THE PERFORMANCE OF SHEEP FED MAIZE STOVER SUPPLEMENTED WITH FORAGE LEGUMES AND BLOOD MEAL

BY

HUSSAINA J. MAKUN-LUGARD

(D.V.M A.B.U 1986)

A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ANIMAL SCIENCE.

DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY, ZARIA

OCTOBER, 1995

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my research work. It has not been accepted in any previous application for higher degree.

To the best of my knowledge and belief, this thesis contains no materials previously published or written by another person, except where due reference has been made in the text.

DIGITIZED

HUSSAINA MAKUN-LUGARD

Date 5/10/95

CERTIFICATION

This thesis entitled THE PERFORMANCE OF SHEEP FED MAIZE STOVER SUPPLEMENTED WITH FORAGE LEGUMES AND BLOOD MEAL by HUSSAINA MAKUN-LUGARD meets the regulations governing the award of MASTER OF SCIENCE of AHMADU BELLO UNIVERSITY and is approved for its contribution to scientific knowledge and literary presentation.

PROF. N. N. UMUNNA
Member supervisory committee.
ILRI ADDIS ABABA

DR J. P. ALAWA
Chairman, supervisory committee.
Dept. of Animal Science

DR T. F. BALOGUN
Member, supervisory committee.
Head of Dept.
Dept. of Animal Science

PROF J.Y. OLAYEMI
Dean, Postgraduate School.

DR ASAMOAH LARBI
External examiner
International Livestock Research Institute (ILRI) IBADAN.

DEDICATION

This work is dedicated to BABA, MAMA, my SIBLINGS and my FRIEND, NANA for standing by me in the trying year.

ACKNOWLEDGEMENT

I thank God almighty for seeing me through these turbulent years.

I wish to express my sincere gratitude to Prof. N.N. Umunna and Dr P.O. Osuji for their guidance and encouragement while doing this work. I am also very grateful to Dr J. P. Alawa for seeing to the success of this thesis. My appreciation also goes to Profs. T.F. Balogun and D.B. Olumeyan for their advice.

Dr K. Agyemang of ILRI Kaduna had been very helpful and concerned with the progress of this work. Mrs E. Obaba also of ILRI Kaduna worked tireless days to type this thesis.

My acknowledgement will not be complete without mentioning some families who stood by me for the past one year. They include the Boyos, Badas, Buharis, Bandeles and particularly Tope.

ABSTRACT

In Experiment 1 sixty (60) male Ethiopian Menz sheep of average live weight of 19.00kg (SE 1.42) maintained on maize stover ad libitum were supplemented with either lablab (250g) (LL); cowpea (250g) (CW); blood meal (50g) (BM); lablab (125g)+ cowpea (125g) (LC); lablab (125g)+ blood meal (25g) (LB) or cowpea (125g)+ blood meal (25g) (CB) for a period of 75 days. Voluntary intake, weight gain and changes in rumen environment were studied. Sheep fed blood meal, and blood meal in combination with forages legume consumed significantly more stover ($P<0.001$) than sheep fed the other supplements.

Sheep on blood meal and blood meal in combination with forage legumes had significantly higher ($P<0.001$) weight gains than those fed the other supplements. Treatments did not differ significantly in the rumen degradation parameters for organic matter and nitrogen, microbial protein yield and rumen digestion kinetics parameters.

In Experiment 2, 36 male Ethiopian Menz sheep of average liveweight 19.2 (SE 0.042)kg) fed maize stover were supplemented with urea-molasses block containing one of the following supplements: wheat bran (WB), cottonseed cake (CC), blood meal (BM) or CC + BM (CB) over a period of 75 days. Voluntary intake and changes in the rumen environment

were measured.

Differences in the stover DM intake were not significant but the supplement intake differed significantly ($P<0.05$) among treatments. There were significant differences ($P<0.01$) in the weight gains between treatments. There were no significant differences in purine derivatives and microbial protein yield. Rumen degradation parameters did not differ significantly among the various urea molasses blocks.

The use of blood meal increased stover DM intake, weight gains and improved the rumen environment for microbial protein synthesis. It was concluded that blood meal could be used as supplement to poor quality roughages.

Table of contents **Page**

	Declaration	i
	Certification	ii
	Dedication	iii
	Acknowledgement	iv
	Abstract	v
	Table of contents	vii
	List of tables	xi
	List of figures	xiv
1.1.0	**Chapter One: Introduction**	1
2.1.0	**Chapter two: Literature review**	3
2.1.1	Limitation to productivity of tropical breeds of livestock	3
2.1.2	Feeds and feeding	3
2.2.0	Poor quality roughage	5
2.2.1	Description	5
2.2.2	Factors affecting feeding quality of roughages	6
2.2.3	Nutritive value of crop residues	6
2.2.4	Rumen conditions necessary for optimum intake	7
2.3.0	Methods of improving poor quality roughage	7
2.3.1	Physical treatment	7
2.3.2	Chemical treatment	7
2.4.0	Supplementation	8
2.4.1	Browse plants	9
2.4.2	Legume hay	10
2.5.0	Agricultural by-products	11

2.5.1 Molasses and urea 12

2.5.2 Oil seed cakes 13

2.6.0 Animal by-products 14

3.0 Chapter 3

Experiment 1 : Response of growing sheep to chopped maize stover supplemented with forage proteins, blood meal or a combination of forage proteins and blood meal

3.1.1 Introduction 16

3.1.2 Materials and Methods 17

3.1.3 Location 17

3.1.4 Growth trial 17

3.1.5 Digestibility Trial 19

3.1.6 Rumen digestion kinetics 20

3.1.7 In sacco rumen degradation 21

3.1.8 Rumen pH and ammonia 22

3.1.9 Botanical composition of maize stover 22

3.1.10 Statistical analyses 23

3.2.0 Results 25

3.2.1 Voluntary intake 25

3.2.2 Changes in liveweight 27

3.2.3 Feed conversion efficiency 27

3.3.0 Digestibility Trial 27

3.3.1 Voluntary intake 27

3.3.2 Digestibility of nutrients 29

3.3.3 Rumen pH and ammonia nitrogen 29
3.3.4 In sacco rumen degradation 31
3.3.5 Digestion kinetics 35
3.3.6 Botanical fractions 39
3.3.7 Microbial protein yield 39
3.4.0 Discussion 40

4.0 Chapter four: Résponse of growing sheep to chopped maize stover supplemented with urea-molasses block

4.1.1 Introduction 44
4.1.2 Material and methods 44
4.1.3 Location 44
4.1.4 Growth Trial 44
4.1.5 Digestibility trial 47
4.1.6 In sacco rumen degradation 47
4.1.7 Rumen pH and ammonia 48
4.1.8 Botanical fractions 48
4.1.9 Statistical analysis 48
4.2.0 **Results** 49
4.2.1 Voluntary intake 49
4.2.2 Changes in liveweight 49
4.2.3 Feed conversion efficiency 49
4.3.0 Digestibility trial 52
4.3.1 Voluntary intake 52
4.3.2 Digestibility of nutrients 52
4.3.3 Rumen pH and ammonia nitrogen 54
4.3.4 In sacco rumen degradation 54
4.3.5 Microbial protein yield 55

4.3.6	Proportion of leaf and stem	55
4.4.0	**Discussion**	62
5.1.0	**General Discussion**	64
5.1.1	Practical Implications	66
6.1.0	References	68
7.1.0	Appendices	81

List of Tables

Table	Title	
1	Dietary composition (g) of different supplements fed to sheep	18
2	Least squares means of liveweight changes, daily voluntary intake, average daily gain and feed conversion of sheep fed basal diet of maize stover supplemented with forage legumes and blood meal	26
3	Mean daily intake and apparent digestibility of dry matter (DM), organic matter (OM), neutral detergent fibre (NDF) and nitrogen by sheep fed forage legumes and blood meal	28
4	Mean rumen pH and ammonia nitrogen of rumen fluid for sheep fed basal diet of maize stover supplemented with forage legumes and blood meal	30
5	Rumen degradation characteristics of dry matter of forage legumes and blood-meal incubated in rumen of fistulated sheep	32
6	Rumen degradation characteristics of organic matter of forage legumes and blood-meal incubated in rumen of fistulated sheep	33
7	Rumen degradation characteristics of nitrogen of forage legumes and blood-meal incubated in rumen of fistulated sheep	34

8 Rate of passage (h) of chromium mordanted maize stover supplemented with forage legumes and blood meal in sheep 36

9 Weight of morphological components and proportion of orts and maize stover offered to sheep fed maize stover supplemented with forage legumes and blood meal 37

10 Least squares mean for purine derivatives (PD) and microbial protein yield (MPY) of sheep fed forage legumes and blood meal 38

11 Dietary composition of urea molasses semi solid block 46

12 Least squares means of liveweight changes, mean daily voluntary dry matter intake, average daily gain (ADG) and feed conversion of sheep fed maize stover supplemented with urea-molasses block 51

13 Least squares means of daily voluntary intake and digestibility of dry matter(DM), organic matter (OM), neutral detergent fibre (NDF) and nitrogen by sheep fed a basal diet of maize stover supplemented with urea-molasses block 53

14 Mean pH and ammonia nitrogen of rumen fluid for sheep fed basal diet of maize stover supplemented with urea molasses block 56

15 Rumen degradation characteristics of dry matter of urea molasses block incubated in rumen of fistulated sheep 57

16 Rumen degradation characteristics of organic matter of urea molasses block incubated in rumen of fistulated sheep 58

17 Rumen degradation characteristics of nitrogen of urea molasses block incubated in rumen of fistulated sheep 59

18 Least squares means for purine derivatives (PD) and microbial protein yield (MPY) of sheep fed urea molasses block 60

19 Weight of morphological components and proportion of maize stover refused by sheep fed maize stover supplemented with urea-molasses block 61

LIST OF FIGURES

Figure

1 Ammonia N levels of rumen fluids of sheep fed forage legumes and blood meal. 85

2 pH levels of rumen fluids of sheep fed forage legumes and blood meal. 86

3 Dry matter disappearance (g/kg) of maize stover , lablab, cowpea, blood meal and their combinations. 87

4 Organic matter disappearance (g/kg) of maize stover, lablab, cowpea, blood meal and their combinations. 88

5 Nitrogen disappearance (g/kg) of maize stover, lablab, cowpea, blood meal and their combinations. 89

6 Ammonia N levels of rumen fluids of sheep fed urea-molasses block. 90

7 pH levels of rumen fluids of sheep fed urea-molasses block. 91

8 Dry matter disappearance (g/kg) of urea-molasses fed to sheep. 92

9 Organic matter disappearance (g/kg) of urea-molasses fed to sheep. 93

10 Nitrogen disappearance (g/kg) of urea-molasses fed to sheep. 94

1.1.0 Introduction

Small ruminants play a significant role in the production of meat, milk, hide and skin which contribute in monetary terms to the economy of most third world countries. A greater number of these animals are in the hands of rural small holder farmers and the traditional systems of management expose these animals to erratic feed supplies. The feed resources are generally of low quality and quantity. These combine to cause poor growth rate, low production, delayed puberty, long parturition intervals and high neonatal mortality.

Crop residues are very useful in ameliorating the problem of inadequacy of feeds during the dry season. Most small holders use residues of cereals (maize , sorghum, millet, wheat, barley and oats) and legume (cowpea, groundnut and soya bean haulms). Although useful as dry season feeds, crop residues particularly those of cereal origin are low in protein and energy (Chenost and Mayer 1976; Sibanda and Said 1991; and Adu et al., 1992). Therefore they have low voluntary intake and poor digestibility (Umunna and Iji, 1993). In order to improve the utilization of crop residues by livestock, several methods have been employed to alter both the physical and chemical properties of these crop residues. Such methods include hydration (Ndlovu and Manyeme, 1989), and ammoniation (Tuah and Orskov 1989). For example, the addition of urea and supplementation using browse plants, molasses and leguminous crop residues have appreciably improved the utilization of basal diets of cereal crop residues.

Nitrogen supplementation is considered essential for crop residue intake and utilization. This has been demonstrated through supplementation with oilseed cakes,

legume hay and animal by-products. Oil seed cakes such as groundnut cake (GNC), cottonseed cake (CSC), soya bean meal (SBM) are standard protein supplements known to have elicited good animal response. But their prohibitive cost limit their use by resource poor farmers in Sub-Saharan Africa (Kandylis et al., 1992). Animal by-product supplements especially fish meal which offers higher proportion of undegraded protein are more costly and rare, thus precluding their inclusion in livestock feeds by small holders even at low levels, usually recommended by extensionists and researchers.

Legume hays which are moderate in rumen degradability have been used to improve the utilization of poor quality roughage. Notably among these are lablab , leucaena, cowpea and groundnut haulms. The use of these legume hay has gained tremendous recognition or acceptance among livestock farmers. While it is recognised that other factors involved in livestock production are important in determining the success or otherwise of livestock enterprises, feed cost which accounts for 70% of the total cost of livestock production is a relevant factor in determining the success of almost all livestock enterprises. Attempts to reduce cost of production to maximize profit have been the concern of several workers. This has involved the search for cheaper feed supplements that can be used in low to medium quality rations.

The objective of the current study is to study the effect of supplementation of forage legumes and blood meal on cereal residue based-diets to determine their interactive effects. Blood meal is a cheap protein source but its acceptability is low. Therefore it was presented and also included with molasses in urea-molasses block and fed to sheep.

CHAPTER TWO

2.1.0 Literature review

2.1.1 Limitation to productivity of tropical breeds of livestock

It is estimated that the sheep, goats and cattle population in Nigeria numbers 22.1, 34.5 and 13.9 million, respectively (ILCA et al., 1993). While these population figures appear to be numerous in terms of annual protein supply to the populace, the quantity of livestock products meat, milk, and eggs produced in the country is yet to meet the level of animal protein intake of 35g/head/day recommended by FAO. The poor performance of the indigenous livestock breeds in this regard is attributable to many factors including genotype, poor management, poor health and inadequate feed quality and supply.

A detailed review of the genotype, management and health factors have been presented in earlier reports (Oyedipe et al., 1982; Umunna and Iji, 1993 ;). Therefore this review will focus attention on feed supply and quality.

2.1.3 Feeds and feeding

Feed problems have been identified as a major limiting factor affecting livestock productivity in most parts of Africa. In characterising the productivity of livestock in Nigeria in terms of weight gains and milk production, Lakpini et al., (1992) showed fluctuating pattern which closely followed the pattern of rainfall as it affected quality and availability of feeds. Lufadeju et al., (1987) found that most indigenous grasses in Nigeria rapidly declined in crude protein (CP) and soluble carbohydrate but increased in lignin with maturity. In an earlier study, de Leeuw (1979) observed tropical pastures to have between 2-3% CP during the dry season and this low level of CP affected the voluntary intake and digestibility of feed by the animals. Voluntary

intake of tropical grasses by animals have been increased by supplementation with oil seed cakes and other industrial by-product during the dry season and has been reported to have caused improved animal performance (Kandylis et al., 1992).

Due to pressure on the available land as a result of crop production, available grazing area has been reduced, thus necessitating the need to make better use of crop residues as viable alternative livestock feed. Despite the estimated fifty million tones of crop residue produced annually in Nigeria (Olayiwole and Olorunju, 1987), Lakpini et al., (1992) observed that crop residue are yet to be fully evaluated and maximally utilized. A more recent estimate put production of sorghum stover alone at about 23.6 million tones annually in Nigeria (Lakpini et al., 1992).

The utilization of cereal crop residues such as maize and sorghum stovers have been enhanced in several ways. Supplementation with agro-industrial by-products either as energy or protein source to increase annual performance has been extensively documented (Alhassan, 1985; Kumwenda and Msiska, 1990; Givens et al.,1992).

Molasses and wheatbran are agro-industrial by-products which serve as energy source. Apart from the primary role as energy source, molasses is used as a binder in pelleted feeds and a carrier of urea and unpalatable feeds (Alhassan, 1985). A survey by Adu et al., (unpublished data) showed that kitchen wastes such as cassava and yam peels form good source of energy supplement for small ruminant in Southwest Nigeria.

In most African countries brewers dried grains (BDG), a by-product of brewery industries has been shown to be suitable supplement for fattening animals. Work in

Nigeria (Adu, 1985) showed that 25% replacement of maize with BDG was appropriate to support gains of about 112g/day in sheep. In the recent past however, the nature of BDG in Nigeria has changed from barley-based to sorghum and maize-based as a result of change in government policy that requires sourcing of industrial raw materials locally. The quality of sorghum and maize BDG in use now are yet to be fully evaluated. One major limitation of the use of these as supplement is its bulk due to wetness.

Other products of nutritional significance in livestock industry are animal waste which include blood meal, meat and bone meal and poultry litter. Although various studies have shown blood meal to be good source of rumen undegradable protein (Mosimanyana and Mowat, 1992), it is known to support high livestock productivity (Harvey and Spears, 1989). Their unpalatability and therefore low voluntary intake especially blood meal and poultry litter are problems to contend with (Iwanyanwu et al., 1990a).

2.2.0 Poor quality roughage

2.2.1 Description

Roughage are plant materials usually fed to ruminant animals as sources of energy. They do not normally meet the energy requirement of the animal because of low levels of fermentable carbohydrate and nitrogen. Their high fibre content also adversely affect voluntary intake and digestibility. Orskov (1986) described roughage as feeds ingested and digested by animals with an energy cost that exceeds the energy benefit the animals obtain from feeding such roughage. Tropical grasses and cereal rice, wheat, oat and teff are all classified as roughage.

2.2.2 Factors affecting feeding quality of roughage

Factors such as stage of maturity, method of harvest, storage and feeding system all affect the nutritive value of crop residues (Sibanda & Said, 1991). Fleischer et al.,(1989) observed that while different varieties of maize gave stovers of different CP contents, time of harvest also affected CP content, as residue of maize harvested earlier had a higher CP of 7.61% compared with those that were harvested late in the season which averaged only 2.60%.

2.2.3 Nutritive value of crop residues

The chemical composition of some crop residues showed them to have low CP. Rice straw was reported to have CP of 3.5% (Preston, 1982; Roxas et al., 1985) while maize stover had CP of 4.05% (Wegad and Ndumbe, 1987). For most cereal stovers and straws Sibanda and Said (1991) gave 6% as the mean CP content. This level of protein is too low to supply nitrogen required by the rumen microbes for their multiplication and efficient break down of roughage. Apart from low fermentable energy and nitrogen contents, the highly fibrous nature of crop residues makes them slowly degraded by the rumen microbes.

With the new method of fiber analysis developed by Goering and Van Soest (1970), the unreliability of reported fiber contents of feed stuffs was highlighted. With the new method the cell wall constituents of the feed stuff are measured by the levels of neutral detergent fiber (NDF) and acid detergent fiber (ADF). Expressing the fiber contents in terms of NDF, Lakpini et al., (1992) reported 82.4% for sorghum stover. Urio and Kategile 1987 reported NDF value of 80.7% for maize stover. Lufadeju et al., (1987) reported NDF value of 76.4% for Gamba hay (Andropogon gayanus).

2.2.4 Rumen conditions necessary for optimum intake

Preston and Leng (1987) cited by Sibanda and Said (1991) have observed that feeding straws and stovers alone cause low propionate fermentation as well as reducing microbial population or growth in the rumen. Several workers have reported long retention time of these residue in the rumen, which results in low intake. Intake as low as 10 to 15g DM/kg of body weight have been reported (Sibanda and Said, 1991). For optimum degradation and increase intake of roughage with low CP, rumen ammonia concentration exceeding 150mg/litre has been recommended (Sibanda and Said, 1991). A rumen pH of 6.5-6.8 has been reported optimum for rumen activity (Ndlovu, 1992).

2.3.0 Methods of improving poor quality roughage

2.3.1 Physical treatment

To improve utilization of roughage as dry season feeds treatment is necessary before being fed to animals. Various methods have been used to physically treat roughage; these include chopping or grinding, ball milling, irradiation and steaming. In sheep chopping or grinding of roughage have been shown to increase voluntary intake and digestibility (Donefer, 1976). El Hag, (1992) found that chopping of silage increased digestible CP from 54.66 to 59.37%. The physical method of treatment improves intake by increasing the surface area for microbial activity.

