UNIVERSITI PUTRA MALAYSIA

THE EFFECTS OF PROTEIN AND ENERGY SUPPLEMENTS ON RUMEN METABOLISM IN SHEEP FED GUINEA GRASS *AD LIBITUM*

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MASTER OF SCIENCE
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Thesis Submitted in Fulfillment of the Requirements for the Degree of Master of Science in the Faculty of Veterinary Medicine and Animal Science Universiti Pertanian Malaysia

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table		Page
29	Means for Nitrogen Rumen Degradability, Rumen Microbial Efficiency, Rumen Liquid Dilution Rate and Rumen Volume of Sheep Fed Guinea Grass as a Basal Diet with Different of Protein and Energy Supplements	103
30	Protein and Energy (E) Ratio and Efficiency of Microbial Cell synthesis in the rumen Sheep fed Guinea grass as a Basal Diet with Different Protein and Energy Supplements..	106
31	Most Probable Number (MPN).....	167
32	The Energetic Values of Volatile of Fatty Acids.....	171

LIST OF FIGURES

LIST OF ABBREVIATIONS

AOAC	-	Association Official Agricultural Chemists
ANOVA	-	Analysis of Variance
ARC	-	Agricultural Research Council
GLM	-	General Linear Model
NRC	-	National Research Council
SAS	-	Statistical Analysis System
Kg	-	Kilogram (s)
g	-	Gram (s)
mg	-	Milligram (s)
μg	-	Microgram (s)
ppm	-	Part Per Million
L	-	Liter (s)
ml	-	Milliliter (s)
μl	-	Microlilter (s)
DM	-	Dry Matter
OM	-	Organic Matter
ADF	-	Acid Detergent Fibre
NDF	-	Neutral Detergent Fibre
DMADR	-	Dry Matter Apparently Digested in the rumen
DMTDR	-	Organic Matter True Digested in the rumen
OMADR	-	Organic Matter Apparently Digested in the rumen
OMTDR	-	Organic Matter True Digested in the rumen
DDMI	-	Digestible Dry Matter Intake

DOMI	-	Digestible Organic Matter Intake
NAN	-	Non Ammonia Nitrogen
NANM-N	-	Non Ammonia Non Microbial-Nitrogen
VFA	-	Volatile Fatty Acids

Abstract of the thesis submitted to the Senate of Universiti Pertanian Malaysia in fulfillment of the requirements for the degree of Master of Science.

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By

THONGSUK JETANA

MAY 1996

Chairman : Associate Professor Dr. Norhani Bt Abdullah

Faculty : Veterinary Medicine and Animal Science

A series of studies based on the 4 × 4 Latin square design was conducted to determine the effects of protein [fish meal (FM) or soybean meal (SBM)] and energy [paper pulp (PP) or corn flour (CF)] supplements on sheep fed guinea grass (1.7 % N content) *ad libitum.* The dietary treatments arranged in 2 × 2 (protein × energy) factorial were: FM+PP; FM+CF; SBM+PP and SBM+CF.

Three sets of studies were carried out. They were *in situ* degradability of feeds; rumen fermentation pattern and microbial population and feed intakes and digestion, nutrients flow and rumen nitrogen metabolism.

In the first study, *in situ* experiment showed that the degradation of DM, OM and N of SBM were significantly ($P<0.05$) higher than that of FM. The percentage losses of DM, OM, NDF, ADF and N of guinea grass were significantly ($P<0.05$) lower in sheep fed CF at 12 h incubation. The rates of degradation 'c' of DM, OM,

NDF and ADF of guinea grass were lowest in sheep fed the highly degradable protein and carbohydrate in the rumen (SBM+CF). The rate of degradation 'c' of N of guinea grass was enhanced by the highly degradable fibre (PP).

In the second study, rumen pH was significantly ($P<0.05$) lower at 3 h after feeding in sheep fed CF when compared to sheep fed PP supplements. Molar proportions of acetate were greater ($P<0.05$) for sheep fed PP than sheep fed CF. Sheep fed SBM+CF showed significantly ($P<0.05$) higher ammonia-N concentration at 0 and 9 h after the onset of feeding when compared to sheep fed other diets. The concentrations of ammonia-N were significantly ($P<0.05$) higher in animals fed SBM supplements. The numbers of protozoal counts of rumen fluids were significantly ($P<0.05$) lower in animals fed FM+PP when compared to sheep fed other diets. The number of viable bacteria tended to be high ($P<0.07$) in sheep supplemented with FM when compared to sheep fed other diets.

