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Faculty of Veterinary Medicine and Biosciences
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Effect of Bypass Protein on Growth Performance of Khari Goats in Nepal

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Master in Feed Manufacturing Technology

Effect of Bypass Protein on Growth Performance of Khari Goats in Nepal

BY

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Feed Manufacturing Technology

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Declaration

I, Dipendra K C, do hereby declare to Norwegian University of Life Sciences that, this thesis is a result of my own research investigations and findings. Sources of information other than my own works have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic/non-academic degree.

Signature..............................

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Abstract

The bypass protein feeding study was carried out using twenty-four seven months old Khari goat kids at Sarasawati goat farm, Naubise, Dhading, from June to October, 2014. Goats were grouped randomly in three complete blocks (RCBD) and two goats from each of the block were allocated to each of four treatment. Before starting the experiment, goats were drenched against internal parasites with Fenbendazole@5mg/kg body weight. Four types of ration were formulated marked as ***T_1:*** *Foliage of Stylosanthes guianensis and Leucaena leucocephala (Ad libitum);* ***T_2:*** *Foliage of Stylosanthes guianensis 34%, Leucaena leucocephala 33% and commercial concentrate feed 33% (DM basis);* ***T_3:*** *Foliage of Stylosanthes guianensis 34%, Leucaena leucocephala 33%, HCHO treated maize meal and commercial concentrate feed 33% (DM basis) and* ***T_4:*** *Foliage of Stylosanthes guianensis 34%, Leucaena leucocephala 33%, HCHO untreated maize meal and commercial concentrate feed 33% (DM basis). The average dry matter feed intake was highest for T_1 (54.23 kg) followed by T_2 (53.13 kg). Similarly, feed conversion efficiency was higher in T_1 (4.42) followed by T_4, T_2 and T_3 (3.91; 3.87and 3.43 respectively). Protein conversion efficiency was not significantly influenced by different concentrate level in diets. The total body weight gain was highest in T_2 (2.73 kg) with average daily gain of 27 g followed by T_3 with total weight gain of 2.23 kg and daily gain of 22 g. Crude protein intake varies significantly with respect to treatment and highest value of 64 g/day was observed for T_3 and lowest value of 57 g/day was observed for T_1 treatment. Significant differences in nitrogen intake were observed between different experimental feeds. Rumen pH affects gaseous balances with lower NH_3-N losses (12.86 mg/L) and CH_4:CO_2 (0.018:1) ratio was noted for T_3. To get optimize rumen activities and enhancing bypass properties yielding higher benefits, it can be concluded that the supplementation of formaldehyde treated maize meal and concentrate mixture is beneficial for Khari goats in addition to ad libitum feeding of protein roughages like Stylosanthes guianensis and Leucaena leucocephala.*

Keywords: Khari goats, bypass protein, Dry Matter Intake (DMI), Average Daily Gain (ADG), Feed Conversion efficiency (FCE), Protein Conversion Efficiency (PCE), Rumen pH and gaseous loss

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Acronyms and Abbreviations

ADF	Acid Detergent Fiber
ADG	Average Daily Gain
ADL	Acid Detergent Lignin
AGDP	Agricultural Gross Domestic Product
CBS	Central Bureau of Statistics
CF	Crude Fiber
CP	Crude Protein
CT	Condensed Tannin
FAO	Food and Agriculture Organization
FCE	Feed Conversion Efficiency
FUG	Forest User Groups
GIT	Gastro Intestinal Tract
HMGN	His Majesty Government of Nepal
LSB	Lao Statistics Bureau
LWG	Live Weight Gain
m.a.s.l	meter above sea level
ME	Metabolic Energy
MOAC	Ministry of Agriculture and Cooperatives
NAS	National Academy of Sciences
NDF	Neutral Detergent Fiber
NRC	National Research Council
PCE	Protein conversion efficiency
SEM	Standard Error of Mean
SIA	Statistical Information on Agriculture
TDN	Total digestible nutrient

1. Introduction

1.1 General Overview

Livestock is important for subsistent Nepalese farmers through value generation from milk, meat, draught power and manure. It provides 37% of income for hill farmers in Nepal (Pandey *et al.*, 2013) and 55% of on-farm income for small-scale farmers in Nepal (Degen *et al.*, 2010). Furthermore, in Nepal, livestock contributes 32% of Agricultural Gross Domestic Product (AGDP) and about 12% of country GDP (CBS, 2011). Ruminants are the backbone of Nepalese livestock industry and particularly goats act as a major source of livelihood for small, landless farmers in rural areas (Pandey *et al.*, 2013). Because of versatile adaptive capacity, goats in Nepal are raised successfully from low lying grassland i.e. Terai belt (60 m.a.s.l.) to Mountain belt (>8000 m.a.s.l) and these goats play an effective role in converting forage feeds whether they are farmed in cool, temperate or tropical conditions (Lebbie, 2004).

There is a close integration between crops, livestock and trees in Nepalese agriculture (Dhakal *et al.*, 2005). According to Floyd *et al.*, 1999 "These components are closely linked, with the forest (trees) acting as the resource base by which crop and livestock production are sustained." In Nepal, farmers use more than 180 species of trees, shrubs and vines as fodder and among them almost 50 are traditionally cultivated by farmers (Khanal and Subba, 2001). Leaves of fodder tree is particularly important for goat feeding especially during period of dry winter from mid-January to mid-June when there is very less availability of other feeds. This leaves of fodder tree act as good supplement of nitrogen to poor crop quality residues (Khanal and Upreti, 2008). However, during other periods, grasses and crop residues remain primary sources of goat feeding.

In Nepal, goats are the second most popular source of meat after poultry. Hence, most farmers kept goat for meat purpose rather than milk. About 9.5 million animals were recorded during year 2011/12 and goat has a very healthy annual growth rate of 4% per annum (MOAC, 2011/12). Similarly, meat production was also increased by 3.6% per annum as it was recorded 53953 metric tons in year 2011/12. These figures clearly demonstrate the popularity of goats and demand for its meat. However, degradation of forests and range lands are a major constraint for the availability of fodder trees. Therefore, there is a need rehabilitation of degraded land and maintenance of forests for sustainability of goat production (Floyd *et al.,* 1999; Neupane *et al.,* 2002). Forest User Groups (FUG) has developed a new concept for regulation and collection of fodder and group members are expected to invest part of the revenues from goat keeping benefits to improve forest resources (Pokharel and Suvedi, 2007). In spite of this initiative, there is still shortage of browse for the growing number of goats and crop residues are of poor quality, partly due to poor harvesting techniques. Production of oil seed cakes is also low and quantities of grains harvested are used primarily for human consumption. Therefore, it is very important to find additional feed sources for goats.

Sustainability in goat keeping can be achieved by optimizing feed rations that cannot be utilized directly by man. Introduction of forage legumes into the farming system has been suggested as one of the most reliable and sustainable strategies for goat as well as crop production (Pandey *et al.,* 2013). Forage legumes provide quality feed for livestock and improve soil fertility and crop productivity through nitrogen fixation. Besides being rich in protein, legumes also act as good source of vitamins and other essential minerals (Horne and Sturr, 2000).

1.2 Feed resources for goat feeding

Stylosanthes guianensis (commonly known as Stylo grass) is a widely used forage legume in Nepal, fed as hay (sun dried), grazed or used fresh in a cut-and-carry-system. During dry season, Stylo grass can be used as protein supplement in rations based on low quality forages, like rice straw, maize stover and other feed materials (Kiyothong *et al.,* 2004; Thang *et al.,* 2010; Pen *et al.,* 2013). Stylo is a perennial fodder legume with presence of nodules in strong taproot. Due to presence of bristle on young steams, palatability of Stylo increases with maturity (FAO, 2014). Its forage is a rich source of moderately soluble protein (Magalhaes *et al.,* 2003) and contains condensed tannins. The tannins, due to reversible binding capacity with protein, will increase levels of bypass protein and thereby improve animal productivity Baloyi *et al.,* 2001; Thang *et al.,* 2010). Stylo forage, only can meet both energy – and protein demands of adult sheep (Mupangwa *et al.,* 2000). Stylo forage also improves the utilization of Ca in goats (Bamikole, 2003).

Leucaena leucocephala (Commonly known as Ipil-ipil) is a widely used and fast growing, evergreen multipurpose tree with height of 5-20m (FAO, 2009) producing palatable feed of high nutritive value (Ecoport, 2009). For ruminants, Leucaena is an important source of highly digestible protein. It contains large amount of mimosine (12%), a toxic amino acid for monogastric animals. However in ruminants, this amino acid is broken-down into DHP (dihydroxy-piridone). If protected with a substance like formaldehyde, further degradation of protein in rumen can be avoided, thereby increasing levels of bypass proteins (Kamalal *et al.,* 2005). Feeding high quantities of Leucaena over extended periods (more than 30% on DM basis) may have toxic effects, even in ruminants (Norton, 1998). Leucaena is also rich in β-carotene (Ecoport, 2009) and in condensed tannins (3% DM) that enhances by-pass protein (Cook *et al.,* 2005; FAO, 2009). In addition, it grows well in combination with Stylo grass. A 50-75% inclusion of Leucaena foliage in a grass as basal diet, can give higher DM intake, weight gain, reproductive performance and semen quality (Akingbade *et al.,* 2002 & 2004; Kanani *et al.,* 2006) and milk production (Clavero *et al.,* 2003) of goats.

Supplementation of concentrate mixture to goat feed depends on the availability of fodder and pasture. However, to achieve healthy growth in goats, it is general thumb rule in Nepal to supply them one third concentrate feed and two third leguminous roughages. When feeding, we need to be careful and avoid wet fodder as much as possible. By offering smaller amounts of fodder in each feeding, we can also reduce wastages. Since goats normally find leguminous forages palatable, treating these forages and combine with a concentrate mixture, may increase bypass property by decreasing rumen protein degradation and increasing intestinal degradation of protein.

Formaldehyde treatment is most widely used chemical method for the protection of protein. Generally, 3-4 kg of commercial formalin (40-45%, formaldehyde HCHO) per 100 kg of CP is recommended as treatment dose (Kanjanapruthipong *et al.,* 2002). In addition, this treatment increases fecal nitrogen and decreases urinal nitrogen. Principle behind effectiveness of HCHO treatment is that the solubility of protein decreases at around pH 6.0 after gets bonded with HCHO that protect them from strong rumen microbial attack without decreasing digestibility in small intestine (Ferguson, 1967).

Supplementation of locally available leguminous forages with commercial concentrate mixture can be a good option for successful goat farming in Nepal where feed counts for more than 75% of total cost. Growth performance of goats fed with formaldehyde treated different leguminous forages and concentrate mixture is not evaluated so far in Nepal. Hence, a study was carried out to compare the growth performance of Khari goats fed with formaldehyde treated forage mixture of Stylo and Leucaena with commercially available concentrate mixture at Sarasawati Goat Farm, Dhading, Nepal. This area located within mid-hill of Nepal, is suitable for commercial goat farming due high availability of grazing and fodder resources.

1.3 Objective

The overall aim of this study was to investigate the effect of bypass protein supplementation on growth performance of Khari goats with specific objectives to:

1. Evaluate potential local feed resources for goats and to recommend their use to smallholder farmers.
2. Determine nutrient characteristics, foliage yield and utilization of *Stylosanthes guianensis* and *Leucaena leucocephala* as goat feed.
3. Determine the profitability of formaldehyde treated feed.

1.4 Hypothesis

In order to achieve above objectives following hypothesis was tested:

i. Supplementation of *Stylosanthes guianensis* and *Leucaena leucocephala* improve the growth performance of goats.

ii. Treatment mixture of Stylo, Leucaena and commercial concentrate with formaldehyde facilitates the rumen reaction, decreases protein degradation and hence increases By-Pass properties.

2. Literature Review

2.1 Goat Production in Nepal

Small ruminant like goats are an essential component of sustainable farming systems in Nepal. Every household keep some of the goats with other livestock to maintain their day to day life and this trend is more popular in hilly region than in other parts of Nepal. Mainly they are kept for meat and beside this fiber and manures are other important products from this animal. Goat also acts as main source of income especially for the subsistence farmers of hills. Most commonly, goats are raised under a sedentary or a migratory system in hills of Nepal (Ghimire, 1992). Goats can efficiently survive on available shrubs and trees in adverse harsh environment in lands with low fertility where no other crops can be grown. The goat is also known as “Poor man’s cow” all over the world. Since goat can be sold at any time, it is popularly known as living bank; or live ATM (Rajwar, 2013).

2.1.1 Indigenous Goat Breeds of Nepal

Indigenous Goat breeds in Nepal might have similar lineages especially in areas having similar ecological zones to India and China. However, there are at least four types of indigenous goat breeds identified in Nepal (Khanal et al., 2005; Joshi and Shrestha, 2003; Shrestha, 1996) such as Chyangra, Sinhal, Khari and Terai goat, other breeds Jamunapari, Barbari, Kiko, Beet al, and Saanen have been introduced and crossbred (Upreti and Mahato, 1995; Neopane and Sainju, 1995). Terai and Khari goat represent about 9% and 54%, respectively (Gorkhali et al., 2011). Chyangra and Sinhal goat accounts 6% and 31% respectively.

Table 1: Geographical distribution of indigenous goat breeds in Nepal

Name	Area	Percentage %
Sinhal	High Mountain	31
Chyangra	High Mountain	6
Khari	Mid Hills	54
Terai	Terai	9

2.1.2 Characteristics feature of Khari goats

Khari goats are widespread and more abundant (54%) than other indigenous breeds and are present in the mid-hills. Khari goats are relatively small bodied with body weight ranging between 20 kg to 40 kg. The average wither height is 53-63 cm. They are the most prolific among the four indigenous breeds and can adopt in different agro-climatic zones. They generally produce first kid by the age of 16 months with a kidding interval of 9 months. The average birth weight of kids has been reported to be 1.5 kg and yearling weight of male and female kids to be 15 kg and 12.5 kg, respectively. From the different locations of Nepal (east and west), seven color variants were identified with dominance of black followed by brown. Cluster analysis of various body part measurements of goats identified three different types, for eastern, central and western parts of Nepal. The combined information of morphological and genetic genogram implied that the goat populations from mid-west, and east were markedly different, while the goats from central region were intermediate between these two extremes. In general, horns are medium sized, cylindrical and straightway backward (47.9%) followed by straightway upward (31.2%) projected (Joshi and Shrestha, 2003). The gene frequency of horned condition was higher (99%) than for polled (1%).

