Short communication

Effect of dietary cobalt supplementation on plasma and rumen metabolites in Mehraban lambs

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Article info

Article history:
Received 6 October 2009
Received in revised form 18 January 2010
Accepted 16 February 2010
Available online 19 March 2010

Keywords:
Mehraban lambs
Cobalt
Performance
Nutrient digestibility

Abstract

Two experiments were conducted to study the effects of different levels of dietary cobalt on performance, plasma and rumen metabolites and nutrient digestibility in Mehraban male lambs. Experiment 1: 28, 8–9-month-old lambs were randomly divided into four groups. Animals were fed a basal diet containing 0.088 mg Co/kg DM and were supplied with 0 (control), 0.25, 0.50, or 1.00 mg Co/kg DM as reagent grade CoSO4·7H2O. The experiment lasted for 70 days. Experiment 2: four lambs from each group in Experiment 1 were randomly allocated to the individual metabolic crates to measure the effects of dietary Co on nutrient digestibility. Final body weight, average daily gain and gain efficiency were higher (p < 0.05) in the group supplemented with 0.50 mg Co/kg DM compared to other groups. Plasma glucose and vitamin B12 concentrations increased (p < 0.05) at all levels of Co supplementation on day 68 of the experiment and for vitamin B12 were higher (p < 0.05) at 0.50 and 1.00 mg Co/kg DM compared to 0.25 mg Co/kg DM. There was no significant difference among treatments for TVFA and ruminal fluid pH. Digestibility of dry matter, organic matter, crude protein and neutral detergent fiber increased (p < 0.05) by Co supplementation, but did not differ among Co supplied treatments. The obtained results showed that lambs fed the control diet containing 0.088 mg Co/kg DM had a reduced appetite and gained less than the supplemented animals, suggesting that the level of 0.088 mg Co/kg DM was inadequate for normal growth of Mehraban male lambs, and a total level of 0.58 mg Co/kg DM might be optimum level for enhancing performance.

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1. Introduction

Cobalt (Co) has been demonstrated to be an essential nutrient for ruminants and is required by ruminal microorganisms for the synthesis of vitamin B12 (McDowell, 2000). In ruminants, a Co-induced vitamin B12 deficiency results in reduced intake and ADG (Wang et al., 2007), decreased plasma, liver and ruminal vitamin B12 (Tiffany and Spears, 2005), elevated plasma methylmalonic acid (MMA) and homocysteine (Stangl et al., 2000). Recent findings have demonstrated that 0.10 mg/kg DM of Co intake does not meet the rumen microbial requirements (Kisidayova et al., 2001; Johnson et al., 2004) and ADG, ADFI and nutrient digestibility had been increased in growing lambs when a diet with 0.086 mg Co/kg DM was supplemented with 0.50 mg Co/kg DM (Wang et al., 2007). Singh and Chhabra (1995) reported that 0.3–0.5 mg Co/kg DM enhanced ruminal microbial activity, fermentation and vitamin B12 synthesis. The effects of dietary Co concentration on growth, nutrient metabolism and ruminal microbial activity in Mehraban lambs are not well understood. Therefore, objectives of the present study were to determine effects of dietary Co levels on performance, plasma and
rumen metabolites, nutrient digestibility and microbial protein synthesis in Mehraban lambs.

2. Materials and methods

To conduct Experiment 1, 28 Mehraban male lambs 8–9-month-old with 37.1 ± 2.3 kg initial body weight were housed in individual pens (1.9 m × 1.1 m) and fed a basal diet containing 0.088 mg Co/kg DM. The basal diet was formulated to meet or exceed all nutrient requirements with the exception of Co (NRC, 1985). Diets were offered twice a day. After a 2-week adjustment period to the experimental feeding system, lambs were weighed and randomly assigned to four treatments with seven each. No differences were observed among treatments in terms of body weights. At the end of the growing period four lambs from each group were randomly selected and allocated to individual metabolism crate to study the effects of dietary Co on apparent nutrient digestibility for the Experiment 1. Daily fecal output was weighed and 20% residual of diet and feces were collected and recorded. Lambs were fed the same diet as in Experiment 1. Daily fecal output was weighed and 20% was kept for subsequent analysis.

