Effect of two levels of organic selenium supplementation on the nutrient digestibility of matured Boer bucks

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Abstract

A digestibility trial was conducted at the MARDI Jeram Pasu, Kelantan, to determine the effect of two levels of organic selenium supplementation on the apparent nutrient digestibility, nutrient balance, total digestible nutrient, and metabolizable energy of matured Boer bucks. A total of nine matured bucks (age of two years) were selected and randomly and equally allotted to three different dietary treatments: Groups A and B were supplemented with 0.3 and 0.6 mg Se/kg DM, respectively, while group C with no Se supplementation (control group). The mean initial body weight was 31.67±0.60 kg. They were fed a basal diet with 60% formulated pellet and 40% *Brachiaria dictyoneura* grass (age of 6 weeks) at 3% DM of body weight. The bucks were placed in individual metabolic cages with separated faecal and urine collection facilities. The digestibility trial was carried out for five days using a completely randomized design (CRD). Supplementation of Se at 0.3 mg/kg DM significantly increased (P<0.05) the digestibility (%) of CP and Se and the Se balance (%). Se supplementation at 0.60 mg/kg DM had significantly increased (P<0.05) the digestibility of nutrients in the Boer bucks. Se supplementation at 0.60 mg/kg had improved (P<0.05) the digestibility (%) of ash, CP, EE, CF, ADF, NDF, P, Ca, Cu and Se, as well as CP, P, Ca, Cu and Se balances. Se supplementation at 0.60 mg/kg DM also had significantly increased (P<0.05) the dietary TDN (%) and ME. In conclusion, supplementation at 0.60 mg/kg DM can influence the nutrient digestibility of matured Boer bucks.

Keywords: Organic selenium, Boer, matured bucks, nutrient digestibility.

Introduction

Selenium (Se) is acknowledged to be an essential dietary mineral required for several physiological functions. Se that presents in several selenoproteins has participated in various biological processes, including an antioxidant, fertility in males and females, thyroid metabolism, immune function, and muscle development and function (Aghwan et al., 2016; Song et al., 2015). For animal feeds, Se is supplemented mainly in two forms, inorganic and organic forms (Bano et al., 2018). Inorganic Se includes sodium selenite and sodium selenate. Meanwhile, organic Se includes selenomethionine and Se enriched yeast. Many studies have focused on utilizing organic Se, especially on Se enriched yeast, to avoid toxicity in animals (Chung et al., 2007; Khalili et al., 2019; Liguang et al., 2011; Shi et al., 2018). Se enriched yeast is non-toxic even consumed at higher doses (Juniper et al., 2008; Shi et al., 2018).

Se supplementation is well known to influence the male reproductive performance of farm animals (Abd & Tortora, 2010; Ahsan et al., 2014; Bano et al., 2018; Pal, 2015). The supplementation of Se in the animal feed also positively affected growth performance (Shi et al., 2017). Studies on the effect of Se supplementation on nutrient digestibility are limiting especially in goats. Pregnant Iranian native goats supplemented with Se were reported to have a significant impact ($P<0.05$) on the EE digestibility (%) (Taheri et al., 2018). They also noted that the pregnant goats supplemented with Se had significantly higher ($P<0.05$) CP balance (%), significantly ($P<0.05$) reduced N excretion via faeces and urine, which had a significant effect ($P<0.05$) on energy production. In contrast, nutrient digestibility (%) on the Katjang bucks and Cashmere goats were not affected by the supplementation of Se (Aghwan et al., 2016; Qin et al., 2011). However, information on the effect of Se supplementation on nutrient digestibility in matured Boer goats is lacking. Therefore, this study was conducted to determine the effect of two levels of organic Se supplementation on the apparent nutrient digestibility, nutrient balance, total digestible nutrient, and metabolizable energy of matured Boer bucks.

Materials and Methods

Experimental animals and dietary treatments

The five-day digestibility trial was conducted at the MARDI Jeram Pasu, Kelantan. This trial was agreed by the Universiti Malaysia Kelantan Animal Ethics Committee (UMK/FPV/ACUE/RES/4/2020). A total of nine matured Boer bucks, two years old of age with an initial body weight of 31.67±0.60 kg were selected. The bucks were randomly divided into three different dietary treatments with three bucks for each group (Table 1) using a completely randomized design (CRD).