2.3.2 Chemical treatment

Chemical treatment of roughage is known to enhance intake, digestibility and utilization. One way of achieving this is by the use of sodium hydroxide which destroys the ligno-cellulose bond thereby releasing cellulose to be attacked by

microbes (Homb et al., 1976). Urea has also been used to treat roughage which acts by dissolving the ligno-cellulose bond releasing cellulose for microbial breakdown. Lufadeju et al., (1987), Iwanyanwu et al., (1990b) and Nuwanyakpa and Butterworth (1987) reported that urea improved voluntary intake and digestibility and also supplied additional rumen degradable nitrogen to the microbes. Ammonia solution has been used to improve the nutritive value of poor quality roughage, by improving intake and apparent organic matter digestibility (Tuah and Orskov, 1989; Avalos-Martinez et al., 1985; Jimenez and Shimanda, 1984). Soaking of chopped maize stover and teff straw in water for 24 hours has been reported to increase DM intake (Ndlovu and Manyeme, 1989; Gitachew and Tadesse, 1992).

2.4.0 Supplementation

Supplementation of poor quality roughage with oil seed cakes , (Little et al., 1987), forage legumes (Ahuja et al., 1991), and browse plants (Bamualin et al., 1986) all have been found to improve their utilization significantly. Supplementing crop residue diets with legume hay improves rumen activity in form of available cellulose and hemi-cellulose that stimulate fiber digestion (Silva and Orskov, 1988).

Browse legumes offer a considerable potential for enhancing animal productivity (vans Eys et al., 1986). Among these are leucaena, (Kimambo et al., 1992), tagasaste, (Varvikko et al., 1992), gliricidia and acacia (D'mello, 1992) have been found to increase liveweight gains in cattle and sheep.

Agro-industrial by-products such as brewers dried grains, (Umoh, 1982) wheat offal, (Alhassan, 1985; Aletor, 1986) maize offal (Ogundola, 1989 ; Kumwenda and Msiska, 1990;) have been used to improve livestock productivity.

2.4.1 Browse plants

Browse legumes offer a considerable potential for enhancing animal productivity (van Eys et al., 1986).. Topps, (1992) reviewed experiment involving supplementation of a napier grass diet with Gliricidia, Leucaena sp and Sesbania and noted that they increased dry matter intake and weight gains. Banmulin et al., (1986) also noticed an increase in digestible CP and OM when sheep were fed tropical pasture supplemented with Leucaena. Kimambo et al., (1992) reported an increase in total dry matter intake of maize stover by increasing the level of supplemented Leucaena in sheep. Varvikko et al., (1992) found that supplementation of a basal natural grass hay with leucaena, cowpea and tagasaste resulted in increased weight gains. Good as the browse plants are in solving problems of weight losses, some however, have been found to have anti - nutritional factors that limit their use as feed stuff. Condensed tannins have been reported as being present in Gliricidia, Leucaena, Acacia Sp and Albizia falcateria (D'mello, 1992), but they are however found to protect the proteins from microbial degradation in the rumen. Tannins are being used to protect degradation of some soluble proteins to make them available for digestion in the small intestine (Ehoche et al., 1983). A toxin known as mimosine is reported present in Leucaena (Banmualin et al., 1986) and this has limited the level of inclusion in ruminant animal diets.

2.4.2 Legume hay

Legume hays have been used to supplement livestock feeds especially in the dry season. Groundnut tops (Munthalis, 1987; Mahabile, et al., 1990), cowpea hay (Ahuja et al., 1991 ; Varvikko et al., 1992;), lablab hay (Kiflewalid and Mosimanyana, 1989; Adu et al., 1992) are a few of the legume hays that have been used as supplement to roughage diets.

Dolichos lablab (Lablab) is a dual purpose legume that remains green into the dry seasons and is easy to cultivate (Adu et al.,1993). It has been reported to have a mean DM, CP and CF composition of 91.5%, 16.4% and 27.7%, respectively, while the DM and OM digestibility was 60.8% and 55.1%, respectively (Kiflewalid and Mosimanyana, 1989). Adu et al., (1993) showed that lablab significantly improved nutrient disappearance in the rumen. They reported a DM disappearance of 33 and 41g/100g at 48 and 72 hr of incubation, whereas Smith et al., (1990) obtained 61 and 84% for DM and N disappearance respectively at 48 and 72 hr. Lablab as supplement to sorghum stover increased both total DM intake and liveweight gain in sheep. Sheep fed lablab gained up to 67g/day compared to those fed stover alone. At 20% inclusion rate the lablab supplemented diet did not allow substitution and sheep consumed 35% more DM. Similarly Mafwere and Mtenga (1992) using lablab seed meal reported increased liveweight gain and total DM intake with increasing levels of dietary lablab seed meal in the diet of lambs. Smith et al., (1990) reported that lablab although reduced intake of stover, increased total DM intake. In cross-bred cows, milk yield improved when sorghum stover was supplemented with lablab (Kiflewalid and Mosimanyana, 1989).

Vigna ungiuculata (Cowpea) is usually produced as grains for humans and the residue as feed for ruminant livestock. In Nigeria cowpea hay is used by small scale farmers to feed livestock. Average OM, CP and digestible crude protein (DCP) of 92.3%, 23.7%, 9.2% respectively have been reported (Smith et al., 1990; Ngwa and Tawah, 1992), with DM and N disappearance values of 77 and 87% respectively. These workers obtained a DM and OM digestibility of 55 and 57% in sheep. Ahuja et al., (1991) compared the nutritive value of maize fodder grown with or without cowpea

and obtained CP of 11.6% with a mixture of maize and cowpea. With maize alone CP was 7.6% while cowpea alone had a CP of 16.9%. In a feeding trial with the fodder involving calves, the average liveweight gain were 650, 590 and 700g/day for maize and cowpea mixture, maize alone and cowpea alone, respectively. In their work Ngwa and Tawah (1992) found that rice straw supplemented with cowpea hay resulted in higher total daily DM intake of 877g as compared with 736g for the basal diet alone. There was also more than 100% increase in average daily gain above that of the basal diet feed alone. Similarly Smith et al., (1990) reported increased stover intake with a supplement of cowpea vines in sheep.

2.5.0 Agricultural by-products

Agro-industrial by-products are residues of food manufacturing industries. Umoh, (1982) and Alhassan, (1985) documented different agro-industrial by-products in use in Nigeria. On the basis of their nutritive value, these by-products can be classified into high energy, high protein and energy-protein concentrates and these have been used as supplements to roughage diets to improve livestock productivity.

2.5.1 Molasses and urea

Molasses is a by-product of the sugar manufacturing industry. In Nigeria, during the 1980/81 period, the total production capacity was reported to be sixteen thousand tonnes (Alhassan, 1985). Several workers have used molasses as an animal feed (Givens et al., 1992; Sibanda et al., 1987; Mwenda and Khasatsili, 1990). Molasses is known to be a rich source of fermentable carbohydrate but with low nitrogen content. With these characteristics, molasses is usually used to improve palatability

of poorly accepted feeds and to serve as binder in pelleted feeds. It is also used to carry the rather volatile urea in semi-solid or solid blocks.

Using graded levels of cane molasses in sheep, Givens et al., (1992) reported significant increase in DM and OM digestibility (about 82 and 84% respectively). Similarly Sibanda et al., (1987) also observed increased total food intake, weight gain and significant difference between treatment and control diets in feed conversion efficiency in sheep. Molasses is almost always used along with urea, so that while molasses supplies the readily fermentable carbohydrate, urea provides the ruminally degradable protein, jointly enhancing microbial synthesis and multiplication. Although use of urea alone has been reported to increase DM intake (Iwanyanwu et al., 1990b), toxicity associated with feeding urea alone tends to encourage it's combination with molasses. Molasses and urea are usually presented in semi-solid and solid forms. The block encourages chewing which prevents toxicity associated with licking of urea (Sahoo et al., 1992).

Although, Olayiwole and Olorunju, (1987), Nuwanyakpa and Butterworth, (1987) and Munthalis et al., (1992) observed increased roughage and total DM intake in association with the use of urea molasses in sheep, this increase was not significant over diets without molasses. However Mehra et al., (1991) reported a significantly higher DM intake in calves fed molasses and urea. Nuwanyakpa and Butterworth, (1987) fed urea molasses blocks to sheep and reported daily intake of 68gDM/head and straw intake of 359gDM. Level of molasses intake differ widely among species of livestock. Whereas Mehra et al., (1991) reported 690 - 1220g/day intake in calves, Lakpini et al., (1992) reported a block intake of 67g/head per day in Yakassa sheep.

As expected the animal response to these differential intakes have varied. Growth rate of 170.6g in steers (Munthalis et al., 1992) and (13.6-28.6g) in sheep (Lakpini et al., 1992) has been reported for different urea molasses block.

2.5.2 Oil seed cakes

Oil seed cakes, by-products of vegetable oil producing factories have been used extensively as livestock feeds especially in monogastrics. These include groundnut cake (GNC), soya bean meal (SBM) or cake (SBC), sun flower seed cake (SSC) and cotton seed cake (CSC). These by-products have the advantage of providing protein as well as concentrated energy.

Cotton seed cake (CSC) a by-product of textile and vegetable oil industry has been used extensively in livestock production. Supplementing straw with CSC in sheep and goats, Fomunyam and Mbomi, (1989) observed a higher feed intake in sheep and goats when straw was supplemented with CSC. Yilala, (1990) also reported significant differences in the liveweight changes when CSC was used as a supplement to low quality straw diets.

Ngwa and Tawah, (1992) observed increased ADG by over 100% when CSC was supplemented to basal diet in sheep, whereas Kandylis et al., (1992) could successfully replace soya bean meal with CSC in a lamb fattening ration. The latter workers obtained ADG of between 0.18-0.25kg/day with different levels of CSC replacement, but the 15% inclusion gave the maximum response. Yilala, (1990) suggested 60g/kg DM of diet as the possible economic and efficient level of inclusion of CSC. With its high phosphorus (P) level it could be used to correct the P

deficiency in tropical pasture hay. The presence of a toxic substance (Gossypol) in CSC could however hinder its use as livestock feed if not well processed.

2.6.0 Animal by-products

These are obtained from meat and fish processing industries as well as recyclable manure of livestock. These include meat and bone meal, blood meal, fish meal and poultry litter. In more developed countries it may include inedible offal of ruminants.

Fish meal is known to be a superior source of protein in livestock especially when used in feeding poultry. Although its cost and availability in developing countries prohibits its use for ruminants as supplementary feed. Fish meal has also been found to significantly increase fibre digestibility as well as liveweight gains (Steen, 1989).

Blood meal an abbatoir by-product has been used as protein source for livestock including poultry. In Nigeria an estimated blood meal production for the year 1975 was put at about 14,194 tonnes (Adewoye, 1982). The chemical composition of blood meal was reported by Umoh, (1982) to be 89.5, 88.5, 0.5, 5.0, 0.12, and 0.47% for DM, CP, CF, ash, Ca (calcium) and P, respectively. With its high CP content, blood meal has been reported to be degraded rather slowly in the rumen (Mosimanyana and Mowat, 1991) leading to minimum ammonia losses, thereby increasing nitrogen utilization in the rumen.

Comparing blood meal and soya bean meal, Harvey and Spears, (1989) did not obtain any significant difference in feed intake. But when they compared vat dried and ring dried blood meal, they reported a significant difference in average daily gain of 0.81

and 0.88kg respectively. Sibanda et al., (1992) reported 18% increased dry matter intake of veld hay offered to steers supplemented with a combination of blood meal, meat and bone meal. They however noted little effect on the rumen pH(7.2) ammonia (300mg/l) and degradation.

3.0 CHAPTER 3

Experiment 1 : Response of growing sheep to chopped maize stover supplemented with forage proteins, blood meal or a combination of forage legumes and blood meal

3.1.1 Introduction

Maize stover has been known to have low crude protein content and high NDF both of which combine to cause low digestibility (Sibanda and Said, 1991; Urio and Kategile, 1987). To use maize stover as livestock feed, it will have to be improved to increase intake and digestibility. Various methods have been used to achieve this improvement. Such methods rely mostly on physical and/or chemical processing to change the physical or chemical nature of these roughages as well as supplementation with deficient nutrients notably nitrogen. However the energy cost of modifying the physical and chemical characteristics of maize stover or other low quality roughages may make the use of such processed roughages uneconomic, especially in Africa. Even if physically or chemically processed, the inherent nitrogen deficiency suggests the need for supplementation. Supplementation with feeds of nitrogenous origin in itself encourages more roughage intake and digestion. Notable amongst these are forage legumes and animal by-products which degrade to varying extents in the rumen with consequent differing effects on nutritive value of the total diet.

In this experiment the effect of supplementing maize stover diets with various forage legumes and/or blood meal was investigated to determine how these various forms of protein in diet affect the performance of sheep.

3.1.2 Materials and Methods

3.1.3 Location

The study which consisted of separate growth and digestibility trials was carried out at the International Livestock Centre for Africa (ILCA) Debre Zeit Research Station which is 50 km south of Addis Ababa,the capital city of Ethiopia. The station is on an altitude of 1800m above sea level with a total rainfall of about 770mm per year. The rainfall is bimodal, with the short rain between February and May while the long rain is between July and October. The mean monthly temperature is about 25^{0}C. The soil is largely vertisol and water logging is a problem during the rainy season.

3.1.4 Growth trial

Sixty Ethiopian highland sheep of the Menz breed were used. The liveweight of the experimental animals ranged between 18.2 and 22.6kg. The animals were about 12 months of age. The 60 animals were divided into six groups of 10 each based on liveweight and age. Animals in each group were randomly assigned to one of the six experimental treatments shown in Table 1.

Table 1: Dietary composition (g) of different supplements fed to sheep

Composition	Treatments					
	LL	CW	BM	LC	LB	CB
Lablab	250	-	-	125	125	-
Cowpea	-	250	-	125	-	125
Blood meal	-	-	50	-	25	25
Stover	1000	1000	1000	1000	1000	1000

[1] Maize stover

Symbol: LL = Lablab, CW = Cowpea, BM = Blood meal,
LC = Lablab + cowpea,LB = Lablab + blood meal,
CB = Cowpea + blood meal.

The supplements were fed with maize stover as a basal diet. The animals were housed in individual pens. Water and salt lick were provided ad libitum.

The cowpea (CW) and lablab (LL) hay were harvested from the research farms and they were kept in a store until when required for feeding. Blood meal (BM) in the processed form was bought from an abbatoir. The blood meal contained small quantities of plant material. The diets were formulated to provide equal amounts of nitrogen to sheep.

The maize stover was chopped to about 6 cm pieces before feeding. The supplements and basal diet were fed separately. The supplements were offered to the animals at approximately 07.00 h. Animals were required to consume all the supplements before the basal diet was offered *ad libitum*. Due to poor acceptability of the blood meal, molasses was added at the rate of 50 gm to all treatment groups to enhance the taste of the former. Feed offered and feed refused were recorded daily for each animal. The refusals were bulked for each animal over 14 days. Subsamples were taken fortnightly for the determination of rumen degradation characteristics. Animals were weighed at the beginning of the trial, and at 14-day intervals after 14 h without food and water. The experiment lasted 75 days. Average daily gain (ADG) was calculated by regression of liveweight on time.

3.1.5 Digestibility Trial

Twenty four Menz sheep with average liveweight of 22 kg (range 19.5- 24.2 kg) and about 9 months old were blocked and divided into six groups of four animals based

on age and liveweight. Each group was randomly assigned to one of the six treatments (Table 1). Animals were housed individually in metabolic crates. Feeding management was similar to the growth trial. The trial lasted 21 days with a 14-day adjustment period and a 7-day collection period.

The faeces was collected using harness bags. Faeces collected from individual animals were weighed daily. About a 100 g was immediately dried at 105°C for 24 h for DM determination. About 10 % of the originally weighed faeces was subsampled and bulked. At the end of the collection period, the bulked faeces was oven dried at 60°C for determination of nitrogen and neutral detergent fibre (NDF) (Goering and Van Soest, 1970).

Urine was collected daily over 10 ml of 25% sulphuric acid and weighed. The urine was then diluted with 2 litres of water and 10% subsampled. The daily samples were bulked for 7 days and then subsampled for determination of purine derivatives (PD) and microbial protein yield (MPY) according to methods described by (Chen et al., 1992).

3.1.6 Rumen digestion kinetics

Chromium mordanted maize stover was prepared by thoroughly washing 1000 g of maize stover to reduce contamination. About 330 g of potassium dichromate crystals were added to the stover in a bowl and sufficient water added to submerge the stover. The bowl was covered properly by applying a weight on top to prevent drying out and placed in the oven at 100°C for 24 h. After baking the liquid was poured out and 500 g of ascorbic acid was added to reduce the excess unbound chromium. This was

soaked for about an hour. The stover was thoroughly washed until water was clear, then oven dried at 65°C for 24 h, as described by Uden et al., (1980).

After the collection period in the digestibility trial, each animal was offered 10g of chromium mordanted maize stover, followed by the experimental diets. Faecal samples were collected for a total period of 144 h. The first 48 h, faecal samples were collected at intervals of 4 h, while for the next 48 h samples were collected at every 8 h. During the last 48 h, samples were collected at 12 hrs interval. The samples were stored in a freezer until when required for analysis. Faecal chromium concentration and rate of passage in the alimentary tract of animals were determined.

The data on rate of passage were also fitted to the equation used by Grovum and Williams (1973): $Y = Ae\text{-}k1(t\text{-}TT)\ Ae\text{-}k2(t\text{-}TT)$, where Y and A = adjusted marker concentration in faecal DM; $k1$ and $k2$ = rates constants; TT = calculated time for first appearance of marker in the faeces; t = sampling time after dosing. The mean retention time in the tract (MRT) was calculated as $MRT = 1/k1+1/k2+TT$ (Moore et al., 1992). The retention in rumen (RTR) was calculated as, $RTR = 1/k1$. Retention in the hind gut (RTH) was calculated as, $RTH = 1/k2$. Time available for digestion in each pool t(0.5) was estimated as follows: $t_{1/2} = 0.693/k1 = Tk1$ in rumen; $t_{1/2} = 0.693/k2 = Tk2$ in hind gut (Osuji et al., 1993a).

3.1.7 In sacco rumen degradation

Thirteen rumen-fistulated Menz sheep were used to determine the rumen degradability of the feed samples according to procedures described by Orskov et al., (1980). Animals were fed on teff straw (Eragrostis teff) and cotton seed cake as supplement.

Samples of feed offered and refused in the growth and digestibility trials were oven-dried at 60^{0}C for 24 h and ground through a 2 mm screen. About 5 g air-dried sample were weighed and place in polyamide bags (Polymon Switzerland) of pore size 41 microns and dimension 6 cm x 12 cm. The bags were incubated in the rumen for 3, 6, 9, 12, 24, 48, 72, 96, and 120 h. After these incubation periods, bags were withdrawn, and machine washed with tap water until water was clear. The bags were then oven-dried to a constant weight at 60^{0}C and weighed. The residual samples were ground through a 1 mm screen for nitrogen determination. Degradation constants were estimated from the non-linear equation suggested by Orskov and McDonald, (1979): $P = a+b(1-e^{-ct})$, where a = soluble fraction of DM, OM of N; b = rumen degradable fraction, c =rate of degradation of b at time t, and P = potential degradation.

3.1.8 Rumen pH and ammonia

Rumen fluid was collected from intact animals using a compressor and stomach tube to determine pH of the rumen fluid on the last day of faecal collection. The rumen fluid samples were collected at 3, 6, 12 and 24 h after feeding. About 100 ml of rumen fluid was collected over 10 ml of sulphuric acid for determination of ammonia concentration.