Figure 1: Khari goats

2.2 Current Practices of Goat Management in Nepal

Goat is one of the most dominant ruminants in Nepal. Goat keeping is an integrated approach for majority of the farmers in Nepal as they keep couple of goats as part of the livestock subsystem in the households where crops, vegetables and fruit trees integrate the whole system in a unique and subsistence way (MoAC, 2011). Production system is traditional in most of the cases where goats are either stallfed or grazed in the nearby forest. Most of the farmers keep goats based on partial feed supply (maize grits, wheat bran) and fodder from farmland & forest. Housing system varied in high altitude districts where goats are often kept inside the barn in enclosure type of room with poor ventilation and little space, whereas in the mid-hills housing is semi-open sheds with poor space management (MoAC, 2011).

Goat management system in the country has been found to be influenced by the geographical location and prevailing climate, availability of feed, human resources, tradition and market (Shrestha, 1994). Goats in high hills and mountains (Chyangra and Sinhal) of Nepal are generally managed under migratory system along with sheep (Bhyanglung and Baruwal). The migratory management of small ruminants is practiced in almost all of the northern districts of Nepal adjoining to the southern flank of the Himalayan massifs. This system is adopted for about 65% of the national sheep and about 35% of the goat population (LMP, 1993). In this system, mixed flocks of sheep and goats with many owners are reared on seasonal migration throughout the year, grazing on the fallow crop fields and forest undergrowth during the winter and on the alpine pastures during the wet summer months. The remaining populations of goats (Khari, Terai and crossbred with exotic goat breeds) are particularly managed under sedentary system of management in the lower hills and Terai of Nepal. These goats are generally grazed throughout the daytime in the nearby forest, fallow land and roadside and are housed during the night (Shrestha, 1994). Tethering of goats throughout or particularly during crop season is also practiced. Despite high demand and supply gap, the goat production in the country is mostly subsistence and needs to be transformed in to commercial production to fulfil the national demand (Shrestha, 1994).

2.2.1 Prospects of Goat Farming in Nepal

Goat is a multifunctional animal and plays a significant role in the economy and nutrition of landless, small and marginal farmers in the country. It provides meat, milk, manure, fiber and power for the transportation. In addition to this, goat has religious and ritualistic importance and all communities (Rajawar, 2013) accept and relish the meat of goat (chevon). However, the supply of goat is always in deficit. With a price rise of about 300% over the last decade, goat meat production has become an important means of income generation for rural people.

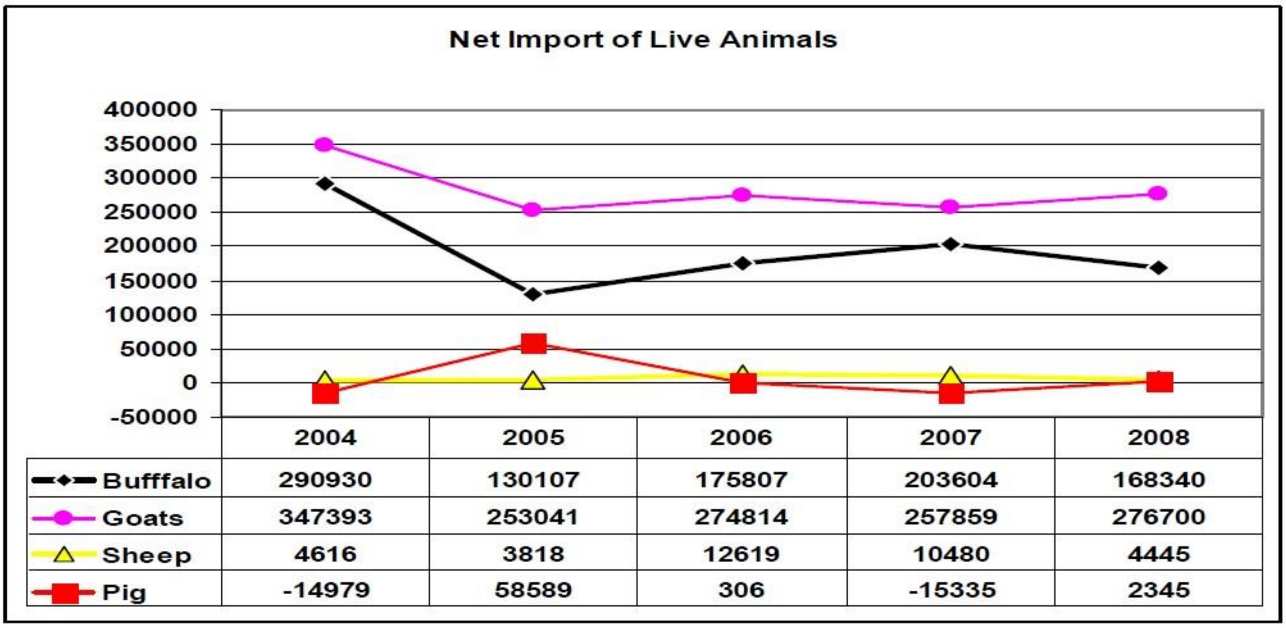
The possibilities of expanding goat meat exports to India and goat skin exports to overseas markets further emphasizes the importance of goat production (Kharel and Pradhan, 1988).

According to Statistical Information on Agriculture (2011), there are about 8.47 million goats in Nepal with healthier growth rate of 5.7%. Meat production from these goats is about 50 thousands metric tons, which is 25% of total meat production in country (Table 2). This figure clearly demonstrates that there was a significant increase in meat production. Still there exists high demand of goat meat.

Table 2: Livestock population of Nepal (SIA, 2011)

Species	Millions 2010 / 11	Growth rate
Cattle	7.17	0.57
Buffalo	4.68	3.80
Goat	8.47	5.70
Sheep	0.80	-3.10
Pig	1.04	2.90
Poultry	24.48	3.02
Duck	0.38	0.51

In order to fulfill consumer demand, every year large number of goats is imported from India. This increasing trend of importing live animal from neighboring county is depicted in figure 2. About 51% of families are rearing at least one goat and most, which are of low productivity. Hence, commercialization in goat is utmost importance for socio-economic development of farmers and for which novel strategy is needed in order to increase productivity (Rajawar, 2013). Beside this, goats could also utilize vast natural resources like pastures that cover about 12% of total land mass thereby achieving a sustainable goat production (Pandey and Gyawali, 2012).



	2004	2005	2006	2007	2008
Buffalo	290930	130107	175807	203604	168340
Goats	347393	253041	274814	257859	276700
Sheep	4616	3818	12619	10480	4445
Pig	-14979	58589	306	-15335	2345

Figure 2: Net import of live animals in the past five years (FAO, 2010)

2.2.2 Constrains of Goat Farming

The productivity of goat is still poor due to unscientific management practices, improper breeding, lack of nutrition and problem related to health and marketing. In Nepalese context, feeding is major constraint for commercial goat farming. Actually, goats are browser animal loving herbs and shrubs. Poor performance of goats is attributed to poor nutrition. McTaggart and Wilkinson (1981/82) found that the growth rate of local goats was 100g/day when fed with berseem plant and if same goats were allowed to graze natural pasture, the growth rate dropped to 33g/day. Hence, development of feeding regime according to behavior of goat is major constraints of commercialized goat farming. Low reproduction rate and poor nutrition are main constraints for livestock production in smallholder systems in Lao PDR (Nampanya *et al.*, 2010). On small landholder farms, lack of land and labor to look after goats is another constraint (Stür *et al.*, 2002). Seasonal variability affects crop production and forage yield. During cropping season, in order to avoid damage in crops, goats are tethered in small confined spaces where feed availability is limited. During dry season, goats are allowed to graze freely. However, availability of good quality feed during this period is very low (Phengsavanh, 2003). Hence, goats normally need to walk more in search of feed which is actually a waste of energy. Lack of knowledge about good goat husbandry practices is another important constraint (Nampanya *et al.*, 2010). Beside this, lack of knowledge about the potentiality of foliage from different leguminous herbs and shrubs and their use in feed resources as dietary supplement is very limited among rural people (Daovy *et al.,* 2008). Diseases and mortality is another serious threat for commercial goat farming. Diseases that can affect health and productivity of goats are parasitic infestation, gut related disorders and bloat (Joshi, 2004; Wilson, 2007). Chalmydia, Leptospira, Mycoplasma are the main factors of abortion and late pregnancy in goats (Joshi, 2004; LSB, 2010). However, hygienic supplementation of feed with adequate vitamins and minerals, clean shed, and decent veterinary care of pregnant does can help to remove these problems (Joshi, 2004).

2.3 Feeding of Goats

Goats can be fed upon locally available cheap feed resources. During preparation of ration for goats, one needs to be careful about factors like bulk, palatability, availability, digestibility and prices. Hygienic supply of feed and water helps in removal of various life threatening diseases of goats.

2.3.1 Feeding Habits of Goat

Goats are a very sensitive animal in feeding habits. They are very active foragers that can cover wide range of area in search of scarce plant materials and can able to graze very short with their small mouths and split upper lips (Devendra and Coop, 1982). This upper lip enables them to pick most nutritious available feed like small leaves, flowers, fruits (Luginbhul *et al.,* 2000). Leguminous fodder is what goat like most. Some of the common green roughages liked by goat are: berseem, Napier, Lucerne, cowpea, soybean, cabbage leaves, and leaves of trees like (babul, neem, pipal etc.) because of their tolerance level of "bitter and high tannin materials", goats may eat unpalatable weeds and shrubs that can be poisonous like cherry or milkweed (Luginbhul *et al.,* 2000). Grazing behavior of goats can be summarized as selection of grass over clover, preference of browsing over grazing pastures, preference of forage in rough land over flat and smooth land, preference to graze along fence line and then in center of pasture and uniformly graze over top of pasture canopy and then in soil level (Schoenian, 2000; Luginbhul *et al.,* 2000).

2.3.2 Nutrient Requirement of Goats

Goats need good amount of nutrient for body maintenance, growth, reproduction, pregnancy, and production of products such as meat, milk and hair. Nutrient requirement is affected by factors like animal productivity and animal biotype. Nutrient requirement varies with maintenance and activity level, pregnancy stage, kidding rate, lactation stage, and weight gain, animal purpose (meat or milk) and also varies according to breed type (Kearl, 1982; Salah *et al.*, 2014)). Goats having proper amount of nutrient have efficient feed conversion ratio and increases productivity. Smaller does eat less so they need to have feeds higher in protein and energy than larger does. For doe, highest nutrient requirement time is late pregnancy and in this stage, avoidance of fat as much as possible can give better utilization of other nutrient for healthy growth (Kearl, 1982). High amount of protein and energy is required for healthy rate of growth gain. Hence low quality grass hay won't meet all nutrient requirements of goats so it is always better to fed leguminous forage and concentrate diet made from locally available feed resources (Mandal *et al.*, 2005; Sahlu *et al.*, 2004).

Like for other ruminant, group of nutrients essential for goats are water, vitamins, minerals, protein and energy. Diet must contain adequate amount of protein (Kearl, 1982). Energy needs can be derived from carbohydrate, fat or from excess protein. Total digestible nutrient (TDN) and protein requirement are shown in Table 3. TDN values vary according to quality of foliage's and concentrate feed have 70-90% TDN (Mandal *et al.*, 2005). There should always be availability of good and clean water to increase animal performance. Nitrate in drinking water should be of concern because it is becoming the predominant water problem for livestock. A safe level in drinking water is less than 100PPM for nitrate nitrogen (Sahlu *et al.*, 2004). Fat should not be more than 5% in diet because it may depress ruminal fermentation. Protein is most expensive feed ingredients in goat diet (Salah *et al.*, 2014). Protein level determines growth rate, milk production, reproduction, disease resistance and other important phenomenon (Pinkerton, 1991). One need to be careful in supply of protein as excess is actually wastage in form of urine. Mineral and vitamins is essential for goats to maintain proper function in body and to have optimum production. Generally, 50:50 ratio of mineral salt and dicalcium phosphate is advisable under most situations (Sahlu *et al.*,2004).

Table 3: Daily nutrient requirements for meat producing goats (Pinkerton, 1991)

NUTRIENT	YOUNG GOATS[3]		DOES (110 lb)				BUCK (80-120 lb)
	Weanling (30 lb)	Yearling (60 lb)	Pregnant		Lactating		
			Early	Late	Avg Milk	High Milk	
Dry matter, lb	2.0	3.0	4.5	4.5	4.5	5.0	5.0
TDN, %	68	65	55	60	60	65	60
Protein, %	14	12	10	11	11	14	11
Calcium, %	.6	.4	.4	.4	.4	.6	.4
Phosphorus, %	.3	.2	.2	.2	.2	.3	.2

[3]Expected weight gain >0.44 lb/day

2.4 Locally available feed resources for ruminant in Nepal

Nepal, a country rich in animal feed resources. Diversified topographical conditions contribute to cultivation and production of wide variety of natural feed resources. Here, people uses products from food crops, crop milling by-product, vegetable and fruit processing, residue from oil seed production and livestock product processing (Reddy, 2001; Pandey and Upreti, 2005). Animal feed resources in Nepal can be grouped as tree fodders, green forages, crop by-products, creepers, crop residues (Panday and Upreti, 2005; Pandey *et al.*, 2013). Leaves and twigs collected from several species of fodder trees are a main source of green forage for ruminants in dry winter and wet summer (Khanal and Upreti, 2008). Khanal and Upreti (2008) evaluated four species of fodder trees cultivated for feeding ruminant animal in hills of Nepal and found that DM intake, nutrient digestibility, daily weight gain was higher in goats feeding fodder of *Aetocarpus lakococha* than Ficus and Bahunia. According to Degen et al. (2010), most of the household in hilly region of Nepal fed their livestock with tree foliage, green crops and rice straw. Beside this 25% of household grazed their livestock in communal degraded forests and marginal land. Almost 62 different fodder trees offered to goats in hilly region of Nepal. Out of this, 6 fodder trees dominate other and their uses and availability varies according to season and month as illustrated in figure 3. Khanayo is most dominant one with uses in almost all month (Upreti and Shrestha, 2006). Beside this other locally available feed resources used by locals to feed their goat is illustrated in table 4.