Table 1. Dietary treatments

Groups	No. of animals	Treatments
A	3	Basal diet + 0.3 mg organic Se/kg DM
B	3	Basal diet + 0.6 mg organic Se/kg DM
C	3	Basal diet (No Se supplementation), (Control group)

Note: The basal diet consisted of 60% formulated pellet and 40% roughage. Se supplementation was mixed with the formulated pellet.

Se-enriched yeast (Selemax® 2000, Brazil) as an organic Se source was used in this trial. The two levels of Se were compared to see which level would be appropriate for influence the nutrient digestibility of matured Boer bucks. Se level at 0.30 mg/kg DM was chosen because it was within the adequacy range of 0.10 mg/kg DM to 0.30 mg/kg DM for goats (NRC, 2007), while Se level at 0.60 mg/kg DM was chosen as the double level of maximum requirement of goats (0.30 mg/kg DM).

Then, Se-enriched yeast was mixed with the ingredients of the formulated pellet and pelleting at the IA Agro feed mill, Melor, Kelantan. *Brachiaria dictyoneura* grass, six weeks of age was used as the roughage. Feed offered was calculated based on 3% body weight (DM basis). Table 2 is shown the ingredients of the formulated pellet for treatment groups, while Table 3 is shown the nutrient composition (%) of the basal diet between treatment groups.

Table 2. The ingredients of the formulated pellet (% as fed) for treatment groups

Ingredients (% DM)	Group A	Group B	Group C
Palm Kernel Cake (PKC)	34.00	34.00	34.00
Rice straw	30.00	30.00	30.00
Ground corn	14.00	14.00	14.00
Soya bean meal	13.00	13.00	13.00
Di-Calcium phosphate (DCP)	1.50	1.50	1.50
Salt	0.50	0.50	0.50
Molasses	5.00	5.00	5.00
Limestone	1.00	1.00	1.00
Ammonium chloride	0.50	0.50	0.50
Mineral vitamin premix	0.50	0.50	0.50
Selenium (mg/kg DM)	0.30	0.60	-

Notes: Supplemented with 0.30 mg organic Se/kg DM, Group B-Supplemented with 0.60 mg organic Se/kg DM, Group C-No Se supplementation (control).

Table 3. Nutrient composition (%) of the basal diet between treatment groups (±SEM)

Parameters	Basal diet			
	Roughage	Formulated pellet		
		Group A	Group B	Group C
<u>Nutrients (%)</u>				
DM	30.43±0.14	90.13±0.01	90.13±0.01	90.13±0.01
Ash	4.72±0.06	8.15±0.21	8.15±0.21	8.15±0.21
CP	8.17±0.03	14.02±0.34	14.02±0.34	14.02±0.34
EE	1.51±0.03	4.75±0.10	4.75±0.10	4.75±0.10
CF	34.59±0.32	14.30±0.97	14.30±0.97	14.30±0.97
ADF	40.34±0.74	25.47±0.55	25.47±0.55	25.47±0.55
NDF	74.71±0.81	47.3±0.81	47.3±0.81	47.3±0.81
<u>Minerals</u>				
Ca (%)	0.33±0.04	0.66±0.04	0.66±0.04	0.66±0.04
P (%)	0.23±0.03	0.30±0.03	0.30±0.03	0.30±0.03
Cu (mg/kg)	0.05±0.01	0.13±0.02	0.13±0.02	0.13±0.02
Se (mg/kg)	0.001±0.01	0.30±0.01	0.60±0.01	0.006±0.01
Ca:P		2.2:1	2.2:1	2.2:1

Notes: SEM–Standard Error of Means. Roughage- *Brachiaria dictyoneura* grass aged 6 weeks. DM-Dry matter, CP-Crude protein, EE-Ether extract, CF-Crude fiber, ADF-Acid detergent fiber, NDF-Neutral detergent fiber, P-Phosphorus, Ca-Calcium, Cu-Copper, Se-Selenium.