3.1.9 Botanical composition of maize stover

Maize stover refusals were separated into sheath, stem and leaf to study the selectivity of the sheep. About 250 g subsample of maize stover offered and a similar amount of the subsample of maize stover refused for each animal were hand separated into leaf sheath, stem, leaf blade and minute particle referred to as dust in this work. Each component was then weighed and recorded.

3.1.10 Statistical analyses

a) Data on feed intake, feed digestibility, average daily gain and maize stover fragmentation were subjected to analysis of variance using the General Linear Model (SAS/STAT, 1987).

b) Estimates of degradability of the feed materials were obtained by fitting the equation: $P = a+b(1-c^{-t})$,

where P= actual degradation after time (t);

a= the intercept of degradation curve at time zero. This represents the relatively more rapidly degradable component of the material.

b= the potential degradability of fraction which will be degraded with time.

c= the rate constant for degradation of b.

t= time.

The potential degradability (P) of a sample is given by a+b which should not exceed 100 (Orskov et al., 1980)

The data on rate of passage were also fitted to the equation used by Grovum and Williams (1973)

$Y = Ae^{-k1(t-TT)}\ Ac^{-k2(t-TT)}$

where Y and A are adjusted marker concentration in faecal DM;

k1 and k2 are rates constants

TT= calculated time for first appearance of marker in faeces;

t= sampling (t) after dosing;

The mean retention time in the tract (MRT) was calculated as

MRT= 1/k1+1/k2+TT (Moore et al., 1992)

The retention in the rumen (RTR) was calculated as RTR = 1/k1 while retention in the in hindgut RTH = 1/k2

Time available for digestion in each pool t(0.5) was estimated as follows

$t1/2 = 0.693/k1$ = TK1 in rumen

$t1/2 = 0.693/k2$ =TK2 in hindgut (Osuji et al., 1993a)

3.2.0 RESULTS

3.2.1 Voluntary intake

The mean daily voluntary stover intake differed significantly among treatments (Table 2). Average stover intake expressed on the basis of metabolic weight were similar for treatments BM, LB and CB which were significantly ($P<0.05$) higher than LL, CW and LC .

Mean daily supplement intake differed among treatments (Table 2)). Daily intakes of LC, CW and LL (range 21.3 - 21.7 g/kg $W^{0.75}$) were significantly ($P<0.05$) higher than LB and CB. The average supplement intake of LB and CB were significantly ($P<0.01$) higher than BM.

Table 2: Least squares means of liveweight changes, daily voluntary intake, average daily gain and feed conversion of sheep fed basal diet of maize stover diet supplemented with forage legumes and blood meal

Variables	Treatments[1,2]						
	LL	CW	BM	LC	LB	CB	SE
Intake							
Stover (g/head)	353.0^{a}	356.0^{a}	418.2^{b}	345.7^{a}	411.9^{b}	389.5^{b}	14.27
Stover (g/kgW$^{0.75}$)	35.1^{a}	35.2^{a}	41.2^{b}	33.9^{a}	40.5^{b}	38.5^{b}	1.19
Supple. (g/head)	214.3^{d}	219.3^{e}	44.1^{a}	220.5^{f}	132.5^{c}	131.9^{b}	0.05
Supple.(g/kg W$^{0.75}$)	21.3^{c}	21.7^{c}	4.4^{a}	21.5^{c}	13.1^{b}	13.0^{b}	0.17
Total (g/head)	567.2^{c}	575.3^{c}	462.8^{a}	566.2^{c}	544.5^{b}	521.4^{b}	14.39
Total (g/kg W$^{0.75}$)	57.4^{c}	57.8^{c}	45.7^{a}	55.6^{c}	53.6^{b}	51.5^{b}	1.21
Weight							
Initial (kg)	20.4	20.4	20.7	20.3	20.2	20.9	0.60
Final (kg)	23.4^{a}	24.4^{a}	23.8^{a}	24.2^{a}	24.2^{a}	24.2^{a}	0.29
ADG (g)	34.4^{a}	52.9^{b}	66.3^{c}	47.3^{b}	65.9^{c}	67.1^{c}	4.99
Feed conversion[3]	17.5^{c}	11.3^{b}	7.4^{a}	14.0^{b}	9.4^{ab}	7.7^{a}	1.39

[1]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal .

[2]Means in a row with the same superscript letter(s) are not significantly different (P>0.05).

[3]Feed conversion expressed in kg feed consumed/kg gain.

The mean daily total intake differed significantly among treatments (Table 2). Total intake of CW, LL and LC (range 55.6 - 57.8 g/kg $W^{0.75}$), was significantly ($P<0.05$) higher than LB and CB. Total consumption of BM diet was significantly ($P<0.05$) lower than LB and CB.

3.2.2 Changes in liveweight

The initial and final weights did not differ significantly among treatments (Table 2). The average daily gain of sheep fed maize stover supplemented with CB, BM, and LB were significantly ($P<0.05$) higher than LL, CW, and LC, whilst the average daily gain of CW and LC were significantly ($P<0.05$) higher than LL.

3.2.3 Feed conversion efficiency

There were significant differences between treatments in feed conversion efficiency (Table 2). Treatment LL used significantly ($P<0.01$) more feed to gain weight than the rest of the treatments. The feed conversion efficiency of treatments LC and CW were also significantly ($P<0.05$) higher than BM and CB.

3.3.0 Digestibility Trial

3.3.1 Voluntary intake

Table 3 shows summaries of the results of the digestibility trial. Stover DM intake on metabolic weight basis did not differ significantly ($P>0.05$) among treatments. The DM intake of supplements differed significantly ($P<0.01$) among treatments, ranging from 3.5 g/kg $W^{0.75}$ for treatment BM to 18.5 g/kg $W^{0.75}$ in LB. Mean total DM and OM intake on a metabolic liveweight basis did not differ significantly among treatments.

Table 3: Mean daily intake and apparent digestibility of dry matter (DM), organic matter (OM), neutral detergent fibre (NDF) and nitrogen by sheep fed forage legumes and blood meal

Variables	Treatments[1,2] LL	CW	BM	LC	LB	CB	SE
Intake							
Stover (gDM/head)	491.3[b]	497.9[b]	547.6[c]	461.6[a]	486.3[b]	541.2[c]	13.14
Stover (gDM/kg $W^{0.75}$)	45.5	46.1	50.7	42.7	45.0	50.1	4.55
Supple. (gDM/head)	193.4[c]	188.9[c]	38.2[a]	191.2[d]	195.6[b]	113.7[b]	1.23
Supple. (gDM/kg $W^{0.75}$)	17.9[c]	17.5[c]	3.5[a]	17.7[c]	18.5[c]	10.5[b]	0.77
Total (gDM/head)	684.9[d]	686.8[d]	585.8[a]	652.8[c]	609.9[b]	654.9[c]	13.02
Total (gDM/kg $W^{0.75}$)	63.4	63.6	54.2	60.4	56.5	60.6	4.52
Total (gOM/head)	609.6[d]	608.2[d]	525.6[a]	579.3[c]	539.2[b]	585.7[c]	11.66
Total (gOM/kg $W^{0.75}$)	54.4	56.3	48.7	53.6	49.9	54.2	4.16
Nitrogen (g/head)	7.1[a]	7.6[b]	8.3[c]	7.2[a]	11.7[d]	12.0[e]	0.09
NDF (g/head)	452.4[d]	441.4[c]	409.9[a]	422.8[b]	400.5[a]	435.5[bc]	9.46
Digestibility (g/kg)							
DM	683.0	679.0	681.0	689.0	693.0	662.0	0.30
OM	712.0	710.0	712.0	713.0	712.0	698.0	0.10
Nitrogen	521.0[a]	530.0[b]	630.0[d]	552.0[c]	739.0[f]	708.0[e]	0.40
NDF	744.0	722.0	739.0	708.0	733.0	688.0	0.30

[1]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal.

[2]Means in a row with the same superscript letter(s) are not significantly different ($P > 0.05$).

There were significant ($P<0.01$) differences among treatments in the mean N intake (Table 3). The mean daily values ranged from 7.1 to 12.0 g. Treatment CB had the highest nitrogen intake followed in descending order by treatments LB, BM, CW, LC and LL. Sheep fed LL and LC consumed similar ($P>0.05$) amounts of nitrogen, which were significantly ($P<0.05$) lower than the rest of the treatments. Daily consumption of NDF varied significantly among treatments (Table 3). The highest NDF intake was recorded for treatments LL and CW, which had similar ($P>0.05$) intakes.

3.3.2 Digestibility of nutrients

There were no significant differences in DM, OM and NDF digestibilities among treatments (Table 3). The digestibility of nitrogen differed significantly ($P<0.01$) among treatments, order of ranking being: LB > CB > BM > LC > CW > LL.

3.3.3 Rumen pH and ammonia nitrogen

There were significant differences in rumen pH among the treatments (Table 4). The pH of LB was below 7.0, and was significantly ($P<0.05$) lower than the rest of the treatments.

Treatment BM had the highest rumen ammonia concentration (18.62 mg/100 ml) which differed significantly ($P<0.05$) from the other treatments (range 7.90 - 10.73 mg/100 ml).

Table 4: Mean rumen pH and ammonia-nitrogen concentration in rumen fluid of sheep fed basal diet of maize stover supplemented with forage legumes and blood meal

Treatments[1,2]	pH	Ammonia (mg/100ml)
LL	7.12[b]	7.90[a]
CW	7.11[b]	9.14[a]
BM	7.07[b]	18.62[b]
LC	7.04[b]	10.22[a]
LB	6.08[a]	10.73[a]
CB	7.11[b]	9.08[a]
SE	0.065	1.301

[1]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal .

[2]Means in a column with the same superscript letter(s) are not significantly different ($P > 0.05$).

3.3.4 In sacco rumen degradation

There were wide variations in rumen degradation characteristics of DM (Table 5), OM (Table 6) and nitrogen (Table 7). The ranking order of treatments for DM degradation characteristics were: *a (soluble or rapidly degraded fraction)* , LB > LL > CB > LC > CW > BM; *b* (amount which in time will degrade) , BM > CB > LC > CW > LB > LL; *c (rate of degradation of b at time t)*, CW > LC > LL > LB = CB > BM; and *P (potential degradation)*, BM > CB > LC > LB > LL > CW (Table 5). Ranges for *a, b, c* and *P* were respectively 270.3 - 380.2 g/kg, 359.1 - 723.2 g/kg, 0.013 - 0.031 /h, and 728.2 - 993.6 g/kg.

Table 5: Rumen degradation characteristics of dry matter in forage legumes and blood-meal incubated in rumen of fistulated sheep

Treatments[2]	Degradation constants[1]			
	a (g/kg)	b (g/kg)	c (/h)	P (g/kg)
LL	380.0	359.1	0.023	739.1
CW	324.0	404.1	0.031	728.2
BM	270.3	723.3	0.013	993.6
LC	345.5	419.1	0.025	770.7
LB	380.2	362.8	0.020	743.1
CB	377.7	419.3	0.020	797.1

[1]Degradation constants estimated from the equation: $P = a + b(1 - e^{-ct})$, where a = soluble fraction; b = rumen degradable fraction, c = rate of degradation of b at time t, and P = potential degradation.

[2]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal .

Table 6: Rumen degradation characteristics of organic matter in forage legumes and blood-meal incubated in rumen of fistulated sheep

Treatments[2]	Degradation constants[1]			
	a (g/kg)	b (g/kg)	c (/h)	P (g/kg)
LL	329.9	381.9	0.023	711.8
CW	255.9	440.6	0.031	696.5
BM	257.9	752.8	0.013	1010.7
LC	296.7	447.2	0.025	743.8
LB	342.5	390.9	0.019	733.4
CB	342.4	447.8	0.019	790.2

[1]Degradation constants estimated from the equation: $P = a + b(1 - e^{-ct})$, where a = soluble fraction; b = rumen degradable fraction, c = rate of degradation of b at time t, and P = potential degradation.

[2]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB
= Lablab and blood meal ; CB = Cowpea and blood meal .

Table 7: Rumen degradation characteristics of nitrogen in forage legumes and blood-meal incubated in rumen of fistulated sheep

Treatments[2]	Degradation constants[1]			
	a (g/kg)	b (g/kg)	c (/h)	P (g/kg)
LL	600.7	279.9	0.039	880.7
CW	605.3	283.1	0.039	888.4
BM	365.1	690.4	0.015	1055.5
LC	468.3	674.4	0.106	1142.6
LB	679.5	214.1	0.031	893.9
CB	646.1	181.7	0.061	827.8

[1]Degradation constants estimated from the equation: $P = a + b(1 - e^{-ct})$, where a = soluble fraction; b = rumen degradable fraction, c = rate of degradation of b at time t, and P = potential degradation.

[2]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal .

The ranking order for treatments for OM degradation characteristics were: *a* (soluble or rapidly degraded fraction), LB > CB > LL > LC > BM > CW; *b* (amount degraded which in time will degrade) , BM > CB > LC > CW > LB > LL; *c* (rate of degradation of b at time t), CW > LC > LL > LB = CB > BM; and *P* (potential degradation), BM > CB > LC > LB > LL > CW (Table 6). The ranges for *a*, *b*, *c* and *P* were: *a*, 255.9 - 342.5 g/kg; *b*, 381.9 - 752.8; *c*, 0.013 - 0.031 /h; and *P*, 696.5 - 1010.7 g/kg.

The ranking order of treatments for nitrogen degradation characteristics were: *a* (soluble or rapidly degraded fraction), LB > CB > CW > LL > LC > BM; *b* (amount which in time will degrade), BM > LC > CW > LL > LB > CB; *c* (rate of degradation of b at time t), LC > CB > LL = CW > LB > BM; and *P* (potential degradation), LC > BM > LB > CW > LL > CB. The ranges were: *a*, 365.1 - 679.5 g/kg; *b*, 181.7 - 690.4 g/kg; *c*, 0.015 - 0.106 /h; and *P*, 827.8 - 1142.6 g/kg.

3.3.5 Digestion Kinetics

There were no significant differences between treatments for all parameters related to the rate of passage (Table 8).

Table 8: Rate of passage (h) of chromium mordanted maize stover supplemented with forage legumes and blood meal

	Treatments[1,2]						
Variable[3]	LL	CW	BM	LC	LB	CB	SE
A1	7.93[a]	7.82[a]	8.38[a]	7.91[a]	8.16[a]	8.78[a]	0.43
A2	8.50[a]	8.40[a]	8.81[a]	8.40[a]	8.52[a]	9.11[a]	0.38
K1	0.03[a]	0.03[a]	0.03[a]	0.03[a]	0.03[a]	0.04[a]	0.01
K2	0.09[a]	0.09[a]	0.08[a]	0.08[a]	0.07[a]	0.07[a]	0.01
TK1	22.3[a]	25.6[a]	22.0[a]	24.2[a]	21.7[a]	20.6[a]	3.28
TK2	7.9[a]	8.4[a]	9.7[a]	8.9[a]	10.1[a]	10.1[a]	1.42
RTR	32.2[a]	36.9[a]	31.8[a]	34.9[a]	31.3[a]	29.7[a]	4.73
RTH	11.4[a]	12.1[a]	13.9[a]	12.8[a]	14.6[a]	14.6[a]	2.05
MRT	43.6[a]	49.0[a]	45.7[a]	47.6[a]	45.8[a]	44.3[a]	3.58

[1]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal (CB).

[2]Means in a row with the same superscript letter(s) are not significantly different ($P>0.05$).

[3]Variables estimated from the equation: $Y = Ae\text{-}k1^{(t-TT)}\ Ae\text{-}k2^{(t-TT)}$; where Y and A are adjusted marker concentration in faecal DM; *k1*, *k2* = rates constants; *TT* = calculated time for first appearance of marker in the faeces; *t* = sampling time after dosing; *MRT* = mean retention time calculated as *MRT* = *1/k1+1/k2+TT*; *RTR* = retention time in rumen; *RTH* = retention time in the hind gut; *TK1* = digestion time in the rumen; *TK2* = digestion time in the hind gut.

Table 9: Weight of morphological components and proportion of orts and maize stover offered to sheep fed maize stover supplemented with forage legumes and blood meal

	Treatments[1,2]						
	LL	CW	BM	LC	LB	CB	SE
Weight (g)							
Stem	82.9	181.2	188.6	183.5	192.5	190.3	5.96
Sheath	32.8	35.6	30.9	31.1	30.7	31.8	3.82
Leaf	25.5	27.0	23.3	22.8	25.1	22.9	3.88
Dust	8.8[b]	6.3[b]	7.2[b]	12.3[b]	1.7[a]	5.0[b]	4.13
Total Leaf[3]	67.1	68.8	61.4	66.1	57.5	59.7	5.96
Percentage							
Stem	73.2	72.5	75.4	73.7	77.0	76.1	2.38
Leaf	26.9	27.5	24.6	26.4	23.0	23.9	2.38

[1]LL = Lablab ; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood meal ; CB = Cowpea and blood meal .

[2]Means in a row with the same superscript letter(s) are not significantly different (P>0.05).

[3]Total leaf = Sheath + leaf + dust.

Table 10: Least squares mean for purine derivatives (PD) and microbial protein yield (MPY) of sheep fed forage legumes and blood meal

Treatments[1,2]	PD (mmol)	MPY (g/d)
LL	2.53	1.84
CW	2.15	1.56
BM	2.32	1.69
LC	2.44	1.77
LB	1.38	1.00
CB	2.96	2.15

[1]LL: = Lablab; CW = Cowpea ; BM = Blood meal ; LC = Lablab and cowpea ; LB = Lablab and blood-meal (LB); CB = Cowpea and blood meal .

3.2.6 Botanical fractions

The weight of dust differed significantly between treatments (Table 9). The percentage of stem in the maize stover refused ranged from 72.5 in treatment CW to 77.0 in LB. The percentage of leaf ranged from 23.0 in treatment LB to 27.5 in CW.

3.2.7 · Microbial nitrogen yield

Mean purine derivative (PD) did not differ significantly among treatments (Table 10). Least squares means ranged from 1.38 mmol in treatment LB to 2.96 mmol in treatment CB. These values correspond to daily microbial protein yield one gram for treatment LB and 2.15 g for treatment CB respectively.

3.4.0 DISCUSSION

There were significant ($P<0.05$) differences in voluntary intake of maize stover, supplement, total DM, nitrogen and NDF, and digestibility of nitrogen among treatments. Organic matter and nitrogen degradation characteristics also varied widely among treatments. These variations in determinants of forage quality resulted in significant differences in average daily gain and feed conversion efficiency among treatments. Treatments CB, BM and LB had the highest ADG which was above 60 g, treatments LC and CW were intermediate with ADG of above 45 g, and treatments LL had the lowest ADG of less than 40 g. The much higher ADG of CB compared with LL may be due to higher intake of stover and nitrogen digestibility as well as higher rumen ammonia concentrations of sheep on treatment CB than LL. Weight gains obtained for the treatment involving forage legumes alone were similar to those obtained by Adu et al., (1992), Mafwere and Mtenga, (1992) and Smith et al., (1990).

Forage legumes are usually degraded very well in the rumen to provide ammonia and coupled with the molasses supplied, they could increase microbial protein synthesis. The LB and CB provided better stover DM intake than LL and CW. This could be due to the availability of both ruminally degraded protein (RDP) as well as the rumen undegraded protein (RUP). It is recognised that intake is a function of many factors, including genotype, physiological status, environmental conditions as well as nutritive qualities of feeds (Ketelars and Tolkamp, 1992). For example feeds of poor nutritive value restrict intake. As most crop residues are known to be of poor quality, intake is usually poor (Alhassan et al., 1986). This may result from several factors including the physical properties of the feed. For most crop residues the cell content is

relatively small but with high cell wall content including lignin (Orskov et al., 1988). Several ways of improving the nutritive value of crop-residues and straws have been employed (Tuah et al., 1986: Guitierrez-Ornelas and Klopfenstein, 1991). It has been reported from several developing countries that supplementation trials especially those involving forage legumes, have provided encouraging results (Adu et al., 1992). Supplementation with nitrogen has been known to increase roughage intake (Sibanda et al., 1993; Alhassan et al., 1986). In this experiment all the supplements supplied nitrogen, some supplied rumen degradable nitrogen others were of rumen low degradable nitrogen. Osuji et al., (1993a) suggested that protein of low degradability usually increase intake by increasing digestibility.