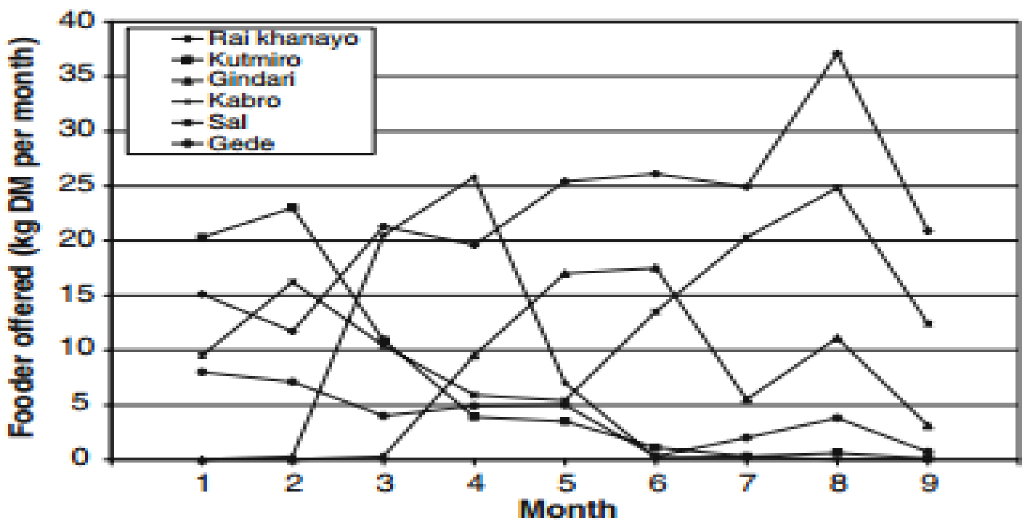


Figure 3: Fodder offered per month (kg) over a 256 day period for top six fodders in Hilly region of Nepal (Degen *et al.*, 2010)

Table 4: Feed resources available in Nepal (Upreti and Shrestha, 2006)

Feed categories	Feed resources
Crop residue	: Rice Straw, Wheat straw, Maize stover, pulses residues, oil crop residues, maize cobs, sugarcane tops, and bagasses.
Grains and grains By-products	: Broken rice, Rice bran, Wheat, Wheat bran, Barley , Barley bran, Soy bean, Soybean cake, Mustard cake, and Molasses.
Green forage	: Fodder crops and pastures
Fodder tree leaves	: From forest plants and planted fodder trees.

2.4.1 *Stylosanthes guianensis* (Stylo) as feed for goat in Nepal

Stylo is semi-erect or erect type perennial herb able to tolerate low soil fertility and even can be adapted to acidic soil. Stylo plant can survive long dry period and hence is more popular as fodder plant. Stylo plant is grown as cover plant in Nepal and harvesting is performed in every 2-3 months. Stylo can be fed fresh or in dried for hay and leaf meal. During harvesting one need to be careful not to destroy the plant buds. First cut should be at 10-20 cm to encourage branching and good regrowth (Horne and Stür, 1999). Digestibility of young stylo plant is around 60-70% and it reduces to 40% with lignification when plants mature. Dry matter nitrogen content ranges from 1.5-3% with crude protein value from 15-18% (Mannetje and Jones, 1992). Other important chemical characteristics as depicited in table 5 (g/kg DM) of stylo to be used as goat feed is as: CP 135.3, NDF (Neutral Detergent Fiber) 539, ADF (Acid Detergent Fiber) 506, ADL (Acid Detergent Lignin) 241, Calcium 16.6, Phosphorus 1.0, CT (Condensed Tanin) 17.0, 5.3

KJ/gm DM of ME (Pandey *et al.*, 2013). This leguminous fodder can provide high protein feed so that it can replaces expensive concentrate for goats (Phengsavanh, 2003). Phengsavanh (2003) reported growing goats consuming stylo as a supplement to a medium quality grass diet increased feed intake. Nijwe and Kona (1994) reported a supplementation of 200g/DM stylo hay increases feed intake, nutrient utilization and weight gain in yearling lambs raised by smallholder farmers. Lambs grazing on a silvopastoral system and supplemented with either concentrate or *Stylosanthes hamata* had higher average daily gains and better feed efficiency than those that were not supplemented (Rao *et al.*, 2007).

Table 5: Nutritive value of *Stylosanthes guinensis* as %DM (FAO,1998)

	DM	CP	Ash	CF	NDF	ADF
Fresh, late vegetative	-	18.1	8.3	26.8	-	-
Fresh, 40-45days old	20.2	19.0	5.5	64.2	-	-
Hay, 3 month old cutting	87.9	11.5	7.2	44.2	62.4	46.1
Hay, 60 days old cutting	84.8	16.7	10.0	31.7	-	-

2.4.2 *Leucaena leucocephala* (Ipil-ipil) as feed for goat in Nepal

Ipil-ipil is a fast growing forage multipurpose tree. For ruminants, it is palatable, digestible, nutritious plant that increases meat and milk production in goats (Girdhar *et al.*, 1991). Annually it can yield 12-20 tons per hectare of DM, which is equivalent to 800-4300 kg of protein per hectare (Shelton, 1998). Leucaena feed, due to its excellent palatability, digestibility, balanced chemical composition of protein and minerals, low fiber content and moderate tannin content can be promoted to achieve better by-pass protein value (Wheeler, 1994; Gridhar *et al.*, 1991; Jones *et al.*, 2000; Waipanya and Srichoo, 2003). Leucaena can be good replacement for expensive concentrate ingredients in feed. It is rich in all kind of nutrients required by goats so that it can provide goat with better DM intake, weight gain and reproductive performance (Devendra, 1992; Akingbade *et al.*, 2004; Kanani *et al.*, 2006). Beside this it also reduces the cost of parasitic control (Medina *et al.*, 2006). The major drawbacks of using Ipil as fodder for goats are presence of the amino acid “Mimosine” in foliage. Mimosine comprises 3.5% of the protein of Leucaena fodder. When using Leucaena, we need to be careful so that level of incorporation does not exceed 10% of total DM intake, otherwise it can cause loss in weight, loss of appetite, stunted growth, goiter and aleopecia (NAS, 1977; Ekpenyong, 1986). All fresh and dry leaves together with seeds can be used as livestock feeds due to high protein and other nutrient as shown in table 6. It is good source of minerals like calcium, sodium and rich in β-carotene (Ekpenyong, 1986).

Table 6: Nutrient composition of leaves and seeds of Leucaena % DM basis

(Ekpenyong, 1986)

Composition (%)	Fresh Leaves (%)	Dry Leaves (%)	Mature Seeds (%)
Dry Matter (DM)	22.73	36.46	81.73
Crude protein (CP)	28.92	25.25	30.81
Crude fiber (CF)	18.24	9.33	20.45
Ether Extract (EE)	5.44	6.61	7.24
Total Ash	8.83	10.76	8.80
	Minerals (%)		
Calcium	1.24	1.12	1.09
Phosphorus	0.19	0.94	0.69
Potassium	1.41	1.02	1.50
Magnesium	0.64	0.95	1.11
Sodium	0.07	0.04	0.05

2.5 Ruminal Bypass Protein

Ruminant animal has unique properties of microbial digestion in rumen. Greatest advantage of this is the utilization of dietary fiber by microbes and release energy required for host animal to maintain their body metabolism. Beside this, they also degraded large portion of protein known as microbial protein (Walli, 2005). This protein is utilized by microbes themselves making less available for host animal and is less sufficient during rapid growth period and milk production stages. Microbial degradation of protein in rumen is actually wastage as most of these protein converted into ammonia and break down to urea in liver that finally excreted in form of urine (Tandon, 2008). Hence, it is very important to have some protection protein that can easily bypass rumen and become digested and absorbed in intestine providing adequate protein for bodybuilding of ruminant. This kind of protein that escapes from ruminal degradation is known as bypass protein or rumen un-degradable protein (UDP). This bypass protein has the property of escaping digestion in rumen, passes intact to lower digestive tract, digested and absorbed in lower GIT, provides dietary protein and amino-acid directly to animals and improve overall performance of animals (Walli, 2005; Tandon, 2008. Most of the naturally occurring protein sources have some bypass characteristics. Percentages of UDP of most of the feed are shown in table 7.

Table 7: Percentage of UDP in common feed and fodders (NRC, 1985)

Feed	UDP %	Feed	UDP %
Maize (grain)	65	Blood meal	76 – 82
Barley	21(11-27)	Fish meal	71 – 80
Sorghum	52	Meat meal	53 – 76
Bajra	68	Brewers dried	53
Oat grain	14–20	Corn gluten	53
Wheat grain	20–36	Wheat bread	29
Cotton seed meal	41–50	Corn silage	27
Linseed meal	11–45	Rice straw	63
Ground nut meal	30	Wheat straw	45
Rapeseed meal	23	Para grass	52
Soybean meal	28 (15–45)	Cow pea	32 – 45
Sunflower meal	24	Berseem	37 – 52
Subabul	51 – 70	Alfa-Alfa	28

2.5.1 Formaldehyde treatment of protein protection

It is most popular chemical treatment for the protection of protein to enhance bypass properties. Addition of 37-45% formalin (HCHO) per 100 kg CP or 1-1.2 g per 100 g of cake protein in sprayed on feed cake in closed chamber (Kumar *et al.*, 2015). After this, feed resources need to be sealed in plastic bags for 4 days so that the formalin is adsorbed by feed particles. This treatment with formalin is reversible and pH dependent. Hence, in acidic environment in abomasum, bonds are loosened (Tiwari *et al.*, 2013). Formaldehyde treatment protects essential amino acid necessary for protein synthesis. Treated formaldehyde is degraded to CO_2 and H_2O in liver (Tandon, 2008). This kind of treatment improves growth performance and yield of animal as depicted in table 8. Other advantages of feeding bypass protein to ruminant are: reducing dietary amino acid loss as ammonia and urea, energy conservation through less urea synthesis, efficient protein synthesis and improvement in reproductive efficiency (Maiga *et al.*, 1997; Garg, 1998; Tandon, 2008; Kumar *et al.*, 2015).

Table 8: Effect of feeding formaldehyde treated bypass protein (Chatterjee and Walli, 2003)

Parameters (%)	Untreated MOC	Treated MOC
Buffalo Calves		
Average daily body weight gain (g)	386	**600**
Average DM intake (Kg/day)	3.28	3.59
DM intake (kg/kg gain)	8.68	5.93
Cost of feeding per kg live weight gain (NRs.)*	31.32	22.42
Lactating Buffalos		
Milk Yield (kg/day)	5.98	**6.65**
Fat Yield (kg/d)	383.63	452
SNF yield (kg/d)	553.7	616.2

* ***NRs. = Nepalese Rupees***

2.5.2 Bypass protein feeding and animal performance

Proper feeding of protein allows proper utilization of nitrogenous material. Feeding of bypass protein allows proper formulation of diet so that nitrogen need of rumen microbes could be met by cheaper sources of nitrogen like urea and costly protein sources can be effectively utilized by host animal (Walli, 2005; Tiwari *et al.*, 2013). However, one need to be careful regarding cost analysis after supplying bypass protein. For example, supply of regular protein sources where only 25% passes from rumen but has almost same performance that can be achieved by supplying rich bypass protein. Therefore, one need to decide about cost analysis and supply of bypass protein for improving animal performance. Upadhya and Gupta (1988) suggested 66% treated HCHO protein sources gives highest daily growth rate in crossbred male calves. Grubic (1991) reported that in cattle increases intake of bypass protein increases daily gain, body weight, DM intake, milk production (Osti *et al.*, 2013; Kumar *et al.*, 2015). Hence, supply of bypass protein increases animal production performance, lactation and reproduction performance through following biochemical and nutritional changes (Garg, 1998; Tandon *et al.*, 2008):

- Additional supply of amino acids at intestinal and tissue level
- Lower ammonia production in the rumen because proteins are fermented to ammonia and low degradation of protein will lower ammonia
- Energy saving process as it lower the synthesis of urea in liver
- Excess amino acids go for gluconeogenesis

3. Material and Methods

3.1 Experiment Location

This experiment of bypass protein feeding on Khari goat was conducted at the Sarasawati goat farm, Naubise, Dhading, from June to October, 2014. Climate in this region is characterized by warm and temperate. Rainfall in characteristics feature of this zone and even in dry period there can expect some rainfall. Average temperature of this region is 24°C and average annual rainfall is 2350 mm.

Figure 4: Nepal map and experimental location

3.2 Experimental Feeds

Stylosanthes guianensis and *Leucaena leucocephala* were used in this experiment. Some of the feeds were collected from fodder plantation area of farm and some were planted 60 days before the start of experiment. Soft, tender and green forages were collected before onset of wet season and harvesting was done one time per day, mainly in and around 12:00. Concentrated feed was formulated through ingredients as illustrated in table 9 in Hetauda Feed Industry, Makawanpur, Nepal. This concentrate feed has crude protein (CP) 18.23%.

Table 9: Ingredients composition of commercially available feed

Concentrate Feed Formulation	
Rice bran: 30%	**Wheat: 15%**
Sunflower seed cake: 15%	**Soybean cake: 19%**
Molasses: 17%	**Minerals: 2%**
Urea: 1%	**Salt: 1%**

3.3 Formaldehyde treatment of maize meal

Maize meal was treated with 1-1.2g formalin (40%)/100 g crude protein (CP) as suggested by (Thomas *et al.,* 1979; Hagemeister *et al.,* 1980). Formalin solution was sprayed over meal and mixed manually for five minutes and stored in plastic bags to avoid leakage.

3.4 Experimental Animal

Twenty-four goats of farm with an average weight of 15±1 kg were used in this experiment. These goats were almost seven months of age and their adult proximate weight is about 25-30 kg. Experimented goats were drenched with Fenbendazole @ 5 mg/kg body weight against internal and external parasites and vaccinated against infectious diseases before the experiment was started. Each of these animals was kept in individual wooden cages for 20 days in order to make animal adapted to experiment and experimental fed. The animals were fed twice per day: one at morning 07:00 and other at afternoon 14:00. Water, mineral (Na, Fe, Cu, Mn, Mg, Cl, Zn, I, Co) and salt were available for animals all the time.

3.5 Experimental Design

The experiment was designed as a randomized complete block design (Table 10). Each block represents a replicate where different treatment of *Stylosanthes guianensis*, *Leucaena leucocephala*, and commercial concentrate feed and formaldehyde treated-untreated maize meals were allocated. 24 experimented goats were kept into 3 blocks. This is done to minimize experimental error. Two goats from each of these blocks were allocated to each of four treatments as mention below:

T_1: Foliage of *Stylosanthes guianensis and Leucaena leucocephala (Ad libitum)*

T_2: Foliage of *Stylosanthes guianensis, Leucaena leucocephala (Ad libitum)* and commercial concentrate feed (@1.5% of body weight)

T_3: Foliage of *Stylosanthes guianensis, Leucaena leucocephala (Ad libitum),* HCHO treated maize meal and commercial concentrate feed (@1.5% of body weight)

T_4: Foliage of *Stylosanthes guianensis, Leucaena leucocephala (Ad libitum),* HCHO untreated maize meal and commercial concentrate feed (@1.5% of body weight)

All the experimented goats were weighed at the start of the experiment. Weight measurement was done once in a week at 06:30 before feeding. Total time period of experiment was 100 days. DM requirement of goats was calculated based on 5 kg per 100 kg body weight.