Housing and feeding

The bucks were placed in individual metabolic cages with separated faecal and urine collection facilities. The feeder and drinker were provided in the cage. A 10-day adjustment period was allocated before the start of the trial. They were fed twice daily at 9:00 am and 3:00 pm. They were given the formulated pellet at first to ensure all bucks received the required amount of Se. Then, they were fed roughage in the evening. Drinking water was provided *ad libitum* throughout the trial.

Apparent nutrient digestibility

The amount of feed offered and feed residue was weighed daily. Every morning the faeces were collected and weighed daily, then pooled for 5 days. The offered feed, feed residue and faeces samples were dried at 60˚C in the oven for 48 h. Later, all samples were ground, placed in plastic bags and stored in the chiller at 2°C until analysed. All samples were analysed in triplicate for the analysis of DM, Ash, CP, CF, EE, ADF and NDF. The P, Ca, Cu and Se were analysed by ICP-MS. The apparent nutrient and mineral digestibility were calculated as described by McDonald et al. (2002):

Nutrient balance (%) =

$$\frac{[\text{Nutrient intake} - \text{Nutrient excreted (faeces + urine)}]}{\text{Nutrient intake}} \times 100$$

Nutrient balance

Urine collection and processing were as described by Sadi et al. (2015). The urine from each buck was collected at the same time as the faeces collection. The urine volume from each buck was measured using a measuring cylinder and recorded daily and added with sulphuric acid 10% (H_2SO_4) at a ratio of 1:14 to prevent urine sedimentation and to avoid urine odour. The urine was stored in the chiller at 2°C. Finally, urine samples from each buck were pooled for the 5 d. The sub-sample of the urine was analysed in triplicate for the nutrient in DM and CP; and minerals of P, Ca, Cu and Se using ICP-MS. The nutrient and mineral balance was calculated as described by McDonald et al. (2002):

Nutrient balance (%) =

$$\frac{[\text{Nutrient intake} - \text{Nutrient excreted (faeces + urine)}]}{\text{Nutrient intake}} \times 100$$

Total digestible nutrient (TDN) and metabolizable energy (ME)

TDN was generated based on data from the digestibility trial. The TDN (%) was calculated as described by McDonald et al. (2002):

TDN (%) = DCP (%) + DCF (%) + DNFE (%) + (DEE (%) x 2.25)

(Notes: DCP-Digestible crude protein, DCF-Digestible crude fiber, DNFE-Digestible nitrogen-free extractive, DEE- Digestible ether extract).

The ME values were calculated as described by McDonald et al. (2002):
ME (MJ ME/kg DM) = TDN (%) x 0.15104

(Note: MJ ME/kg DM is the amount of energy in megajoules produced for each kilogram of dry matter of that feed).

Statistical analysis

The IBM SPSS Statistics version 26 (2019) was used as a statistical tool. Values of apparent nutrient digestibility, nutrient balance, TDN and ME were analysed using a One-way of Analysis of Variance (ANOVA) and a post hoc test using the Duncan Multiple Range Test.

Results and Discussion

Apparent nutrient digestibility

The DMI, nutrient digestibility (%) and mineral digestibility (%) between the treatment groups is presented in Table 4. The DMI and DM digestibility (%) in the current study were not significantly affected (P>0.05) by Se supplementation. Previous research also showed that supplementation of 0.30 mg Se/kg DM did not affect (P>0.05) DM digestibility (%) of pregnant goats (Taheri et al., 2018) and rams (Liguang et al., 2011b). The DM digestibility (%) also was not significantly affected (P>0.05) by supplemented of 1 mg Se/kg DM in the Cashmere goats (Qin et al., 2011).

In the present study, DM digestibility (%) in the group supplemented with 0.30 mg Se/kg DM and 0.60 mg Se/kg DM were 58.41% and 60.43%, respectively as compared to 58.16% in the control group. The DM digestibility below 55% was considered poor based on studies on Dorper sheep (Norhayati, 2020). Hence, all treatment groups had moderate digestibility as their DM digestibility was above 55%. It was owing to the mixing of the protein-rich formulated pellet (14% CP) into the low-protein *Brachiaria dictyoneura* grass (8% CP). The activity of microorganisms may perhaps increase due to enhance protein intake (Jolly, 2013) and believed that the Se supplementation might improve the metabolism of nutrients such as CP (Taheri et al., 2018), where the availability and utilization of metabolic N caused the reduction of N loss via urine.