In this study BM usually known to be characterized by low degradation in the rumen was associated with high stover DM intake. This was equally the case for CB and LB. There was an increase of 16.7% and 9.4% in the stover intake when BM was combined with LL and CW, respectively in the growth trial. In this experiment rumen readily available energy was provided in the form of molasses as well as to improve acceptability of blood meal.

The differences observed in intake for the various treatment groups could be attributed to the different amounts of supplements offered in order to obtain *isonitrogenous diets.*

In this experiment all supplements had similar rapidly degraded components *a* for DM and OM except BM . These results of low degradation of blood meal agree with the works of Harvey and Spears, (1989) and confirm that blood meal is usually

slowly degraded. These differences in the degradation of forage legumes could be attributed to variation in reporting of the time of harvest and maturity of the legumes. The *P* was high for CB, BM and CW. This observation contradicts the work of Schloesser et al., (1993) where about 82% of BM was not degraded as compared to 80% degradation in the current study. The BM in this study appeared to exhibit slower but more potential degradation which again contradicts the works of Schloesser et al.,(1993), and Anderson et al.,' (1988). Similarly, Lardy et al., (1993) suggested that most of the component of the BM is usually passed to the duodenum. For BM, CW and CB over 80% of the diet was degraded by time 120 h. This suggests that all these supplements would potentially be completely degraded in the rumen. Lignification adversely affects degradation, consequently supplements with high NDF content like LL may have lower degradation (Adu et al., 1992). But those with lower NDF (BM and CW) may be more highly degraded.

There were no significant differences among treatments in variables relating to the rate of passage. The time range for rumen and hind gut (RTR and RTH) were 29.6-36.0 h and 11.4-14.5 hours respectively and agrees with results obtained by Moore et al., (1992) (25-28 h for RTR and 10-15 h for RTH) . The mean retention time (MRT) for the total tract was less by 10 h from that obtained by Moore et al., (1992). Although not statistically significant results from this study show that BM encouraged less retention of feed in the rumen and more in the hind gut than the other supplements, and indicate that BM encouraged more of intestinal activity (Lardy et al., 1993). Results from this study also agree with that of Luginbuhl et al., (1994) where it was suggested that feeding of low quality feed greatly increases the time that digesta is retained in the gastrointestinal tract (GIT). However, BM which improved the quality of the feed reduced the retention time in the GIT.

Ranges of PD (1.38 - 2.99 mmol) and MPY (1 - 2.15 g/day) obtained in this experiment were similar to the lower limits of those obtained by Chen et al., (1992) (2 -17.5mmol and1.8 -15.2g/day), but was lower than those of Osuji et al., (1993b) (2 - 5.4mmol and 3.2 - 7.3g/day). The differences may be partly due to variation in chemical composition and rumen degradation characteristics of diets used in the different studies.

Feed conversion efficiency was affected by treatment in this experiment. Blood-meal was most efficient in feed conversion and LL was least efficient. Consequently, BM improved the feed conversion efficiency for the LB and CB. This observation may be explained on the basis that only 50 gm of BM was enough to supply the same amount of nitrogen when compared with LL or CW which required about 250 gm. It is also possible that complimentarily of rumen degraded nitrogen obtained from the forage legumes and rumen undegraded/bypass protein from the blood meal may have caused the feed conversion superiority of the blood meal containing diets. Cowpea had a better feed conversion efficiency than LL because of the higher nitrogen intake.

CHAPTER FOUR

Experiment 2: Response of growing sheep to chopped maize stover supplemented with urea-molasses block

4.1.1 Introduction

Agro-industrial by-products have been used as supplements to roughage diets fed to livestock in order to improve productivity. These include molasses, and oilseed cakes which have been fed with urea as supplements to roughage (Umoh, 1982). In a previuos study molasses and urea were combined in a semi-solid block and fed to cattle where it was found to improve total intake and digestibility of roughage (Sahoo, 1992). Blood meal is unpalatable and therefore of low acceptability when fed alone to animals, even though it is quite high in crude protein. This experiment was therefore undertaken with the aim of including blood meal in a urea-molasses semi-solid block and fed to sheep offered maize stover, to evaluate its effect on the nutritive value of maize stover and the performance of sheep. Comparisons were made with semi solid urea-molasses blocks developed with the inclusion of wheatbran, cottonseed cake, blood meal and a combination of cottoseed cake and blood meal.

4.1.0 Material and Methods

4.1.1 Location

The experiment was conducted at the same site as Experiment 1. It consisted of two separate growth and digestibility trials.

4.1.2 Growth Trial

Thirty six Ethiopian Menz sheep were divided into four groups of nine based on weight taken for two consecutive days before the start of the experiment. Animals in each group were then randomly assigned to one of the four treatments in Table 11. The animals were fed a basal diet of maize stover supplemented with four types of urea-molasses blocks: 1) wheatbran (WB, control); 2) cottonseed cake (CC); 3) blood meal (BM); and 4) cottonseed cake and blood meal (CB). The compositions of the different treatment blocks are shown in Table 11.

Table 11: Dietary composition of urea molasses semi solid block.

	Treatment			
	WB	CC	BM	CB
Ingredients (kg)				
Molasses	42	42	42	42
Wheat bran	25	11.5	12.5	14
Urea	10	8	6	8
Blood meal	-	-	16.5	7
Cotton seed cake		15.5	-	6
Cement	15	15	15	15
Diammonium phosphate(DAP)	3	3	3	3
Salt	5	5	5	5
Total	100	100	100	100
Symbol[1]				

[1]Symbol: WB = Wheat bran, CC = Cottonseed cake, BM = Blood meal, CB = Cottonseed cake + blood meal.

Maize stover was similar to the one used in Experiment 1. The urea-molasses blocks were made at the research station using concrete mixing machine. The ingredients used are shown in Table 11. During mixing, molasses was first poured into the mixer followed by urea, diammonuim phosphate and salt in that order. Each ingredient was added slowly, after which the mixer was rotated to allow proper mixing before adding another ingredient. Blood meal and cotton seed cake were added after the initial mixing. This was followed by addition of cement to bind the ingredients together, thereafter wheat bran was added and allowed to run for 10 minutes. The mixture was then poured into wooden mortars, and compressed until compact, and air-dried. Each block weighed approximately 3 kg.

The animals were housed in individual pens and water was provided *ad libitum*. Maize stover was offered at 07.00 h. The urea molasses blocks were offered in plastic buckets *ad libitum*. Refusals of the block were weighed weekly. Maize stover refused was recorded daily for each animal, bulked fortnightly and subsampled. Animals were weighed fortnightly to monitor weight changes.

4.1.3 Digestibility Trial

The procedures used are similar to those described in Experiment 1.

4.1.4 In sacco rumen degradation

Procedures used in sections 4.1.4, 4.1.5 and 4.1.6 indicated below were similar to those described in Experiment 1.

4.1.5 Rumen pH and ammonia

4.1.6 Botanical fractions

4.1.7 Statistical analysis

Data were analysed using the General Linear Models procedure (SAS, 1987).

4.2.0 RESULTS

4.2.1 Voluntary intake

Dry matter intake of maize stover did not differ significantly among treatments (Table 12). There were significant differences ($P<0.01$) in DM intake of supplement among treatments (Table 12). The average supplement intake ranged from 16.8 g/kg $W^{0.75}$ for WB to 25.2 g/kg $W^{0.75}$ for BM. The order of supplement DM intake for the treatments were: BM > CC > CB > WB.

Total intake differed significantly ($P<0.05$) among treatments (Table 12). Expressed on the basis of metabolic weight, animals fed diets supplemented with BM consumed significantly more DM than their counterparts fed WB, CC and CB. Total intake for WB, CC and CB on metabolic liveweight basis did not differ significantly ($P>0.05$).

4.2.2 Changes in liveweight

Initial weights of sheep did not differ significantly among treatments (Table 12). Final weight was significantly higher for sheep on treatment BM than for those fed CC ($P<0.05$), WB ($P<0.01$) and CB ($P<0.05$). Average daily gain of sheep also differed significantly ($P<0.01$) among treatments. The ADG of sheep fed BM was significantly higher ($P<0.05$) than those fed treatments WB, CC and CB. The ADG of sheep on treatment CC was significantly higher than WB ($P<0.05$), whilst ADG of sheep on WB was higher than CB ($P<0.05$).

4.2.3 Feed conversion efficiency

Treatments BM and CB had similar ($P>0.05$) feed conversion efficiency of 14.4,

showing that significantly more feed was consumed per kg gain than those fed CC and WB ($P<0.05$); (Table 12). Animals fed CC consumed significantly more feed ($P<0.05$) per kg gain than those fed WB.

Table 12: Least squares means of liveweight changes, mean daily voluntary dry matter intake, average daily gain (ADG) and feed conversion of sheep fed maize stover supplemented with urea-molasses block

Variables	Treatments[1,2,3]				
	WB	CC	BM	CB	SE
Intake					
Stover (g/head)	517[a]	535[a]	513[a]	519[a]	0.05
Stover (g/kg $W^{0.75}$)	54.7[a]	54.7[a]	51.6[a]	53.3[a]	0.04
Suppl. (g/head)	158[a]	196[b]	251[c]	196[b]	0.03
Suppl. (g/kg $W^{0.75}$)	16.8[a]	20.3[b]	25.2[c]	20.1[b]	1.07
Total (g/head)	675[a]	732[c]	764[d]	715[b]	0.04
Total (g/kg $W^{0.75}$)	71.4[a]	75.0[a]	76.9[b]	73.2[a]	1.80
Weight					
Initial (kg)	17.8[a]	18.5[a]	18.0[a]	19.1[a]	0.04
Final (kg)	22.6[a]	23.8[c]	24.6[d]	23.0[b]	0.06
Daily gain (g)	56.0[b]	58.0[c]	69.0[d]	53.0[c]	0.05
Feed conversion[3]	12.6[a]	13.7[b]	14.4[c]	14.4[c]	0.19

[1]WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal; CB = Cottonseed cake and Blood meal.

[2]Means in a row with same superscript letter(s) are not significantly different ($P > 0.05$).

[3]Feed conversion expressed in kg feed consumed/kg gain.

4.3.0 Digestibility Trial

4.3.1 Voluntary intake

The results are presented in Table 13. Stover DM intakes were highest for sheep fed WB than for others. The difference between WB and CC was significant ($P<0.05$) while that between CC on the one hand and BM and CB on the other was also significant. Stover intakes on a metabolic liveweight basis were not significant ($P>0.05$) among treatments. Daily intake of nitrogen did not differ significantly among treatments and ranged from 13.0 - 14.2 g/head. Daily intake of NDF for treatment WB was significantly higher than CC, BM and CB.

4.3.2 Digestibility of nutrients

There were no significant difference between treatments in DM, OM, nitrogen and NDF digestibilities (Table 13), although absolute values for N digestibility were higher for the two blood meal-containing diets (BM and CB).

Table 13: Least squares means of daily voluntary intake and digestibility of dry matter (DM), organic matter (OM), neutral detergent fibre (NDF) and nitrogen of sheep fed a basal diet of maize stover supplemented with urea-molasses block

Variables	Treatments[1,2] WB	CC	BM	CB	S E
Intake					
Stover (g/head)	563.1[c]	521.3[b]	508.0[a]	498.7[a]	13.67
Stover (g/kg $W^{0.75}$)	51.7[a]	47.8[a]	47.0[a]	45.7[a]	4.27
Suppl (g/head)	188.4[a]	179.3[a]	203.6[b]	183.5[a]	10.11
Suppl. (g/kg $W^{0.75}$)	17.3[a]	16.4[a]	18.9[a]	16.8[a]	3.41
Total (gDM/head)	751.4[c]	700.6[b]	711.7[b]	682.1[a]	16.39
Total (gDM/kg$W^{0.75}$)	68.9[a]	64.3[a]	65.9[a]	62.6[a]	5.32
Total (gOM/head)	634.5[c]	594.5[b]	600.7[b]	571.4[a]	15.11
Total (gOM/kg$W^{0.75}$)	58.2[a]	54.5[a]	55.6[a]	52.4[a]	4.61
Nitrogen (g/head)	13.7[a]	13.0[a]	14.2[a]	13.4[a]	0.58
NDF (g/head)	432.3[b]	401.2[a]	393.2[a]	385.6[a]	10.22
Digestibility (g/kg)					
DM	581.0[a]	588.0[a]	580.0[a]	591.0[a]	16.40
OM	640.0[a]	643.0[a]	653.0[a]	648.0[a]	14.60
Nitrogen	677.0[a]	673.0[a]	707.0[a]	704.0[a]	11.19
NDF	641.0[a]	644.0[a]	652.0[a]	646.0[a]	14.79

1WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal ; CB = Cottonseed
cake and Blood meal.

[2]Means in a row with same superscript letter(s) are not significantly different ($P > 0.05$).

in time will degrade), CC > CB > BM > WB; *c* (rate of degradation of b at time t), CC > WB > CB > BM; and *P* (potential degradation), WB > CB > BM > CC. The ranges of *a*, *b*, *c* and *P* were: 546.7 to 860.8 g/kg, 122.8 to 346.5 g/kg, 0.031 to 0.200 /h and 846.9 to 983.6 g/kg respectively (Table 17).

4.3.5 Microbial nitrogen yield

The purine derivative (PD) and the microbial protein yield (MPY) did not differ significantly among treatments (Table 18). The PD ranged from 5.32 mmol in CB to 6.43 mmol in CC. The calculated microbial protein yield corresponding to these values were 3.87 and 4.67 g/day respectively.

4.3.6 Proportion of leaf and stem

The increasing order of percentage stem in the maize stover refused were 71.4, 72.5, 78.9 and 79.1 for CB, WB, CC and BM respectively (Table 19). Corresponding values for percentage leaf in the maize stover refused were: 20.9, 21.2, 27.5 and 28.6 for BM, CC, WB and CB respectively.



Table 14: Mean pH and ammonia of rumen fluid for sheep fed basal diet of maize stover supplemented with urea molasses block

Treatments[1,2]	pH	Ammonia (mg/100ml)
WB	7.10[a]	35.38[a]
CC	7.07[a]	32.13[a]
BM	7.15[a]	35.15[a]
CB	7.10[a]	28.55[a]
SE	0.048	5.471

[1]WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal ; CB = Cottonseed cake and Blood meal.

[2]Means in a column with the same superscript letter(s) are not significantly different (P>0.05).

Table 15: Rumen degradation characteristics of dry matter in urea molasses block incubated in rumen of fistulated sheep

Treatments[2]	Degradation constants[1]			
	a (g/kg)	b (g/kg)	c (/h)	P (g/kg)
WB	642.2	171.4	0.055	813.6
CC	569.7	214.4	0.168	784.1
BM	590.3	117.7	0.034	708.0
CB	570.0	128.4	0.053	698.4

[1]Degradation constants estimated from the equation: $P = a + b(1 - e^{-ct})$, where a = soluble fraction; b = rumen degradable fraction, c = rate of degradation of b at time t, and P = potential degradation.

[2]WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal ; CB = Cottonseed cake and Blood meal.

Table 16: Rumen degradation characteristics of organic matter in urea molasses block incubated in rumen of fistulated sheep

Treatments[2]	Degradation constants[1]			
	a (g/kg)	b (g/kg)	c (/h)	P (g/kg)
WB	620.6	256.9	0.083	877.6
CC	554.5	300.0	0.091	854.5
BM	564.5	229.2	0.049	793.7
CB	542.4	264.3	0.036	806.7

[1]Degradation constants estimated from the equation: $P = a + b(1 - e^{-ct})$, where a = soluble fraction; b = rumen degradable fraction, c = rate of degradation of b at time t, and P = potential degradation.

[2]WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal ; CB = Cottonseed cake and Blood meal.

Table 17: Rumen degradation characteristics of nitrogen in urea molasses block incubated in rumen of fistulated sheep

Treatments[2]	Degradation constants[1]			
	a (g/kg)	b (g/kg)	c (/h)	P (g/kg)
WB	860.8	122.8	0.096	983.6
CC	600.4	346.5	0.200	846.9
BM	546.7	308.9	0.031	855.6
CB	597.4	312.9	0.081	910.3

[1]Degradation constants estimated from the equation: $P = a + b(1 - e^{-ct})$, where a = soluble fraction; b = rumen degradable fraction, c = rate of degradation of b at time t, and P = potential degradation.

[2]WB = Wheatbran ; CC = Cottonseed cake ;BM = Blood meal ; CB = Cottonseed cake and Blood meal.

Table 18: Least squares means for purine derivatives (PD) and microbial protein yield (MPY) of sheep fed urea molasses block

Treatments[1]	PD (mmol)	MPY (g/d)
WB	5.52	4.01
CC	6.43	4.67
BM	5.66	4.11
CB	5.32	3.87

[1]WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal ; CB = Cottonseed cake and Blood meal.

Table 19: Weight of morphological components and proportion of maize stover refused by sheep fed maize stover supplemented with urea-molasses block

	Treatments[1,2]				
	WB	CC	BM	CB	SE
Weight (g)					
Stem	181.2	197.1	197.8	178.5	6.96
Sheath	26.5	21.1	22.9	29.7	2.92
Leaf	17.1	11.3	12.5	17.3	1.98
Dust	25.1	20.5	16.7	24.5	5.04
Total Leaf[2]	68.8	52.9	52.2	71.5	6.96
Percentage					
Stem	72.5	78.9	79.1	71.4	2.78
Leaf	27.5	21.2	20.9	28.6	2.78

[1]WB = Wheatbran ; CC = Cottonseed cake ; BM = Blood meal ; CB = Cottonseed cake and Blood meal.

[2]Total Leaf = Sheath + leaf+ dust.

4.4.0 DISCUSSION

The ADG of sheep on treatments BM and CC was more than 16% higher than WB, the control. This observation may be partly due to relatively higher total DM and lower NDF intake by sheep on treatment BM than WB. The ADG observed in this trial were higher than those obtained by Lakpini et al., (1992), where urea molasses block containing maize bran gave gains of between 13-28g/day.

Total DM intake for sheep on treatment WB was significantly lower than CB, CC and BM in that order. Animals on treatments BM consumed more of the supplement, followed by treatments CC, CB, WB in that order. This pattern is in agreement with Osuji et al., (1993a), where they suggested that the presence of a slowly degraded protein encourages more intake of roughage. Similarly, treatments CB seemed to have relatively reduced the supplement intake as compared to BM and CC.

The average rumen pH level for all treatments was above 6.2. Levels below this are suggested to decrease microbial activity (Orskov, 1994). It is reported that pH of 7.0 provides for an optimum microbial protein synthesis.

The lowest ammonia level obtained in this study (7.9 mg/100 ml) was higher than the limiting level of 2mg/100ml suggested by Hafley et al., (1993). The rumen ammonia concentration of sheep on treatments BM was higher than those fed CB. The high rumen ammonia concentration associated with BM in this study could be due to the processing method used. Heating blood meal protects against activity in the rumen (Harvey and Spears, 1989) resulting consequently in very low degradation

characteristics. In the present study the blood meal showed moderate rumen ammonia concentration and high degradation characteristics. In the presence of molasses in all treatments the moderate ammonia nitrogen produced could have encouraged better rumen microbial multiplication and subsequent protein synthesis (Osuji et al., 1993b; Orskov, 1994).

The *a* fraction for OM for all treatments was above 500 g/kg. This observation may be partly attributed to the presence of molasses in the treatments. Molasses is known to be readily soluble. In agreement with other workers, BM was degraded at a slower rate as judged from its lower c values than CC (Osuji et al., 1993b, Lardy et al., 1993).

