

**NUTRITIVE VALUE OF MULBERRY (*MORUS ALBA*) HAY  
AS A FEED SUPPLEMENT FOR SHEEP**

**By**

**ARSYADI ALI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfilment of the Requirement for the Degree of  
Master of Agricultural Science**

**November 2006**

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Agricultural Science

**NUTRITIVE VALUE OF MULBERRY (*MORUS ALBA*) HAY  
AS A FEED SUPPLEMENT FOR SHEEP**

By

**ARSYADI ALI**

**November 2006**

**Chairman: Professor Zainal Aznam bin Mohd Jelani, PhD**

**Faculty: Agriculture**

A study comprising of three experiments was conducted on the utilization of mulberry (*Morus alba*) hay as feed supplement in sheep. The first experiment determined the duration of the sun-drying of mulberry foliage until it reached 10% moisture content and the nutritive values of the hay five (W5) and seven weeks (W7) old forage. The second experiment elucidated the characteristics of the hay with respect to *in situ* degradation of dry matter (DM) and crude protein (CP). The third experiment determined the effect of supplementation of mulberry hay on the total digestibility of the ration based on oil palm frond (OPF) pellet. The drying time of W7 mulberry foliage was significantly ( $P < 0.05$ ) longer than W5. The drying time of stem was significantly ( $P < 0.05$ ) longer than leaf fraction at both ages of maturity (W5 and W7). The DM and neutral detergent fiber (NDF) content of mulberry was not significantly ( $P > 0.05$ ) different with advancing plant maturity, but increased significantly ( $P < 0.05$ ) with the drying process. The CP content of mulberry decreased with the plant maturity (W5 to W7) and the drying process. The ash content was affected by the advancing plant maturity, drying and plant fraction. The acid detergent fiber (ADF) and acid detergent lignin (ADL) content increased with

plant maturity (W5 to W7) and was not affected by drying. The DM degradation of mulberry harvested at 5 weeks of age and oven-dried (MHO5) and mulberry harvested at 5 weeks of age and sun-dried (MHS5) was significantly ( $P<0.05$ ) higher than mulberry harvested at 7 weeks of age and oven dried (MHO7) and mulberry harvested at 7 weeks of age and sun-dried (MHS7) at 12, 24, 36 and 48 h of rumen incubation. Meanwhile, the CP degradation of MHO5, MHS5, MHO7 and MHS7 was not significantly ( $P>0.05$ ) different at 0, 6, 12, 24, 36 and 48 h of incubation. The degradability of water insoluble (b), potential degradability (PD) and effective degradability (ED) of DM of MHO5 and MHS5 were higher than MHO7 and MHS7. Meanwhile, the PD and ED of CP were significantly ( $P<0.05$ ) decreased with advancing plant maturity. Supplementation of mulberry hay to OPF pellet based diet from 20 to 60% increased the DM, organic matter (OM), CP, NDF digestibility, N intake and absorption and  $\text{NH}_3\text{-N}$  concentration. Increasing level of mulberry hay supplementation did not influence total dry matter intake (DMI), N retention and total volatile fatty acid (VFA). Mulberry hay of 5 weeks compared to 7 weeks old forage contained higher CP, lower cell wall and lignin content and higher DM degradability, ED and PD values. Supplementation of mulberry hay as a CP source significantly ( $P<0.05$ ) improved the utilization of OPF pellet as base diet in sheep. However, higher level of mulberry hay supplementation is not recommended because it did not increase the total DMI and N retention.