Table 10: Experimental layout

	T_4 B	T_1 B	T_3 B	T_2 B		T_2 A	T_1 A	T_4 A	T_3 A	
	T_2 C	T_4 C	T_3 C	T_1 C		T_3 C	T_2 C	T_1 C	T_4 C	
	T_1 A	T_3 A	T_4 A	T_2 A		T_1 B	T_3 B	T_4 B	T_2 B	

3.6 Feed and Feeding System

Foliage of Stylo and Ipil-ipil were collected daily from fodder growing area of farm. Feed is provided in trough. Goats like to feed upon hanging branches so that some of the branches were hanged above the feed trough. All goats in experiment received *ad libitium* Stylo and

Ipil-ipil as basal diet. However concentrate mixture were provided according to body weight that is 1.5% of body weight. As weight measurement was done every Monday, so for whole week same amount of feed (both concentrate and roughages) were provided for each of the goats. As mentioned earlier, animals were fed twice a day, 50% of their daily ration at 07:00h and 50% at 14:00h. Concentrated mixture was provided once a day in morning. Animals had free access to water.

3.7 Data Collection

The feed offered and refusal from previous day of individual animals was weighed daily. DM content of the feed and refusals was calculated after drying in microwave oven. This all was done every morning before feeding time. At the same time live weight was also recorded. This was repeated for 5 days for each treatment.

In plastic buckets, 20 ml solution of 10% sulphuric acid was poured to acidify and preserve urine. Then the urine was collected in buckets and to prevent further urinary nitrogen, losses 1% citric acid was rinsed and stored at -20°C. Similarly, feces were collected daily for 5 days for each of the treatment and stored at -20ºC temperature. After this all subsamples of same treatment was mixed together and ground with grinder for analysis. In each of alternate days (2^{nd} and 4^{th}), 2hrs after feeding in morning, methane and carbon dioxide gas was measured using PGas-41 (Portable Multiple Gas Detector, Henan, China). Actually from this method carbon monoxide (CO), Methane (CH_4) and oxygen (O_2) concentration was measured and CO_2 concentration was calculated from obtained data and finally ration between methane and carbon dioxide was calculated.

3.8 Analysis

Data from feed samples and animal samples was analyzed chemically and statistically.

3.8.1 Chemical Analysis

All feed samples, foliage samples, concentrate mixture supplied to and refused by goats were collected and analyzed for proximate analysis. These samples were analyzed for dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), total ash contents (TA), acid-detergent fibre (ADF), neutral-detergent fibre (NDF). The ***DM*** was determined by oven drying at 100°C for 24 hrs. ***Crude protein*** of the samples was determined using the Kjeldahl distillation method as outlined in AOAC, 1990. First of all, samples were digested at 400°C in digestion tubes in presence of concentrated sulphuric acid (specific gravity, 1.84) and a selenium based catalyst tabl*et.* After this, reduction was performed with 40% NaOH (w/v) and then digests were steam distilled. Finally, distillate was collected in 2% boric acid solution and titrated against standard HCl (0.10 N). Crude protein (CP) was calculated as (CP=N*6.25). Similarly fecal and urinal N was analyzed by AOAC (1990) procedures. ***Ether extract*** was determined using Soxhlet apparatus. Ash was calculated after ashing in muffle furnace at 550°C for 3 hours (AOAC, 1990). ***Crude fiber*** of the samples was determined using the Van Soest method (Goering and Van, 1970). ***Neutral detergent fibres (NDF) and acid detergent fiber (ADF)*** were determined according to Van Soest and Robertson (1985). In order to measure ***pH***, rumen fluid was collected by stomach tube and measured by gas electrode and pH meter. **Ammonia** from sample was measured by steam distillation (Ly and Nguyen, 1997). ***CO_2 and CH_4*** were measured using PGas-41 (Portable Multiple Gas Detector, China). Except gases, all of these analyses were performed in Nepal Animal Science Research Institute (NASRI), Khumaltar, Lalitpur, Nepal.

3.8.2 Cost-benefit analysis of the supplementation programme

Throughout the experimental period, all the costs associated with the feed supplementation were recorded properly and partial budget analysis was performed to determine the net benefit or loss of using different level of diet supplementation with or without formaldehyde treatment. Following are the major cost attributing parameters: cost of commercial concentrate feed, cost of formaldehyde, cost of maize meal and other costs attributed to drying of forages and variable costs like cost of feeding, deworming, spraying etc. Weight gain over the experimental period and prevailing price of chevon of NRs. 800/kg was used to calculate the total return during partial budget analysis. Because of very low differences in labour cost between each diet, it is not included in budget analysis. Following formula is used to calculate benefit cost ratio (BCR):

$$BCR = \frac{Expected\ Benefits}{Expected\ Costs}$$

3.8.3 Statistical Analysis

The data from the experiments were analyzed statistically through computerized statistical package Minitab version 17.2:2015 (Ryan *et al.*, 2004). Utilized model includes General

Linear Model (GLM), linear regression, correlation and analysis of variance (ANOVA). An F-test was performed to determine significance of variance of two means and if it is significantly different at $p<0.05$ then an independent t-test for unequal variances was performed through tukey's pair wise comparison procedures. But for no significant different treatment, independent T-test for equal variances was performed. Sources of variation in GLM model were animals, blocks, feed-foliages and error. Following model was used in the experiment:

GLM model:

$$\mathbf{Y_{ij}=\mu + \alpha_i + \beta_j + \varepsilon_{ij}}$$

Where,

Y_{ij} = Growth/ Feed consumption

μ = Overall Mean

α_i = Effect of feed

β_j = Block effect

ε_{ij} = Random error effect

Linear regression model:

$$\mathbf{Y_{ij}= \alpha + \beta X_i + \varepsilon_{ij}}$$

Where,

Y_{ij} = Live weight gain

α = Intercept

β = Slope of Y_i against corresponding value of X_i

X_i = intake of feed as % of total DM intake

ε_{ij} = Random error effect

4. Results

4.1 Chemical composition of feeds

Leucaena leucocephela had higher level of CP (Crude Protein) and CT (Condensed Tannin) than *Stylosanthes guianensi* (Table 11). Condenses tannin enhances bypass protein in rumen of goats. Similarly, protein content of prepared commercial concentrate feed and formaldehyde treated feed is presented in table 12. Crude protein content of maize meal is much higher than that of *Stylosanthes and Leucaena*. Neutral Detergent Fiber (NDF %) and Acid Detergent Fiber (ADF %) content is more in *Stylosanthes* than in *Leucaena*.

Table 11: Feed characteristics of different feed materials offered to goats

Feed	DM (%)	% DM							ME (KJ/g DM)
		CP	CF	NDF	ADF	TA	EE	CT	
Stylosanthes	28.1	15.4	31.4	49.3	38.9	8.7	2.3	17.0	5.89
Leucaena	30.1	24.6	19.9	41.8	26.3	8.8	4.3	27.8	6.12
Maize Meal	87.3	40.5	1.5	3.2	1.2	2.1	2.7	-	16.2

Table 12: Chemical composition of prepared concentrate feed (% DM basis)

Particular	DM	OM	NDF	ADF	TA	CP	CF
HCHO treated maize meal with concentrate mixture	89.3	92.1	15.1	6.2	11.6	13.4	8.3
Untreated maize meal with concentrate mixture	88.9	91.4	14.6	5.8	10.8	13.2	7.4
Commercial feed	91.8	88.9	12.7	5.3	13.7	16.3	6.8

4.2 Growth performance of goats

Growth is a complex phenomenon having important implications in goat production as it significantly influence the value of goats and the production result. More precisely, it is a highly integrated process involving numerous interactions among different factors like nutrients, environment, genotype hormones and receptors of these hormones in various tissues (Spencer, 1985). Growth performance of goats is measured in term of weight gain.

4.2.1 Average live weight gain (LWG)

Average live weight gain and total weight gain of goats during experiment is illustrated in table 13 and figure 5. There is significant differences between different feed treatments with respect to initial weight of goats ($p<0.05$). No difference in initial weight was found between T1 and T2 treatments. Goats categorized in T3 treatment have higher initial weight with value of 12.5 kg. During 100 days of experimental period, the weight of goats changed into 12.26 for T1, 13.7 for T2, 14.73 for T3 and 13.4 for T4. Still, there exist non-significant relationship between different treatments and final live weight of goats ($p<0.05$). However, there exist significant relationship in total weight gain by goat ($p=0.084$) and larger weight gain is observed for goats fed with T2 treatment (2.73 kg). In comparison with treatment and total weight gain, there exist significant differences between T1 and T4 treatment and non-significant relationship between T2 and T3 treatment (Table 13).

Table 13: Growth performance of goats fed different prepared diets

Treatment	Weight gain			
	Initial Live Weight (kg)	Final Live Weight (kg)	Total Weight Gain (kg)	Average live weight gain (g/day)
T1	10.06	12.26	2.2^{a}	22
T2	10.96	13.7	2.73^{ab}	27.33
T3	12.5	14.73	2.23^{ab}	22.33
T4	11.4	13.4	2^{b}	20
SEM	0.057	0.133	0.29	0.12
P - Value	0.000	0.000	0.084	0.084

Treatment that do not share a letter are significantly different

Similarly, figure 5 demonstrates average live weight gain (g/day) by goats during experimental period. Higher average live weight gain was observed for treatment 2 (27 g/day) and for other treatment there exist non-significant differences in average live weight gain per day (22 for T1, 22 for T3 and 20g/day for T4).

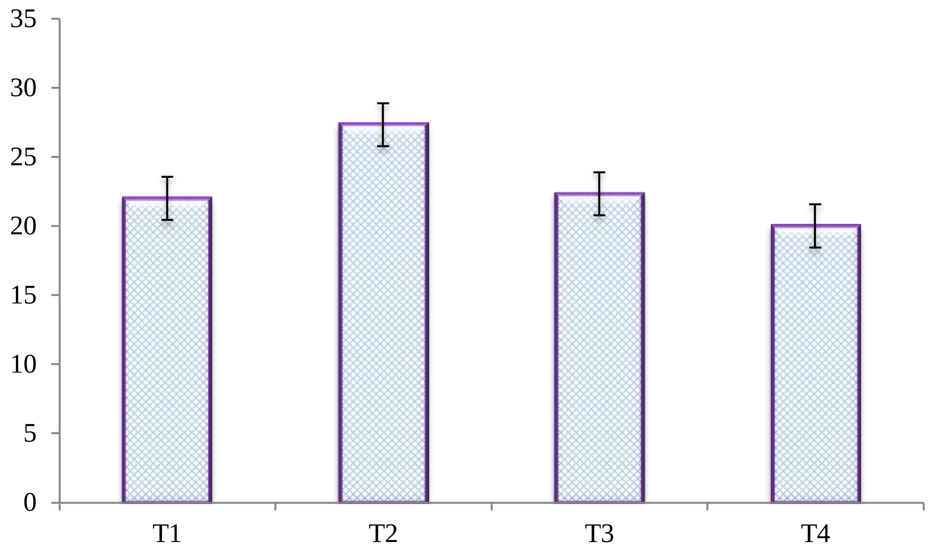


Figure 5: Average live weight gain (g/day) of goats fed with treated feed

4.2.2 Average daily live weight gain (Growth trends)

There exist changes in body weight of goats fed with different prepared diets. All these changes are illustrated in figure 6. The daily live weight gain differs between different treatments. From beginning to end period of experiment, goats fed with treatment 3 feed shows higher weight gain in comparison with other treatments. However, goats fed with treatment 4 feed does not follow same pattern like that of treatment 2. Both these treatment shows slightly increase in weight gain of goats from week number 1 to weak number 13. In addition, during end period of experiment at week 14 increases in weight gain for treatment 2 goats is more than that of treatment 4. Goats fed with treatment 1 feed show less weight gain in comparison with other treatment from week number 1 until end period of experiment. Moreover, in all treatments we can see an increasing pattern of weight gain of experimental goats from beginning until end period of experiment (Figure 6).

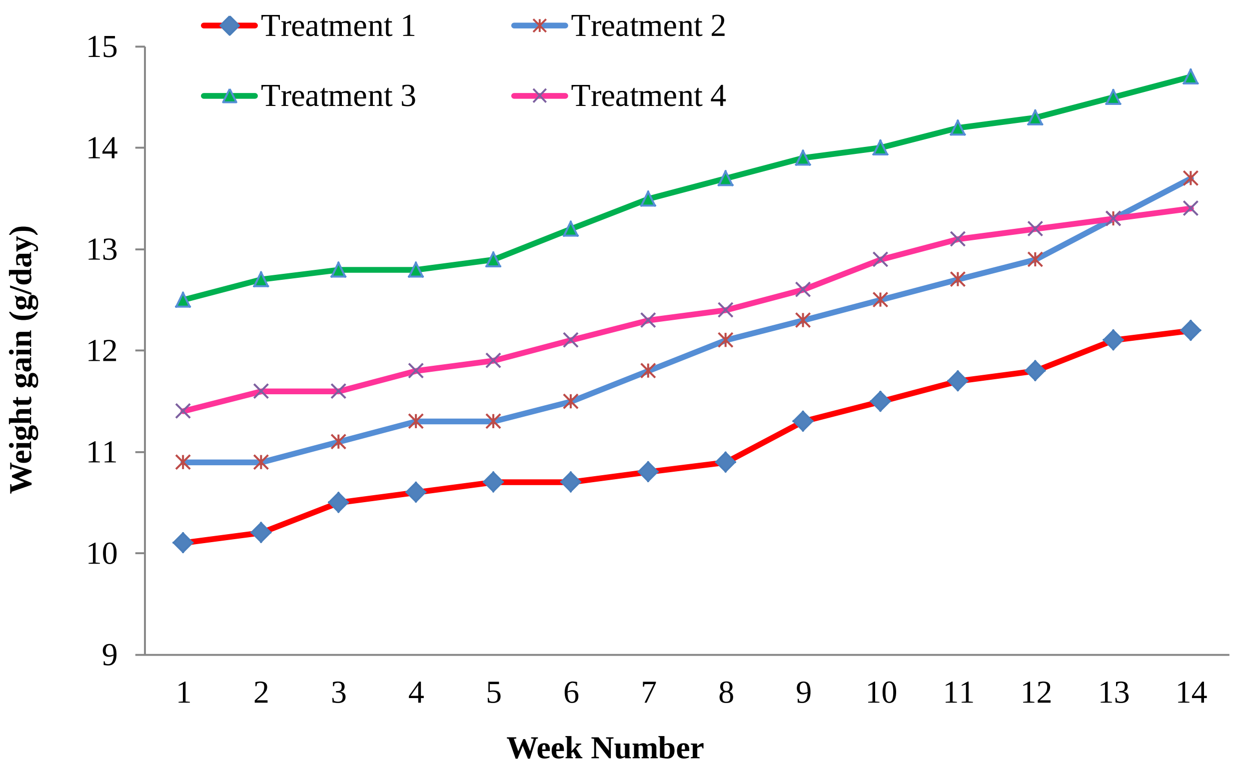


Figure 6: Body weight gain trends of goats during experimental period

4.3 Feed Intake of goats

Feeding of goats with high protein feed significantly increases ($p<0.05$) crude protein intake (CPI) compared with low protein diet. Treatment 3 differs significantly with respect to treatment 1 and treatment 2 and vice-versa. Higher level of CPI was observed for treatment 3 with value of 64 g/day and lower was observed for treatment 1 with value of 57 g/day. Similar kind of relationship also exists for dry matter intake (DMI), FCE and protein conversion efficiency (PCE). However, dry matter intake of feed was significantly higher ($p<0.05$) for low protein feed diet (54.22 kg). As illustrated in table 14, there exist non-significant relationship in dry matter intake for goats fed with treatment 2 and treatment 4. Lower value of dry matter intake (50.65 kg) was observed for treatment supplementing high level of protein diet.