The range for daily PD (5.3-6.43 mmol) and MPY (3.87-4.67 g) were similar to those reported(3.4-4.9g) by other workers (Chen et al., 1992; Osuji et al., 1993b). In accordance with the results of Sibanda et al., (1993) the higher PD of CC compared to WB, BM, and CB resulted in higher MPY for CC than these other diets.

CHAPTER FIVE

5.0 General Discussion

Supplementation of low quality roughage with protein sources has been known to improve animal performance (Alhassan et al. , 1986). Provision of Rumen degradable protein (RDP) improves animal performance by improving the rumen conditions for microbial activities while provision of escape protein has been known to improve performance better than the RDP's (Hafley et al., 1993).

In the current studies protein was supplied as RDP or escape protein, as well as a combination of both. Lablab and cowpea known to degrade very well in the rumen (Smith et al., 1990; Adu et al., 1992) provided the rumen degraded protein while blood meal provided the escape protein to sheep.

The intake of basal diet was increased by about 15% with blood meal supplementation over the forage legumes. When it was combined with the legumes, blood meal increased basal diet intake by about 13% over the forage legumes fed alone.

Blood meal in this experiment was found to be slowly degraded. The digestibility of diets in the current studies was not different among the treatment groups. Blood meal could have increased intake by increasing digestibility. (Osuji et al., (1993b). The basal diet intake in Expt. 2 was generally higher than the basal diet intake in Expt. 1 by almost 36%. However, the intake for basal diet were similar for all the blocks. The high intake of blocks expressed in Experiment 2 could be attributed to the highly (about 500g/kg) soluble portion (Orskov, 1994). Calculations suggest that in the present studies, sheep consumed DM in excess of 2.2% of body weight in

Experiment 1 and 3.4% in Experiment 2 which was similar to values of averagely 2.3% obtained by Iwanyanwu et al., (1990b). These amounts of DM intakes are moderate and suggest that fairly high levels of intakes can be obtained from poor quality roughage supplemented with blood meal, forage legumes or combination of these. As recorded in this study, sheep are likely to gain weight on feeding regimes based on these roughage and supplements. Supplementation with blood meal, a slowly degraded protein, increased weight gain by about 50% over the forage legume groups in the current studies. The increase in weight gain noticed when it was combined with the forage legumes was also noticed when it was combined in the urea- molasses block Experiment 2. The improvement in weight changes could be attributed to the improved basal diet intake and improved rumen environment.

Rumen degradation was slow but efficient for blood meal, because being slow in degradation, blood meal was able to provide continuous ammonia to maintain the microbial digestion (Cellulolysis) of the fibrous crop residue (Mommont et al., 1993). When it was combined with forage legume both (RDP) and rumen undegraded protein(RUP) were expected to have become available leading to more efficient feed utilization. This was true for the digestion kinetics values where mean retention time MRT observed in these studies was similar to the suggested range of 48 - 60 h by Orskov, (1994). Even though the difference was not significant, blood meal and it's combination had less retention time in the rumen and more in the intestines. This may suggest that blood meal provided most of it's nutrients after passage through the rumen in form of amino acids to the host. Most of the activities in the intestines relate to digestion and absorption of microbial protein, as well as by-pass proteins. Blood meal as well as it's combinations improved the microbial protein which was evident

by the increased purine derivative (not significant among treatment groups). Because of the increased microbial protein, more time is needed in the intestines for protein digestion as well as absorption of amino acids obtained from blood meal (Lardy et al., 1993; Luginbughl et al., 1994). Blood meal contains a lot of amino acids (Umoh, 1982) which would be expected to be available to the animal post ruminally (Schloesser et al., 1993) and this would also improve animal performance. When urea-molasses block were fed to the sheep, the liveweight gain obtained was similar to that obtained when blood meal was fed alone or with forage legumes. Urea is so volatile, rapidly degraded in the rumen into ammonia, which together with the molasses were expected to be used in microbial synthesis (Mommont et al., 1993). The block containing blood meal alone, BM gave better liveweight which then suggested that the post ruminal digestion characteristics of blood meal (Schloesser et al., 1993) is responsible for the difference in liveweight gains.

The urea-molasses block provided very good rumen condition, about neutral pH, high ammonia concentration which could translate into better microbial synthesis and animal performance, but the difference in weight gains associated with blood meal would be attributed to the higher intake of block consequently higher total DM intake. The combination of CC and BM in urea-molasses block CB had negative interactive effects, because they depressed stover intake and had lowered liveweight gains.

5.1 Practical Implications

Feeding of low quality roughage is known to result in decreased intakes and consequently decreased animal performance, whereas improvement of the quality of the roughage is usually found to improve livestock performance. Improvement of quality can be achieved by physical or chemical changes in the roughage or by

supplementation with nitrogenous materials. Supplementation in SSA especially with agricultural by-products is known to be of some value. In these studies maize stover was supplemented with blood meal and fed. It was also combined with lablab or cowpea and fed as supplement. Blood meal on its own did better than the forage legumes. It appeared superior when compared with its combination with urea-molasses block.

The availability of blood meal and its relatively low cost makes it a good supplement to low quality crop residues. However not accepted, sheep were initially kept together and fed blood meal mixed with molasses and applied on to the stover before offer. It took the animals two weeks to adjust to blood meal before commencement of the experiment. Since more money and time are required for the formulation and production of urea-molasses blocks, and given the observation that blood meal alone did better than in combination with urea-molasses it makes economic sense to recommend the package that consists of blood meal only. Furthermore, blood meal does not require any technical capability and so can be used by small scale farmers as well as large scale farmers.

The summary results from this study, have shown that use of blood meal alone had more value than combining it with forage legumes or putting it in a urea-molasses block.

REFERENCES

Adegbola, T.A and Oriawote, P.E. 1985. The intake and digestibility of silage with or without poultry excreta by sheep. In: Adu, I.F, Taiwo, B.B.A, Osinowo, O.A and Alhassan, W.S. (eds) Small ruminant production in Nigeria. Proceedings of the national Conference on Small Ruminant Production held in Zaria, Nigeria 6-10 October, 1985. National Animal Production Research Institute (NAPRI), Zaria. pp 281 - 282.

Adegbola, A. A.; Smith, O. B. and Okeudo, J. 1990 Responses of West African dwarf sheep fed cassava peel and poultry manure based diets. In: Dzowela, B. H, Said, A. N, Wenden-Agenehu, A. and Kategile, J. A. (eds). Utilization of research results on forage and agricultural by-products material as animal feed resources in africa. Proceedings of the first joint workshop held in Lilongwe, Malawi 5-9 Dec. 1988 PANESA/ARNAB, ILCA Addis Ababa. pp 357-366

Adewoye, R. O. 1982. The utilization of by-products of the beef industry. In:Osiwo O. A., Ikhatua U. J.and Ehoche W. O. (eds) Beef production in Nigeria. Proceedings of the national conference on beef production 27th - 30th July, Kaduna Nigeria. Published by NAPRI Zaria pp 574-601.

Adu, I.F. 1985. Utilization of graded levels of brewer's dried grains by growing/finishing sheep. Journal of Animal Production Research 5: 59-66.

Adu, I. F., Fajemisin, B. A. and Adamu, A. M. 1992. The utilization of sorghum stover fed to sheep as influenced by urea of graded levels of lablab supplementation. In: Rey B, Lebbie S. H. B; and Reynolds L. (eds) Small ruminant research and development in Africa. Proceedings of the first Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya 10-14 December 1990. ILCA Nairobi Kenya. pp 367-374

Adu , I. F., Fajemisin, B. A., Hena, S. W., Tanko R. J., Eduvie L.O., and Adewuyi A. A. 1993. The use of lablab purpureus as supplement to sorghum stover fed to Yankassa sheep. In: Adamu, A. M, Mani, R. I, Osinowo, O. A, Adeoye, K. B, and Ajileye, E. O. Proceedings of a workshop on forage production and utilization in Nigeria. 11-14 Feb. 1991, National Livestock Project Department Kaduna , Nigeria. pp151-156.

Ahuja, A. K., Gupta, B. K., Sohoo, M. S. and Bharchwaj, B. L. 1991. Comparative nutritive value of maize fodder grown with and without cowpea. Indian Journal of Dairy Science 6(44): 389-391

Alawa, J. P. and Hemingway, R. G. 1986. The voluntary intake and digestibility of straw diets and the performance of wether sheep as influenced by formaldehyde treatment of soya bean-meal. Animal Production 42: 105-109

Aletor, V. A. 1986. Some agro-industrial by-products and "wastes" in livestock feeding: A review of prospects and problems. World Review of Animal Production vol. XXII, No. 4 pp 35-41

Alhassan, W. S.. 1985. The potential of agro-industrial by- products and crop residues for sheep and goat production in Nigeria. In: Adu, I.F, Taiwo, B.B.A, Osinowo, O. A and Alhassan, W.S. (Eds) Proceeding of national conference on small ruminant production held on 6-10 October, 1985, Zaria. National Animal Production Research Institute Shika, Zaria. pp 165-183.

Alhassan, W. S., Ehoche, O. W. and Adu, I. F. 1986. Influence of graded levels of cottonseed cake supplementation on the nutritive value of cereal straws fed to sheep and goats. Journal of Animal Production Research 6:39-53.

Anderson, S. J., Klopfenstein, T. J, and Wilkerson, V. A. 1988. Escape protein supplementation of yearling steers grazing smooth brome pastures. Journal of Animal Science 66: 237-242.

Avalos-Martinez, A. M. M., Torres, J. S. and Shimada, A. S. 1985. Growth of male Pelibuery sheep fed on maize stover treated with anhydrous ammonia."Tecnica Pecuaria-en-Mexico" No. 48: 54-61.

Bamualin, A., Weston, R. H., Hogan, J. P. and Murray, R. M. 1986. The contributions of leucaena leucocephala to post ruminal digestible protein for sheep fed tropical pasture hay supplemented with urea and minerals. Animal Production in Australia, vol. 15: 255-262

Brown, W.F. 1993. Cane molasses and cotton seed supplementation of ammoniated tropical grass hay for yearling cattle. Journal of Animal Science 71: 3451-3457.

Chen, X.B, Chen, Y.K., Franklin, M.F, Orskov, E.R and Shand, W.J. 1992. The effect of feed intake and body weight on purine derivatives excretion and microbial protein supply in sheep. Journal of Animal Science 70:1534-1542.

Chenost, M. and Mayor, L. 1976. Potential contribution and use of agro-industrial by-products in animal feeding. FAO Animal Production and Health paper No. 4 pp 87-110.

de Leeuw, P. N. 1979. A review of the ecology and fodder resources of the subhumid zone. ILCA-NAPRI symposium on intensification of livestock reproduction in the subhumid tropics of West Africa held in Kaduna, 23rd-30th march 1979.

Donefer, E. 1976. Physical treatment of poor-quality roughage at commercial and farm levels. FAO Animal production and Health Paper No 4: 17-23.

D'Mello, J. P. F. 1992. Chemical constraints to the use of tropical legumes in animal nutrition. Animal feed Science and Technology 38: 237-261.

Djajaregara, A., Doyle, P. T. and Molina,B. 1985. Fibre digestion and mineral balance in sheep fed calcium hydroxide treated straw In: Doyle P. T. (eds). The utilization of fibrous agricultural residues as animal feeds. Proceedings of the forth animal workshop of the Australian-Asian Fibrous Agricultural Residues Research Network held in Khonkaen, Thailand 10-14 April 1984. Published by international Development Program (IDP) of Australia Universities & Colleges limited, pp 94-102.

Dulphy, J. P. and Demarquilly, C. 1994 The regulation and production of feed intake in ruminants in relation to feed characteristics. Livestock Production Science 39: No.1: pp 1-12.

Dzowela, B.H. 1987. Efforts to enhance maize stover utilization for small holders livestock production in Malawi In: Little, D.A. and Said, A.N (eds) Proceedings of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 27-36.

Ehoche, O.W, Theresa, Y.M, Buvanendran, V and Adu, I.F. 1983. The nutritive value of tannin-treated cotton seed cake for growing lambs. Journal of Animal Production Research. 3: 15-26.

Elangovan, A. V., Mehra U. R., Singh U. B., and Sahoo A., 1991. Response of urea-molasses semi-solid block supplement on live weight gain and nutrient utilization in under-fed buffalo calves Indian Journal of Dairy Science 44: 543-545.

El-Hag, F.M. 1992. The effects of chopping and wilting on tropical grassland silage quality in south Kordofan, Sudan. African Livestock Research 1:11-15

Fleischer, J.E.; Barnes, A.R.; Awumbila, B.; Amaning-Kwarteng, K. and Tieku, C.K. 1989. Grain yeild and nutritive value of crop residues from three varieties of maize (Zea Mays) crop. In Said, A.N. and Dzowela, B.H. (Eds). Overcoming constraints to the efficient utilization of agricultural by products as animal feeds. Proceedings of the Fourth annual workshop held at the Institute of Animal Research, Bamenda, Cameroun. 20-27 October, 1987. Pp 239-255.

Fomunyam, R.T and Mbomi, S.E. 1989. Tephrosia spp and cotton seed (Gossypium spp) cake supplementation of rice and maize stalks fed to sheep and goats in the dry season. In: Said, A.N and Dzowela, B.H (eds). Overcoming constraints to the efficient utilization of agricultural by-products as animal feeds. Proceedings of the fourth annual workshop held at the Institute of Animal Research, Bamenda, Cameroun. 20 - 27 October, 1987. pp 133-141.

Gitachew, L. and Tadaesse, A. 1992. Effects of feeding hydrated teff straw and protein sources on teff straw voluntary intake and growth of young Horro

sheep grazing native pasture during the dry season. In: John E. Stares, Abdullahi N. Said and Jackson A. Kategile (eds), "The complementarity of feed resources for animal production in Africa". Proceeding of the joint feed resources networks workshop held in Gaborone Botswana 4-8 march 1991. African feeds Research Network ILCA (International Livestock Centre for Africa) Addis Ababa, Ethiopia, pp 147-148.

Givens, D. I., Angela R. Moss and Jeannie M. Everington 1992. Nutritional value of cane molasses in diets of grass silage and concentrates fed to sheep. Animal Feed Science and Technology 38: 281-291.

Goering, H. K. and Van Soest, P. J. 1970. Forage fibre analysis Agriculture Hand book No. 379 United States Department of Agriculture. 20 pp

Gutierrez-Ornelas, E. and Klopfenstein, T. J. 1992. Diet composition and gains of escape protein - supplemented growing cattle grazing corn residues. Journal of Animal Science 69: 2187-2195

Grovum, W.L, and Williams, V. J. 1973. Rate of passage of digesta in sheep. British Journal of Nutrition 30: 313-328

Hafley, J. L., Anderson, B. E. and Klopfenstein, T. J. 1993. Supplementation of growing cattle grazing warm-season grass with proteins of various ruminal degradabilities, Journal of Animal Science 71: 522-529.

Harvey, R. W. and Spears, J. W. 1989. Effect of blood-meal processing method on performance and nitrogen utilization by growing cattle. Animal Feed Science and Technology 24: 337-343

Henning, P. H., Steyn, D. G. and Meissner, H. H. 1993. Effect of synchronization of energy and nitrogen supply on ruminal characteristics and microbial growth. Journal of Animal Science 71: 2516-2528.

Homb, T.; Sundstol, F. and Amasor, J. 1976. Chemical treatment of straw at commercial and farm levels. FAO Animal Production and Health Paper No.4: Pp 25-37.

International Livestock Centre for Africa (ILCA). 1988. Annual Reports and Programme Highlights, Addis Ababa, Ethiopia.

International Livestock Centre for Africa (ILCA). 1991. Annual Reports and Programme Highlights, Addis Ababa, Ethiopia.

International Livestock Centre for Africa (ILCA). 1993. Handbook of African Livestock Statistics, Addis Ababa, Ethiopia.

Iwanyanwu, I. E. J. Umunna, N. N. and Dim, N. I. 1990a . Performance of beef heifers fed low quality hay and supplemented with urea, blood meal and /or bone meal. Bulletin of Animal Health and Production in Africa 38:207-212.

Iwanyanwu, I. E. J., Umunna, N. N. and Dim, N. I. 1990b . Effects of urea supplementation with or without molasses on the intake digestibility and weight changes of beef heifers fed native hay. Animal Feed Science and Technology 31: 277-284.

Jimenez-D, A. and Shimanda, A. S. 1984. Performance of growing Pelibuery lamb fed on rations based on maize stover treated with alkalis (NH3, NaOH, Urea). Tecnica-Pecuaria-en-Mexico No. 47 pp 142-146.

Kabaija, E., Akalework, N. and Leng, R. A. 1989. Sheep productivity in the Ethiopian highlands on a diet supplemented with urea- molasses block and/or noug cake. Tropical Animal Health Production 21:183- 190.

Kandylis, K., Nikokyris, P., Liamądis, D. and Deliqiannisk, H. 1992. Evaluation of cottonseed cake as feed ingredient for fattening sheep. Journal of the Science of Food and Agriculture. 58:291- 299.

Kayongo, S.B, Wanyoike, M.M, Nyagah, P.N, Maitho, T.E and Mbugua, P.N. 1992. Cage-layer waste as a nitrogen source in crop-residue utilization. In: Stares, J.E.S, Said, A.N and Kategile, J.A (eds) The complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Gaborone, Botswana 4-8 March, 1991. Published by ILCA, Addis Ababa. pp143-151.

Kerley, M. S., Fahey, G. C. Jr., Berger, L. L.and Gould, J. M. 1985. Effects of pre-treating lignocellulolytic materials with alkaline hydrogen peroxide on in situ DM disappearance and nutrient digestibility by lambs. Journal of Animal Science 61: supplement 1, 357-366.

Ketelars, J. J. M. H. and Tolkamp, B. J. 1992. Toward a new theory of feed intake regulation in ruminants, causes of differences in voluntary feed intake: Critique of current views. Livestock Production Science 30: 269-296.

Khalili, H., Osuji, P. O., Umunna, N. N. and Crosse, S. 1994. The effect of forage type (maize-lablab or oat-vetch) and graded levels of supplementation (wheat middlings) on food intake of cross-bred (Bos Taurus x Bos indicus). Animal Production 58: 321-328.

Kiflewalid, B. and Mosimanyana, B. 1989. Dolichos lablab (lablab_purpureus) in by-product based diets for lactating cows in Botswana. In: Said, A. N. and Dzowela B. H. (eds) African Research network for Agricultural by-products (ARNAB) overcoming constraints to the efficient utilization of agricultural by-products as animal feed. Proceedings of the fourth Annual Workshop held at the institute of animal Research Mankon Station, Bamenda Cameroun, 20-27 October 1987. ARNAB Addis Ababa Ethiopia pp 155-172.

Kimambo, A. E, Makiwa, A. M. and Shem, M.N. 1992. The use of leucaena lcocephala supplementation to improve the utilization of maize stover In:

Stares, J.E.S, Said, A.N. and Kategile, J.A. (eds) The Complementarity of Feed Resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Gaborone, Botswana, 4-8 March, 1991. Published by ILCA, Addis Ababa, pp 163-172.

Kumwenda, M.S.L. and Msiska, H.D.C. 1990. On farm evaluation of maize bran and cottonseed cake and introduction of improved forage technologies for milk production in Mzuzu milkshed area of Malawi In: Dzowela, B.H, Said, A.N, Wendem-Agenehu, A and Kategile, J.A. (eds) Utilization of research results on forage and agricultural by-products materials as animal feed resources in Africa. Proceedings of the first Joint Workshop held in Lilongwe, Malawi 5-9 Dec. 1988. PANESA/ARNAB ILCA, Ethiopia. pp 280- 309.

Lapkini, C. A. M., Nolan, J. V., Jayasuriya, M. C. N., Owen, E., Adu, I. F. Umunna, N. N. and Balogun, T. F., 1992. Improving the intake and utilization of Sorghum stover by sheep. Final research co-ordination meeting on "The development of feeding strategies for improving Ruminant Productivity in Areas of fluctuating nutrient supply through the use of nuclear and related techniques held in Vienna Austria 30th March - 3rd April 1992. Joint FAO/IEA Division of nuclear techniques in Food and Agriculture.

