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Prosopis Juliflora Pod as a Replacer for Concentrate Supplement for Afar Goats in Ethiopia
Effects on Intake, Body Weight and Digestibility

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Abstract
Thirty yearling Afar goats of mean weight 14.4 kg ± 1.3 (mean ± SD) were used to measure the effects of feeding increasing amounts of ground *prosopis juliflora* pod (GPJP) to replace a commercial concentrate mixture (CCM) as a supplement to a basal diet of Rhodes grass hay. Measurements of feed intake, live weight change and digestibility were made. Animals were equally divided into five dietary treatments in a randomized complete block design based on their initial body weight. The feeding trial was continued for ninety days followed by a seven days of digestibility analysis. The treatments were 300 g/day CCM or mixtures of CCM and GPJP viz : CCM (control), 0.25 GPJP : 0.75 CCM, 0.5 GPJP : 0.5 CCM, 0.75 GPJP : 0.25 CCM, 1.0 GPJP: 0 CCM. In addition 300 g Rhodes grass hay was used as a basal diet in daily basis with all the treatment levels. Results of total dry matter and nutrient intakes, growth rate and feed conversion were appreciable as the proportion of ground *Prosopis juliflora* pod in the total ration increased to 0.5. However, these values dropped sharply when the replacement proportion increased to 1.0. The dry matter and nutrient digestibility also found to decrease ($P<0.001$) gradually with the increasing level of replacement. It was concluded that replacement of commercial concentrate with ground *Prosopis juliflora* pod at the proportion of 0.5 showed no adverse effect on growth and digestibility of Afar goats.
Keywords: *Prosopis juliflora*, Pod, Concentrate, Afar goats, Digestibility

1. Introduction
Seasonal fluctuations in feed supply and pasture quality as well as malnutrition are considered to be the major constraints impeding the livestock feeding system in Ethiopia (Ahmed et al. 2012). In Ethiopia ruminant productivity is based on poor quality forages, crop residues or agro-industrial by-products. Therefore it requires additional protein and roughage sources to maintain an efficient rumen ecosystem that will improve nutrient intake and digestibility (Nurfeta, 2010). However, since additional protein and roughage sources are rarely available and unaffordable by the pastoral community, utilization of locally available feed resources is highly advisable. And hence fodder trees and shrubs can be used as supplements to livestock, especially during long dry season and fodder stress periods (Abusuwar and , 2010).

Prosopis juliflora is among trees and shrubs of the legume family *Leguminosae*, subfamily *Mimosoideae* that can grow in a wide range of soil and climatic conditions. The tree is native to arid and semi-arid areas of the Americas (Seturaman et al. 2014). It was widely distributed in Ethiopia as a biological soil and water conservation agent during the late 70s. The tree has an aggressive invasive character. It is invading range lands, cultivated lands and irrigation canals causing irreversible displacement of natural pasture as well as native tree species because of this it is now considered as major invasive plant in Ethiopia (Kassahun et al. 2005). It can grow in areas with rainfall amount of less than 200 mm/year (Mahgoub et al. 2005), and on sandy, saline, stony or other soil types unsuitable for cultivation (Seturaman et al. 2014**).** Contrary to its adverse effects, *Prosopis juliflora* is also a considerable multipurpose tree that provides timber, fire wood, livestock feed, human food, shade, shelter and soil improvement (Ahmed et al. 2012). Generally the tree produces pods twice a year. However, in some regions, flowering and fruiting are continuous. The number of pods produced per inflorescence varies greatly, with 1-16 fruit per inflorescence (Dave and Bhandari, 2013**).**

The pods of *Prosopis juliflora* have a crude protein level of 7-22% and a carbohydrate level of 30-75% based on the soil type and the process of extraction (Choge et al. 2007). This makes the pod a good feed resource and low cost alternative feed stuff almost for all ruminant species (Abdullah et al. 2011).

However, feeding large amount of *prosopis juliflora* pod for prolonged time according to Tabosa et al. (2000) may cause mandible tremors, mainly during chewing. Therefore, mixing the pod with other feed resources as concentrates is nutritional and economically recommendable.

