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Utilization of Micro-Organic Minerals in Feed Based on Agroindustry by Products to Improve Ruminant Production

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Abstract: The aims of this research were to evaluate the effects of feed supplementation with organic minerals (Zn, Cu, Se and Cr organic/micro-organic) on nutrient digestibility and ruminant performance. The research used four cattle breeds and a Latin square design. Four treatments and four replications were applied: R0 = basal feed; R1 = R0 + micro-organic minerals: 20 ppm Zn, 5 ppm Cu, 0.05 ppm Se and 0.15 ppm Cr-organic; R2 = R0 + micro-organic minerals: 40 ppm Zn, 10 ppm Cu, 0.10 ppm Se and 0.30 ppm Cr-organic and R3 = R0 + micro-organic minerals: 60 ppm Zn, 15 ppm Cu, 0.15 ppm Se and 0.45 ppm Cr-organic. The treatments had no significant effect on the rumen parameter values of NH_3 or volatile fatty acids (VFAs) which were 4-12 mM and 70-150 mM, respectively, consistent with recommended values. Similarly, the treatments had no significant effects on nutrient digestibility (organic matter, dry matter, protein and crude fiber). Among the treatments, R2 yielded the highest digestibility for all nutrient types. The rates of gain were 0.68 kg/head/day for the basal treatment and 0.78, 0.8 and 1.2 kg/head/day for the organic mineral treatments. The values of feed efficiency increased with increasing organic mineral levels and were 0.22, 0.23, 0.25 and 0.30 for R0, R1, R2 and R3, respectively.

Key words: Organic mineral, digestibility, agroindustry by-product

INTRODUCTION

The bioprocesses of the rumen and postrumen can be optimized if the nutritional balance and all precursor microbial needs are met. However, bioprocessing in the rumen and postrumen relies on the availability of minerals (macro and micro-minerals). Many factors can decrease the availability of minerals including fatty acids, crude fiber and the as interactions among minerals in the digestive tract (Muhtarudin, 2003; Muhtarudin and Liman, 2006).

Supplementation with organic minerals can support bioprocessing in the rumen and postrumen by (increasing the microbial population and improving the absorption of nutrients). Rincker *et al.* (2005) reported that dietary Zn or Fe additions increase the mineral status of nursery pigs. Following tissue uptake of minerals, dietary minerals in excess of the body's requirements are excreted. Furthermore, supplementation with minerals has a positive effect on growth rates. Rojas *et al.* (1995) compared utilization among Zn-lysine, Zn-methionine and $ZnSO_4$ and found that Zn-lysine was more readily absorbed than the other Zn sources. Muhtarudin (2005) reported that the utilization of organic Zn (Zn-lysinate, Zn-PUFA, lysine-Zn-PUFA, Zn-proteinat) could increase protein metabolism and animals performance. Ahola *et al.* (2004) reported that the mineral source may influence the pregnancy rate from artificial insemination (AI). They further reported that the mass of calves weaned per cow was greater in controls than in supplemented cows and tended to be greater in organic (Cu, Zn and Mn-organic) than inorganic ($CuSO_4$, $ZnSO_4$, $MnSO_4$) mineral treatments. In addition, organic Zn was found to improved feed metabolism and potentially increase nitrogen retention (Fathul *et al.*, 2003)

Supplementation with Zn-lysinate or Zn-proteinate had a positive effect on the growth rate and nutrient parameters of animals, but supplementation with Cu-lysinate caused a deacrease in growth. However, Cu-proteinate resulted in the most growth in lambs. Therefore, Cu supplementation might best be administered in the proteinate form (Sutardi, 2001). Pechova *et al.* (2009) reported that supplementation with different forms of zinc did not influence the concentration of Zn in milk but did significantly influence the Zn concentration in blood plasma.

The NRC (1988) has recommended Zn and Cu dietary concentration of 50 ppm and 10 ppm, respectively per day for beef cattle. The biological function of Cu is to bind ceruloplasmin, an antioxidant that protects against free oxygen-radicals. Dismutase superoxide serves as a catalyst in dismutase-converted hydrogen and oxygen (Harmon and Torre, 1997). Another important micro-mineral is selenium (Se). The selenium content of feed is generally not known and its biological availability varies widely. Selenium with tocopherol deficiency caused exudative diathesis in poultry, white muscle disease in

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lambs and infertility in dairy cows (Arthur, 1997). The best sources of selenium, with an availability of up to 74%, is sodium selenate (Cantor, 1997). It has been proposed that dairy cow feed contain 300 mg Se/ton dry matter (NRC, 1988). Lactose is a sugar found in milk. The main precursor of lactose is glucose and major precursor of glucose is propionic acids, which is produced by rumen microbial fermentation. Propionic acids enter alveolus cells in glucose form. Chromium (Cr) mineral could improve the ability of glucose to enter alveolus cells for conversion to lactose. Chromium is a glucose tolerance factor (GTF) (Schwarz and Mertz, 1959). GTF-chromium linkage improves insulin bonding by cell membrane receptors.

