

(別紙様式第3号) (Format No. 3)

学 位 論 文 要 旨

SUMMARY OF DOCTORAL THESIS

氏名 Name: EVITAYANI

題目 Title: A Study on Nutritive Value, Mineral Distribution and Ruminant Solubilization of Forages in Sumatra, Indonesia.

SUMMARY

In tropical countries, including Indonesia, nutrient deficiency is commonly accepted as one of the limiting factors to ruminants. As insufficient of energy and protein, mineral imbalance (deficiency or excess) in forages has long been believed responsible for low production and reproductive problems. Animals depend almost exclusively upon forages for their mineral requirements because they often do not receive mineral supplementation except for common salt. Rarely, however, can forages satisfy all mineral requirements. Evaluation of mineral status in ruminants and forages for some regions of Indonesia showed a mineral deficient or imbalance. In the present study, three series of experiments have been conducted to evaluate nutritive value and mineral concentration of forages in Sumatra Island, Indonesia. The experiments were :

1. The first experiment was to evaluate nutritive value of forages in North Sumatra., during dry and rainy seasons. Observed variables were chemical composition, concentration of Ca, P and Mg, IVDMD, organic matter (IVOMD) and crude protein (IVCPD); *in vitro* gas production and metabolizable energy (ME) content.
2. The second experiment was to evaluate nutritive value of forages harvested in South and West Sumatra during dry and rainy seasons. Variables observed were chemical composition, *in vitro* dry matter digestibility (IVDMD), minerals concentration of the forages and proportion of minerals associated in neutral detergent fiber (NDF) and acid detergent fiber (ADF).
3. The third experiment was to evaluate bioavailability of minerals of forages harvested in South and West Sumatra during dry and rainy seasons, through measurement of their solubility in the rumen. The mineral solubility was determined by *in situ* nylon bag technique through incubating the forages samples in the rumen at 0, 24 and 72 hr.

Results of the experiment 1 showed that CP content of forages was significantly ($p < 0.05$) higher in rainy season than in dry season. The CP content varied from 6.6 % (*A. gayanus*) to 16.2% (*C. plectostachyus*) in grass and from 17.5 % (*G. maculata*) to 29.1 % (*L. leucocephala.*) in legumes. Grass and legume harvested in dry season contained much higher fiber ($p < 0.05$) than in rainy season; whereas legume contained relatively lower fiber fraction than grass. Data on forages mineral concentration showed that *C. plectostachyus* (within grass) and *L. leucocephala* (within legumes) had higher Ca concentration than the other forage species. Concerning digestibility, forages had higher IVDMD, IVOMD and IVCPD in rainy season than in dry season ($p < 0.05$), except for IVOMD of *A. gayanus* and *G. maculata*, and IVCPD of *A. gayanus* and *P. phaseloides*. The *in vitro* gas production and ME content were numerically higher in rainy season than in dry season. Among the species of forages, *C. plectostachyus* and *P. purpureum* (grass) and *P. phaseloides* and *L. leucocephala* (legume) had better nutritive values compared to the other forages species, the nutritive value of legume was better than grass.

Results of the experiment 2 showed that chemical composition, IVDMD and mineral concentration of forages

were significantly ($p < 0.05$) affected by location, season and species. With exception of *P. maximum*, CP content of grass and legumes was significantly higher ($p < 0.05$) in rainy season than in dry season. As expected, the CP content of legumes was higher than in grass. The highest CP content was found in *P. maximum* for grass and in *L. leucocephala* for legumes. Data on fiber fractions showed that grass contained more NDF and ADF but lower in ADL compared with legumes ($p < 0.01$). Effect of season showed the forages contained more fiber fractions in dry season than in rainy season. In South Sumatra, the highest NDF content of grass was found in *A. compressus* and the highest contents of ADF and ADL were found in *P. maximum*. In West Sumatra, the highest contents of NDF and ADF were found in *P. purpuphoides*, while ADL was in *A. compressus*. Within the legumes in South Sumatra, *C. pubescens* had the highest contents of NDF, ADF and ADL; while the lowest were found in *L. leucocephala*. Similarly, in West Sumatra, *C. pubescens* had highest contents of NDF, ADF and ADL; while the lowest was found in *L. leucocephala*. Consistent with their chemical composition, the highest IVDMD of grass in South Sumatra was found in *P. purpuphoides*, while the lowest was noted in *P. maximum* (48.7 %). These values were relatively lower than in West Sumatra, of which the highest IVDMD of grass was 64.6 % (*P. purpuphoides*) and the lowest was 50.71 % (*A. compressus*). The IVDMD of legumes was significantly higher ($p < 0.05$) than in grass, for the legumes harvested in South Sumatra, the highest value was noted for *L. leucocephala*, while the lowest was occurred in *C. pubescens*. Similarly, for the legumes harvested in West Sumatra, *L. leucocephala* had also highest IVDMD, while the lowest was found in *C. mucunoides*.