Since its introduction in to Afar region of Ethiopia, information on the simultaneous advantage of minimizing the invasion of *Prosopis juliflora* through utilization of its pod as a protein supplement to goats is lacking and thus it has remained underutilized. By now the tree has already covered thousands of hectares of

range lands. Therefore, the objective of this study was to evaluate the supplementary advantage of feeding different levels of ground *Prosopis juliflora* pod with concentrate mixture to Afar goats fed a basal diet of Rhodes grass (*Chloris gayana*) hay.

2. Materials and methods

2.1. Description of the experimental area

The feeding experiment was conducted at Werer Agricultural Research Centre (WARC). Its altitude ranges from 500 to 820 meters above sea level and is located between 90° 30' and 100° 20' N and 400° 30' and 400° 50' E. The mean annual rainfall of the area is 562 mm while the mean annual temperature is 34.1^{0}C.

The basal diet Rhodes grass (*Chloris gayana*) was cultivated at Werer Agricultural Research Center and used to be cut by 35 days interval. It was at early blossom, leafy, light green, soft and chopped using a locally made stand chopper at the length of 15-20 cm. Supplemental feeds used for the study were ground *Prosopi juliflora* pods and a commercial concentrate mix made up of wheat bran, noug cake, molasses and salt. Pods were collected from trees grown in the study area and then dried in the sun, pounded with traditional equipment (*mewqecha* and *zenezena*) and then ground using a hammer mill with a screen size of 2.5 mm. (Wet Type Grinding Mill, manufactured by Selam VTC, Addis Ababa, Ethiopia).

2.2. Chemical analysis of the experimental feeds

The chemical analysis was done in Holeta Agricultural Research Centre (HARC). All samples of feed offered and refused were dried at 55 °C in a forced draft oven to constant weight and ground to pass through 1 mm mesh screen size and subjected for the analysis of dry matter, organic matter, ash, and crude protein according to the procedures of AOAC (1990). Neutral detergent fibre and acid detergent fibre were analysed according to the procedure of Van Soest et al. (1991).

2.3. Management of animals

Thirty intact male Afar goats around eleven months of age with mean body weight of 14.4 ±1.3 kg (mean ± SD) were purchased from the surrounding market. The goats were quarantined for seven days and during this period they were de-wormed against internal and external parasites. After the quarantine period the goats were penned individually in a barn with a concrete floor and separate feeding and watering troughs. The kids were subjected to stay an adaptation period of two weeks followed by ninety days of a feeding trial.

2.4. Experimental design and treatments

The experimental goats were blocked into five blocks of six animals in a randomized complete block design based on their initial body weight and randomly assigned to one of the five dietary treatments. The treatments were 300 g/day CCM or mixtures of CCM and GPJP viz: CCM (control), 0.25 GPJP: 0.75 CCM, 0.5 GPJP: 0.5 CCM, 0.75 GPJP: 0.25 CCM, 1.0 GPJP: 0 CCM and in addition to those treatments 300 g Rhodes grass hay in daily basis was used as a basal diet and mineral salt was also made available *ad libitum.* Supplementation of 300 g concentrate and 300 g hay was applied based on the recommendations of Sebsibe, (2007) and Terefe et al. (2013) for Afar yearling goats. However it was suggested that the amount of feed offered to all kind of goats should be adjusted based on the amount of feed consumed (Mahgoub et al, 2005) and the live weight, maintenance and growth requirement (Mac Donald et al., 2010). Accordingly, the amount of feed offered to the kids was adjusted every two weeks and the ratio of each ingredient in the mixed ration was also adjusted according to the proportion of each feed component to maintain a constant ratio in a fresh basis.

2.5. Feed intake and body weight gain measurement

The respective concentrate and prosopis mixture supplements of each treatment and Rhodes grass hay were offered separately at 8:00 h and 16:00 h in two equal portions. Half of the hay was offered after the consumption of the first half concentrate and prosopis mixture. Daily feed offered and refusals were weighed and recorded for each goat to determine daily feed intake. All animals had free access to water.

