

**EVALUATION OF NON-CONVENTIONAL
ENERGY AND PROTEIN SOURCES IN
LACTATING EWES' RATION**

By

MOHAMED RASHID SALAMA RASHID

B.Sc. Agric. Sci. (Animal Production), Fac. Agric., Cairo Univ., 2009

M.Sc. Agric. Sci. (Animal Production), Fac. Agric., Cairo Univ., 2015

THESIS

**Submitted in Partial Fulfilment of the
Requirements for the Degree of**

DOCTOR OF PHILOSOPHY

In

**Agricultural Sciences
(Animal Production)**

**Department of Animal Production
Faculty of Agriculture
Cairo University
EGYPT**

2022

Format Reviewer

Vice Dean of Graduate Studies

Name of Candidate: Mohamed Rashid Salama Rashid **Degree:** Ph.D.
Title of Thesis: Evaluation of Non-conventional Energy and Protein Sources in Lactating Ewes' Ration
Supervisors: Dr. Mohamed Ahmed Hanafy Ahmed
Dr. Wafaa Mostafa Ali Ghoneem
Dr. Mervat Sayed Hassan Youssef
Department: Animal Production **Branch:** Animal Nutrition
Date: 31/01/2022

ABSTRACT

This study was conducted to evaluate using of some non-conventional feed resources such as *Leucaena leucocephala* (leucaena), *Manihot esculent* (cassava) leaves, and rejected banana (RB) in lactating ewes' diet. This study consisted of three parts; the chemical evaluation, *in vitro* and *in vivo* studies.

The chemical composition, HPLC analysis and GC-MS analysis were performed for the tested ingredients. The *in vitro* study was conducted using gas production technique, to evaluate the rate of gas production and fermentation patterns at 24 hrs of incubation. Regarding the *in vivo* studies two separately lactation trials were conducted using lactating Blackbelly ewes (1 week after lambing). In the 1st lactation trial, 24 ewes were divided randomly into four groups to evaluate the total replacement of alfalfa pellets with leucaena leaves pellets with/without RB. In the 2nd lactation trial, another 24 ewes were divided randomly into four groups to evaluate the total replacement of alfalfa pellets with cassava leaves pellets with/without RB.

The chemical analysis showed that leucaena and cassava leaves had higher crude protein (22 and 20.5%), total phenols (40.7 and 22.1 eq- to Gallic acid (g)/DM (kg)), and total tannins (4.43 and 1.79%) than alfalfa. The HPLC results mentioned that leucaena and cassava leaves extract had high content of valuable phenolic components that have antioxidant and anti-inflammatory properties like gallic acid, ellagic acid and naringenin. The *in vitro* study demonstrated that leucaena leaves had the lowest total accumulative gas production being 90.7 ml/g DM. The RB recorded the lowest ruminal pH (5.24) and ammonia concentration (9.0 mg/100ml) compared to other feed ingredients, while it had the highest gas production (192.9 ml/100ml) and degraded organic matter (905.3 g/kg). The 1st *in vivo* trial illustrated that there were insignificant differences in total DM intake as well 4% fat corrected milk and milk yield and composition between different diets. The 2nd *in vivo* trial indicated that there were insignificant differences in forage pellets intake, however RB addition decreased grass hay intake being 1317.5 g DM/day comparing with diets without RB (1441.3 g DM/day), with insignificant difference in 4% fat corrected milk, milk yield and composition. Addition of RB to diets showed a positive effect (insignificant) on ewes' milk yield.

In general, substitution of alfalfa by leucaena or cassava leaves with RB as non-conventional protein and energy sources in ration detected no depressive effect on lactating ewe's performance and lambs growth rate.

Key words: *Leucaena leucocephala*, *Manihot esculent*, rejected banana, *Medicago sativa* L., *Dichanthium spp.*, *in vitro*, *in vivo*.

CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	5
1. Feedstuffs for livestock in tropical and sub-tropical countries	5
2. Non-conventional feed resources (NCFRs) in ruminant feeding	6
3. Leucaena (<i>Leucaena leucocephala</i>) as a feedstuff	11
4. Influence of leucaena inclusion in ruminant diets on:	13
a. Feed intake.....	13
b. Nutrients digestibility.....	14
c. Rumen fermentation and enteric methane production.....	16
d. Rumen bacteria and protozoa community.....	18
e. Productive performance.....	19
5. Cassava (<i>Manihot Esculenta</i>) as a feedstuff	20
6. Influence of cassava inclusion in ruminant diets on:	23
a. Feed intake.....	23
b. Nutrients digestibility.....	24
c. Rumen fermentation and enteric methane production.....	25
d. Rumen bacteria and protozoa community.....	26
e. Productive performance.....	26
7. Rejected green banana as a feedstuff	28
8. Influence of rejected banana inclusion in ruminant diets as a source of energy on:	29
a. Feed intake.....	29
b. Nutrients digestibility.....	30
c. Rumen fermentation and enteric methane production.....	31
d. Productive performance.....	31
MATERIALS AND METHODS	33