In the third study, sheep fed SBM tended ($P<0.06$) to be greater in post rumen DM digestion and higher ($P<0.13$) in total tract DM digestion. Microbial DM flow passing through the duodenum was greater ($P<0.04$) and rumen microbial OM flow through the duodenum tended ($P<0.06$) to be higher in animals supplemented with CF than in animals supplemented with PP. The post rumen OM digestibility ($P<0.02$) and total tract OM digestibility ($P<0.05$) were higher for sheep fed SBM than for those fed FM. Sheep fed PP supplement tended ($P<0.08$) to have greater NDF intake. However, the amount of NDF digested in the rumen ($P<0.04$), apparent NDF digestion in the rumen ($P<0.05$) and total tract DM digestion ($P<0.02$) were lower in

sheep fed CF than in sheep fed PP. Sheep fed PP supplement had higher ($P<0.02$) ADF intake and ADF digested in the rumen also tended ($P<0.08$) to be higher in these animals when compared to animals fed fed CF supplement. Total tract digestion of ADF in sheep fed PP supplement was greater ($P<0.05$) than those fed CF supplements. Protein supplements did not have any significant effects on fibre digestion.

The amount of non-ammonia-non-microbial-N (NANM-N) was significantly ($P<0.05$) lower in sheep fed FM+CF than in sheep fed other diets. Microbial-N flow through the duodenum tended ($P<0.08$) to be higher in animals fed FM than in those fed SBM. Degradability of N in the rumen of sheep fed CF tended to be ($P<0.07$) higher than that fed PP. The efficiency of ruminal microbial N synthesis based on DMADR, DMTDR, OMADR and OMTDR were similar in animals fed all diets. The effects of rumen dilution on ruminal microbial protein synthesis were not observed. The energy (E) produced in the rumen calculated from VFAs produced per kg of OM digested were similar in animals fed all diets. However, the P/E ratios were low in sheep fed SBM+PP and FM+CF.

It can be concluded that energy supplements influenced fibre intakes and fibre digestion and microbial yields in the rumen of sheep. Protein supplement influenced DM and OM digestion, but microbial yield in the rumen was not affected by protein supplements in sheep.

Abstrak tesis yang dikemukakan kepada Senat Universiti Pertanian Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

KESAN SUPLEMEN PROTEIN DAN TENAGA KE ATAS METABOLISME RUMEN BEBIRI DIBERI MAKAN RUMPUT GUINEA *AD LIBITUM*

Oleh

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Satu siri kajian berdasarkan prinsip '4 × 4 Latin square' telah dilakukan untuk melihat kesan protein [meal ikan (FM) atau meal kacang-soya (SBM)] dan tenaga [pulpa kertas (PP) atau tepung jagung (CF)] sebagai suplemen terhadap bebiri memakan rumput guinea (mengandungi 1.7 % N) *ad libitum*. Rawatan diet dengan susunan faktor 2 × 2 (protein × tenaga) ialah: FM+PP; FM+CF; SBM+PP dan SBM+CF.

Tiga set kajian telah dilakukan. Kajian tersebut ialah degradasi makanan *in situ*; corak fermentasi rumen dan populasi mikrob; dan pengambilan makanan dan penghadaman, aliran nutrien dan metabolisme N dalam rumen.

Dalam kajian pertama secara *in situ*, degradasi bahan kering (DM), bahan organik (OM), dan nitrogen (N) untuk SBM adalah lebih tinggi ($P<0.05$) daripada untuk FM. Peratus kehilangan DM, OM, 'neutral detergent fibre' (NDF), 'acid

detergent fibre' (ADF) dan N rumput guinea adalah lebih rendah (P<0.05) dalam bebiri diberi CF pada 12 j eraman berbanding bebiri diberi PP. Kadar degradasi 'c' DM, OM, NDF dan ADF rumput guinea paling rendah dalam beberi yang diberi suplemen protein SBM dan karbohidrat CF. Kadar degradasi 'c' N rumput guinea meningkat dalam bebiri yang diberi suplemen serabut (PP).

Dalam kajian kedua, pH rumen adalah lebih rendah (P<0.05) pada 3 j selepas bebiri diberi makan CF bila dibandingkan dengan bebiri yang diberi suplemen PP. Peratusan molar asetat adalah lebih tinggi (P<0.05) untuk bebiri yang diberi PP daripada bebiri yang diberi CF. Bebiri yang diberi SBM+CF mempunyai kepekatan amonia rumen yang lebih tinggi (P<0.05) pada 0 dan 9 jam selepas diberi makan. Bebiri yang disuplemen SBM mempunyai kepekatan amonia rumen yang lebih banyak (P<0.05). Jumlah protozoa dalam bendalir rumen adalah rendah (P<0.05) dalam bebiri yang diberi FM+PP. Jumlah bakteria agak tinggi (P<0.07) dalam bebiri yang diberi FM.