MATERIALS AND METHODS

This research used four cattle breeds in a Latin square design consisting of four treatments and four replications:

R0 = Basal feed (20% forage + 80% concentrate)
R1 = Basal feed + micro-organic minerals: 20 ppm Zn, 5 ppm Cu, 0.05 ppm Se, 0.15 Cr-organic
R2 = Basal feed + micro-organic mineral: 40 ppm Zn, 10 ppm Cu, 0.10 ppm Se, 0.30 Cr-organic
R3 = Basal feed + micro-organic mineral: 60 ppm Zn, 15 ppm Cu, 0.15 ppm Se, 0.45 Cr-organic

The basal feed consisted of processed agroindustry by-products including corn silage, rice bran, hydrolyzed feather meal, hydrolyzed shrimp by-product, cassava leaf silage, cassava flour waste, corn stalks and coffee seed hulls.

The research parameters consisted of nutrient digestibility measured using the total collection method (dry matter, protein, organic matter and crude fiber); volatile fatty acids (VFAs) measured using the steam distillation method and rumen ammonia fluid measured using the Conway microdiffusion technique.

RESULTS AND DISCUSSION

An analysis of variance revealed that the rumen parameter of ammonia rumen fluid and the volatile fatty acids did not differ significantly among the treatments. The values of rumen ammonia were between 9.35 and 11.00 mM and within the recommended range of 4-11 mM. The VFA values in the treatments were between 107.5 and 140 mM, within the recommended range for microbial growth (70-150 mM).

The results indicated that the treatments with supplemental micro-organic minerals yielded more VFAs and rumen NH_3 than did the basal feed. Higher levels of VFAs and NH_3 might have been due to an increase in the rumen microbial population. Rumen microbes require micro-minerals for their metabolism and the presence of such minerals may have increased the bioprocessing efficiency.

An analysis of variance showed that there was no significant effect of treatment on nutrients digestibility. R2 had the highest values of digestibility (crude fiber, protein, organic matter and dry matter). The treatments with micro-organic minerals may have improved the amino acid balance of lysine, resulting in an increase in protein digestibility. The research finding are summarized in Table 1.

According to an analysis of variance, there was a significant effect of treatment on daily gain. The separation of means based on the least significant difference test revealed that, R3 had a significantly greater effect on daily gain than did the others treatments, but that the effects of R0, R1 and R2 did not significantly differ from one another. Supplementation with organic micro-mineral (Zn, Cu, Cr, Se) had many effects on protein and energy metabolism, including increased metabolism in both the rumen and the microbes. These increases improved production efficiency as shown by the increases in daily gain and feed efficiency. The rate of daily gain was 0.68 kg/head/day for basal feed and 0.78, 0.8 and 1.2 kg/head/day for R1, R2 and R3, respectively.

The feed efficiency increased with the combined increase in organic micro-mineral levels (0.22, 0.23, 0.25 and 0.35 for R0, R1, R2 and R3, respectively).

Table 1: Effect of treatments on rumen parameters, digestibility and daily gain

	Treatment			
Parameter	R0	R1	R2	R3
NH_3 (mM)	9.35	9.61	10.36	11.00
VFA (mM)	107.50	120.00	127.50	140.00
Dry matter digestibility (%)	83.18	83.56	84.96	80.80
Organic matter digestibility (%)	80.41	80.55	82.01	80.59
Protein digestibility (%)	77.16	77.77	80.56	79.54
Crude fiber digestibility (%)	77.15	78.12	78.47	77.61
Feed consumption (kg/head/day)	6.56	6.88	7.12	7.19
Daily gain (kg/head/day)	0.68	0.78	0.85	1.2
Feed efficiency	0.020	0.023	0.024	0.032

R0 = Basal feed (20% forage + 80% concentrate)
R1 = Basal feed + micro-organic minerals: 20 ppm Zn, 5 ppm Cu, 0.05 ppm Se, 0.15 Cr-organic
R2 = Basal feed + micro-organic minerals: 40 ppm Zn, 10 ppm Cu, 0.10 ppm Se, 0.30 Cr-organic
R3 = Basal feed + micro-organic minerals: 60 ppm Zn, 15 ppm Cu, 0.15 ppm Se, 0.45 Cr-organic

Conclusion: There was no significant effect of treatment on the rumen parameters of NH_3 and VFAs and the treatments yielded values within the recommended ranges for ammonia (4-12 mM) and VFAs (70-150 mM). There was no significant effect of treatment on any of the digestibility parameters (organic matter, dry matter protein and crude fiber). The highest digestibility values were observed for the R2 treatment. The daily gain of the cattle was affected by supplementation with organic micro-minerals. The daily gain was 0.68 kg/head/day for the basal feed treatment and 0.78, 0.8 and 1.2 kg/head/day for the supplemental organic-mineral treatments R1, R2 and R3, respectively. The value of feed efficiency was 0.22, 0.23, 0.25 and 0.30 for R0, R1, R2 and R3, respectively; i.e., this value increased with the increase in organic mineral levels.

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