abscess, liver tuberculosis or cirrhosis. In addition to ALP, increased serum AST activity is also indicative of conditions like acute viral hepatitis, chronic hepatitis and fatty liver.

The present study showed that supplementation with different concentrations of selenised yeast did not significantly affect serum GGT activity in the experimental cattle. Although serum ALT, AST, and ALP levels varied between the groups, the differences were not significant. The observed changes in the activities of these enzymes were not dose-dependent. A previous study reported that serum levels of some of these enzymes in lambs supplemented with selenised yeast (0.3 mg/kg DM) were not significantly higher than in the control group (Faixová et al., 2007). Therefore, supplementation with selenised yeast at doses up to 1.2 mg/kg DM did not cause any toxicity to the experimental cattle.

There are two types of serum transaminase found in the animal's liver mitochondria, namely ALT and AST, and they perform different functions in cellular protein metabolism (Dalvi et al., 2017). Serum ALT and AST levels are good indicators for determining normal functions of the heart, liver, and other organs. In this study, ALT and AST levels in Xinjiang brown cattle from the control group were lower than the corresponding values reported by Osman and Al-Busadah (2003). This shows that male Xinjiang brown cattle had lower oxidative stress levels than lactating cows from Saudi Arabia, where lower ALT and AST activities indicated reduced liver inflammation caused by high levels of stress (Hu et al., 2009).

Supplementation with a high dose (1.2 mg/kg DM) of selenised yeast did not cause a significant increase in serum transaminase activity, with the exception of AST. However, increasing the supplementation dose of organic yeast to the experimental cattle reduced serum AST activity. Serum ALP level in cattle in group D (highest dose) was also lower than in the control and other treatment groups. As a natural antioxidant, organic Se helped reduce oxidative stress in the experimental cattle. Supplementation with a moderate dose of selenised yeast is recommended.

Serum GGT level is indicative of kidney oxidative status, given its highest concentration in the kidneys, followed by the pancreas and liver. Additionally, it is also found in hepatocyte cytoplasm and intrahepatic bile duct epithelium. The results obtained in this study showed that supplementation of selenised yeast to healthy Xinjiang brown cattle did not elevate serum GGT levels, even in cattle from the highest dose group. Although cattle supplemented with moderate doses of selenised yeast exhibited higher uric acid levels, the BUN level of cattle from group B (0.6 mg/kg DM) was not the highest among the treatment groups. Our finding also demonstrated that supplementing a high dose (1.2 mg/kg DM) of selenised yeast to Xinjiang brown cattle did not elevate renal function indices (Table 4).

Other kidney-related indices, namely creatinine and bilirubin, were not affected by organic yeast supplementation, similarly as GGT. These results are consistent with previous studies in horses (Calamari et al., 2013) and lambs (El-Sayed and Mousa, 2000), which also reported that these kidney injury markers were not affected by Se supplementation. In this study, cattle ingesting moderate doses of selenised yeast had significantly higher uric acid and BUN levels compared to the highdose and control groups. Although cattle in group B had a significantly higher serum uric acid level, serum BUN level was not the highest. Although information on renal function indices of cattle supplemented with selenised yeast is limited, an earlier study showed that pregnant cows treated with a mineral mixture containing Se (5 mg/ml of sodium selenite), copper, zinc, manganese, calcium, magnesium, and phosphorus did not exhibit significant changes in the levels of serum urea/BUN, uric acid, and transaminases (ALT, AST, and GGT) compared to untreated cows (Molefe and Mwanza, 2020). Therefore, these indices reflect a better health status of Xinjiang brown cattle fed different concentrations of selenised yeast.

Conclusions

Xinjiang brown cattle fed different concentrations of selenised yeast did not exhibit physical or cellular oxidative damage. The results showed that the values of triglyceride, albumin, globulin, uric acid, blood urea nitrogen (BUN), creatinine, total bilirubin, alanine aminotransferase, asparate aminotransferase, gamma-glutamyl transpeptidase, and alkaline phosphatase were within normal ranges, except for the dose-dependent reduction in total cholesterol. Cattle administered different doses of selenised yeast also exhibited a linear increase in serum selenium levels. There was also a slight increase in uric acid and BUN levels and no significant changes in creatinine and total bilirubin levels, indicating no renal impairment. Although serum transaminase levels varied, the results showed no hepatic impairment. Therefore, supplementation of moderate doses of selenised yeast to Xinjiang brown cattle is suggested, as it did not cause oxidative damage in the experimental cattle. This study proposes a new approach to maintaining ruminant health through selenised yeast supplementation. Future studies should focus on the cellular metabolism of selenium and its antioxidant pathway in ruminants such as cattle.

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Conflicts of interest

The Authors declare that there is no conflict of interest.

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