Macro minerals concentration of forages in South and West Sumatra were greatly affected by species and season ($p < 0.05$). Generally, concentration of macro minerals in forages was higher in rainy season than in dry season. The concentrations of Ca, P and Mg in grass were above the critical levels, while percentage of S deficiency was 33.3 %. Similarly, in West Sumatra concentration of Ca was above the critical level, but deficiency of P, Mg and S were higher in West Sumatra than in South Sumatra. The deficiency of P, Mg and S were 33.3, 16.7 and 83.3 %, respectively. Data on distribution of macro minerals in legumes harvested in South Sumatra showed that deficiency of P, Mg and S were 50.0, 12.5 and 12.5 % respectively; no deficiency was found for Ca. In West Sumatra, deficiency of P, Mg and S were 87.5, 12.5 and 50 %; there was no Ca deficiency in legumes throughout the experimental. In general, proportion of macro minerals bound in NDF was higher in dry season than in rainy season. The average Ca, P, Mg and S bound in NDF of grass were 27.5, 8.3, 18.1 and 43.7 % in South Sumatra and 26.0, 6.0, 21.5 54.6 % in West Sumatra. While the average Ca, P, Mg and S bound in ADF were 7.8, 1.8, 2.2 and 20.8 % in South Sumatra, and 8.2, 1.4, 2.7 and 25.0 % for Ca, P, Mg and S in West Sumatra. Data on legume showed that the average Ca, P, Mg and S associated in NDF were 14.6, 8.1, 40.7 and 39.9 % in South Sumatra, while in West Sumatra the values were 15.1, 13.2, 29.1 and 62.9 %, respectively. Moreover, the average Ca, P, Mg and S associated in ADF of legumes in South Sumatra were 12.4, 34.7, 6.8 and 11.8 %; and 13.4, 5.9, 9.6 and 16.1 % in West Sumatra, respectively. Data on micro minerals showed significant differences ($p < 0.05$) in micro mineral concentration of grass and legume between species, season and location. In South Sumatra, 33.33 % of observed grass were deficient in Zn, 100 % deficient in Cu and 16.67 % were deficient in Se. While in West Sumatra, deficiency of Zn, Cu and Se was 50, 100 and 16.67 %, respectively. However, concentration of Fe and Mn were higher than the critical levels for all the grass harvested either in South or West Sumatra. In legumes, 75 % of observed legumes in South Sumatra were deficient in Zn and Mn, and 62.5 %; 50 % deficient in Cu and Se. The legumes harvested in West Sumatra were deficient in Zn (62.5 %), Mn (25 %), Cu (50 %) and Se (37.50 %). For legumes harvested in South Sumatra, Zn was the highest mineral associated with NDF (40.95 %), while Mn was the lowest (2.45 %). In West Sumatra, Se was the highest micro mineral bound in NDF (40.57 %) and Mn was the lowest (2.18 %). Furthermore, the highest micro minerals bound in ADF was found for Fe in South Sumatra (38.58 %) and Se in West Sumatra (34.41 %), while the lowest was noted for Cu (2.7 % in South Sumatra and 2.56 % in West Sumatra).