Table 14: Changes in feed intake value for goats supplemented with different diets

Treatment	Feed Intake				
	DM Intake (kg)	DM Intake (% LW)	FCE (DMI/LWG)	CP Intake (g/day)	PCE (CPI/LWG)
T1	54.223[a]	44.228[a]	4.4228[a]	57.437[c]	0.4685[a]
T2	53.13[b]	38.788[b]	3.8788[b]	59.597[b]	0.4351[b]
T3	50.657[c]	34.394[c]	3.4394[b]	64.147[a]	0.4355[b]
T4	52.437[b]	39.141[b]	3.9141[c]	58.343[bc]	0.4354[b]
SEM	0.410	1.07	0.107	0.796	0.00476
P - Value	0.000	0.000	0.000	0.000	0.002

Means that do not share a letter are significantly different

Figure 7 demonstrates effect of feed intake with respect to treatment. Crude protein intake was higher for treatment level 3 with high amount of protein diet supplementation and lower CPI was observed for treatment 1 supplementing low protein diet to goats. Case is opposite for dry matter intake, highest value was observed for treatment 1 and lowest for treatment 3.

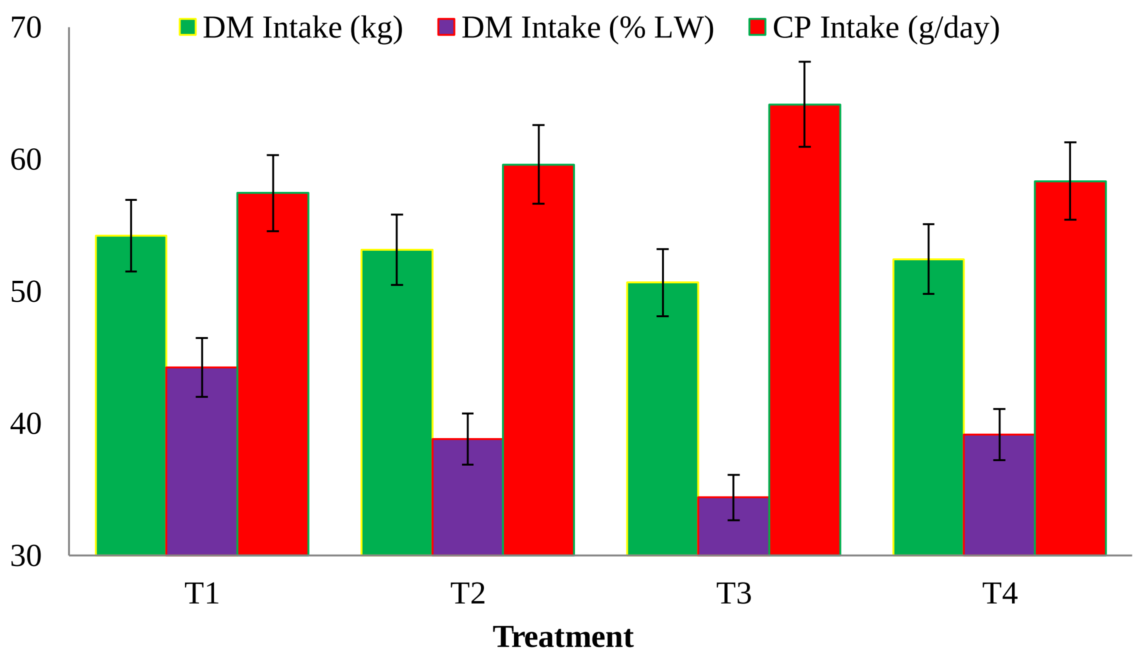


Figure 7: Main effects for change in feed intake (DMI and CPI) for goats supplemented with different diets

4.3.1 Feed conversion efficiency (FCE)

Feed conversion efficiency (FCE) is the ratio between dry matter intake and live weight gain of goat. As illustrated in table 14, there exist non-significant relationship ($p>0.05$) between different treatment for FCE. However, treatment 2 and treatment 3 have significant FCE value. Highest feed conversion efficiency value was noted for treatment level 1 with highest DMI and lowest FCE was noted in treatment level 3 with lowest DMI. However, as illustrated in figure 8, treatment 2 and treatment 4 follows zigzag pattern for FCE. On the first week of experiment, treatment level 2 has highest FCE value than that of treatment level 4 and at the end of experiment period, FCE value for treatment 4 is significantly higher than that of treatment 2. Lower feed conversion ratio is generally better for good goat performance than higher one.

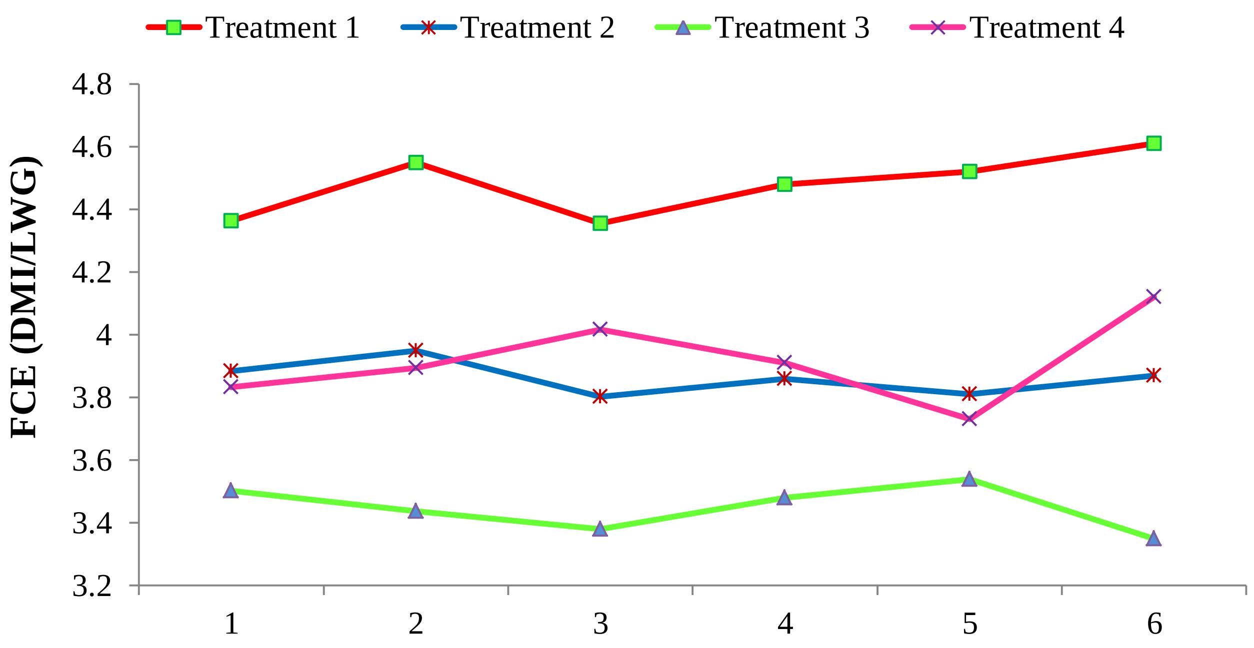


Figure 8: Feed Conversion efficiency of goats supplemented with different diets

4.3.2 Protein conversion efficiency (PCE)

Protein conversion efficiency is a ratio between crude protein intake and live weight gain. For goats feeding at treatment level 3 has higher CPI and LWG value, their protein conversion efficiency become lowest (0.43). Highest PCE value was observed for goats supplemented with treatment level 1 feed (Figure 9). Also for PCE, there exist significant relationship ($p<0.05$) between goats feeding at different treatment level. Goats fed with T1 diet shows significant relationship with other treatment level. During beginning weak of experiment, goats supplemented with T3 feed shows high level (0.44) of PCE comparing with T4 (0.42). But during end period of experiment, goats supplemented with T4 level feed has highest (0.45) PCE value than goats supplemented with T3 diets (0.44). Some degree of non-significant relationship occurs between T2, T3 and T4 treatment as illustrated in table 14 and figure 9.

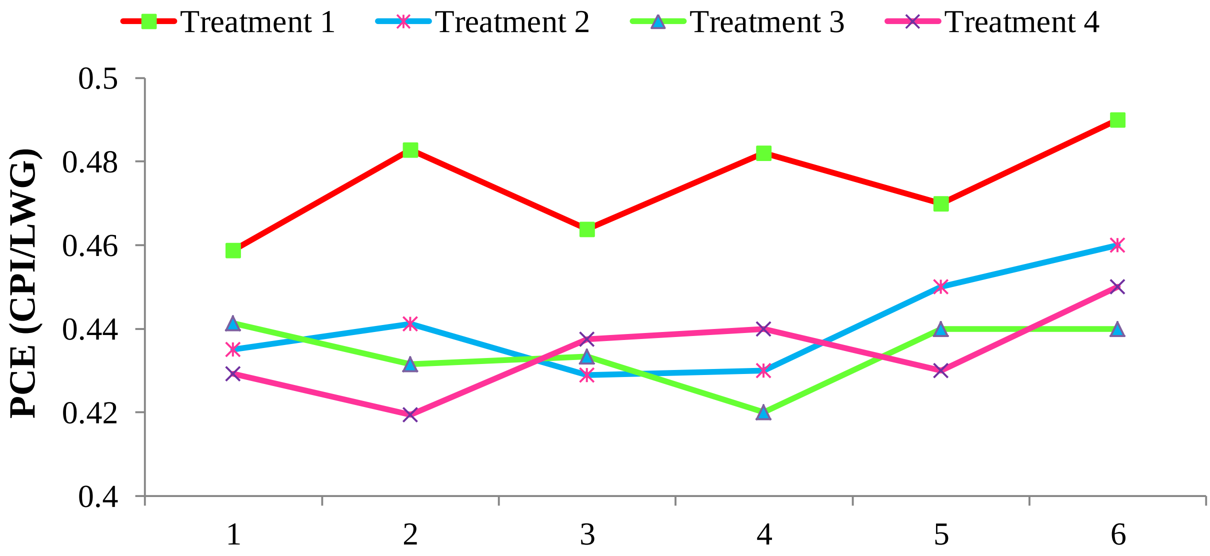


Figure 9: Feed Conversion efficiency of goats supplemented with different diets

4.4 Digestibility of diets

The digestibility of a feed refers to the amount of feed nutrient that can be actually digested, metabolized and absorbed by an animal body for optimum growth, reproduction etc. Table 15 summarizes the main effect for digestibility coefficient in goats fed with different feed diets. Figure 10-12, further summarizes relationship between different parameter of digestibility like DM digestibility, OM digestibility and N digestibility with different nutrient supplement to goats and further illustrates degree of correlation of these parameters with respect to treatment.

Table 15: Mean digestibility coefficient in goats fed with different diets

Treatment	Digestibility %		
	Dry Matter (DM)	Organic Matter (OM)	Nitrogen (N)
T1	73.6d	68.57c	62.53b
T2	79.6c	77.3a	69.73a
T3	86.9b	62.83d	57.03b
T4	82.8a	73.33b	61.27c
SEM	1.49	1.64	1.41
P- Value	0.14	0.01	0.61

Means that do not share a letter are significantly different

4.4.1 DM digestibility

Figure 10 illustrates relationship between dry mater digestibility and different feed diet treatment of experimental goats. There exist strong positive correlation between DM digestibility and feed treatment (R^2=0.89). However, this relation is not significant (p>0.05). Highest value of DM digestibility is measured for T3 treatment (86.9%) and lowest is T1 treatment with 73.6% (Table 15).

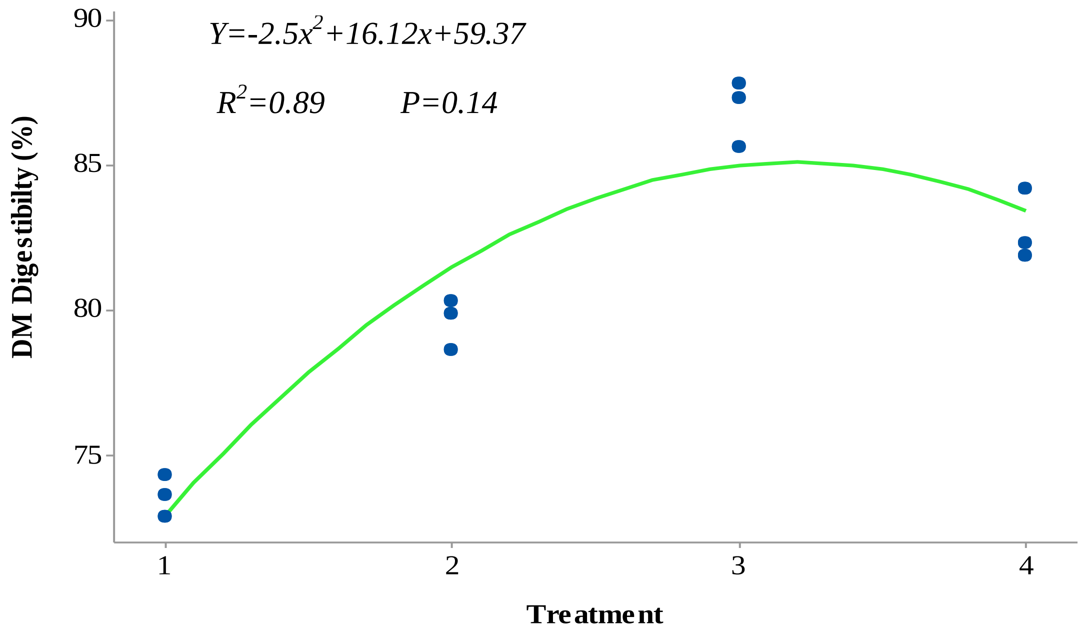


Figure 10: Relationship between DM digestibility and different diet supplemented to goats

4.4.2 OM digestibility

OM digestibility shows significant relationship ($p<0.05$) with different diet supplemented to experimented goats. However as illustrated in figure 11, the relationship between OM digestibility and diet supplementation is weak (R^2=0.41). High value of OM digestibility is observed for T2 treatment with 77.3% and lowest value of 62.8% is noted for T3 treatment. Similarly, more scattering of OM digestibility is noted for T2 treatment (Figure 11).