Representative samples of feed offered per batch and refusals per goat were collected and pooled on treatment for determination of chemical composition. The feed conversion ratio was calculated as a proportion of daily dry matter intake to daily body weight gain. Initial body weight of each goat was determined by taking the mean of two consecutive weights after overnight fasting, and body weight was subsequently measured every 14 days after overnight fasting. Average daily gain was calculated by a difference.

2.6. Feces collection

At the end of the feeding trial all of the goats were fitted with faecal collection bags for three adaptation days, followed by total collection of faeces for seven consecutive days. Daily faecal excretions per animal were collected and weighed every morning. Twenty percent of the total collected faeces were sampled daily and kept

in air-tight plastic containers for each animal until the end of the collection period, during this time samples were thoroughly mixed and sub- sampled for chemical analysis.

The Digestibility Co-efficient (DC) of nutrients was calculated by using the equation,

$$DC = \frac{\text{Total amount of nutrients in feed - Total amount of nutrients in faeces}}{\text{Total amount of nutrients in feed}}$$

Nutrient intake (NI) was calculated by using the equation

NI = DMO *nutrient content – DMR*nutrient content

DMO= Dry Matter Offered

DMR= Dry Matter Refused

2.7. Statistical analysis

The analysis of variance (ANOVA) on the experimental data was run using the general linear model procedure of SAS (2003). The treatment means were separated by Tukey test. The model used for the analysis of feed intake, growth and digestibility was $Yij= \mu + Ti + Bj+ eij$, Where; Yij = response variable, μ = overall mean, Ti = treatment effect, Bj = block effect, eij = random error.

3. Results

3.1. Chemical composition of the treatment feeds

The result of the chemical analysis of the experimental diets showed higher crude protein content for commercial concentrate mixture (Table 1) followed by concentrate prosopis mixture but both of them had lower neutral detergent fiber and acid detergent fiber than the other experimental diets. The crude protein content of ground *Prosopis juliflora* pod also found to be higher than Rhodes grass hay but lower than both commercial concentrate mixture and concentrate prosopis mixture. However, its organic matter was found to be higher than all the diets used in the experiment.

3.2. Feed intake and body weight parameters

The dry matter intake, acid detergent fiber intake and organic matter intake were higher ($P<0.001$) for goats supplemented with concentrate prosopis mixture compared to animals supplemented with commercial concentrate mixture and ground *prosopis juliflora* pod only (Table 2). The crude protein intake of the experimental feeds decreased as the replacement level of ground *prosopis juliflora* pod in the concentrate increased.

Except for those animals supplemented with ground *Prosopis juliflora* pod only, all animals supplemented with commercial concentrate mixture and concentrate prosopis mixture in general had higher ($P<0.001$) final body weight, body weight change and average daily gain. Feed conversion ratio was also found to increase ($P>0.05$) across the feeding regimes.

3.3. Dry matter and nutrient digestibility

All the experimental animals which were supplemented with commercial concentrate mixture and concentrate prosopis mixture had higher ($P<0.001$) dry matter digestibility than animals which were supplemented with ground *Prosopis juliflora* pod only (Table 3). The dry matter, neutral detergent fibre, acid detergent fibre, organic matter and crude protein digestibility were generally found to decrease ($P>0.001$) gradually as the proportion of ground *Prosopis juliflora* pod increases in the diet.

4. Discussion

4.1. Chemical composition of the treatment feeds

The crude protein content of commercial concentrate mixture was found to be higher than the other diets used in the experiment. Likewise, the crude protein content of concentrate prosopis mixture was also found to be higher than Rhodes grass hay and ground *Prosopis juliflora* pod. The crude protein value of ground *Prosopis juliflora* pod was found to be (148.1 g/kg) which is adequate for growing goats (NRC, 1981) and above the minimum requirement (0.07g/kg) for optimal microbial activity in the rumen (Juma et al. 2006). The crude protein content of ground *Prosopis juliflora* pod in this experiment was found to be higher than (123 g/kg DM) what was reported by Sebsibe (2007) but it was lower than (154.3 g/kg DM) what was reported by Girma et al. (2011) for *Prosopis juliflora* pod samples taken from the same area where this research is cinducted.

