SUPLEMENTASI SE DAN ZN ORGANIK PADA SAPI PERAH TERHADAP KARAKTERISTIK FERMENTASI RUMEN,PRODUKSI, DAN KUALITAS SUSU SERTA POTENSINYA SEBAGAI IMMUNODULATOR

INTISARI

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Trace mineral (TM), seperti selenium (Se) dan zinc (Zn), diketahui memiliki peran spenting sebagai antioksidan dan ko-faktor baik bagi mikrobia rumen maupun ternak inang. Penelitian ini terdiri dari empat tahap, dengan **tujuan umum** yaitu untuk mengevaluasi suplementasi kombinasi mineral Se dan Zn organik terhadap mikrobiom rumen, karakteristik fermentasi rumen, produktivitas sapi perah awal laktasi, serta potensi produk susu yang dihasilkan sebagai immonodulator. **Penelitian I** terdiri dari suplementasi Se organik: CON-S = pakan basal + premix (kontrol), Low-Se = CON-S + Se 0,15 mg/kg, Med-Se = CON-S + Se 0,30 mg/kg, High-Se = CON-S + Se 0,45 mg/kg. Suplementasi Zn organik: CON-Z = pakan basal + premix (kontrol), Low-Zn = CON-Z + Zn 30 mg/kg, Med-Zn = CON-Z + Zn 60 mg/kg, dan High-Zn = CON-Z + Zn 90 mg/kg. **Penelitian II** terdiri dari CON = pakan basal tanpa suplementasi TM, SZ-1 = Se 0,30 mg/kg BK + Zn 60 mg/kg BK, SZ-2 = Se 0,45 ppm + Zn 60 mg/kg BK, SZ-3 = CON + Se 0,30 mg/kg BK + Zn 90 mg/kg BK (SZ-3), dan SZ-4 = CON + Se 0,45 mg/kg BK + Zn 90 mg/kg BK. **Penelitian III** dilakukan secara *in vivo*, dengan menggunakan 24 ekor sapi perah awal laktasi. Ternak dibagi ke dalam tiga kelompok perlakuan meliputi: CON = *current feeding system*, FS = CON + *feed supplement* 1 kg/ekor/hari, FS-SZ = CON + *feed supplement enriched* Se-Zn 1 kg/ekor/hari (Se = 0,45 mg/kg BK, Zn = 60 mg/kg BK). Pengamatan dilakukan selama 49 hari (7 minggu). **Penelitian IV** meliputi T1 = tikus sehat tanpa susu, T2 = tikus sehat + susu standar, T3 = tikus sehat + susu tinggi Se-Zn, T4 = tikus malnutrisi tanpa susu, T5 = tikus malnutrisi + susu standar, T6 = tikus malnutrisi + susu tinggi Se-Zn.

Hasil **penelitian I** menunjukkan bahwa suplementasi Se organik pada dosis 0,30 dan 0,45 mg/kg dan atau/ Zn organik pada dosis 60 dan 90 mg/kg meningkatkan aktivitas enzim CMC-ase, amilase, dan protease dibandingkan dengan kontrol ($P<0,05$). Meskipun tidak mempengaruhi pH cairan rumen dan rasio A/P, suplementasi Se organik pada dosis 0,30-0,45 mg/kg dan Zn organik pada dosis 60-90 mg/kg secara signifikan meningkatkan kadar total VFA dan protein mikrobia rumen ($P<0,05$). Suplementasi tersebut juga memberikan peningkatan terhadap kecernaan BK, BO, PK, dan SK ($P<0,05$). Hasil **penelitian II** menunjukkan bahwa perlakuan SZ-2, SZ-3, dan SZ-4 meningkatkan aktivitas enzim CMC-ase, amilase, protease, kadar total VFA, propionat, dan protein mikrobia dibandingkan kelompok CON dan SZ-1 ($P<0,05$), sedangkan kadar butirat, rasio A/P, dan NH_3 mengalami penurunan ($P<0,05$). Analisis mikrobia rumen melalui sekuensing 16S rRNA menunjukkan bahwa suplementasi kombinasi Se dan Zn organik tidak memberikan perubahan terhadap *diversity* ($P>0,05$) namun mempengaruhi *abundance* mikrobia rumen pada beberapa filum dan genus ($P<0,05$).

Penelitian III menunjukkan bahwa perlakuan FS dan FS-SZ meningkatkan produksi susu dibandingkan dengan CON ($P<0,05$). Penggunaan *feed supplement*

enriched with Se-Zn organik meningkatkan kandungan Se dan Zn dalam susu dan serum, serta meningkatkan kadar GSH-Px, SOD, dan T-AOC (P<0,05). Tidak terjadi perubahan pada profil biokimia darah maupun hematologi darah, kecuali adanya peningkatan kadar AST dan BUN pada perlakuan FS dan FS-SZ serta adanya peningkatan WBC pada perlakuan FS-SZ. Hasil **penelitian IV** menunjukkan bahwa selama periode re-nutrisi (minggu 3-6), susu tinggi Se-Zn meningkatkan indeks stimulasi supernatan hasil kultur limfosit serta kadar IL-10 dibandingkan dengan susu standar atau tanpa pemberian susu di antara kelompok malnutrisi (P<0,05). Suplementasi tersebut juga meningkatkan kadar serum IgG dan IgM pada kelompok tikus malnutrisi (P<0,05). **Kesimpulan** dari penelitian ini yaitu kombinasi Se dan Zn organik dapat memodulasi mikrobia rumen dan karaktersitik fermentasi rumen, dan aplikasi penggunaan *feed-supplement enriched with* Se-Zn organik dapat meningkatkan produktivitas sapi perah awal laktasi, serta kadar Se-Zn dalam susu, dimana produk susu tinggi Se-Zn tersebut dapat berperan sebagai immunodulator pada tikus malnutirisi.