The digestibility (%) of ash, CP, EE, CF, ADF and NDF were significantly affected (P<0.05) by Se supplementation at 0.60 mg Se/kg DM. The digestibility (%) of CP was significantly affected (P<0.05) by Se supplementation at 0.30 mg Se/kg DM. These findings were in agreement with Taheri et al. (2018), who reported that the Se supplementation had a significant effect (P<0.05) on EE digestibility (%) in pregnant goats. The Se supplementation had a significant effect (P<0.05) also on the digestibility (%) of OM, CP, EE, ADF and NDF in rams (Liguang et al., 2011b). In Sohagi rams, Se supplementation had a significant effect (P<0.05) on the digestibility (%) of OM, CP and EE (Hafez et al., 2016). In dairy cows, digestibility (%) of OM, CP, EE, ADF and NDF were significantly affected (P<0.05) by Se supplementation (Wang et al., 2009). However, the result in this study was contradicting to research on Katjang bucks (Aghwan et al., 2016) Cashmere goats (Qin et al., 2011) and rams (Kumar et al., 2008). They reported no significant effect (P>0.05) of Se supplementation on nutrient digestibility (%). The variation in the response could be due to varying forms of Se supplementation used (Wang et al., 2009). Additionally, significant improvement in nutrient digestibility (%) was obtained from animals supplemented with organic Se (Hafez et al., 2016; Liguang et al., 2011b; Taheri et al., 2018; Wang et al., 2009) than those fed with inorganic Se (Aghwan et al., 2016; Kumar et al., 2008). According to Liguang et al. (2011b), organic Se had increased the rumen microbes population, thus improving the rumen fermentation, leading to an increase in nutrient digestibility (%). The organic Se had improved the microbial protein synthesis in the rumen and resulted in increased digestibility of CP (Hafez et al., 2016).

The basal diet is likely to meet the nutrient demand of the rumen microbes. Hence, it had improved the digestibility of low-quality forage in the basal diet (Reinhardt & Faris, 2014). This condition had resulted in increased NDF digestibility

(%) more than the ADF digestibility (%). The use of Se supplementation at 0.60 mg Se/kg DM gave a positive effect to improve the fiber digestion than Se supplementation at 0.30 mg Se/kg DM and unsupplemented Se (the control group).

The digestibility (%) of P, Ca and Cu were significantly affected (P<0.05) by Se supplementation at 0.60 mg/kg DM. The Se digestibility (%) was significantly influenced (P<0.05) by both Se levels in this study. There was limited information on the mineral digestibility (%) in goats. Faecal Se was higher (0.71 mg/kg) when Katjang bucks were fed with Se (Aghwan et al., 2016). However, Se digestibility (%) was not indicated. Low Se digestibility (%) in those animals is likely, as Se excretion is high. It could be the Se content (0.124 mg/kg DM) in their basal diet that had fulfilled the Se requirement of the goats. Se digestibility (%) in the present study was higher (99.21% and 98.38%) when bucks were supplemented with 0.60 mg Se/kg DM and 0.30 mg Se/kg DM, respectively. This is highly related to Se deficiency in the basal diet.

Table 4. Total dry matter intake (DMI) (kg/d), apparent nutrient digestibility (%) and mineral digestibility (%) between treatment groups (±SEM)