The neutral detergent fiber content of ground *Prosopis juliflora* pod obtained in this study was higher than the value (298 g/kg) reported by Ahmed et al. (2012) and the value (402 g/kg) reported by Mahgoub et al. (2005) but much lower than (518 g/kg) what was reported by Koech (2010). Similarly the acid detergent fiber content of ground *Prosopis juliflora* pod in current study was lower than the value (298 g/kg) reported by Koech (2010) and the value (276 g/kg) reported by Chaturvedi and Sahoo (2013). According to Adesogan et al. (2012), all those variations could be due to genotype, stage of maturity at sampling, season of harvesting, pre and post-

harvest management, soil type, climate, time and intensity of grazing and plant fraction as well as method of analysis used in the laboratories.

The higher the crude protein content of ground *Prosopis juliflora* pod which is enough for growing goats (NRC, 1981) and its acid detergent fiber value which lays under the normal range (0.25-0.45 g/kg dry matter) according to Ruddell et al. (2002), and its neutral detergent fiber value which falls below the range (0.47-0.53 g/kg dry matter) for those legumes which have a crude protein range of 0.14-0.16 g/ kg as mentioned by Upreti (2006) and its highest organic matter content as compared to the other feed resources used in this experiment, suggest its proximity to conventional agro-industrial by-products in terms of chemical composition.

4.2. Feed intake and body weight gain

The total dry matter intake as percent of body weight in the present study (2.6-2.9 %) is in agreement with the report (1.7- 4.8 % body weight) for various breeds of goats in the tropics (Sebsibe, 2007). The highest dry matter intake as percent of body weight in this experiment is (2.9 %w body weight) also in agreement to what was reported for Afar goats by Sebsibe (2007). The total dry matter intake show a constant decreasing pattern as the level of ground *Prosopis juliflora* pod inclusion in the concentrate mixture increased from 0.25 to 1.0. Goats fed with Control: 1CCM and 0.25 GPJP: 0.75 CCM had higher ($P<0.05$) feed intake than others. A similar pattern occurred when feed intake was expressed as a percentage of body weight. The lowest intake was observed for animals supplemented with 1.0 GPJP: 0 CCM (300 g GPJP). Similarly Mahgoub et al. (2005) also reported that goats can feed 0.20 GPJP: 0.8 CCM but increasing the proportion of GPJP up to 0.30 had shown reduction in intake. This reduction could be due to the presence of tannins, and other phenolic compounds, in the pods that resulted in suppressed appetite (Koech, 2010).

In the current study goats which were supplemented with 1 GPJP: 0 CCM (300 g GPJP) had the least weight gain record. This could be due to the poor palatability and composition of the diet which greatly affect voluntary intake and weight gain.

The feed conversion ratio is also an important economic factor. The objective is to lower the amount of feed used per unit of weight gained and therefore a lower feed conversion ratio. In the current study, feed conversion ratio was increased continuously as the proportion of ground *Prosopis juliflora* pod increased in the commercial concentrate mixture. Similarly, Abdullah et al. (2011) reported that increasing the proportion of ground *Prosopis juliflora* pod in the diet mixture of black goats increased the feed conversion ratio. This could be due to the substitution effect of high quality commercial concentrate mixture by lower quality ground *Prosopis juliflora* pod which directly increased the amount of feed required per unit of weight gain. All of the feed conversion ratio values in the current study were lower than what was reported to be 13.7 by Sebsibe (2007) for Afar goats supplemented with wheat bran and noug seed cake.