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

**NILAI PEMAKANAN HAY MALBERI  
(*MORUS ALBA*) SEBAGAI SUPLEMEN MAKANAN PADA BIRI-BIRI**

oleh

**ARSYADI ALI**

**November 2006**

**Pengerusi: Profesor Zainal Aznam bin Mohd Jelani, PhD**

**Fakulti: Pertanian**

Kajian terdiri daripada tiga eksperimen telah dijalankan keatas penggunaan hay malberi (*Morus alba*) sebagai suplemen makanan pada biri-biri. Eksperimen pertama menentukan masa pengeringan foliaj mulberi dengan sinaran matahari sehingga ia mencapai kandungan air 10% dan nilai pemakanan hay yang dibuat dari malberi yang dituai pada minggu kelima (W5) dan ke tujuh (W7) pertumbuhan. Eksperimen kedua menjelaskan ciri-ciri hay dari aspek degradasi DM dan protein kasar (CP) *in situ*. Eksperimen ketiga menentukan kesan suplementasi hay malberi pada jumlah keseluruhan pencernaan pelet pelepah kelapa sawit (OPF) sebagai makanan asas. Masa pengeringan foliaj malberi W7 ketara lebih lama ( $P < 0.05$ ) berbanding malberi W5. Masa pengeringan batang ketara lebih lama ( $P < 0.05$ ) berbanding daun pada kedua umur kematangan (W5 dan W7). Kandungan DM dan gentian neutral detergent malberi tidak berbeza ( $P > 0.05$ ) dengan peningkatan umur pokok, tetapi ketara meningkat ( $P < 0.05$ ) dengan proses pengeringan. Kandungan CP malberi menurun dengan peningkatan umur pokok (W5 kepada W7) dan dengan proses pengeringan. Peningkatan umur pokok, proses pengeringan dan bahagian pokok memberi kesan kepada kandungan abu. Kandungan gentian asid detergen

(ADF) dan lignin detergen asid (ADL) meningkat dengan peningkatan umur pokok (W5 kepada W7) dan tidak terkesan oleh pengeringan. Degradasi DM malberi yang dituai pada 5 minggu pertumbuhan dan dikeringkan dengan oven (MHO5) dan malberi yang dituai pada 5 minggu pertumbuhan dan dikeringkan dengan sinaran matahari (MHS5) ialah ketara lebih tinggi ( $P < 0.05$ ) dibanding malberi yang dituai pada 7 minggu pertumbuhan dan dikeringkan dengan oven (MHO7) dan malberi yang dituai pada 7 minggu pertumbuhan dan dikeringkan dengan sinaran matahari (MHS7) pada masa inkubasi 12, 24, 36 dan 48 jam. Sementara itu, degradasi CP MHO5, MHS5, MHO7 and MHS7 adalah tidak berbeza ( $P > 0.05$ ) pada masa inkubasi 0, 6, 12, 24, 36 dan 48 jam. Degradabiliti insoluble (b), degradabiliti potensi (PD) dan degradabiliti efektif (ED) DM daripada MHO5 dan MHS5 adalah lebih tinggi berbanding MHO7 dan MHS7. Sementara itu, PD and ED CP adalah ketara menurun ( $P < 0.05$ ) dengan peningkatan umur pokok. Suplementasi hay malberi dari 20 kepada 60% terhadap pelet OPF sebagai diet asas meningkatkan pencernaan DM, bahan organik (OM), CP, NDF, pengambilan dan penyerapan N dan konsentrasi  $\text{NH}_3\text{-N}$ . Peningkatan paras suplementasi hay mulberi tidak mempengaruhi jumlah pengambilan bahan kering (DMI), retensi N dan jumlah asid lemak meruap (VFA). Hay malberi pada umur lima minggu mengandungi kandungan CP yang lebih tinggi, kandungan dinding sel dan lignin yang lebih rendah dan degradabiliti DM, nilai ED dan PD lebih tinggi berbanding hay pada umur tujuh minggu. Suplementasi hay malberi sebagai sumber CP telah meningkatkan dengan ketara penggunaan pelet OPF sebagai diet asas pada biri-biri. Walaubagaimanapun, suplementasi hay malberi yang lebih tinggi tidak digalakan kerana ia tidak meningkatkan jumlah DMI dan retensi N.