Lardy G. P., Catlett G.E., Kerley M.S. and Paterson J. A. 1993. Determination of ruminal escape value and duodenal amino acids flow of rapeseed meal. Journal of Animal Science 71: 3096-3104.

Lemma, B., Lambourne, L.J. and Tesfahunei, F. 1990. Feeding value of sesbania and Leucaena browses. In: Dzowela, B.H, Said, A.N, Wendem-Agenehu, A and Kategile, J.A. (eds). Utilization of research results on forage and agricultural by-products materials as animal feed resources in Africa. Proceedings of the first Joint Workshop held in Lilongwe, Malawi 5-9 Dec. 1988. PANESA/ARNAB ILCA, Ethiopia. pp 381 - 388.

Little, D. A., Anderson, F.M. and Durkin, J.W. 1987. A note on the effect of supplementation with noug cake (Guizotia abyssinica) on the milk production of cross-bred cows In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 136- 141.

Lufadeju, E. A., Olayiwole, M. B. and Umunna, N.N. 1987. Intake and digestibility of urea treated Gamba (Andropogon gayanus) hay by cattle In: Little, D. A. and Said, A.N. (Eds). Utilization of agricultural by-products as livestock feeds in Africa. Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 7-14.

Luginbuhl, J.M, Pond, K.R and Burns, J.C. 1994. Whole tract digesta kinetics and composition of techniques for the estimation of feed output in steers fed Coastal bermuda grass hay at four levels of intake. Journal of Animal Science 72:201-211.

Mafwere W. D, and Mtenga, L. A. 1992 Lablab (Dolichos lablab) meal as protein supplement for weaned fattening lambs. In: Rey B, Lebbie S. H. B; and Reynolds L. (eds) Small Ruminant Research and Development in Africa. Proceedings of the first Biennial Conference of the African Small Ruminant Research Network, ILRAD, Nairobi, Kenya 10-14 December 1990. ILCA Nairobi Kenya. pp 375- 386.

Mahabile, W., Masilo, B. and Kiflewahid, B. 1990. Use of sorghum bran and groundnut haulms in sorghum stover based diets of crossbred cows. In: Dzowela B. H., Said A. N., Asrat Wendem- Agenehu and J. A. Kategile (eds). PANESA/ARNAB (Pasture Network for Eastern and Southern Africa/African Research Network for agricultural by-products). Utilization of Research Network for agricultural by-product materials. as animal feed resources in Africa. Proceedings of the first joint workshop held in Lilongwe, Malawi, 5-9 December 1988 PANESA/ARNAB Addis Ababa, Ethiopia, pp 436-451

Mehra, U. R., Challa, J.and Singh, U. B. 1991. Effect of supplementation of urea molasses mineral block and wheat bran in a wheat Bhoosa based diet on growth performance and nutrient utilization in buffalo calves Indian Journal of Dairy Science 44:522- 525.

Merchen, N., Hanson, T. and Klopfenstein, T. 1979. Ruminal by- pass of Brewers' dried grains protein. Journal of Animal Science 49: 192-198.

Mohammed-Saleem, M. A. 1985. Effects of sowing time on the grain yield and fodder potential of sorghum undersown with stylo in subhumid zone of Nigeria. Tropical agriculture (Trinidad) 62: 151-153.

Mommont, P. A., Pruitt, R. J. and Johnson, P. S. 1993. Effect of Methionine addition into a urea grain supplement on intake and digestibility of mature, dormant grasses and performance of cows grazing winter Range. Journal of Animal Science 71: 515-521.

Moore, J. A, Pond, K. R, Poore, M. H. and Godwin, T. G. 1992. Influence of model and marker on digesta kinetic estimates for sheep. Journal of Animal Science 70: 3528-3540.

Mosi, A. K. and Butterworth, M. A. 1985. The voluntary intake and digestibility of combinations of cereal crop residues and legume hay for sheep.

Mosimanyana, B. and Kiflewahid, B. 1987. Feeding of crop residues to milking cows in small scale farms in Botswana In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 127-135.

Mosimanyana, B. M. and Mowat, D. N. 1991. Rumen protection of heat treated with soya beans proteins. Canadian Journal of Animal Science 72: 71-81

Munthalis, J. T. 1987. Cattle fattening on basal diets of maize stover and groundnut tops in Malawi. In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 45- 52.

Munthalis, J. T. K., Jayasuriya, C. N., Bhaffachrya, 1992. Effects of urea treatment on maize stover and supplementation with maize bran or urea-molasses block on performance of growing steers and heifers. In: John E. Stares, Abdullahi N. Said and Jackson A. Kategile (eds), "The complementarity of feed resources for animal production in Africa". Proceeding of the joint feed resources networks workshop held in Gaborone Botswana 4-8 march 1991. African feeds Research Network ILCA (International Livestock Centre for Africa) Addis Ababa, Ethiopia, pp 205-214.

Mwendia, C. W. and Khasatsil, 1990. Molasses energy blocks for beef cattle. In: Dzowela B. H., Said A. N., Asrat Wendem- Agenehu and J. A. Kategile (eds). PANESA/ARNAB (Pasture Network for Eastern and Southern Africa/African Research Network for agricultural by-products). Utilization of Research Network for agricultural by-product materials. as animal feed resources in Africa. Proceedings of the first joint workshop held in Lilongwe, Malawi, 5-9 December 1988 PANESA/ARNAB Addis Ababa Ethiopia, pp 389-403.

Ndlovu,. L.R. 1992. Complementarity of forages in ruminant digestion: Theoretical considerations. In: Stares, J.E.S., Said, A.N.and Kategile, J.A. (eds). The complementarity of Feed Resources for animal production in Africa. Proceedings of the joint feed resources networks held in Gaborone, Botswana. 4-8 March, 1991. ILCA, Addis Ababa. pp 17-24.

Ndlovu, L. R. and Manyeme, Z. 1989. Hydration as a means of improving utilization of maize stover fed to steers. In: Said, A. N. and Dzowela B. H. (eds) African Research network for Agricultural by-products (ARNAB) overcoming constraints to the efficient utilization of agricultural by-products as animal feed. Proceedings of the fourth Annual Workshop held at the Institute of Animal Research Mankon Station, Bamenda Cameroun, 20-27 October 1987. ARNAB Addis Ababa Ethiopia, pp 343-353.

Nelson, M. L., Klopfenstein, T. J.and Britton, R. A. 1984 Protein supplementation of ammoniated roughage. Corncobs supplemented with a blood meal-corn gluten meal mixture - lamb studies.

Ngwa, A.T. and Tawah, C. L. 1992. Effect of legume crop residues and concentrate supplementation on voluntary intake and performance of Kirdi sheep fed basal diet of rice straw. In: Stares, J.E.S., Said, A.N., Kategile, J.A. (eds). The complementarity of Feed Resources for animal production in Africa. Proceedings of the joint feed resources networks held in Gaborone, Botswana. 4- 8 March, 1991. ILCA, Addis Ababa, pp 239-248.

Njwe, R. M. and Olubajo, F. O. 1989. Evaluation of cassava flour and groundnut cake as concentrate supplements for West African Dwarf goats. In: Said, A. N. and Dzowela B. H. (eds) African Research network for Agricultural by-products (ARNAB) Overcoming constraints to the efficient utilization of agricultural by- products as animal feed. Proceedings of the fourth Annual Workshop held at the Institute of Animal Research Mankon Station, Bamenda Cameroun, 20-27 October 1987. ARNAB Addis Ababa Ethiopia, pp 306-323.

Nour, A.M. 1987. Rice straw and rice hulls in feeding ruminants in Egypt. In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 53-61.

Nuwanyakpa, M.Y. and Butterworth, M.H. 1987. Effects of urea, molasses, hay on the intake and digestibility of teff straw by Highland Sheep. In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 87-98.

Odhuba, E.K. 1989. Towards efficient utilization of poultry waste by ruminants In: Said, A.N and Dzowela, B.H (eds). African Research network for Agricultural by-products (ARNAB) Overcoming constraints to the efficient utilization of agricultural by-products as animal feeds. Proceedings of the fourth annual workshop held at the Institute of Animal Research, Bamenda, Cameroun. 20 - 27 October, 1987. pp 152-157.

Orskov, E. R. 1982. Protein nutrition in ruminants. Academic Press, London.

Orskov, E. R. 1986. Factors affecting utilization of poor quality roughage. In Ibrahim M. M. and Shiere J. B. (eds). Rice Straw and Related feeds in Ruminant Rations. Proceedings of an international workshop in Kandy Sri Lanka on 24-28 March 1985 pp 129-137.

Orskov, E. R. 1994. Recent advances in understanding of microbial transformation in ruminants. Livestock Production Science 39: 53- 60.

Orskov, E.R. and McDonald, I. 1979. The estimation of Protein degradability in the rumen from incubation measurements weighted according to rate of passage. Journal of Agricultural Science. Cambridge 92: 499-503.

Orskov, E.R, Ojwang, I. and Reid, G.W. 1988. A study on consistency of differences between cows in rumen outflow rate of fibrous particles and other substrates and consequences for digestibility and intake of roughage. Animal Production 47:45-51.

Orskov, E.R, Tait, C.A.G, Reid, G.W. and Flachowsk, G. 1986. Effect of Straw quality and ammonia treatment on voluntary intake, milk yield and degradation characteristics of faecal fibre. Animal Production 46:23-27.

Orskov, E.R, PebHorell, F.D and Mould, F. 1980. The use of the nylon bag technique for the evaluation of feedstuffs. Tropical Animal Production, 5: 195-213.

Ogundola, F. I. 1989. Studies of the utilization of brewers, dry grains and wheat offal by calves. In: Said, A.N and Dzowela, B.H (eds). Overcoming constraints to the efficient utilization of agricultural by-products as animal feeds. Proceedings of the fourth annual workshop held at the Institute of Animal Research, Bamenda, Cameroun. 20 - 27 October, 1987. pp 256 - 266.

Olayiwole, M.B. and Olorunju, S.A. 1987. Feedlot performance of yearling steers previously maintained on different crop residue/supplementation regimes. In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 72- 82.

Orji, B.I. 1985. Research on reproduction in small ruminants and their applicability in Nigerian production systems In: Adu, I. F, Taiwo, B.B.A, Osinowo, O.A and Alhassan, W.S. (eds) Small ruminant production in Nigeria. Proceedings of national conference on small ruminant production, Zaria, Nigeria 6-10 October, 1985. Published by NAPRI, Zaria. pp 70-84.

Osuji, P.O, Nsahlai, I.V, Khalili, H. 1993a. Feed evaluation. ILCA Manual 5: ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. 40p

Osuji, P. O., Sibanda, S. and Nsahlai, I. V. 1993b. Supplementation of maize stover for Ethiopian menz sheep: Effects of cottonseed, noug (Guizotia abyssinica) or sunflower cake with or without maize on the intake, growth, apparent digestibility, nitrogen balance and excretion of purine derivatives. Animal Production 57: 429-436

Oyedipe, E. O., Buvanendran, V. and Eduvie, L. O. 1982. Some factors affecting the reproductive performance of White Fulani (Bunaji) Cattle Trop. Agric. (Trinidad) 59: 231-234

Partida, B. E. Jimenez, D. A., Martinez, R. L. and Shimada, A. S. 1984. Improvement of nutritive value of maize stover for lambs by addition of ammonium hydroxide and urea. Tecnica Pecuaria-en- Mexico 47: 33-38.

Pearce, G. R. 1982. Plant cell wall structure and the effect of pre-treatments on the digestibility of fibrous residues. FAO Animal Production and Health paper 32 pp 19-28

Preston, T. R. 1982. A strategy for the efficient utilization of crop residues and agro-industrial by-products in animal production based on their nutritional constraints. FAO Animal Production and Health Paper No. 32: pp 30-47

Roxas, D. B., Obsioma, A. R., Lapitan, R. M., Castillo, L.S. Momongan, V. G. and Juliano, B. O. 1985. The effects of varieties of rice, level of nitrogen

fertilization and season, on the chemical composition and in-vitro digestibility of straw. In: Doyle, P.T., Pearce, G. R. and Wanapat. M. (eds). The utilization of fibrous agricultural residues as animal feeds. Proceedings of the fourth annual workshop on Australian-Asian fibrous agricultural residue research network, held in Khon Kaen, Thailand. 10 - 14 April, 1984.

Sahoo, A., Elangovan, A. V, Mehra, U.R and Singh, U.B. 1992. Response of urea molasses semi-solid block and urea-molasses liquid polypack supplement on blood biochemical constituents. Indian Journal of Dairy Science 45, 3: 154-156.

Sansoucy, R. and Emery, B. 1982. General review of the present use of agro-industrial by-products and crop residues in animal feeding. FAO Animal Production and Health paper No. 32: pp 6-18

SAS/STAT 1987. Guide for personal computers, version 6 edition, Cary, NC: SAS institute inc; 1028pp.

Schloesser, B. J., Thomas, V. M., Peterson, M. K., KOH, R. W. and Hatfield, P. G. 1993. Effects of supplemental protein source on passage of nitrogen to the small intestines, nutritional status of pregnant ewes and wool follicle development of progeny. Journal of Animal Science 71: 1019-1025.

Sibanda, S., Chakanyuka, C. and Mlilo, N. 1987. Effect of Level of cane molasses in fattening diets on performance of beef steers and heifers. In: Little, D.A. and Said, A.N. (eds) Proceeding of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 62-71.

Sibanda, S., Osuji, P. O. and Nsahlai, I. V. 1993. The degradation of oilseed cakes and their effects on the intake and rumen degradation of maize stover given to Ethiopian menz sheep. Animal Production 57: 421-428.

Sibanda, S. and Said, A. N., 1991. The role of crop residues and agro-industrial by-products as animal feed resources in subsaharan Africa. A paper presented at the NLPD/ACIAR - forage production and utilization workshop Kongo campus Hall Zaria, Nigeria 11-14 February 1991 20 pp

Silva, A. T. and Orskov, E. R. 1988. Fibre degradation in the rumen of animals receiving hay untreated or ammonia treated straw. Animal feed Science and Technology 19: 227-287

Smith, T., Manyuchi. B., and Mikayiri, S. 1990. Legume supplementation of maize stover In: Dzowela B. H., Said A. N., Asrat Wendem-Agenehu and J. A. Kategile (eds). PANESA/ARNAB (Pasture Network for Eastern and Southern Africa/African Research Network for agricultural by-products). Utilization of Research Network for agricultural by-product materials. as animal feed resources in Africa. Proceedings of the first joint workshop held in Lilongwe, Malawi, 5-9 December 1988 PANESA/ARNAB Addis Ababa Ethiopia.

Song, M.K. and Kenelly, 1990. Ruminal fermentation pattern, bacterial population and ruminal degradation of feed ingredients as influenced by ruminal ammonia concentration. Journal of Animal Science. 68: 1110-1120.

Steen, R. W. J. 1989. A comparison of soyabean, sunflower and fish meal as protein supplement for yearling cattle offered grass silage based diets. Animal production 48: 81-89

Tolera, A. and Said, A.N. 1992. Prospects of integrating food and feed production in Welayita Sodo, Ethiopia. In: Stares, J.E.S, Said, A.N. and Kategile, J.A (eds) The complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Gaborone Botswana 4-8 march, 1991. Published by ILCA Addis Ababa pp 309-318.

Topps, J. H. 1992. Potential composition and use of legume shrubs and trees as fodder for livestock in the tropics. Journal of agricultural science,(Cambridge) 118: pp 1-8.

Tuah, A. K, Lufadeju, E, Orskov, E.R and Blackett, G.A. 1986. Rumen degradation of strain: 1 untreated and ammonia treated barley oat, and wheat straw varieties and triticale straw. Animal Production 43: 261-269.

Tuah, A. K. and Orskov, E. R. 1989 The degradation of untreated and treated maize cobs and cocoa pod husks in the rumen. In: Stares, J.E.S, Said, A.N. and Kategile, J.A (eds) The complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Gaborone Botswana 4-8 march, 1991. Published by ILCA Addis Ababa. pp 363-378

Udedibe, A. B. I., Umoh, I. and Shaibu, I. 1985. The Vom herd: Effect of lactation number and season of calving on lactation characteristics of imported Friesian cows. Journal of Animal Production Research 5,1: 31-44.

Uden, P., Pablo, E., Colucci, E. and Van Soest, P. 1980. Investigation of chromium, cerium and cobalt as markers in digesta rate of passage studies. Journal of the Science of Food and Agriculture 31: 625- 632.

Umoh, J. E. 1982. The use of concentrates and by-products in beef production. Emphasis on use of concentrates on pasture. In: Osinowo, O. A., Ikhatua, U. J. and Ehoche, O.W. , Beef production in Nigeria, Proceedings of the national conference on beef production, Kaduna Nigeria 27-30 July 1982. National Animal Production Research Institute (NAPRI) ABU Zaria pp 226-266

Umoh, J.E. 1983. Effects of graded levels of sugar cane molasses on the performance of growing cattle. Tropical Agriculture (Trinidad) 60, No.4: 297-300.

Umunna, N.N. 1982. Utilization of poor quality roughage: Response of sheep fed native hay supplemented with urea by different methods. Journal of Agricultural Science,(Cambridge). 98: 348- 354.

Umunna, N. N. and Iji, P. A. 1993. The natural feed resources for ruminant animals in Nigeria In: Adamu A. M., Mani R. I., Osinowo O. A., Adeoye K. B., and Ajileye E. O. Proceeding of a workshop on Forage Production and utilization in Nigeria 11-14 feb. 1991 National Livestock Projects Division (NLPD) Kaduna Nigeria pp 16- 31

Urio, N.A and Kategile, J.A. 1987. Maize stover and cobs as a feed resource for ruminants in Tanzania. In: Little, D.A. and Said, A.N. (eds) Proceedings of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 37-44.

van-Eys, J. E., Manthius, I. W., Pongsapan, P. and Johnson, W. L. 1986, Foliage of the tree legumes Gliricidia Leucaena and Sesbania as supplements to napier grass diets for growing goats. Journal of agricultural Science (Cambridge) 107: 227-233

Varvikko, T., Khalili, H. and Crosse, S. 1992. Supplementation of native grass hay with cowpea (Vigina Unguiculata) hay, wilted Leucaena (Leucaena leucocephala) forage, Tagasaste (Chamaecytisus palmensis) forage or a wheat middling for young friesian x zebu (Boran) crossbred steers. Agricultural Science Finland pp 247-254

Warambwa, A. R. and Ndlovu, L. R. 1992 Use of whole sunflower seeds and urea as supplements to crop-residue-based diets for goats In: Stares, J.E.S, Said, A.N. and Kategile, J.A (eds) The complementarity of feed resources for animal production in Africa. Proceedings of the joint feed resources networks workshop held in Gaborone Botswana 4-8 march, 1991. Published by ILCA Addis Ababa. pp 197-204

Wegad, D. and Ndumbe, R.D. 1987. The effect of different protein supplements on weight gain and voluntary intake of maize stover by cattle In: Little, D.A. and Said, A.N. (eds) Proceedings of a workshop held at Blantyre, Malawi in September, 1986. ARNAB. Published by ILCA, Addis Ababa, pp 99-102

Yilala K. 1990. Effects of supplements of oil-seed by-products on the utilization of low nitrogen fibrous diets by sheep. In: Dzowela B. H., Said A. N., Asrat Wendem- Agenehu and J. A. Kategile (eds). PANESA/ARNAB (Pasture Network for Eastern and Southern Africa/African Research Network for agricultural by- products). Utilization of Research Network for agricultural by-product materials. as animal feed resources in Africa. Proceedings of the first joint workshop held in Lilongwe, Malawi, 5-9 December 1988 PANESA/ARNAB Addis Ababa Ethiopia, pp 416-435.