Dalam kajian ketiga, bebiri yang diberi SBM menunjukkan pengahadaman DM yang lebih tinggi dalam bahagian pos-rumen (P<0.06) dan dalam keseluruhan usus (P<0.13). Aliran DM mikrob melalui duodenum adalah tinggi (P<0.04) dan aliran OM mikrob juga meningkat (P<0.06) dalam bebiri yang diberi CF daripada haiwan yang diberi PP. Digestibiliti OM di pos-rumen (P<0.02) dan digestibiliti OM di seluruh usus (P<0.05) adalah lebih tinggi untuk bebiri yang diberi SBM daripada bebiri yang diberi FM. Bebiri yang diberi suplemen PP menunjukkan pengambilan NDF yang tinggi (P<0.08). Walaubagaimana pun, kadar yang rendah dilihat dalam

bebiri yang diberi CF untuk jumlah NDF yang terhadam dalam rumen ($P<0.04$), NDF yang terhadam ketara dalam rumen ($P<0.05$) dan DM terhadam dalam seluruh usus ($P<0.02$) daripada bebiri yang diberi PP. Bebiri yang diberi PP mempunyai kadar tinggi untuk pengambilan ADF ($P<0.02$) dan ADF terhadam dalam rumen ($P<0.08$) bila dibandingkan dengan bebiri yang diberi suplemen CF. Penghadaman ADF dalam seluruh usus untuk bebiri yang disuplemen PP adalah lebih tinggi ($P<0.05$) daripada bebiri yang disuplemen CF. Suplemen protein tidak mempengaruhi penghadaman serabut.

Jumlah 'non-ammonia-non-microbial-N' (NANM-N) adalah rendah ($P<0.05$) untuk bebiri yang diberi FM+CF daripada bebiri yang diberi makanan lain. Aliran N-mikrob melalui duodenum adalah lebih tinggi ($P<0.08$) untuk bebiri yang diberi FM daripada haiwan yang diberi SBM. Degradasi N dalam rumen untuk bebiri yang diberi CF adalah lebih tinggi ($P<0.07$) daripada bebiri yang diberi PP. Kecekapan sintesis N-mikrob rumen berdasarkan penghadaman ketara DM dalam rumen (DMADR), penghadaman sebenar DM dalam rumen (DMTDR), penghadaman ketara OM dalam rumen (OMADR) dan penghadaman sebenar OM dalam rumen (OMTDR) adalah sama untuk kesemua haiwan yang diberi kesemua diet. Kesan pencairan rumen terhadap sintesis protein mikrob tidak dilihat. Tenaga (E) terhasil dalam rumen yang dikira berdasarkan asid lemak meruap terbentuk per kg OM terhadam adalah sama untuk kesemua haiwan yang diberi kesemua diet. Walaubagaimana pun, nisbah protein/tenaga (P/E) adalah rendah untuk bebiri yang diberi SBM+PP dan FM+CF.

Sebagai kesimpulan, suplemen tenaga mempengaruhi pengambilan dan penghadaman serabut dan penghasilan mikrob dalam rumen bebiri. Suplemen protein mempengaruhi penghadaman DM dan OM dan tidak mempengaruhi penghasilan mikrob dalam rumen bebiri.

CHAPTER I

INTRODUCTION

Tropical pastures are generally high in fibre but low in available N content, and this condition always limits rumen microbial growth and digestibility of feed. Ruminants rely on dietary and ruminal microbial protein as sources of amino acids absorbed in the small intestine. The higher the protein transferred to the intestine, the greater the response in the host animal.

Protein supplement is necessary to compensate low-N feed nutrients to promote microbial growth. There are various grades of protein which are either of low, intermediate and high ruminal degradability. Each group of protein is able to cause response in different types of rumen microorganisms (Wallace et al., 1987; Newbold et al., 1989; Cruz Soto et al., 1994). Protein supplement may be ineffectively utilised in the rumen if appropriate energy sources are not available. Under such condition, protein breaks down into amino acids which undergo deamination process. The ammonia-N generated is absorbed and excreted in the urine in the form of urea (Nolan, 1993).

In energy-deficit diets, additional energy input is necessary to optimise protein synthesis (Poppi and McLennan, 1995). Energy sources can be classified as non-structural carbohydrates such as starch and sugar; structural carbohydrates