The Co concentrations in feeds and feces were determined using an atomic absorption spectrophotometer (PHILIPS Model PU9100, Solebay, Costa Mesa, CA, USA) and plasma glucose concentration by a commercial kit (Pars Azmon, Tehran, Iran). Content of volatile fatty acids was estimated in the laboratory by markham apparatus.

All traits were analyzed according to a completely randomized design. The model used for analysis was: $Y_{ij} = \mu + c_i + e_{ij}$, where $\mu$, $c_i$, and $e_{ij}$ are overall mean, level of cobalt and residual effects, respectively. Initial body weight was considered as a covariate for analysis of final body weight and average daily gain. Duncan’s multiple range test was used for comparison of means considering $\alpha = 0.05$. The GLM procedure of SAS (SAS Institute, 2004) was used for analysis of data.

3. Results

3.1. Performance

Final body weights, ADG, ADFI, and gain efficiency are shown in Table 1. Final BW, ADG, ADFI, and gain efficiency were improved ($p < 0.05$) by Co supplementation. Final BW, ADG and gain efficiency were higher ($p < 0.05$) in the treatment group supplemented with 0.50 mg Co/kg DM compared to other groups. There was no difference in ADFI among Co supplemented groups ($p < 0.05$).

3.2. Vitamin B12 and glucose

There was no significant difference in plasma vitamin B12 concentration on day 0 among treatments (Table 1). Plasma vitamin B12 concentrations on day 68 of the experiment increased ($p < 0.05$) at all levels of Co supplementation. Plasma glucose concentrations differed only on day 68 of the experiment ($p < 0.05$) and increased at all levels of Co supplementation.

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Effects of dietary Co supplementation on plasma metabolites and performance of lambs.</td>
</tr>
<tr>
<td>Co supplemental levels (mg/kg)</td>
</tr>
<tr>
<td>Vitamin B12 (pmol/L)</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
</tr>
<tr>
<td>Performance</td>
</tr>
<tr>
<td>Final BW (kg)</td>
</tr>
<tr>
<td>Gain:feed</td>
</tr>
<tr>
<td>ADG (g)</td>
</tr>
<tr>
<td>ADFI (g/day)</td>
</tr>
<tr>
<td>Gain:feed</td>
</tr>
</tbody>
</table>

Means within the same row with different letters are significantly different ($p < 0.05$).

<table>
<thead>
<tr>
<th>Table 2</th>
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<tbody>
<tr>
<td>Effects of dietary Co supplementation on ruminal fluid pH and TVFA.</td>
</tr>
<tr>
<td>Co supplemental levels (mg/kg)</td>
</tr>
<tr>
<td>TVFA (mmol/day)</td>
</tr>
<tr>
<td>Ruminal fluid pH</td>
</tr>
<tr>
<td>Gain:feed</td>
</tr>
</tbody>
</table>

Means within the same row with different letters are significantly different ($p < 0.05$).
4.2. Vitamin B12 and glucose

The results of the present study indicate that there were no differences in TVFA production and ruminal fluid pH between treatments (p > 0.05). Similar to our results, Kisidayova et al. (2001) found the supplementation of Co had no effects on TVFA production. Adding large amounts (5.0 or 10.0 mg/kg) of Co to cultures did not affect TVFA in vitro (Hussein et al., 1994).

4.4. Digestibility of nutrients

The results in nutrient digestibility were consistent with the findings of Kadim et al. (2003) who reported that low levels of dietary Co in goats resulted in lower apparent nutrient digestibility compared to goats supplemented with parenteral injections of vitamin B12. Similarly, Wang et al. (2007) observed that a 0.50 mg Co/kg DM addition to a basal diet containing 0.08 mg Co/kg DM increased ADFi by Chinese Poll Dorset × Small Tailed Han lambs. These results suggest a higher Co requirement of lambs than recommended by NRC (1985) (i.e., 0.10–0.20 mg Co/kg DM).