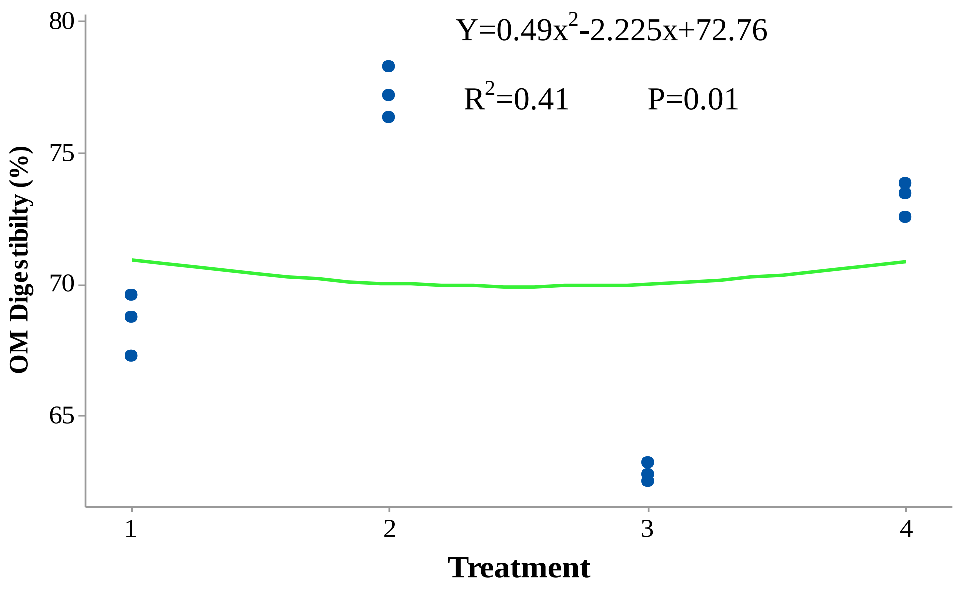


Figure 11: Relationship between OM digestibility and different diet supplemented to goats

4.4.3 N digestibility

Nitrogen digestibility of feed also varies according to diet supplement to goats. Non-significant relationship exist between N digestibility and different diet supplemented to goats ($p>0.05$). However, there exist significant relationship of nitrogen digestibility between goats supplemented with T1 and T3 level of diets (Table 15). Ay weak positive correlation (R^2=0.18) occurs between N digestibility and diet supplemented to goat (Figure 12) resulted in negative curvilinear curve for N digestibility. Highest N digestibility value is observed in treatment T2 with 69.7% and lowest in treatment T3 with value of 57.03%.

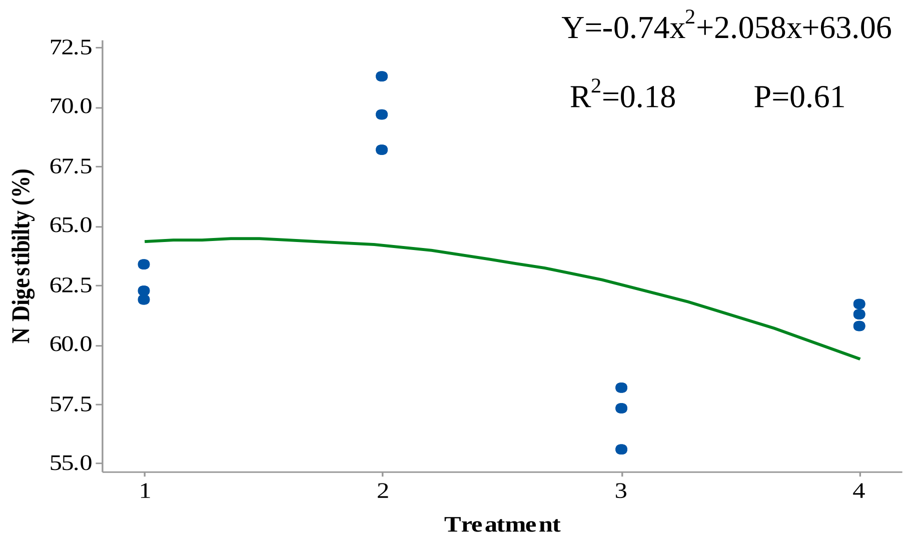


Figure 12: Relationship between N digestibility and different diet supplemented to goats

4.4.4 N balances and Retention

Measuring nitrogen balances and retention amount helps to determine the utilization of dietary protein by goat after feeding different level of diets. Nitrogen retention was obtained by establishing nitrogen balances. Nitrogen balance is determined by subtracting the end products of nitrogen metabolism and fecal nitrogen from ingested nitrogen. Table 16 and figure iii illustrates nitrogen balances of goats fed with different experimental diets.

Table 16: Percentage of nitrogen balances in different diet supplemented to goats

Treatment	**Nitrogen Balance (%)**			
	Intake	Feces	Urine	Retention
T1	6.47^{d}	1.7^{c}	1.63^{b}	3.13^{c}
T2	8.267^{c}	2.8^{a}	3.13^{a}	2.33^{c}
T3	12.3^{a}	2.17^{b}	1.87^{b}	8.27^{a}
T4	11.06^{b}	3.07^{a}	3.2^{a}	4.8^{b}
SEM	0.72	0.17	0.23	4.63
P- Value	<0.05	<0.05	<0.05	<0.05

Means that do not share a letter are significantly different

Nitrogen intake increased in treatment level 4 and lowest intake of nitrogen was obtained at T1 treatment. As illustrates in table 16, there exist significant relationship for nitrogen intake by goats fed in different level of experimental diet. Highest value of nitrogen intake was in T3 treatment (12.3%) and lowest in T1 treatment (6.47%). According to figure iii for N intake, data of T1 and T4 treatments are highly skewed with high level of similarity with each other. More skewness of Intake is noted for T2 and T3 treatments. Similarly, significant relationship of fecal and urinal nitrogen is noted with respect to supplied experimental diets ($p<0.05$). However, nonsignificant relation of fecal nitrogen is noted for T2 and T4 treatment and similar is the case for urinal nitrogen (Table 16). High degree of scattering of fecal nitrogen is in treatment level 2. In case of urinal nitrogen, more scattering is observed for treatment level 4 (Figure 13). Fourth part of figure iii illustrates nitrogen retention of diets provided to goats. In general significant relation ($p<0.05$) exist between nitrogen retention and treatment level providing high retention value for T3 (8.27) and lowest for T2 (2.33). However, T1 and T2 treatment do not differ significantly for N retention. More agreement in nitrogen retention is noted for T4 (Figure iii, 13). Higher and lower level of boxes in figure iii demonstrates differences between treatment groups for each of the parameter.

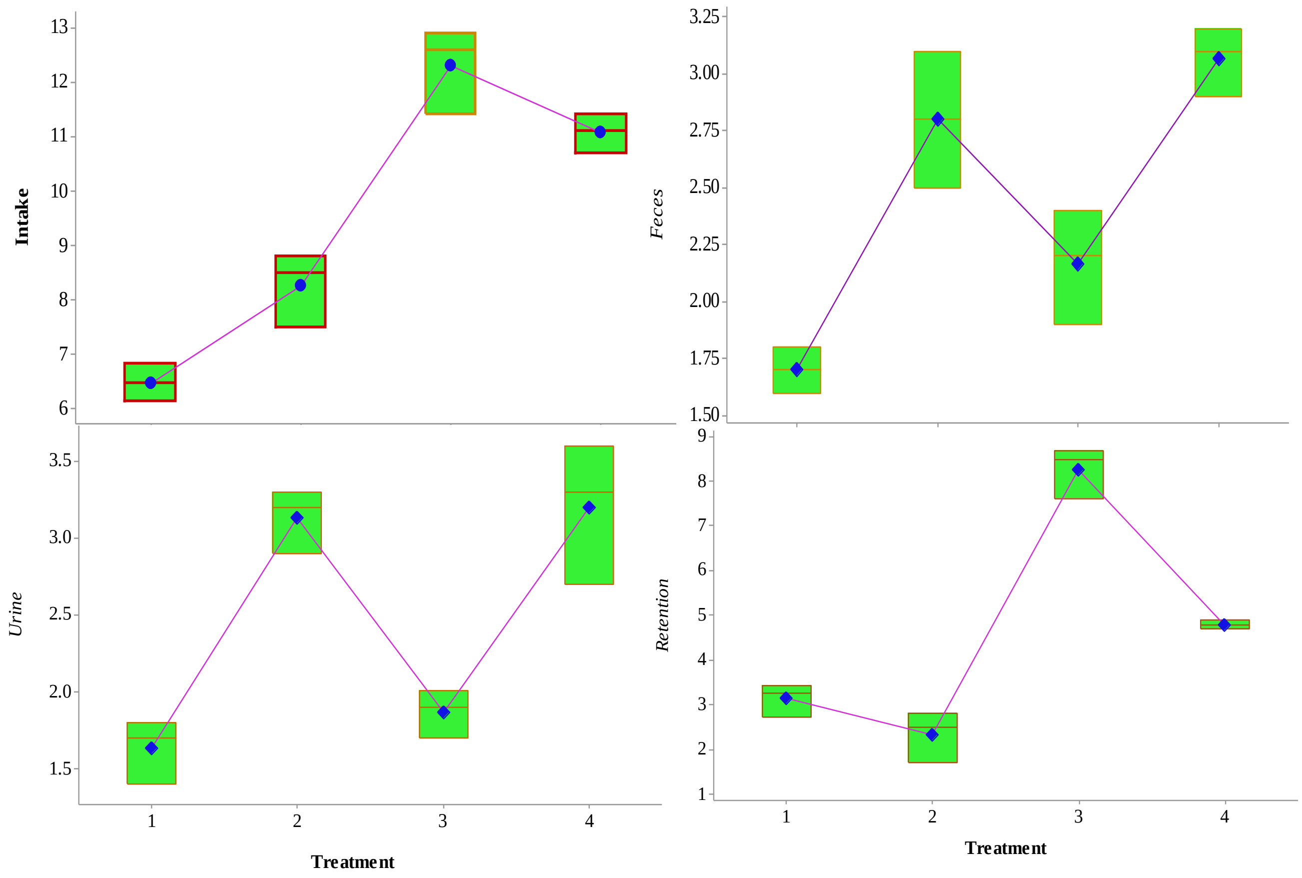


Figure 13: Percentage of diet N intake, excreted and retained by experimental goats supplemented with different diets

4.5 Rumen pH and gaseous emission

Table 17 and figure 14-16 illustrates relationship between rumen pH and gaseous balance in rumen environment with respect to different diet supplement to goats. With respect to pH and different treatment, there is significant difference in rumen environment ($p<0.05$). Highest pH (6.86) is recorded for treatment T1 and lowest (6.03) for treatment T3. Moreover, non-significant relationship in rumen pH value is observed for treatment level T1, T2 and T4. Figure 14 demonstrate weak correlation (0.43) between pH and different diets provided to goat.

Table 17: Mean rumen pH and gaseous balance in goats fed with different feed supplement

Treatment	Rumen pH and Gaseous Balances		
	pH	NH_3-N (mg/1000 ml)	CH_4:CO_2
T1	6.867^{a}	15.467^{b}	0.0336^{b}
T2	6.667^{a}	14.867^{bc}	0.0457^{a}
T3	6.033^{b}	12.867^{c}	0.0187^{c}
T4	6.567^{a}	20.267^{a}	0.01^{c}
SEM	0.112	0.86	0.004
P- Value	0.021	0.003	0.004

Means that do not share a letter are significantly different

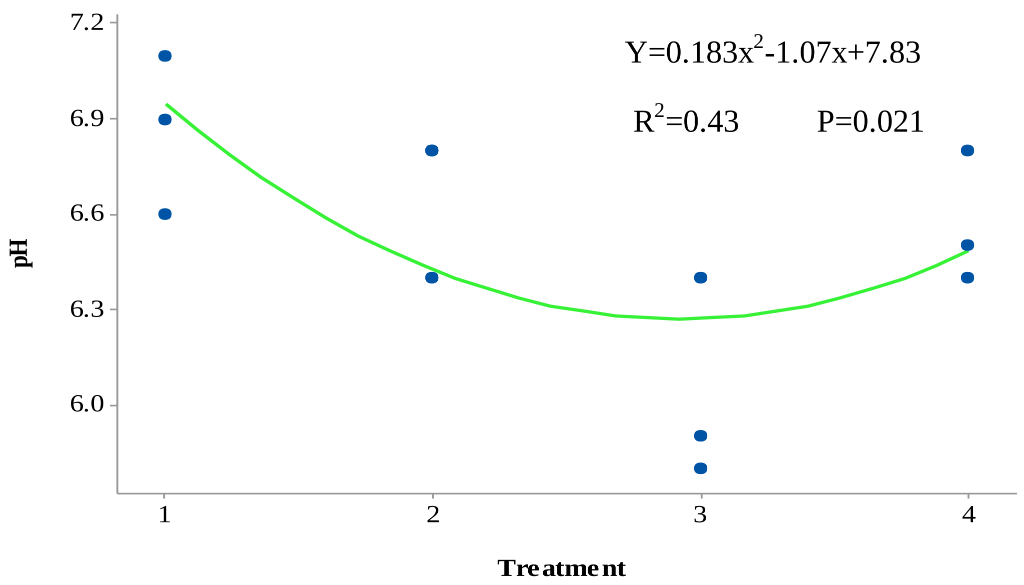


Figure 14: Relationship between pH and different diet supplemented to goats

Similarly, non-significant relationship between NH3-N and different treatment level is observed in table 17. Highest loss of ammonia nitrogen is in treatment level T4 (20.26) and lowest is in treatment level T3 (12.86). However, treatment level 4 differs significantly with respect to other treatment (Table 17). As suggested by figure 15, there exist good positive correlation (R^2=0.67) between ammonia-nitrogen and diet supplement with good curvilinear graph.