Tabosa et al. (2000) reported that goats fed 600 g/kg and 900 g/kg ground *Prosopis juliflora* pod had mandible tremors, mainly during chewing. However, supplementation of all levels of ground *Prosopis juliflora* pod to Afar goats in this experiment did not visibly reflect any health problem. Using prosopis pod with commercial concentrates was also found to be effective in terms of feed intake and body weight change as compared to supplementation of commercial concentrates or ground *Prosopis juliflora* pod only.

4.3. Dry matter and nutrient digestibility

The values of dry matter, crude protein, neutral detergent fiber, acid detergent fiber and organic matter digestibility are found to decrease ($P<0.001$) gradually as the proportion of ground *Prosopis juliflora* pod increased in the total ration. The reason could be according to Mac Donald et al. (2010) because of the gradual increment of lignification which created dense masses of cells that resist invasion by microorganisms. Birhanu et al. (2013) also indicated that decreasing CP in concentrates decreases the digestibility of dry matter, neutral detergent fiber, acid detergent fiber and organic matter.

Conclusion and recommendation

The results of the present study demonstrate the potential of using the same amount ground *Prosopis juliflora* pod inclusion with commercial concentrates for growing Afar goats with appreciable effects on intake, growth performance and digestibility. It can also be concluded that *Prosopis Juliflora* pod can be used as a cheap protein source for growing goats and can replace expensive commercial concentrates. However, the crude protein of *Prosopis juliflora* is very variable and hence an analysis for crude protein should be undertaken before adopting a level of inclusion in the diet.

Lack of manifestation of health problems in the goats in the current study may be due to the short period of feeding or to the smaller proportions of the pods in the diet. Therefore, further studies are extremely important to investigate the potential of improving *Prosopis* based diets to increase feed intake, growth and digestibility of Afar goats without reflecting any health problems.

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Table 1. Chemical compositions of experimental feeds during the feeding trial.

				Mixture of CCM and GPJP		
	RGH	GPJP	CCM	0.25 GPJP 0.75 CCM	0.50 GPJP 0.50 CCM	0.75 GPJP 0.25 CCM
Chemical composition						
DM (g/kg)	915.3	894.1	844.9	857.2	857.3	881.70
CP (g/kg DM)	89.0	148.1	172.3	166.2	160.3	154.2
NDF (g/kg DM)	682.0	430.8	424.2	425.9	430.8	429.2
ADF (g/kg DM)	453.0	271.9	193.5	213.1	232.7	252.3
OM (g/kg DM)	881.4	956.9	901.8	915.6	929.4	943.2
Ash (g/kg DM)	118.6	43.1	98.2	84.5	70.7	56.9

DM = dry matter; CP = crude protein; NDF = neutral detergent fiber ; ADF = acid detergent fiber; OM = organic matter; RGH= Rhodes grass hay; GPJP = Ground *Prosopis juliflora* pod; CCM = Commercial concentrate mix. CPM= Concentrate prosopis mix; 0.25 GPJP: 0.75 CCM = 225g concentrate + 75 GPJP + 300 g grass hay; 0.5 GPJP: 0.50 CCM = 150 g concentrate +150 g GPJP +300 g grass hay; 0.75 GPJP: 0.25 CCM = 75 g concentrate +225 g GPJP + 300 g grass hay.

Table 2. Mean feed intake and body weight change of Afar goats fed Rhodes grass hay and different

Variable	Control 1.0 CCM	0.25 GPJP 0.75 CCM	0.50 GPJP 0.50 CCM	0.75 GPJP 0.25 CCM	1.0 GPJP 0.0 CCM	Significance
Intake (g/d)						
Hay	259.0^{a}	225.0^{c}	229.7^{c}	239.0^{b}	258.3^{a}	***
Supplement	263.8^{b}	293.5^{a}	263.7^{b}	260.4^{b}	218.5^{c}	***
Total	524.2^{a}	518.5^{a}	493.4^{b}	499.5^{b}	476.6^{c}	***
Growth performance						
Initial weight (kg)	14.8	14.9	14.9	14.2	14.2	NS
Final weight (kg)	21.0^{a} ± 2.4	20.2^{a} ±0.5	20.2^{a} ±2.9	18.8^{b} ±1.3	18.6^{b}±1.0	***
BW change (kg)	5.9^{a}	5.5^{ab}	5.3^{ab}	5.0^{ab}	4.6^{b}	*
ADG (g/d)[2]	65.7^{a}	61.5^{ab}	58.3^{ab}	55.0^{ab}	51.1^{b}	*
FCR[3]	7.2^{b}	7.7^{b}	8.2^{b}	9.3^{ab}	9.8^{a}	*