4. Discussion

4.1. Performance

As the obtained results showed a level of 0.088 mg Co/kg DM fed to the lambs was inadequate and Co supplementation increased lambs performance. It was supported by Johnson et al. (2004) who indicated that Omani goats fed with diet containing 0.12 mg Co/kg DM exhibited slower growth rate. When steers were fed a diet moderately Co-deficient (0.04–0.05 mg/kg of DM), intake, ADG, and gain efficiency were decreased relative to Co supplemented steers (Tiffany et al., 2002). The present study showed that maximum growth rate in Mehraban lambs was achieved at a level of 0.50 mg/kg DM Co supplementation. Similar to our results, Wang et al. (2007) reported that a 0.50 mg Co/kg DM addition to a basal diet containing 0.08 mg Co/kg DM increased ADG and ADFi by Chinese Poll Dorset × Small Tailed Han lambs. These results suggest a higher Co requirement of lambs than recommended by NRC (1985) (i.e., 0.10–0.20 mg Co/kg DM).

4.2. Vitamin B12 and glucose

Results of the present study showed that control lambs were deficient in Co because the plasma values for vitamin B12 was below normal level (220 pmol/L) on day 68 of the experiment. Plasma vitamin B12 concentrations decreased when sheep (Kennedy et al., 1991) and cattle (Stangl et al., 1999) are fed Co-deficient diets. The results in plasma glucose concentration was in agreement with Tiffany and Spears (2005) who indicated that addition of supplemental Co to the basal diets increased (p < 0.01) plasma glucose concentrations of steers. Feeding diets severely deficient in Co (0.004 mg of Co/kg) to sheep caused an immediate (within 3 days) and dramatic increase in ruminal fluid succinate and a decline in ruminal propionate concentration (Kennedy et al., 1991). Considering propionate as major precursor of glucose in fed ruminants, lower proportions of ruminal propionate might be the reason for lower blood glucose concentration seen in the control group. Also considering importance of propionate as an energy source lowered performance is an expected result. It appears that the basal diet in the present experiment containing 0.088 mg Co/kg DM was no adequate for optimum vitamin B12 synthesis and glucose formation in the Mehraban lambs and supplemental 0.50 mg Co/kg DM seems to be optimum level for enhanced plasma vitamin B12 concentration in Mehraban lambs.

Table 3

Table 3, Effects of dietary Co supplementation on apparent nutrient digestibility in lambs (DM basis).

<table>
<thead>
<tr>
<th>Item</th>
<th>Co supplemental levels (mg/kg)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0.25</td>
</tr>
<tr>
<td>DM</td>
<td>65.02 ± 2.26</td>
<td>68.97 ± 2.20</td>
</tr>
<tr>
<td>OM</td>
<td>66.47 ± 2.91</td>
<td>70.85 ± 2.20</td>
</tr>
<tr>
<td>CP</td>
<td>61.12 ± 2.24</td>
<td>66.59 ± 3.33</td>
</tr>
<tr>
<td>EE</td>
<td>65.91 ± 3.26</td>
<td>68.52 ± 2.17</td>
</tr>
<tr>
<td>NDF</td>
<td>45.11 ± 4.39</td>
<td>51.73 ± 4.31</td>
</tr>
<tr>
<td>NFC</td>
<td>89.35 ± 3.19</td>
<td>91.62 ± 2.69</td>
</tr>
</tbody>
</table>

Means within the same row with different letters are significantly different (p < 0.05).
apparent nutrient digestibility compared to lambs supplemented with Co. The lower digestibility of the control group is likely due to several factors. Cobalt deficient diets have been indicated to reduce the number of rumen microorganisms (Marston and Smith, 1952), leading to lower rumen digestibility (Kadim et al., 2003).

5. Conclusion

A diet containing 0.088 mg Co/kg DM did not meet the Co requirement of Mehraban lambs during the growing period. Based on growth performance, nutrient digestibility and plasma vitamin B12 concentration an addition of 0.50 mg Co/kg DM to the diet (total of dietary Co 0.58 mg/kg DM) will meet the Co requirement of Mehraban lambs.

References