CONTENTS (continued)

RESULTS AND DISCUSSION	44
1. Chemical evaluation of the feed ingredients	44
a. Chemical composition of the feed ingredients.....	44
b. The most abundant chemical components of the experimental feed ingredients.....	45
c. Phenolic compounds of the experimental feed ingredients	51
2. <i>In vitro</i> evaluation of the experimental feed ingredients and diets	54
a. Gas production	56
b. Ruminant pH, ammonia concentration, nutrients degradability and protozoa count.....	61
c. Molar proportions of individual and total short-chain fatty acids (SCFAs) concentration for feed ingredients and diets..	68
3. <i>In vivo</i> evaluation of the experimental diets	75
a. First lactation trial (alfalfa vs leucaena with or without rejected banana).....	75
b. Second lactation trial (alfalfa vs cassava with or without rejected banana).....	79
CONCLUSION	84
SUMMARY	85
REFERENCES	92
ARABIC SUMMARY	

LIST OF TABLES

No.	Title	Page
1.	Chemical composition (g/kg DM) of the experimental feed ingredients.....	44
2.	The most abundant chemical compounds in the ethanolic extract of feed ingredients.....	46
3.	Phenolic components of the experimental feed ingredients detected by high-performance liquid chromatography (HPLC).....	52
4.	Components (% DM) and chemical composition (g/kg DM) of experimental diets.....	55
5.	<i>In vitro</i> gas production for feed ingredients	57
6.	<i>In vitro</i> gas production for alfalfa versus leucaena diets.....	58
7.	<i>In vitro</i> gas production for alfalfa versus cassava diets.....	60
8.	<i>In vitro</i> ruminal pH, ammonia (NH ₃ -N) concentrations, degraded organic matter (DOM), degraded neutral detergent fiber (DNDF), and protozoal count for feed ingredients.....	61
9.	<i>In vitro</i> ruminal pH, ammonia (NH ₃ -N) concentrations, degraded organic matter (DOM), degraded neutral detergent fiber (DNDF), and protozoal count for alfalfa versus leucaena diets.....	64
10.	<i>In vitro</i> ruminal pH, ammonia (NH ₃ -N) concentrations, degraded organic matter (DOM), degraded neutral detergent fiber (DNDF), and protozoal count for alfalfa versus cassava diets.....	66
11.	Molar proportions of individual and total short-chain fatty acids (SCFAs) concentration for feed ingredients.....	69
12.	Molar proportions of individual and total short-chain fatty acids (SCFAs) concentration for alfalfa versus leucaena diets	71
13.	Molar proportions of individual and total short-chain fatty acids (SCFAs) concentration for alfalfa versus cassava diets..	74
14.	Effect of leucaena inclusion in diets with or without rejected banana on dry matter intake (DMI), lambs daily gain (DG) and ewes' body weight (BW) changes.....	76

LIST OF TABLES (continued)

15. Effect of leucaena inclusion in diets with or without rejected banana on milk yield and composition.....	79
16. Effect of cassava inclusion in diets with or without rejected banana on dry matter intake (DMI), lambs daily gain (DG) and ewes' body weight (BW) changes.....	80
17. Effect of cassava inclusion in diets with or without rejected banana on milk yield and composition.....	82

LIST OF FIGURES

No.	Title	Page
1.	<i>Leucaena leucocephala</i> leaves.....	12
2.	Cassava (<i>Manihot esculenta</i>) plant parts.....	21

LIST OF ABBREVIATIONS

ADF	: Acid detergent fiber
ADL	: Acid detergent lignin
AOAC	: Association of Official Agriculture Chemists
BCS	: Body condition score
BW	: Body weight
C₂/C₃	: Acetate to propionate ratio
CF	: Crude fiber
CP	: Crude protein
DG	: Daily gain
DM	: Dry matter
DMI	: Dry matter intake
DNDF	: Degraded neutral detergent fiber
DOM	: Degraded organic matter
EE	: Ether extract
FCM	: Fat corrected milk
GC-MS	: Gas chromatography-mass spectrometry
GP	: Gas production
H	: Head
HPLC	: High performance liquid chromatography
Hrs.	: Hours
Kg	: Kilogram
L	: Liter
μ	: Micro
NCFRs	: Non-conventional feed resources
NDF	: Neutral detergent fiber
NFE	: Nitrogen free extract
NH₃-N	: Ammonia nitrogen
OM	: Organic matter
SEM	: Standard error of the mean
VFA	: Volatile fatty acids
VS.	: Versus