levels of concentrate and ground *Prosopis juliflora* pod mixture during the feeding trial.

Treatment [1]

[1] Diets were Control: 1.0 CCM = 300g concentrate + 300 g grass hay; 0.25 GPJP: 0.75 CCM = 225g concentrate + 75 GPJP + 300 g grass hay; 0.5 GPJP: 0.50 CCM = 150 g concentrate +150 g GPJP +300 g grass hay; 0.75 GPJP: 0.25 CCM = 75 g concentrate +225 g GPJP + 300 g grass hay; 1.0 GPJP: 0.0CCM= 300 g GPJP + 0g concentrate + 300 g grass hay.

abcd Means on the same row with different superscripts differ (P<0.001); (P< 0.05).

[2] ADG=Average daily gain ((final weight-initial weight)/90 days)).

[3] FCR (g DM intake/g ADG) = Feed conversion ratio.

***, * = highly significant and significant respectively; NS= not significant.

Table 3. Apparent digestibility coefficients dry matter and nutrient intake of Afar goats fed Rhodes grass hay and different levels of concentrate and ground *Prosopis juliflora* pod mixture during the digestibility trial.

Treatment [1] Digestibility coefficient	Control 1.0 CCM	0.25 GPJP 0.75 CCM	0.50 GPJP 0.50 CCM	0.75 GPJP 0.25 CCM	1.0 GPJP 0.0 CCM	Significance
DM	0.81[a]	0.79[b]	0.78[c]	0.77[d]	0.75[e]	***
CP	0.83[a]	0.69[b]	0.66[b]	0.60[c]	0.52[d]	***
NDF	0.77[a]	0.72[b]	0.68[d]	0.70[c]	0.67[e]	***
ADF	0.48[a]	0.41[b]	0.40[c]	0.41[b]	0.33[d]	***
OM	0.81[b]	0.78[c]	0.84[a]	0.75[d]	0.72[e]	***
Nutrient intake (g/day)						
Hay DM	175.7[d]	189.0[c]	194.5[b]	202.0[b]	214.3[a]	***
Supplement DM	291.6[a]	280.5[b]	262.2[c]	259.8[c]	217.5[d]	***
Total DM	467.1[a]	469.4[a]	458.1[b]	450.1[c]	434.8[d]	***
DM (% BW)	2.9[a]	2.9[a]	2.8[ab]	2.7[bc]	2.6[c]	***
Total CP	83.1[a]	69.3[b]	66.0[b]	59.6[c]	52.0[d]	***
Total NDF	279.2[a]	261.5[c]	232.4[d]	271.6[b]	262.6[c]	***
Total ADF	162.7[b]	157.3[c]	164.0[b]	179.1[a]	165.6[b]	***
Total OM	345.9[b]	350.1[a]	344.9[b]	350.9[a]	332.8[c]	***

[1]Diets were Control: 1.0 CCM = 300g concentrate + 300 g grass hay; 0.25 GPJP: 0.75 CCM = 225g concentrate + 75 GPJP + 300 g grass hay; 0.5 GPJP: 0.50 CCM = 150 g concentrate +150 g GPJP +300 g grass hay; 0.75 GPJP: 0.25 CCM = 75 g concentrate +225 g GPJP + 300 g grass hay; 1.0 GPJP: 0.0CCM= 300 g GPJP + 0g concentrate + 300 g grass hay.

[abcde] Means on the same row with different superscripts differ (P<0.001).

*** = highly significant.