7.0 APPENDICES

Appendix 1:
Analysis of variance of Weight gains of sheep fed maize stover supplemented with forage legumes and blood-meal:

Parameter (Mean Squares)

source	df	Mean Daily stover intake	Mean daily supp. intake	Mean total intake	Daily gain	Feed conversion ratio
Blk	9	1629.45	0.01	1631.84	242.32	21.15
Trt.	5	9404.05***	46712.01*	16521.54***	1698.61***	151.07***
Res.	45	1606.13	0.02	1605.68	195.96	15.30

*** - Significant at $P<0.001$

* - Significant at $P<0.05$

Appendix 2:
Analysis of variance of feed intake and Digestibility parameters in sheep fed maize stover Supplemented with forage legumes and blood-meal:

Parameters (Mean Squares)

source	df	Stover Intake	Supp. Intake	Total DM intake	DM intake	Nit. Intake	Neutra Det. Intake	DM Digt.	OM Digt.	Nitro. Digt.	NDF Digt
Trt.	5	*** 31342.2	*** 109422	*** 49639	*** 34498	*** 145.4	** 10850.5	.002	.002	*** .246	.009
Res.	32	4833.1	42.0	4745.2	3809.3	.216	2510.2	.024	.021	.037	.019

*** = Significant at $P < 0.001$

** = Significant at $P < 0.01$

Appendix 3:

Analysis of variance of Rumen Ammonia NH3 in sheep fed maize stover Supplemented with forage legumes and blood-meal:

Parameters (mean squares)

Source	DF	NH3 3	NH3 6	NH3 9	NH3 12	NH3 24
Trt.	5	60.56	58.30	46.82	128.13	59.52
Res.	18	23.34	26.05	30.23	39.45	73.69

Appendix 4:

Analysis of variance of Rumen Kinetics in sheep fed Maize stover Supplemented with forage legumes and blood-meal

Parameters (mean squares)

Source	DF	A1	K1	A2	K2	TK1	TK2	RTR	RTH	MRT
Trt.	5	0.27	0.00	0.16	0.00	6.75	1.74	14.06	3.62	8.27
Res.	18	0.37	0.00	0.28	0.00	21.52	4.05	44.81	8.43	25.60

Appendix 5:

Analysis of variance of orts separation of maize stover fed to sheep Supplemented with forage legumes and blood-meal:

Parameters (mean squares)

Source	DF	Stem	Sheath	Leaf	Dust	Leaf1 Percent	Stem Percent	Leaf
Trt.	5	204.60	33.96	28.91	125.00	204.60	32.74	
Res.	18	355.20	145.62	150.27	170.69	355.24	56.84	

Appendix 6:

Analysis of variance of feed intake and Growth rates in sheep fed maize stover supplemented urea-molasses semi-solid blocks:

Parameters (mean squares)

Source	DF	Total intake Kg/day	Initial weight	Final weight	Daily gain	Feed conversion ratio
Block	8	0.48***	1696.28*	1572.52*	0.04***	4933.90***
Trt.	3	0.96***	184.68***	549.00***	0.04***	512.70***
Res.	24	18.11	1.25	2.32	0.00	25.91

*** = Significant at P<0.001

* = Significant at P<0.05

Appendix 7:

Analysis of variance of feed intake Digestibility parameters in sheep fed maize stover Supplement with urea-molasses semi-solid blocks:

Parameter (mean squares)

source	df	Stover Intake	Supp. Intake	Total DM intake	DM intake	Nit. Intake	Neutra Det. Intake	DM Digt.	OM Digt.	Nitro. Digt.	NDF Digt
Trt.	3	** 23038.2	3332.5	* 23959.8	* 18646	6.5	** 11958	.001	.001	.009	.001
Res.	18	4485.6	2452.8	8062.2	5477.6	8.1	2504.7	.006	.005	.004	.007

** = Significant at P<0.01

* = Significant at P<0.05

Appendix 8:

Analysis of variance of maize orts separation of sheep supplemented with urea - molasses semi-solid blocks:

Parameters (mean squares)

Source	DF	Stem	Sheath	leaf	Dust	Leaf2	Stem Percent	Leaf Percent
Trt.	3	939.96	131.57	86.62	138.83	939.96	150.39	
Res.	20	435.43	76.59	35.24	229.02	435.43	69.67	

Appendix 9:

Analysis of variance of Rumen Ammonia concentration of sheep fed maize stover supplemented with urea-molasses semi-solid blocks:

Parameters (mean squares)

Source	DF	NH3 3	NH3 6	NH3 9	NH3 12	NH3 24
Trt.	3	97.05	86.78	215.89	16.79	258.24
Res.	20	87.77	80.60	293.89	119.78	89.52

Figure 1

Ammonia-N levels of rumen fluids of sheep fed *forage legumes and blood meal.*

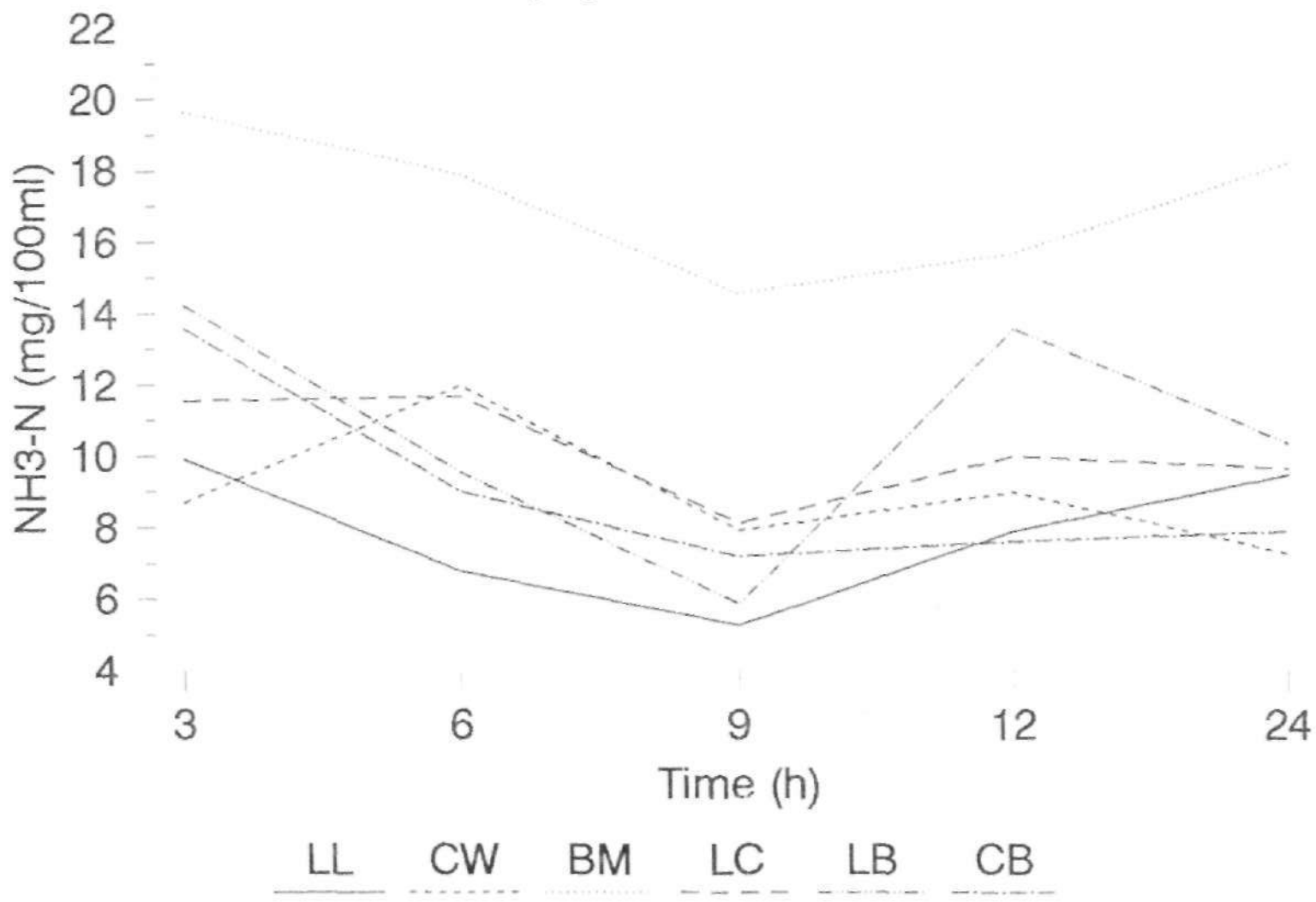


Figure 2

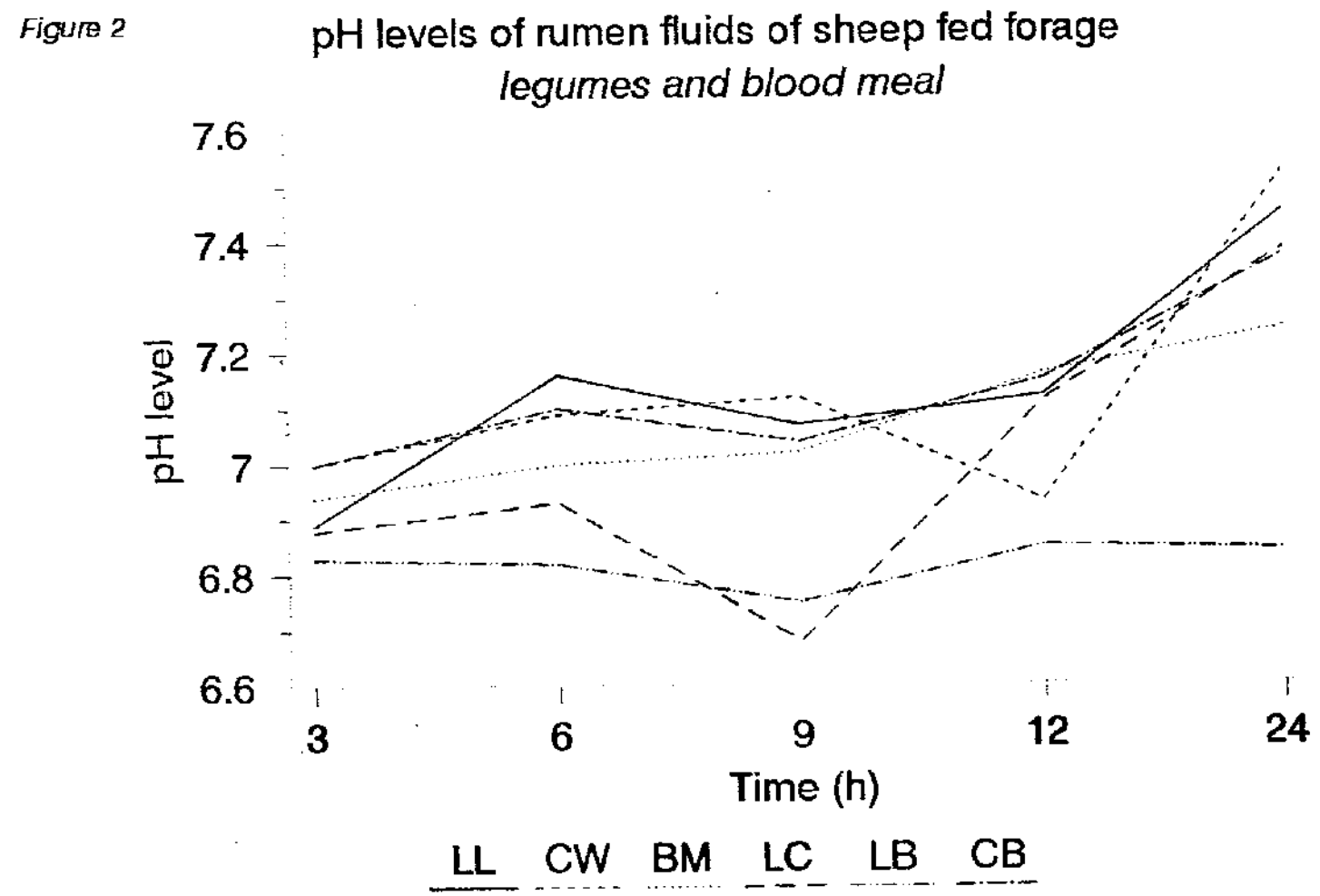

pH levels of rumen fluids of sheep fed forage
legumes and blood meal
7.6
7.4
7.2
7
6.8
6.6
pH level
3
6
9
12
24
Time (h)
LL
CW
BM
LC
LB
CB

figure 3

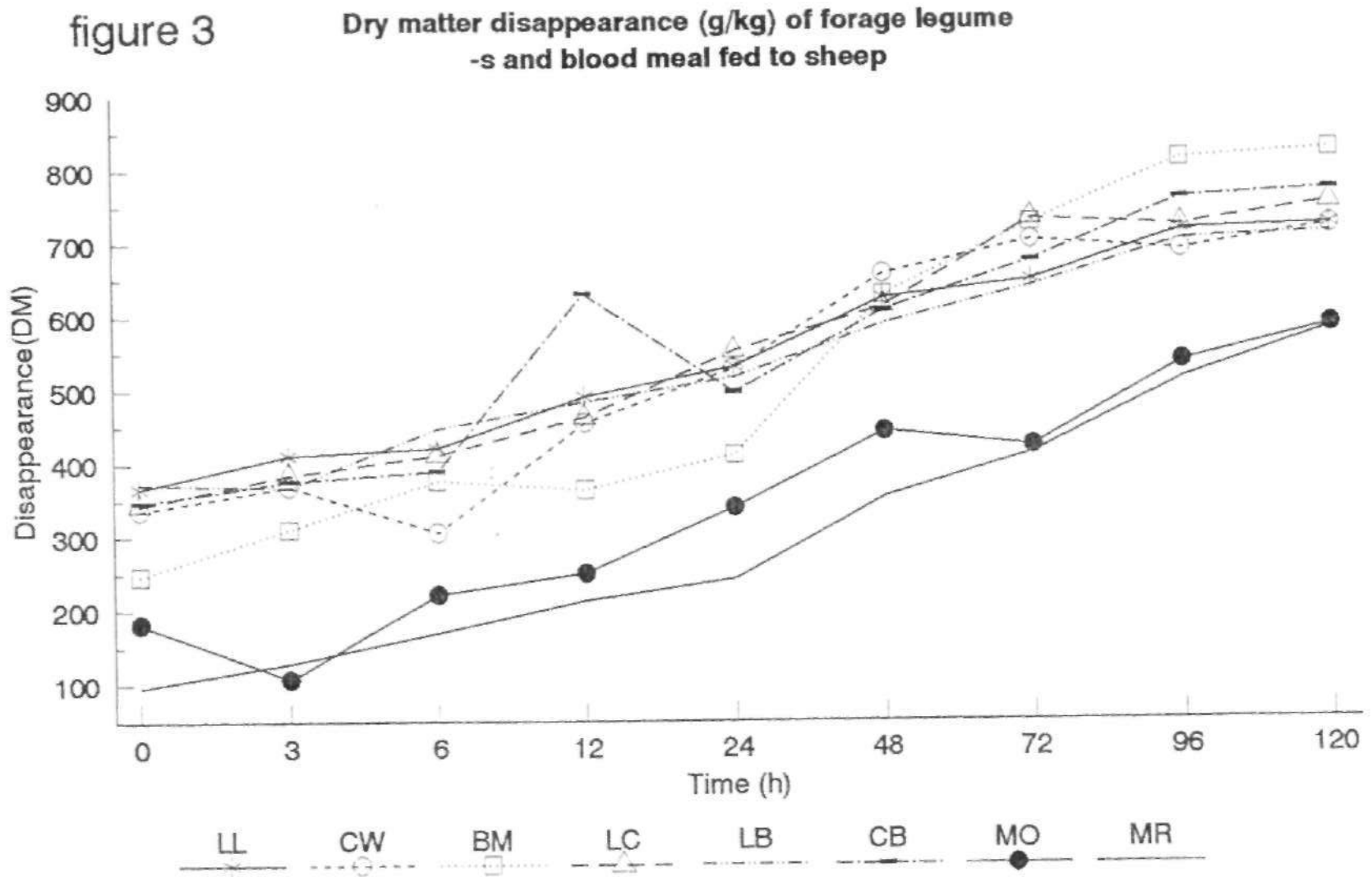

Dry matter disappearance (g/kg) of forage legume -s and blood meal fed to sheep
Disappearance(DM)
900
800
700
600
500
400
300
200
100
0
3
6
12
24
48
72
96
120
Time (h)
LL
CW
BM
LC
LB
CB
MO
MR

figure 4

Organic matter disappearance (g/kg) of forage legumes and blood meal fed to sheep.

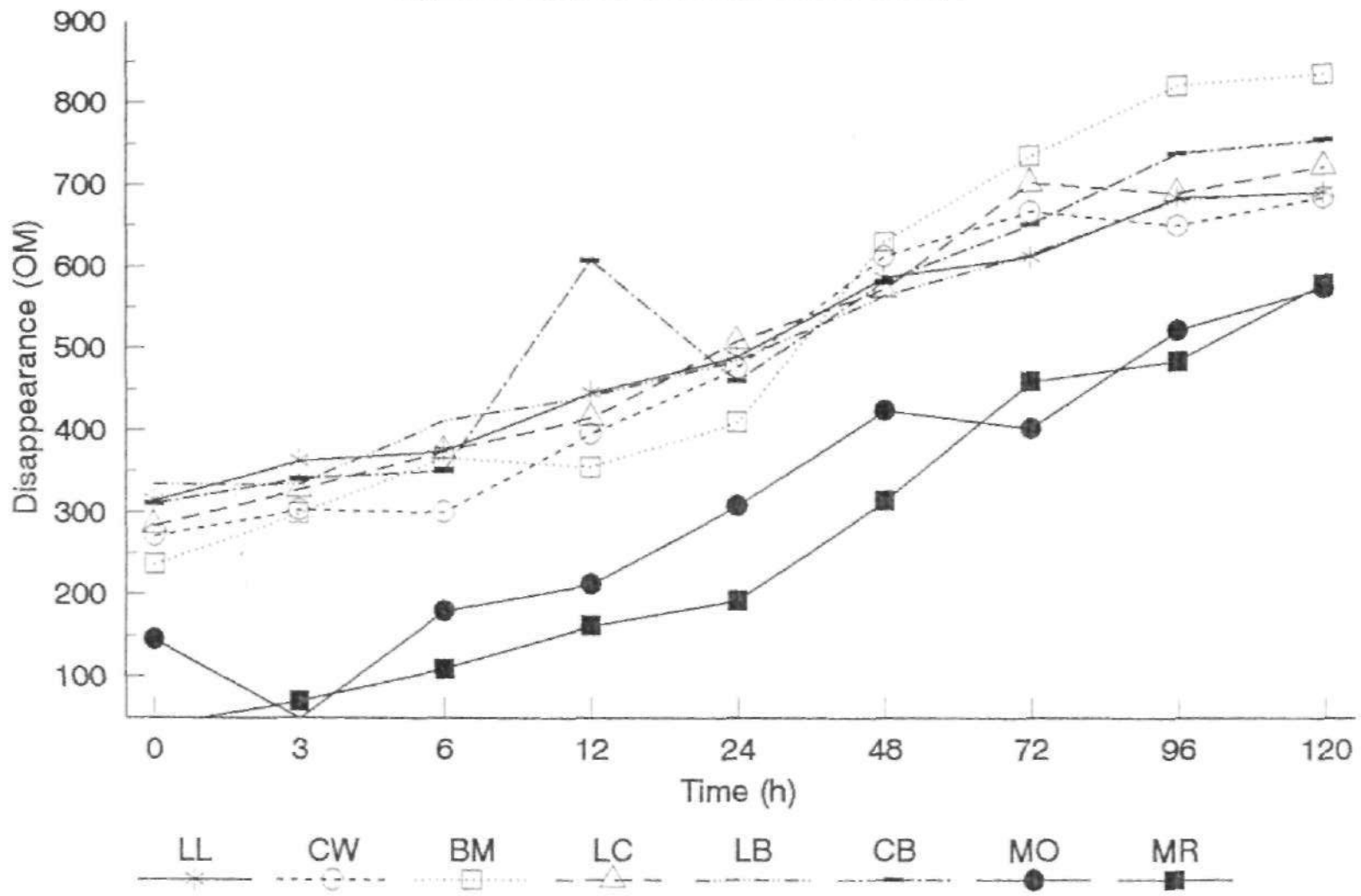


figure 5

Nitrogen disappearance (g/kg) of forage legumes and blood meal fed to sheep.