Parameters	Treatments			Significance
	Group A (n=3)	Group B (n=3)	Group C (n=3)	
Total DMI (kg/d)	$0.92±0.01^{a}$	$0.95±0.00^{a}$	$0.92±0.01^{a}$	NS
Nutrient digestibility (%)				
DM	$58.41±0.43^{a}$	$60.43±0.17^{a}$	$58.16±2.64^{a}$	NS
Ash	$41.36±2.03^{ab}$	$45.13±1.31^{b}$	$37.31±1.64^{a}$	*
CP	$74.37±0.05^{b}$	$74.96±1.12^{b}$	$71.53±0.68^{a}$	*
EE	$73.06±2.28^{ab}$	$77.08±2.02^{b}$	$67.89±2.38^{a}$	*
CF	$53.76±0.76^{a}$	$59.90±0.23^{b}$	$52.05±1.34^{a}$	*
ADF	$54.59±1.64^{a}$	$59.34±0.22^{b}$	$53.85±1.41^{a}$	*
NDF	$64.95±0.77^{ab}$	$68.76±0.17^{b}$	$63.72±2.04^{a}$	*
Mineral digestibility (%)				
P	$70.17±1.53^{a}$	$77.58±1.85^{b}$	$69.25±2.64^{a}$	*
Ca	$71.11±0.46^{a}$	$74.88±0.54^{b}$	$70.19±0.77^{a}$	*
Cu	$58.90±1.27^{ab}$	$61.54±0.80^{b}$	$55.85±0.94^{a}$	*
Se	$98.38±0.02^{b}$	$99.21±0.00^{b}$	$24.45±3.05^{a}$	*

Notes: [a,b] means in the same row with different superscript are significantly different (p<0.05), NS-Not significant (p>0.05), *-Significant at (p<0.05), SEM–Standard error of the mean. Group A-Supplemented with 0.30 mg organic Se/kg DM, Group B-Supplemented with 0.60 mg organic Se/kg DM, Group C-No Se supplementation (control). DM-Dry matter, CP-Crude protein, EE-Ether extract, CF-Crude fiber, ADF-Acid detergent fiber, NDF-Neutral detergent fiber, P-Phosphorus, Ca-Calcium, Cu-Copper, Se-Selenium, n= number of animals.

Nutrient balance

The results of nutrient balance (%) and mineral balance (%) between treatment groups are shown in Table 5. There was no significant effect (P>0.05) of Se supplementation on DM balance (%). Se supplementation at 0.60 mg/kg DM had a significant effect (P<0.05) on CP balance (%) in Boer bucks. The finding in this study is in agreement with Taheri et al. (2018), who stated that supplementation of organic Se in pregnant goats significantly reduced N excretion via faeces and urine, thus increasing their CP balance (%). In different studies, Qin et al. (2011) reported no significant effect (P>0.05) of Se supplementation on CP balance (%) in rams. However, the authors did not mention the source of Se used. The use of organic Se had enhanced cellulolytic bacteria resulted in increased synthesis of protein in the rumen, thus enhancing the absorption and retention of CP in ruminants (Wang et al., 2009).

Table 5. Nutrient balance (%) and mineral balance (%) between treatment groups (±SEM)

Parameters	Treatments: Group A (n=3)	Group B (n=3)	Group C (n=3)	Significance
Nutrient balance (%)				
DM	55.72 ± 0.24^{a}	58.23 ± 0.61^{a}	55.27 ± 2.65^{a}	NS
CP	60.75 ± 0.77^{a}	65.75 ± 0.94^{b}	58.26 ± 0.33^{a}	*
Mineral balance (%)				
P	59.79 ± 3.54^{ab}	67.22 ± 1.86^{b}	53.95 ± 1.54^{a}	*
Ca	58.73 ± 2.62^{ab}	63.86 ± 4.62^{b}	51.69 ± 1.12^{a}	*
Cu	54.08 ± 1.57^{a}	58.22 ± 0.56^{b}	50.96 ± 0.72^{a}	*
Se	98.11 ± 0.04^{b}	99.12 ± 0.01^{c}	14.25 ± 2.50^{a}	*

Notes: ^{a,b,c} means in the same row with different superscript are significantly different (p<0.05), NS-Not significant (p>0.05), *-Significant at (p<0.05), SEM–Standard error of the mean. Group A-Supplemented with 0.30 mg organic Se/kg DM, Group B-Supplemented with 0.60 mg organic Se/kg DM, Group C-No Se supplementation (control). DM-Dry matter, CP-Crude protein, P-Phosphorus, Ca-Calcium, Cu-Copper, Se-Selenium, n= number of animals.