Results of the experiment 3 showed disappearance of dry matter (DM) and minerals (solubility) significantly ($p < 0.05$) affected by species, season and location. At 0 hr incubation, the DM disappearance of grass and legumes was approximately 17 % and 26 %. The highest DM disappearance was found in *P. maximum* (approx. 20 %) for grass and *A. mangium* for legumes (30.4 % in rainy and 33.5 % in dry season). Data on macro mineral showed that P was the most soluble mineral in water followed by S, Mg and Ca, respectively in grass; while Mg was the most soluble in legumes. Among species of grass, the highest water solubility of Ca was found in *P. maximum*, P in *P. purpuphoides*, Mg in *P. maximum* and S was found in *P. purpuphoides*. While for legumes, the highest water solubility of Ca, P and Mg was found in *L. leucocephala*; and S was found in *C. pubescens*. The effect of location showed that solubility of Ca for grass in West Sumatra was higher than in South Sumatra, but no significant difference was found for legumes. Water solubility of P from grass in South Sumatra was significantly lower ($p < 0.05$) than in West Sumatra. Conversely, solubility of P from legumes was significantly higher ($p < 0.05$) in South Sumatra than in West Sumatra. In average, no significant difference was found between water solubility of S in grass harvested in South and West Sumatra, but it was significantly differ ($p < 0.05$) for the legumes. At 24 hr incubation period, the disappearance of DM and macro mineral of forages was higher than at 0 hr incubation. The average increasing was approx. 7.5 and 12.5 % for grass and legume, respectively. The disappearance value at 72 hr incubation represents the actual solubility of minerals when forages are given to ruminants. The average DM disappearance of grass was approx. 60 %, with the highest value was occurred in *P. purpuphoides*. In legumes, the average DM disappearance was 69 %, with the highest value was occurred in *L. leucocephala*. Data on mineral solubility showed the average Ca disappearance of grass was 67.3 % in South Sumatra and 71.3 % in West Sumatra with the highest value was occurred in *P. purpuphoides* in South and *P. maximum* in West Sumatra. The average disappearance of P and Mg in grass harvested in South Sumatra was 67.3 and 48.2 % with the highest values were observed in *P. purpuphoides* and *P. maximum*, respectively. While in West Sumatra, the average disappearance of P and Mg in grass was 77 and 44.5 %, with the highest values were found in *P. purpuphoides* and *P. maximum*. Furthermore, the average S disappearance of grass was approx. 58 %, with the highest value was found in *P. purpuphoides* (South Sumatra) and *A. compressus* (West Sumatra). Data on legumes showed the average DM disappearance at 72 hr incubation was 69.8 % in South Sumatra and 67.7 % in West Sumatra with the highest value was occurred in *L. leucocephala*. In general, the trend solubility of macro mineral in legumes was : Ca > Mg > S > P.

Result of the micro minerals showed that in South Sumatra the average water solubility (0 hr incubation) of grass for Zn, Fe, Mn and Cu was 11.6, 14.8, 25.3 and 22.3 %; while in West Sumatra the values were 16.6, 16.4, 24.6 and 25.9 %, respectively. Data on legumes showed the average water solubility of Zn, Fe, Mn and Cu was 27.8, 45.2, 10.8 and 30.1 % in South Sumatra, while in West Sumatra the values were 31.1, 41.9, 11.6 and 26.7 %, respectively. Similar with macro minerals, the average micro minerals solubility of forages at 24 hr incubation was higher than in 0 hr. The values were also higher in legumes than in grass except for Mn. At 72 hr incubation, the average solubility of Zn in grass was 53.5 and 73.4 % in South and West Sumatra; while for the legumes the values were 57.6 and 75.1 %, respectively. The average solubility of Fe, Mn and Cu of grass in South Sumatra was 61.4, 54.4 and 51.7 %; while the values for legumes were 64.1, 47.2 and 57.7 %, respectively. In West Sumatra, the average solubility of Fe, Mn and Cu of grass was 79.5, 51.5 and 67.1 %; the values for legumes were 74.2, 58.8 and 68.9 %, respectively. Among species of grass, the highest solubility of Zn, Mn and Cu was found in *P. purpuphoides*, while Fe was found in *A. compressus*. Data on legumes showed the highest solubility of Zn and Cu was occurred in *L. leucocephala*, while the highest solubility of Mn and Fe was found in *A. mangium*. Finally, the trend on the average of percentage micro mineral solubility at 72 hr incubation of grass and legumes was : Fe > Zn > Cu > Mn.