## ACKNOWLEDGEMENTS

First of all, I would like to express my sincere gratitude to Allah, the most gracious and merciful. With His blessing and grace, I am able to complete this thesis.

I would like to express my most heartfelt gratitude to my supervisor, Professor Dr. Zainal Aznam bin Mohd. Jelani for his unfailing support, advice and guidance. My deep appreciation is also extended to the member of the Supervisory Committee, Associate Professor Dr. Halimatun Yaakub for her suggestion and advice.

My deepest gratitude is extended to the Government of Riau Province who provided the scholarship, and the Rector of Universitas Islam Negeri Suska Riau, Dean and to my friends at the Faculty of Animal Science, UIN Suska Riau for their support.

I would also like to thank Professor Dr. Abd. Razak Alimon, Associate Professor Dr. Liang Juang Boo, Associate Professor Dr. Jothi Malar Panandam and En. Shokri Jusoh for their assistance. My thank also goes to the technical staff of the Animal Nutrition Laboratory. Many thank also goes to my graduate friends (Dwi Yulistiani, Devika Saddul, Boodee, Lai, Reza, Rahfi, Thanth, Imad, Elizabeth, Khaladi, Abdullah and Nwe) and housemates (Kanda Rizal Fahmi, Rizky Gushendra, Bang Jun, Pak Promadi, Eri and Eka) for their advice and support.

For their unfailing support and love, I would like to express my special gratitude to my parents, my brother, my sisters, my parents in-law and my beautiful wife. This thesis is dedicated to all of you.

I certify that an Examination Committee has met on 24 November.2006 to conduct the final examination of Arsyadi Ali on his Master of Agricultural Science thesis entitled “Nutritive Value of Mulberry (*Morus alba*) Hay as a Feed Supplement for Sheep” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 an Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

**Dahlan Ismail, PhD**

Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Razak Alimon, Phd**

Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Internal Examiner)

**Ismail Idris, PhD**

Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Internal Examiner)

**Wan Zahari bin Mohamed, PhD**

Strategic Livestock Research and Development Institute  
(External Examiner))

---

**HASANAH MOHD. GHAZALI, PhD**

Professor/Deputy Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Agriculture Science. The members of the Supervisory Committee are as follows:

**Zainal Aznam Bin Mohd Jelani, PhD**

Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Halimatun Yaakub, PhD**

Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

---

**AINI IDERIS, PhD**

Professor/Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date: 10 March 2007



## **DECLARATION**

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

---

**ARSYADI ALI**

Date:

## TABLE OF CONTENTS

	<b>Page</b>
<b>ABSTRACT</b>	ii
<b>ABSTRAK</b>	iv
<b>ACKNOWLEDGEMENTS</b>	vi
<b>APPROVAL</b>	vii
<b>DECLARATION</b>	ix
<b>LIST OF TABLES</b>	xiii
<b>LIST OF FIGURES</b>	xv
<b>LIST OF PLATES</b>	xvi
<b>LIST OF ABBREVIATIONS</b>	xvii
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	<b>1</b>
1.1 The importance of fodder tree as an alternative feed sources for ruminants	1
1.2 The potential of mulberry as feed for ruminant	2
1.3 The significance of feed conservation in a farming system	3
1.4 Objectives and aims	5
<b>2 LITERATURE REVIEW</b>	<b>6</b>
2.1 Fodder tree and shrub as ruminant feed	6
2.2 Fodder tree as feeding strategy to increase the utilization of low quality roughages	7
2.3 Fodder tree and shrub as dietary supplement for ruminants	8
2.4 Mulberry	9
2.5 Agronomic management of the mulberry	10
2.5.1 Plant growth	10
2.5.2 Pruning	11
2.5.3 Fertilization	11
2.5.4 Biomass yield and L:S ratio	12
2.5.5 Anti-nutritional compounds in mulberry	13
2.6 The potential of mulberry as ruminant feed	14
2.7 Mulberry as a supplement for ruminants	16
2.8 Conservation of forages	16
2.9 Hay	17
2.10 Haymaking	19
2.10.1 Principles in haymaking	19
2.10.2 Process of haymaking	20
2.10.3 Factors influencing hay quality	21
2.10.4 Losses during haymaking	21
2.10.5 Mechanical losses	25
2.10.6 Leaching losses	26
2.10.7 Heat damage	26
2.10.8 Storage losses	27
2.11 Hay preservatives	28
2.12 Hay storage	28