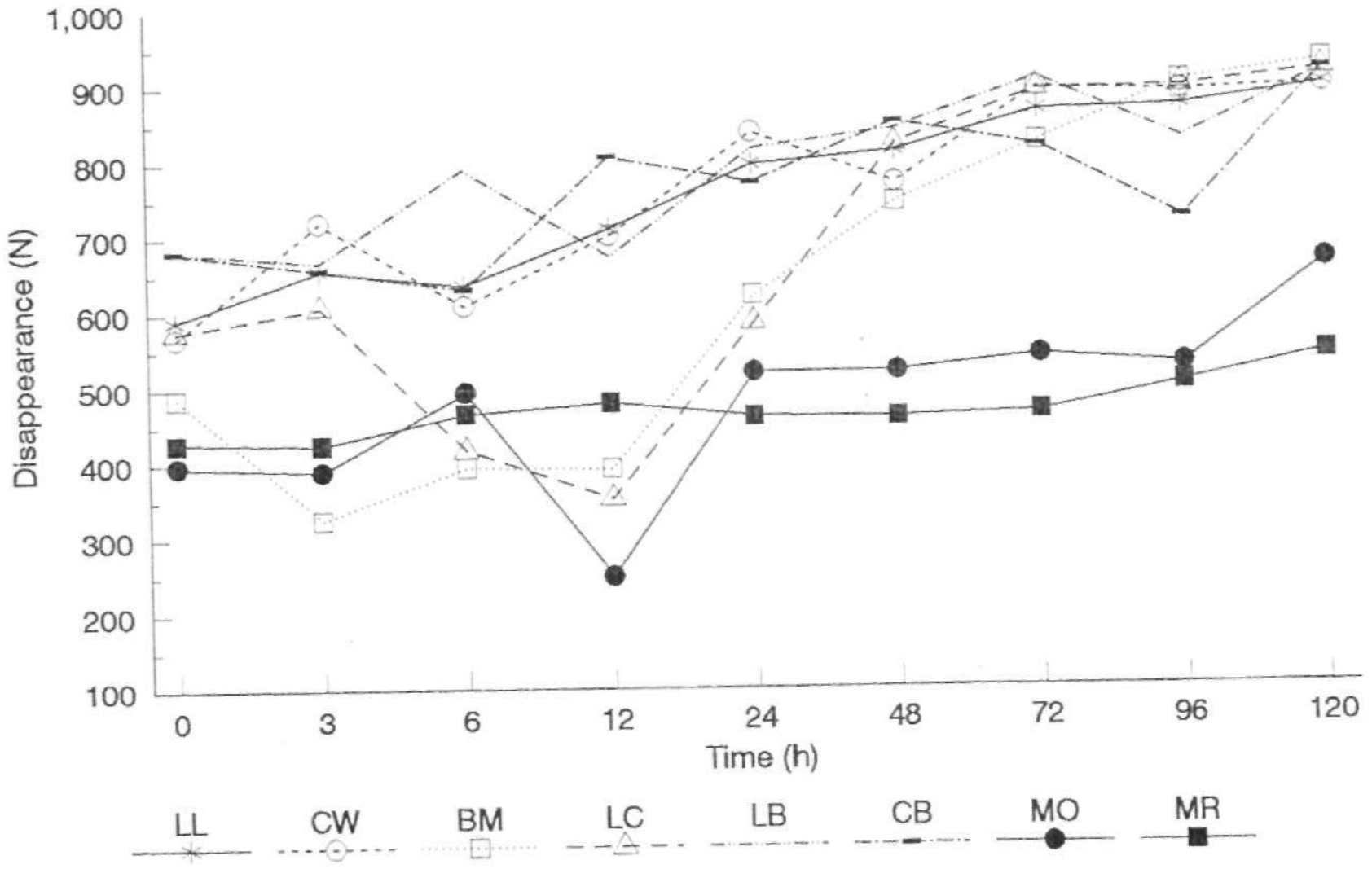


Figure 6

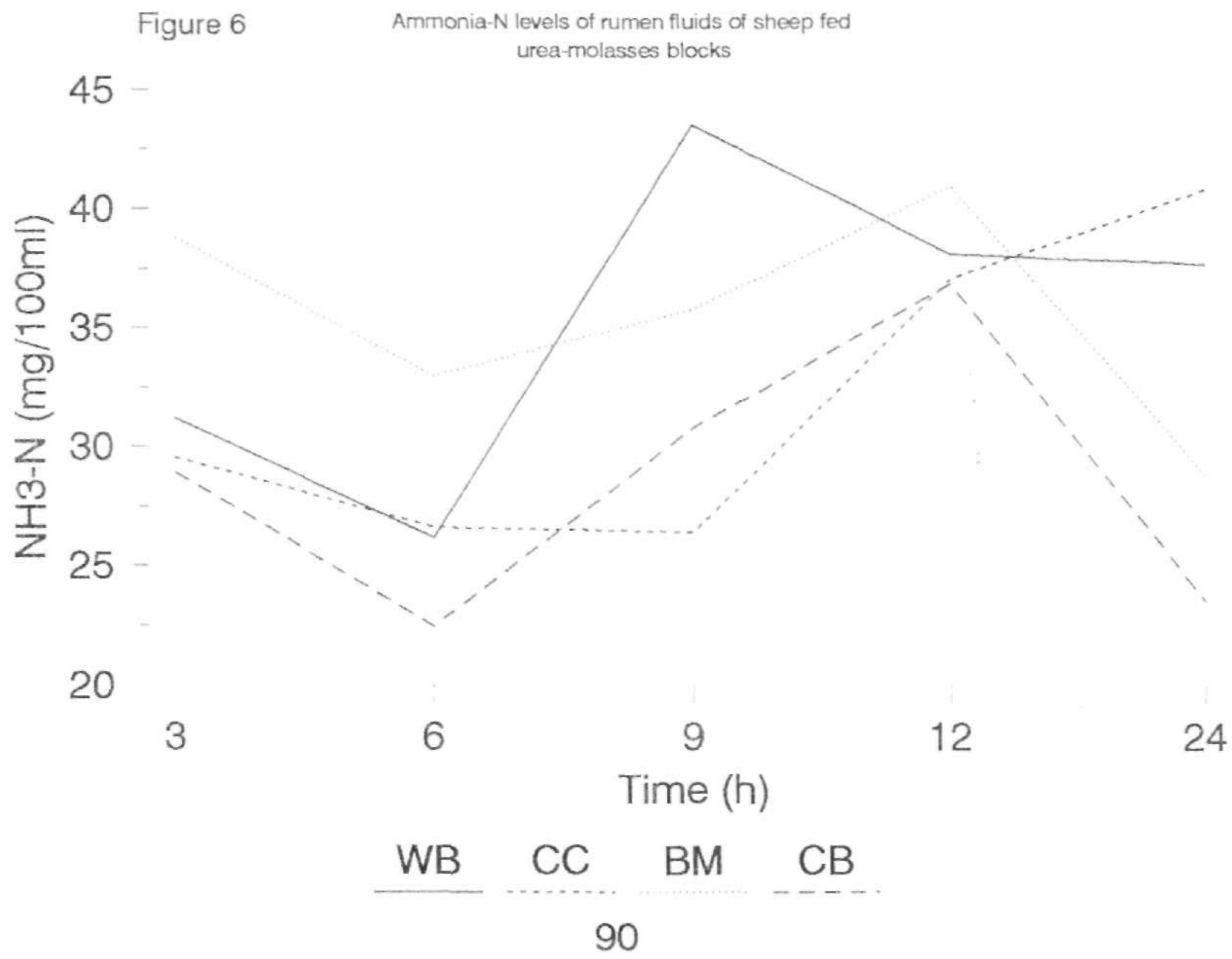

Ammonia-N levels of rumen fluids of sheep fed urea-molasses blocks
NH3-N (mg/100ml)
45
40
35
30
25
20
3
6
9
12
24
Time (h)
WB
CC
BM
CB
90

Figure 7 pH levels of rumen fluid of sheep fed urea molasses blocks

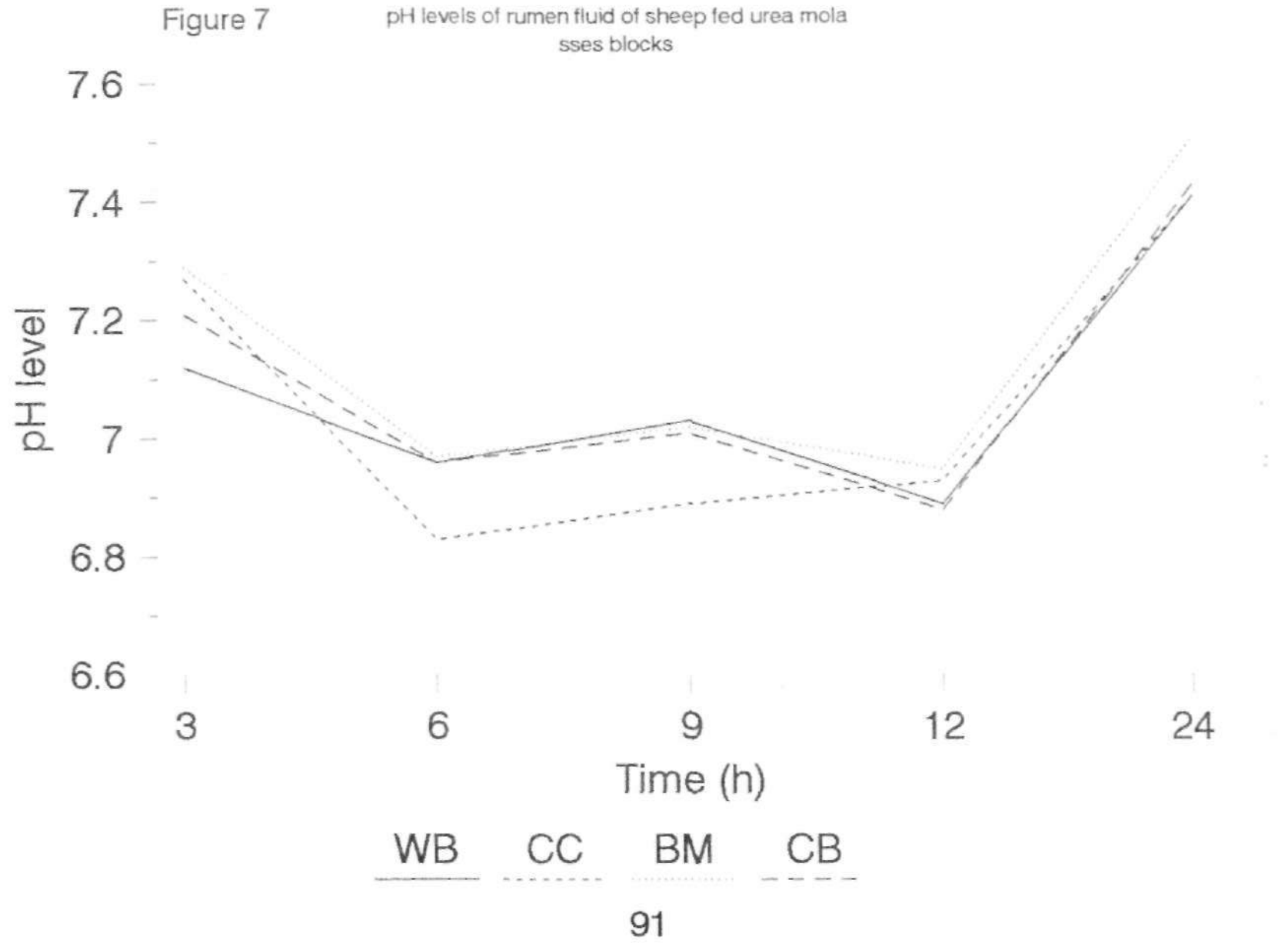


Figure 8: Dry matter disappearance (g/kg) of urea-molasses block fed to sheep

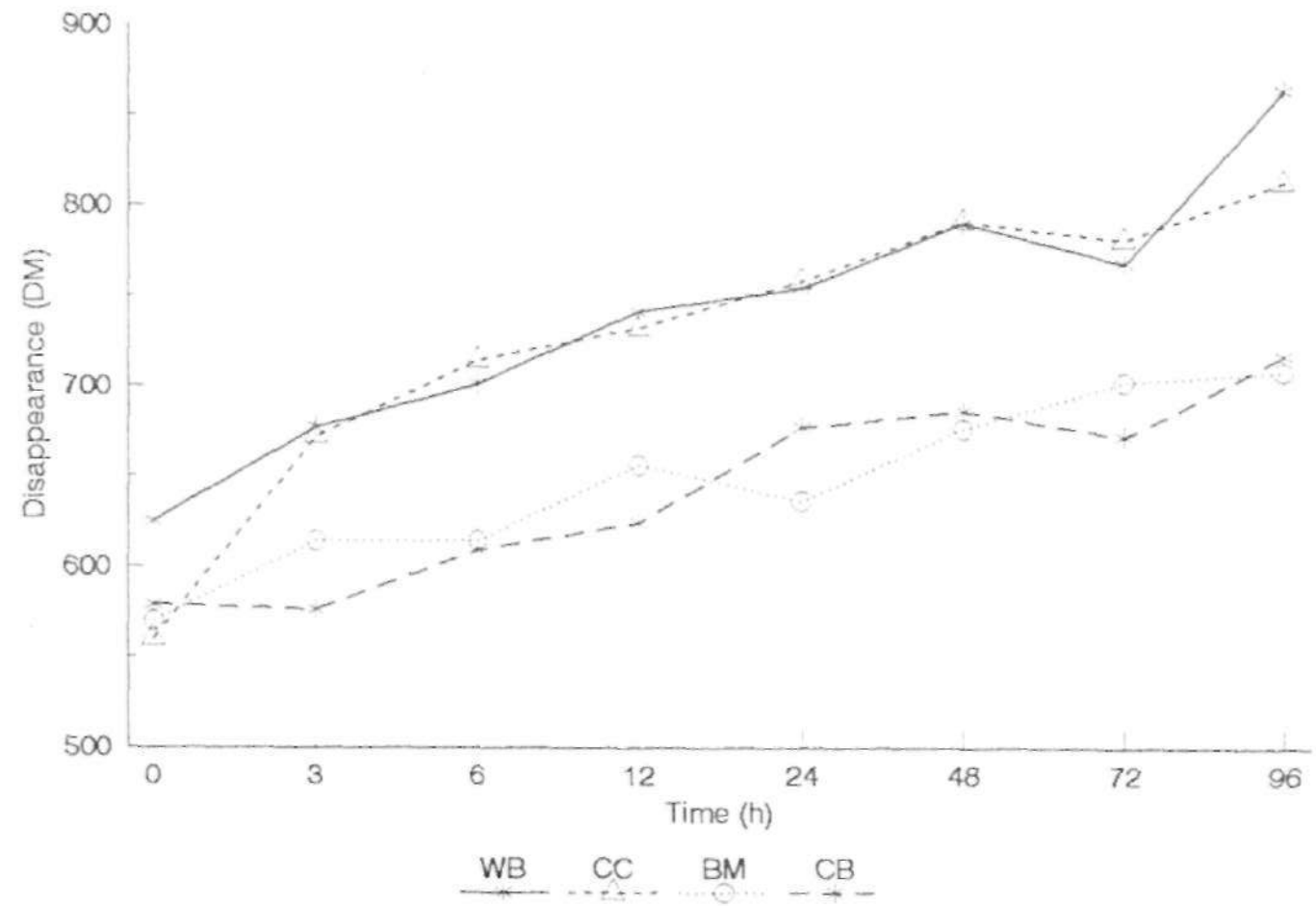


Figure 9 Organic matter disappearance (g/kg) of urea-molasses block fed to sheep

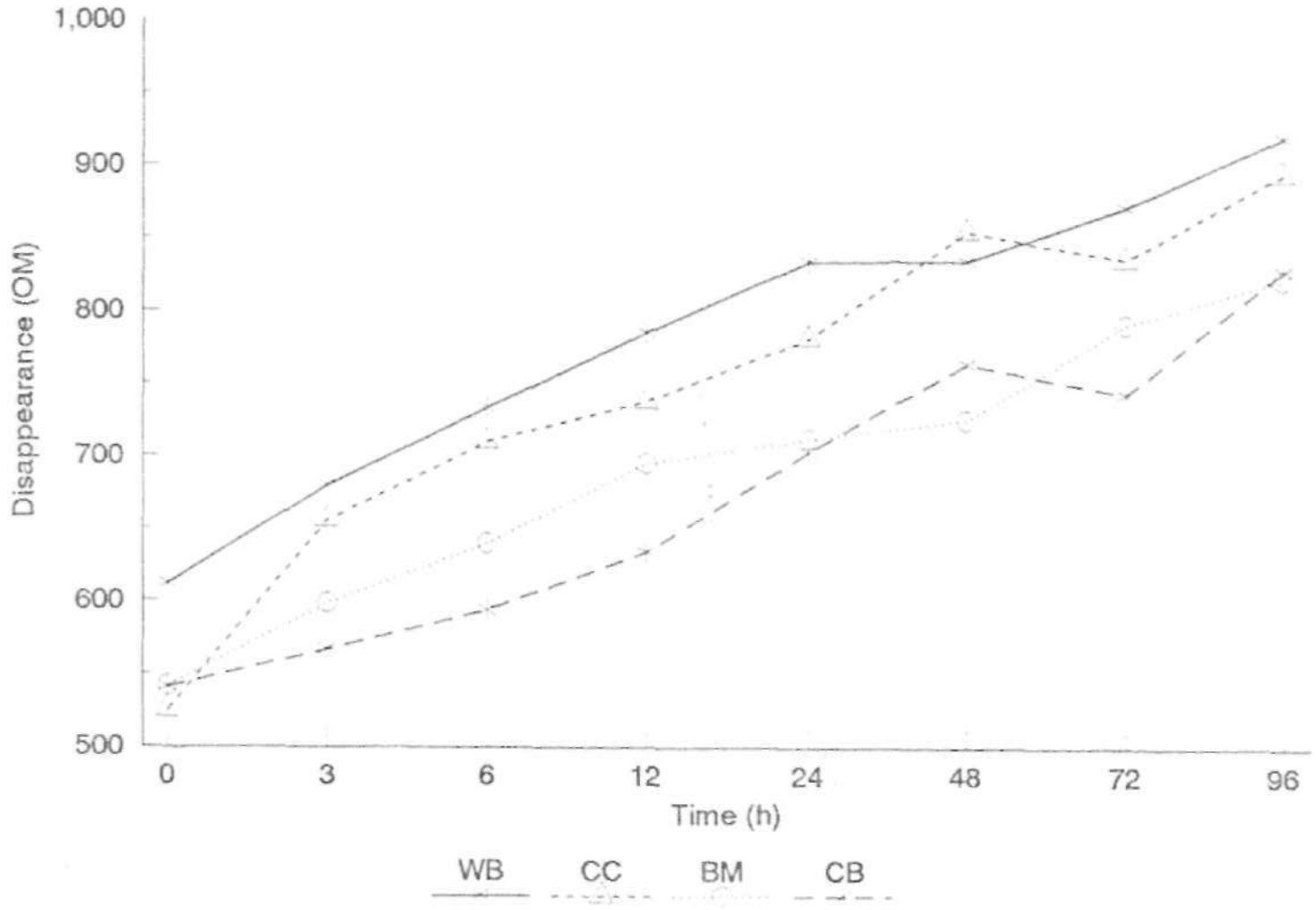


Figure 10: Nitrogen disappearance (g/kg) of urea-molasses block fed to sheep