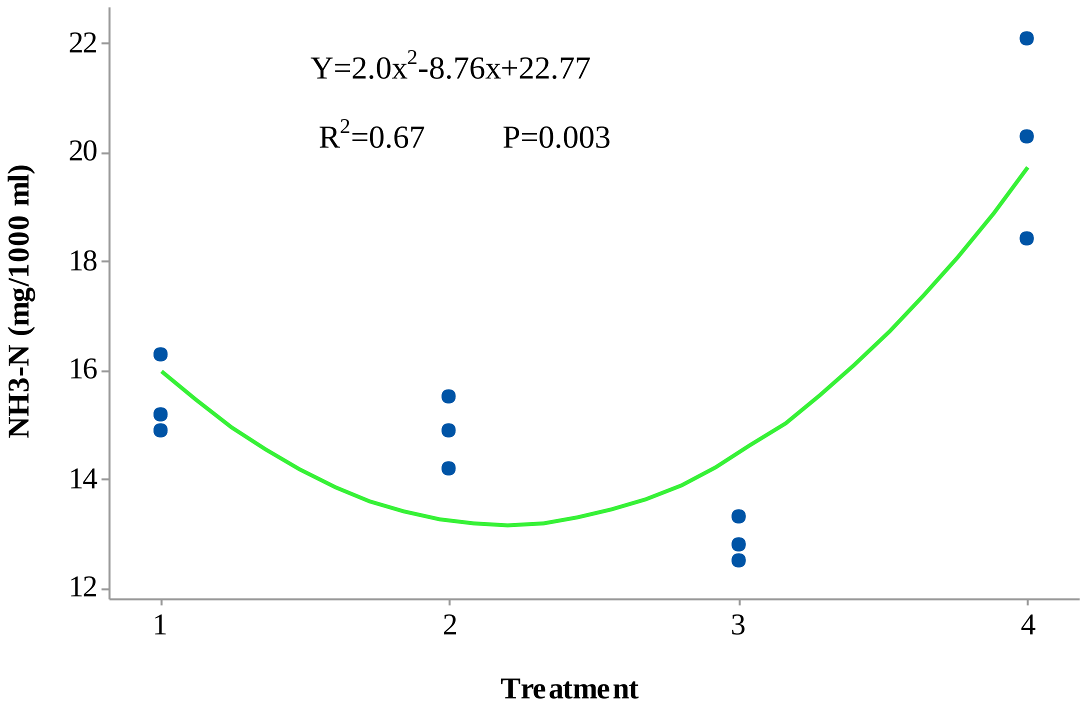


Figure 15: Relationship between NH_3-N and different diet supplemented to goats

There also exist non-significant relationship between methane/carbon dioxide ratio and different treatment level of diets. Highest level of CH_4/CO_2 ratio is observed for treatment level T2 (0.04) and lowest (0.01) for treatment level T1 (Table 17). However, there exist significant relationship between different treatment except for treatment T3 and T4. Graph in figure 16 illustrates good positive correlation (R^2=0.707) between methane/carbon dioxide ration with respect to different diet supplemented to goats. Negative curvilinear graph in figure 16 describes highest value of ratio in treatment level 2 and lowest in treatment level 4 and all values lies significantly nearby the curve.

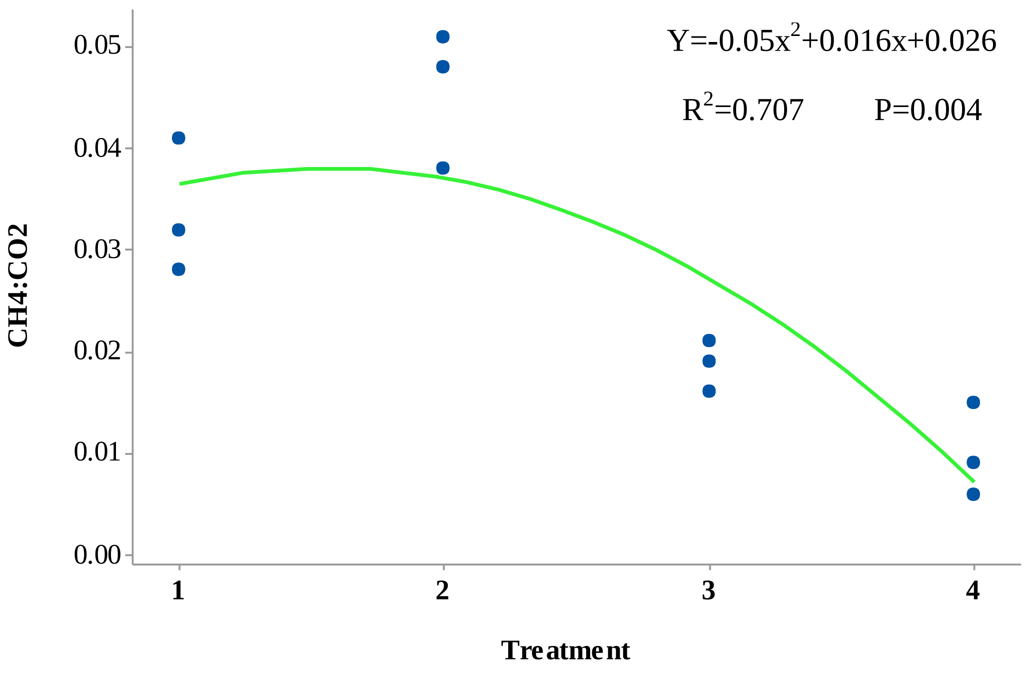


Figure 16: Relationship between ratio CH_4/CO_2 and different diet supplemented to goats

4.6 Cost and benefit analysis of feed supplementation

Economic feasibility of feeding supplementation program to local Khari goats is presented in table 18. As explained before, with more weight gain on T2 followed by T3, it is more obvious to see more profit in T2 treatment compared with other dietary protein treatments. According to this analysis, T2 gave the highest BCR ratio of 1.50, while T4 gave the lowest BCR ratio of 0.82. Slight differences in BCR value for T3 (1.45) as compared to T2 demonstrated that supplementary feeding of *Stylosanthes*, *Leucaena* and formaldehyde treated maize meal and concentrate mixture increases net profit to farmers besides increasing overall growth performance of Khari goats.

Table 18: Benefit cost analysis of different treatments (NRs. = Nepali Rupees)

Treatment	Expected benefits (NRs.)	Expected Costs (NRs.)	Benefit Cost Ratio (BCR)
T1	10400	10196	1.02
T2	16487	10982	1.50
T3	14236	9761	1.45
T4	7976	9708	0.82

5. Discussion

5.1 Chemical composition and nutritional value of experimental diets

The experiment revealed that the dry matter content of maize meal is higher than *Stylosanthes* and *Leucaena.* Tiwari *et al.* (2013) observed maize meal contained 87.69 % DM, 38.92% CP, 2.34% CF and 2.03% TA, similar to the present findings. Similar kind of results was reported of Ortega *et al.* (1986), Osei *et al.* (1999) and Martinez *et al.* (2008). Pandey *et al.* (2013) found that *Stylosanthes* contained a CP value of 135.3g/kg DM with NDF 539 and ADF 506g/kg DM. These findings support present finding. Similarly, Upreti and Shrestha (2006) demonstrate 32.65% DM, 10.5% TA, 22.32% CP, 47.53% NDF and 37.34% ADF in *Leucaena*. Similarly 27.4% DM, 23.56% CP, 17.89% NDF and 6.97% ADF was observed for *Leucaena* by Upreti and Orden (2008) in their experiment on goat performance, similar to present findings while the results for NDF and ADF were in less agreement. Formaldehyde treatment increased the CP content of maize meals due to the fact that N was attached to fibrous components of the meal. Similar kind of improvement in CP content feed through ammonization, from 6.5 to 15% of DM is also reported by Dolberg *et al.* (1981) and Kayouli (1988).

5.2 Effect of nutritional level of diet on growth performance of goats

The growth rate of goat does not vary significantly with respect to treatment level. However, diet containing mixture of *Stylosanthes* and *Leucaena* with formaldehyde untreated concentrate mixture shows less increment when comparing to others. It may be due to the lack of energy provided in the diet. Beside this low increment in T1 level highlights that consumption of roughages, was not even enough to support energy and protein requirement at maintenance level. However, for T2 and T3 treatment, inclusion of formaldehyde treated concentrated meal and maize meal ensured greater amount of OM incorporation that elicited more intake and resulted in better weight gain. According to Zhao *et al.* (1996), this could be due to supplemental energy from formaldehyde treated meal and concentrate feed that increases proportion of easily available carbohydrate for better microbial activity. Kabir *et al.* (2002) also noticed higher daily growth rate of 62.4g/day in goat kids that received higher protein diet. Similarly, Tiwari *et al.* (2013) noticed tendency of increasing live weight in goats given to HP diet, although no significant ($p>0.05$) difference was observed between LP and HP diets provided for goats. Similarly Yates and Pangabean (1988) also reported weight gain, for Katjang goats supplemented with concentrate diets and *Leucaena leucocephala*. Shahjalal *et al.* (1997) observed improvement in growth rate of grazing black Bengal goats under increased protein supplementation. Abdulrazak *et al.* (2006) reported similar kind of finding. According to Njwe and Kona (1994), supplementation of 200g/day *Stylosanthes* hay increases feed intake, utilization and weight gain in yearling lambs raised by smallholder farmers in Kenya. Adding concentrate to a feed ration increases growth rate as suggested by Sikosana and Maphosa (1995) and it corresponds to present studies. Sheridan *et al.* (2000) reported no significant differences in average daily gain (ADG) of Boer goats when fed with two different energy level of diets – one low (2.14 MCal/kg DM) and other high (2.60 Mcal/kg DM). ADG for animals in the two treatments were 0.152 and 162 g/day, respectively. Similarly, Limea *et al.* (2011) concluded that goats fed on more concentrate rich diet had greater average daily gain ($p<0.001$). In contrary of this, Mahgoub *et al.* (2005) reported significant differences in ADG of goat breed native to semiarid region of Sudan when fed with different dietary energy level diet. Their experiment suggest significant ADG value of 48.0, 66.5 and 74.5 g/day for diet supplementing 2.07, 2.38 and 2.68 Mcal/kg DM energy. Higher weight gain in goats fed with *Leucaena*, *Stylosanthes* along with formaldehyde treated maize meal and concentrate feed is due to presence of polyphenols like condensed tannin that may act as enzyme inducer and binds enzyme activate them for several metabolic processes mainly in digestion and absorption of nutrients (Thiyagarajan *et al.*, 2011). In rumen, dietary Sulphur is utmost for microbial synthesis of Sulphur containing amino acids and vitamins (NRC, 1985) and this finally contribute in protein synthesis resulting in better growth performance of lambs (Brown and Johnson, 1991). So it can be concluded that protein content in diet plays significant role in better growth performance of goats but beside this, factors like micronutrient content, amino-acid profiles too can affect the growth performance of lambs (Khalid *et al.*, 2012).

5.3 Effect of concentrate supplementation on feed intake

Dry Matter Intake (DMI)

Dry matter intake (DMI) affect the dietary protein sources due to the fact that they have the ability to affect rumen holding ruminal contents (Bandyk *et al.*, 2001; Khalid *et al.*, 2012) Feeding of goats with high protein diet significantly decreases DMI. Dry matter intake from *Stylosanthes* and *Leucaena* decreased with the increasing supplementation of concentrate and further decreases with formaldehyde treatment of meal. Highest amount of protein supplementation has lowest value of DMI. The possible reason behind this may be due to the low ruminal degradation rate of high volume feeds that slower the rate of passage and digestion leading to greater rumen fill and thereby decreasing DMI (Chizzotti *et al.* 2005). However, Sultana et al. (2012) suggest feeding goats with concentrate as supplement significantly increases DMI intake at $P<0.01$. According to Devendra and McLeory (1983), Ranjhan (1980) and Kabir *et al.* (2012), DMI of meat type goats varies in a range of 1.5% to 3.8% of live weight. Similarly, linear increment in DMI with increase in CP level was observed by Lu and Potochoiba (1990).

In contrast to this finding, an increase in dietary protein level was followed by decrease in DMI was observed by Foldager and Huber (1979), Edwards *et al.* (1980) and Grieve *et al.* (1980), Suliman and Babiker (2007), Irshaid *et al.* (2003) and Kandylis *et al.* (1999) . Their findings match present findings. According to Chakeredza (2003), DMI intake increases when Dorper lambs are fed on a higher protein diet like maize meal and cottonseed meal in addition to maize stovers as basal diet. Similarly, DMI was observed highest in lambs fed fishmeal compared with lambs fed soybean meal and cotton meal and lowest in lambs fed with Lucerne and oat hay as basal diet s in ratio of 20:80 (Ponnampalam *et al.*, 2005). Total DMI intake in feed with Leucaena and Stylosanthes diet is higher may be due to rapid ingestion and thereby reducing rumen filling effects (Plaisance *et al.*, 1997). Enhanced microbial biomass contributes to higher digestion rate thereby increasing post-ruminal flow of amino acids that finally increases DMI (Weisbjerg *et al.*, 1992). Beside this, ingredient composition like supplementation of sodium bentonite in feed also influences dry matter intake (Carneiro *et al.*, 2006; Walz *et al.*, 1988). Hence, DMI intake varies according to protein sources and they are largely dependent on basal composition of diets (Khalid *et al.*, 2012).

CP intake

Crude protein (CP) intake was significantly higher for diets containing *Stylosanthes*, *Leucaena*, formaldehyde treated concentrated feed and maize meal. It is due to the provision of greater amount of rumen degradable OM that enhance microbial activity and degradation of fiber, which finally enhances protein intake in goats (Ørskov, 1990). Kabir *et al.* (2002) and Salim *et al.* (2002) observed similar relationship between CP intake that increased by 76.1g/day when supplementing concentrates at a level of 250g/day. According to Zhao *et al.*

(1996), when by-product feed is supplemented, it increases outflow rate with reduction in gut retention time and this eventually increases consumption rate in goats. Due to this, it can be concluded that animals with relatively low intake need to have supplementation of more energy diets that will match highly soluble nitrogen and encourage adequate consumption (Upreti *et al.,* 2008). In this experiment, we observed a decreasing trend of DMI and an increasing trend of CP intake with increasing level of protein in diet. It might be due to protein bypass from rumen and higher intake of intact protein in lower guts. According to Kabir *et al.* (2014) goats feeding with high protein diet significantly ($p<0.01$) increases CP intake. They observed CP Intake value of 73.14 g in goats on a high protein diet and 59.91g when on a low protein diet. Their finding matches our present experiment. Shahjalal *et al.* (1997) also achieved similar result on grazing black Bengal goats. On contrary, Lu and Potchoiba (1990) suggested a linear and positive relationship between DMI and CP intake in goats. The protein requirement for goats may cover both maintenance and to satisfactory growth rates. According to Chaokaur *et al.* (2012), protein requirements for maintenance and weight gains are 157 and 272g/day, respectively.