2.13	Hay as ruminant feed	29
2.14	Feeding methods of hay for ruminants	30
2.15	Digestion of nutrients	31
2.16	<i>In sacco</i> method of estimating digestion of feed in the rumen	33
2.17	Feed intake	34
2.18	Rumen microbes	36
2.19	Rumen pH	37
2.20	Volatile fatty acids	37
2.21	Rumen ammonia	39
<b>3</b>	<b>PRODUCTION AND NUTRITIVE VALUES OF MULBERRY HAY</b>	<b>41</b>
3.1	Introduction	41
3.2	Materials and methods	42
3.2.1	Location of experiment and management of the mulberry plot	42
3.2.2	Agronomic management of the mulberry	43
3.2.3	Experimental design	44
3.2.4	Sampling procedure	45
3.2.5	Drying process of hay	47
3.2.6	Weather	47
3.2.7	Duration of sun-drying and moisture loss during haymaking	48
3.2.8	Visual observation	48
3.2.9	Chemical analyses	48
3.2.10	Statistical analyses	49
3.3	Results	49
3.3.1	Weather	49
3.3.2	Duration of sun-drying	50
3.3.3	Moisture loss in plant fractions during haymaking	51
3.3.4	Visual observation	54
3.3.5	Nutrient composition	56
3.4	Discussion	63
3.4.1	Duration of sun-drying	63
3.4.2	Moisture loss in plant fractions during haymaking	64
3.4.3	Visual observation and assessment of mulberry hay	65
3.4.4	Nutrient composition	66
3.5	Conclusion	69
<b>4</b>	<b>RUMEN DEGRADABILITY OF MULBERRY HAY</b>	<b>70</b>
4.1	Introduction	70
4.2	Materials and methods	71
4.2.1	Experimental diets	71
4.2.2	Animals and diets	71
4.2.3	Experimental design	73
4.2.4	Measurements of degradation	73
4.2.5	Statistical analyses	75
4.3	Results	75
4.3.1	Dry matter degradation	75
4.3.2	Crude protein degradation	77
4.4	Discussion	79

4.5	Conclusion	81
<b>5</b>	<b>EFFECT OF SUPPLEMENTATION MULBERRY (<i>MORUS ALBA</i>) HAY IN SHEEP FED OIL PALM FROND PELLET BASED DIETS</b>	<b>82</b>
5.1	Introduction	82
5.2	Materials and methods	83
5.2.1	Place of study	83
5.2.2	Management of the experiment animals	83
5.2.3	Feeds used in the study	84
5.2.4	Experimental Diets and design	85
5.2.5	Experimental periods and measurements	86
5.2.6	Sampling method	87
5.2.7	Chemical analyses	88
5.2.8	Statistical analyses	89
5.3	Results	89
5.3.1	Feed intake and apparent digestibility	89
5.3.2	Ruminal pH and NH <sub>3</sub> -N	91
5.3.3	Volatile fatty acids	92
5.3.4	Nitrogen balance	93
5.4	Discussion	94
5.5	Conclusion	98
<b>6</b>	<b>GENERAL DISCUSSION AND CONCLUSION</b>	<b>99</b>
	<b>REFERENCES</b>	<b>103</b>
	<b>APPENDICES</b>	<b>116</b>
	<b>BIODATA OF THE AUTHOR</b>	<b>129</b>