Kata kunci : mikrobia rumen, produksi susu, immunodulator, selenium, suplemen, zinc.

The Effect of Organic Selenium and Zinc Supplementation in Dairy Cows on Rumen Fermentation Characteristics, Milk Production and Quality, and the Potential of Milk as an Immunomodulator

ABSTRACT

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Trace minerals (TM), such as selenium (Se) and zinc (Zn), are known to play significant roles as antioxidants and cofactors for both rumen microbiota and animal hosts. This study consists of four phases, with the primary objective of evaluating the effects of organic Se and Zn mineral supplementation on rumen microbiome, rumen fermentation characteristics, early-lactating dairy cows productivity, and the potential of the milk produced as an immunomodulator. **Phase I** involved supplementation of organic Se: CON-S = basal feed + premix (control), Low-Se = CON-S + Se 0.15 mg/kg, Med-Se = CON-S + Se 0.30 mg/kg, High-Se = CON-S + Se 0.45 mg/kg. For organic Zn supplementation: CON-Z = basal feed + premix (control), Low-Zn = CON-Z + Zn 30 mg/kg, Med-Zn = CON-Z + Zn 60 mg/kg, High-Zn = CON-Z + Zn 90 mg/kg. **Phase II** consisted of: CON = basal feed without TM supplementation, SZ-1 = Se 0.30 mg/kg DM + Zn 60 mg/kg DM, SZ-2 = Se 0.45 mg/kg DM + Zn 60 mg/kg DM, SZ-3 = CON + Se 0.30 mg/kg DM + Zn 90 mg/kg DM, and SZ-4 = CON + Se 0.45 mg/kg DM + Zn 90 mg/kg DM. **Phase III** was conducted *in vivo* using 24 early lactation dairy cows. The cows were divided into three treatment groups: CON = current feeding system, FS = CON + feed supplement 1 kg/cow/day, FS-SZ = CON + feed supplement enriched with Se-Zn 1 kg/cow/day (Se = 0.45 mg/kg DM, Zn = 60 mg/kg DM). Observations were made for 49 days (7 weeks). **Phase IV** involved: T1 = healthy rats without milk, T2 = healthy rats + standard milk, T3 = healthy rats + high Se-Zn milk, T4 = malnourished rats without milk, T5 = malnourished rats + standard milk, T6 = malnourished rats + high Se-Zn milk.

Phase I found that supplementation with organic Se at doses of 0.30 and 0.45 mg/kg and/ or organic Zn at doses of 60 and 90 mg/kg significantly increased the activity of CMC-ase, amylase, and protease enzymes compared to the control ($P<0.05$). Although there was no effect on rumen fluid pH and A/P ratio, supplementation with organic Se at doses of 0.30-0.45 mg/kg and organic Zn at doses of 60-90 mg/kg significantly enhanced total VFA concentrations and rumen microbial protein levels ($P<0.05$). This supplementation also led to improved digestibility of DM, OM, CP, and CF ($P<0.05$). **Phase II** showed that treatments SZ-2, SZ-3, and SZ-4 groups significantly increased the activity of CMC-ase, amylase, and protease enzymes, as well as total VFA concentrations, propionate levels, and microbial protein compared to the CON and SZ-1 groups ($P<0.05$). However, butyrate levels, A/P ratio, and NH_3 concentrations were reduced ($P<0.05$). Rumen microbiota analysis through 16S rRNA sequencing revealed that while organic Se and Zn supplementation did not alter microbial diversity ($P>0.05$), the treatments affected the abundance of rumen microbes at specific phyla and genera ($P<0.05$).

Phase III demonstrated that FS and FS-SZ groups increased milk production compared to the CON group ($P<0.05$). The use of the feed supplement enriched with organic Se-Zn resulted in higher Se and Zn concentrations in milk and serum,

and increased levels of GSH-Px, SOD, and T-AOC ($P<0.05$). No significant changes were observed in blood biochemical profiles or hematology, except for increased AST and BUN levels in the FS and FS-SZ groups and elevated WBC counts in the FS-SZ group. **Phase IV** showed that during the re-nutrition period (weeks 3-6), high Se-Zn milk significantly increased the stimulation index of supernatants from lymphocyte cultures and IL-10 levels compared to standard milk or no milk among malnourished rats ($P<0.05$). This supplementation also elevated serum IgG and IgM levels in the malnourished rats ($P<0.05$). The findings of this study indicate that the combination of organic Se and Zn can modulate rumen microbiota and rumen fermentation characteristics. Applying a feed supplement enriched with organic Se-Zn can enhance early-lactating dairy cows productivity and Se-Zn concentrations in milk, with high Se-Zn milk potentially serving as an immunomodulator in malnourished rats.

Keywords: immunomodulator, milk production, rumen microbes, selenium, supplement, zinc.