Feed and protein conversion efficiency

In the present study, highest feed conversion efficiency (FCE) is noted in treatment 1 due to the highest value of DMI. However, Hossain *et al.* (2003), Sultana *et al.* (2012) and Rahman *et al.* (1991) observed highest value of FCR on their experiment with goat fed highest level of concentrate supplementation. Similarly, Sharma and Ogra (1990) stated protein supplementation through concentrate feed significantly improved FCE if growing goat kids. Lambs fed high levels of concentrates had higher average daily gain and improved FCR (Majdoub-Mathlouthi *et al.*, 2013). Hag and Shargi (1996) and Getinet and Yoseph, (2014) feeding different levels of protein in diet, found no significant relation with respect to FCE. Prieto *et al*. (2000) noticed similar kind of results on different goats receiving different level of CP in diets. Present study of protein conversion efficiency (PCE) suggests no significant difference between different treatment protein treatments and corresponds well with finding of Sultana *et al.* (2012). However, Hossain *et al.* (2003) found higher efficiency of protein utilization that is crude protein per gram live weight gain with increased supplementation of dietary energy. Bishwas (1997) in his experiment with goats feeding different protein supplements found no significant improvement in conversion of dry matter and maintenance energy. Hence, he concludes non-significant relationship of PCE according to different dietary protein levels.

5.3.1 Effect of concentrate supplementation on rumen digestibility of diets

Positive correlation occurs between DM digestibility and N digestibility of diets with respect to different protein supplement in goats. Different protein sources have varying effect on nutrient digestibility. According to Khan *et al.* (1997) different protein sources like cotton meal, soybean meal and cotton seed meal have varying effect on DM digestibility in growing Afghani lambs. In the present study, the low correlation value for OM digestibility compared with DM digestibility can be due to presence of condensed tannins and α amylase causing depression in nutrient digestibility due their adverse effect on digestive enzymes. Keery *et al.* (1993) reported lower apparent digestibility of OM in reticulorumen in lambs supplemented with soybean meal. Improved DM and OM digestibility was noted for sheep fed a diet containing protein supplementation of grass hay and straw mixture (Swanson *et al.*, 2000). Similar to the present study, Jaster *et al.* (1984) and Bernard *et al.* (1991) reported higher digestibility of DM in ruminants fed corn gluten as a protein source. Milis *et al.* (2005) and Irshaid *et al.* (2003) reported no differences between soybean and cotton meal on nutrient digestibility for DM, OM, CP, and CF in Awassi lambs. Araújo *et al.* (2009) noted low significant relation between apparent digestibility of DM and hay as protein sources in diets. The authors therefore concluded that OM apparent digestibility is related with energy level of diet that is with TDN value and decreasing digestibility of diets is attributed to the low energy level in hay based feed rations. In addition, diets high in starch may even depress the ruminal digestibility of fiber (Alves *et al.*, 2003; Silva *et al.*, 2007). Similarly, no differences in DM digestibility in lambs fed diets containing pigeon pea or alfalfa as protein sources was noticed by Phillips and Rao (2001). There occurs a higher rate of consumption of low energy diet like *Leucaena* and *Stylosanthes* as they fed solely and the reason behind this is due to supplementation of higher NDF. NDF and DM intake for ruminants are inversely proportionally to each other (Allen, 1996). DM intake reduction in ruminants due to increase in NDF of diets is due to presence of fibrous mass in reticulorumen that may act as inhibitor of DM intake. Beside this, multifactorial effect of condense tannin (CT) present in maize meal also plays a major role in protein degradation and contribute to N digestibility. Because of insolubility of CT they can inhibit protein degradation through spontaneous binding of protein and make protein feed complex insoluble and unavailable to rumen digestive enzyme and thus increases bypass properties (Silanikove *et al.,* 2006). However, slightly alkaline pH of intestine helps in dissociation of suspected tannin protein complex. Hence, in rumen GI tract hydrogen bond interaction occurring between hydroxyl and amino group of tannins act as promoter in protein tannin interaction. Higher feed intake observed in local Khari goats in this study is due to inclusion of CT in form of formaldehyde treated maize meal. Beside protein tannin interaction, these formaldehyde treated CT may have improved the physical properties of the feed through various effects like decreased moisture level, increased flow ability and act as insulator to retain their palatability. Similar kind of results was noticed by Bengaly and Nashlai, 2007 in their experiment on supplementation of wattle tannins to goats. Supplementation of CT in diets even helps to increase goat performance on a diet of low metabolizable energy (Sheridan *et al.,* 2003). Bengaly *et al.* (2007) on the other hand, did not observe changes in feed intake in goats fed diets containing up to 3% tannins. Furthermore, research by Provenza (1995) concluded that levels of CT exceeding 3% in diet could be detrimental to animal's appetite. Thus, it can be concluded that formaldehyde treatment can provide levels of ammonia that are released slowly in rumen thereby playing an important role to protect the protein from microbial degradation in the rumen and improve the bypass properties of protein.

5.4 Rumen pH and nitrogen balances

N balance is determined by nitrogen intake and fecal and urinary nitrogen level. N intake is dependent on DM intake and CP intake. There will be greater amount of urinal N excretion with feeding of high CP diets to goats (Phillips and Rao, 2001). Beside this, increased amount of post ruminal amino acid absorption due to bypass properties of protein through formaldehyde treatment may also result in increasing urinary nitrogen (Williams, 1991). Formaldehyde treatment of protein sources in diets actually retains N balance in present study, a finding in agreement with Ward *et al.* (2008). It is due to poor digestibility of Nitrogen or due to poor usage of absorbed nitrogen (Khalid *et al.,* 2012). According to them, lambs fed with soybean meal and cottonseed meal supplemented with ferrous sulphate diets retained higher nitrogen in comparison with lambs fed untreated cottonseed meal. However, Matras *et al.* (1991) reported minimum effect of different grain source on nitrogen balance and N intake, retention. However, if these grains are supplemented with urea, it lowers the nitrogen balance in lambs. Similarly, Knowlton *et al.* (2001) clarified non-relationship between protein sources and fecal, urinary and total excreted nitrogen. Contrary to this and in agreement with the present study, Murohy *et al.* (1994) and Swanson *et al.* (2000) reported improvement in N balance and digestion with increasing protein concentration in diet of growing lambs and sheep, respectively.

The N intake retention and balance in ruminants is related to crude protein synthesis and determined by rumen degradable protein (RDP) and un-degradable protein (RUP). According to Tomilnson *et al.* (1996), more than 20% of excreted nitrogen can be reduced if we use different protein sources containing high amount of rumen un-degradable protein. Bailey and Sims (1998) support this statement and conclude that higher nitrogen balance form ruminal un-degradable protein supplements than what is the case for un-supplemented ones (5.7g N vs. 1.7g N/day). Similarly, protein supplements also increases N retention in diets in lambs (Philips *et al.*, 1995, Khalid *et al.*, 2011). Higher amount of nitrogen reaches lower digestive tract of lambs provided with wet and dry distiller's grains than with wet and dry corn gluten feed (Firkins *et al.*, 1984). However, Milis *et al.* (2005) and Knowlton *et al.* (2001) found no significant relationship between protein sources and protein supplements on nitrogen balance of diets in their different experiment with lambs and cows, respectively. In conclusion, it can be said that nitrogen sources with high amount of rumen un-degradable protein affect nitrogen balances and contribute to improvement of N retention compared with diets having low ruminal un-degradable protein content.

According to the present study ruminal pH plays a significant role in gaseous emission. Condensed Tannins and pH are very closely related to each other. Condensed tannins help to make indigestible complex in rumen thereby levels of bypass protein from rumen. Range of pH for optimum combination of protein and tannin are at pH 4 to 7, which is also the pH range of rumen. At lesser pH than 3.5 and higher than 7 that is similar with abomasum and intestine, this tannins-protein complex become more unstable and releases tannin and protein (Kumar and Singh, 1984). However, one need to be careful that higher amount of tannin may affect bacterial requirements needed for protein synthesis. Hence, as recommendation, lower than 5% condensed tannins in rumen diets can be suggested to reduce protein degradation in rumen and to improve intestinal protein digestion. An increase in the concentrate level of the diet reduced the pH of ruminal fluid thereby increasing the substrate for microbial activity that finally results in a greater ruminal fermentation activity, with the increase of NH_3 -N concentration (Pedreira *et al.*, 2013). There is direct relation between ruminal methane production and dry matter consumption. Hence, we need to measure properly without variations in the DM source, related mainly to fiber content and diet quality (Pedreira *et al*., 2013; Moss *et al.*, 1995). In present study, no significant differences in rumen pH and NH_3-N were found. CH_4:CO_2 decreases significantly when feed is supplemented with formaldehyde treatment. Van Zijderveld *et al.* (2010) remarked similar finding in measurement of methane and carbon dioxide production from sheep fed in maize silage supplemented with urea, nitrate and sulphate. Nitrate can replace CO_2 as an electron acceptor in rumen environment that helps in generation of ammonia instead of methane. During this process, nitrate is reduced to nitrite and then to ammonia that results in lowering methane gas emission (Leng, 2008; Silivong, 2012). Thus, the presence of nitrate salts in rumen act as a competitive sink for the hydrogen produced by fermentation of carbohydrate such that it is converted to ammonia rather than methane (Leng, 2008). Hence, CH_4 suppresses the effects of nitrate during rumen gas emission (Leng and Preston, 2010) and fermentable nitrogen sources helps in microbial protein synthesis and possesses a higher affinity than carbon dioxide to accept hydrogen, resulting in lower methane production.

5.5 Cost Benefit Analysis

The main purpose of feeding supplement to the goats is to improve the production efficiency so that the target of production can be achieved easily with optimization of profit. Weight gin analysis suggest significant differences in weight gain according to different level of treatment at $P<0.05$ and this is the reason for analyzing cost benefit ratio before making any decision for proper intervention of feed supplementation. Lowest CBR for treatment level 4 is due to highest supplementation cost and lowest economic return as expected by weight gain. Cost benefit ration analysis helps in making proper decision in term of economic feasibility and in break-even situation CBR value should be 1. However, for T4 as CBR value is lower than break even suggestion, so it can be conclude that treatment level 4 is uneconomical and it actually provide loss in term of supplementation investment. T3 and T2 treatment has highest BCR value which is far greater than break-even point and it suggest both of these treatments are more cost effective with good marginal return for supplementation investment. Higher productivity and more profitable goat farming can only be obtained with heavily utilization of cheap and locally abundant feed resources with good protein sources and mixture of formaldehyde treated concentrate feed can even maximize profitability of goat enterprises.

6. Conclusion

Ruminant like goats growth performances are determined by various factors and among these factors dietary protein are most important and costlier one. In order to achieve healthy growth of goats, these protein need to be protected from rumen degradation to enhance bypass properties that finally meet nutritional demand of goats. This rumen bypass protein of goats actually increases goat productivity. The result of this study specify that the supplementation of protein enriched fodder with formaldehyde treatment of commercial concentrate mixture in the diet of local Khari goats has significantly improved their growth performance. *Stylosanthes* in combination with *Leucaena* can be used as potential fodder for rural area of Nepal and combination of these fodders with formaldehyde treated concentrate mixture can promote economic sustainability of farmers to raise the quality of their livelihood. It is important to undertake further studies about different anti-nutrient components present in *Leucaena* and *Stylosanthes* and their effects on growth performance of goats with special emphasis on rumen fermentation to achieve bypass properties and better nutrient utilization.

From present experiment it can be concluded that diets with high protein content leads to better growth performance of goats and formaldehyde coating further enhance this characteristics and improves feed conversion ratio. Inclusion of *Stylosanthes* and *Leucaena* with formaldehyde treated concentrate mixture and maize meal increases total dry matter intake and digestibility of diets that results in improvement of average daily gain as well as feed conversion efficiency. Although there was no significant effect of protein supplement on growth performance of goats, overall growth performance revealed that inclusion of all dietary protein in goat diets increases amount of organic matter incorporation which result in better weight gain. Hence, to achieve good growth of goats to catch good market value, it is recommended to supply diets containing *Stylosanthes*, *Leucaena* and formaldehyde treated concentrate mixture and maize meal. As *Stylosanthes* and *Leucaena* is available locally in rural area of Nepal. Therefore, extensive utilization of these fodders in combination with formaldehyde treated concentrate mixture and maize meal can really give good turnover for farmers. However, farmers need to be careful with supplementation of *Stylosanthes* as dry matter intake of tree fodders decreases with increase in amount of stylo grass. General recommendation value per day for Khari goats is 600g/day.

Further studies to assess the economics of goat production with respect to supplementation of fodder and formaldehyde treated maize meal and concentrate mixture is very important and furthermore, it is important to assess the cost of gain so that this research can further be used in commercial goat production system in Nepal. Beside this, study on carcass characteristics and reproductive performance is needed.

Formaldehyde treatment of commercial concentrate meal and maize meal suggest the reduction of methane/carbon dioxide ratio on gaseous emission by Khari goats. Methane concentration in gas is dependent on incubation period. Formaldehyde treatment of diet increase gases solubility and thereby reduces methane concentration in gas. High amount of ammonia in goat rumen is due to greater solubility of crude protein in formulated diet. Hence, it can be concluded that formaldehyde treated concentrate meal and maize meal together with *Stylosanthes* and *Leucaena* has higher potential as a protein supplement and can improve feed intake and gives a positive nitrogen balances when fed to local growing Khari goats.

Different dietary protein sources exert different responses on growth performance in goats. It is due to different processing techniques, presence of anti-nutritional factors and amino acid composition. Hence, addition of additives like formaldehyde treatment may improve the utilization of protein sources and improve the ruminal fermentation properties thereby enhancing bypass properties of protein. However, presence of condensed tannins in *Leucaena* may be a major constrains for efficient utilization by goats and further research is required to minimize its effect. Thus in conclusion it can be said that the positive effects of formaldehyde treatment of dietary protein diet increases intake of dry matter, better performance and higher ruminal volatile fatty acid and NH3-N concentration in goats. Furthermore, formaldehyde treatment has also practical implications at small-scale farmer's level in rural livelihood of level.

Thus, the overall findings of this experiment support the original hypothesis that:

i. Supplementation of *Stylosanthes guianensis* and *Leucaena leucocephala* improve the growth performance of goats.
ii. Treatment mixture of Stylo, Leucaena and commercial concentrate with formaldehyde facilitates the rumen reaction, decreases protein degradation and hence increases bypass properties.

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