The balance (%) of P, Ca, and Cu was significantly affected (P<0.05) by Se supplementation at 0.60 mg/kg. The balance (%) of Se was significantly influenced (P<0.05) by both Se levels in this study. There exists limited information on the effect of Se supplementation on mineral balance (%) in goats. In Tibetan sheep, Se balance (%) was significantly higher when organic Se was added to the basal diet (Zhaofeng et al., 2019). They also reported that supplementation of organic Se had significantly reduced Se excretion via faeces and urine. After Se is absorbed in the small intestine, it will be transported to the liver (Bano et al., 2018). From the liver, Se will be distributed to all tissues and organs in the body, mostly in muscle and organs such as the heart, brain, kidneys, pancreas and testis. When Se travels to the kidneys, it will be excreted via urine. Organic Se was less retained in the kidneys compared to inorganic Se (Liguang et al., 2011). Therefore, organic Se will be less excreted via urine.

Total digestible nutrient (TDN) and metabolizable energy (ME)

The TDN (%) and ME (MJ ME/kg DM) between treatment groups are shown in Table 6. Based on the data generated from the digestibility trial, there were significant differences (P<0.05) in TDN (%) between treatment groups. The bucks supplemented with 0.60 mg Se/kg DM were recorded highest in the TDN (%) (53.62) as compared to the bucks supplemented with 0.30 mg Se/kg DM (52.00) and the control group (50.97). All of these TDN values were not meeting the energy requirement for a Boer buck as the values were lower than 60% (Luginbuhi, 2015). The ME values (MJ ME/kg DM) was significantly higher (P<0.05) in the bucks supplemented with 0.60 mg Se/kg DM (8.10) as compared to the bucks supplemented with 0.30 mg Se/kg DM (7.85) and the control group (7.70). This finding was also in agreement with Taheri et al. (2018), who reported that Se supplementation had a significant effect (P<0.05) on the dietary ME concentration in the pregnant goats.

In the present study, the ME value in the group supplemented with 0.60 mg Se/kg DM is comparable to the value of 8.71 MJ ME/kg DM, which is only meeting the energy requirement for maintenance of a 60 kg adult goat. Thus, for a matured buck weighing between 60 kg to 70 kg live weight, the energy content of the ration needs to be increased further to a minimum of 9.0 MJ ME /kg DM, which is also equivalent to a TDN of 60%. Increased ME by supplementing with 0.60 mg Se /kg DM though still not meeting the energy requirement of matured bucks, could increase the total volatile fatty acids (VFA) in the rumen as the main energy source for ruminants (Wang et al., 2009).

Table 6. TDN (%) and ME (MJ ME/kg DM) between treatment groups (±SEM)

Parameters	Treatments			Significance
	Group A (n=3)	Group B (n=3)	Group C (n=3)	
TDN (%)	52.00±0.23^{a}	53.62±0.19^{b}	50.97±0.72^{a}	*
ME (MJ ME/kg DM)	7.85±0.03^{a}	8.10±0.03^{b}	7.70±0.11^{a}	*

Notes: ^{a,b} superscript are significantly different (p<0.05) in the same row, *-Significant at (p<0.05), SEM–Standard error of the mean. Group A-Supplemented with 0.30 mg organic Se/kg DM, Group B-Supplemented with 0.60 mg organic Se/kg DM, Group C-No Se supplementation (control), n= number of animals.

Conclusion

The limited effect of Se supplementation at 0.3 mg/kg DM was observed. Supplementation of Se at 0.3 mg/kg DM only increased the digestibility (%) of CP and Se and the Se balance (%). The lack of responses in Boer bucks is understandable as the level of supplemented Se was within the adequacy range of 0.10 mg/kg DM to 0.30 mg/kg DM. For two years old Boer, the appropriate level of dietary Se supplementation is at 0.60 mg/kg DM. Se supplementation at 0.60 mg/kg DM had increased the digestibility of nutrients in the Boer bucks. Se supplementation at 0.60 mg/kg had increased the digestibility (%) of ash, CP, EE, CF, ADF, NDF, P, Ca, Cu and Se, as well as CP, P, Ca, Cu and Se balances. It also had increased the dietary TDN (%) and ME. The energy content of the basal diet needs to be increased further to meet the daily requirement of matured bucks.

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