

Effects of Pigeon Pea Leaves and Concentrate Mix Supplementation on Biological Performance, Carcass Yield and Market Weight of Central Highland Goats in Ethiopia

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Abstract

The study was conducted to evaluate the effects of pigeon pea leaves and concentrate mixture supplementation on biological performance, carcass yield, market weight and carcass characteristics of male Central Highland Goats (CHG) at Sirinka Agricultural Research Center, Northeastern Ethiopia. A total of 24 yearling intact male goats with an initial body weight of 21.4±1.12 (Mean±SD) were used for this experiment. For the study, randomized complete block design (RCBD) was employed. Experimental goats were divided into 4 treatment groups and blocked into 6 groups based on their initial live weight. Six goats were randomly allocated to each treatment group. The treatments were: T1= grass hay ad libitum+100% Noug seed cake, T2= grass hay ad libitum+65% Noug seed cake+35% pigeon pea hay, T3= grass hay ad libitum+35% Noug seed cake+65% pigeon pea hay and T4=grass hay ad libitum+100% pigeon pea leaf hay on DM base. The finding indicated that total DM intake of T3 goats was 902.3 g/day, which was higher ($p<0.05$) than that of other treatment groups. Goats under T3 and T4 also fed highest ($p<0.01$) average NDF (611.7g/day) at than other treatment groups. However, the lowest ADF (335.6g/d) intake was recorded under T1. There was a significant difference ($P<0.05$) among treatment groups on average daily weight gain and total weight gain in the present study, which attained the highest in T3 (77.8g/day) and (6.5kg/84days), respectively. The feed conversion ratio (FCR) of goats showed no significant ($P>0.05$) difference among treatments. The average dressing percentage (DP) as basis of empty body weight recorded was within the range of (54.25-54.94). Similarly, DP as the bases of slaughter weight was in the range of 45.25-47.6. Hence, it is recommended that Central Highland Goat attained a market weight range of 25-30 kg within 84 day of feeding using pigeon pea leaves as protein supplement. Based on accessibility and other biological importance of pigeon pea and better daily feed intake Central Highland Goat supplement with 65% of pigeon pea and 35% of Noug seed cake as protein supplements mix with 50% Wheat bran of daily supplementation requirement should be recommended

Keywords: carcass, Central Highland goat, dressing percentage, intake, weight gain

1. Introduction

Ethiopia has different agro-ecological zones ranging from semi-arid to arid environments which are suitable for goat production. The goat population of Ethiopia is estimated at 30.2 million [1]. Goats play important roles in

communities by improving the livelihood of resource-challenged farmers by creating alternative employment opportunities, enhancing family income by sale of live animals, skin, manure, etc. Goats act as an income buffer to the risks associated with erratic climatic changes [2], and they also contribute to human nutrition in the form of meat and milk. The annual Ethiopian goat meat and mutton production is 67580 and 86500 tons, respectively for goats and sheep which contributes 16.98 and 21.73% of the total ruminant livestock meat output [3]. Average

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carcass weight per head of sheep and goats is estimated 8 and 10 kg, respectively. A major cause contributing to such low carcass yield is that animals are commonly slaughtered at immature body weights, 18–20 kg for sheep and 16–18 kg for goats [4]. There are different problems that affect productivity of goats such as: diseases, poor genotype, management, and nutrition [5]. Feed and water scarcity in quality and quantity is among major production constraints along the value chain [6].

Feed production covers requirements only in exceptional good years; the deficit reaching 35% in normal years and 70% in bad years [7]. The situation is exacerbated during the dry season when natural pastures usually dry out and are overgrazed, resulting in low contents of protein and energy in the fodder. Therefore, it is important to sought different feed sources that could be used as dry season supplement for goats. Previous works have reported that leaves of multipurpose trees growing in the backyards of the farmers can be used as a cheap source of protein for supplementing livestock [8]. One of such fodder legumes is pigeon pea (*Cajanus cajan*) whose leaves are an important fodder and serves as valuable source of feed for farm animals [9]. Pigeon pea leaf is an excellent source of protein ranging from 16.3–27% [10]. Pigeon pea can be fed along with low quality roughages to improve their utilization and to increase growth rates and average daily body weight gain up to 54.67 g per day of Ethiopian local sheep [11]. In addition Pigeon pea remains one of the most drought-tolerant and adaptable legumes in the tropics [12].

Therefore, increasing the current level of productivity is essential to provide meat to the ever-increasing human population, to increase export earnings and household income thereby improving the living standard of smallholders [13]. So, developing feeding packages that support the existing traditional production and the emerging private producers and exporter is the timely intervention to increase production and productivity in order to meet the demand for meat and live animal export market [14]. It is therefore important to supplement the major available fodder with some amount of concentrates in order to improve intake and digestibility of such poor quality feed resources. The objective of this research was to evaluate feed utilization, growth

and carcass production performance of central highland goat fed different proportion of pigeon pea leaf hay and noug seed cake as protein supplement.

2. Materials and methods

Description of the study area

The study was conducted at Sirinka Agricultural Research Center (SARC) research site, which is located 508 km away from Addis Ababa. The site is located at an altitude of 1850 m *a.s.l* and at 1°45'00"N, 39°36'36"E. The rainfall pattern is bimodal, with two-rainfall season, *Belg* (Feb./Mar.-April) and *Meher* (July–Oct./Nov.) and the mean annual rainfall amount is on average about 950 mm. The area is a moderate warm temperature zone with mean daily temperature ranges from 16–21°C.

Experimental animals and their management

A total of 24 (9–12 month age) intact male central highland goat were purchased from local markets (Mersa, Kobo and Gerana). Totally 21 days for quarantine period were used before adaptation started. All the goats were ear tagged, vaccinated for the protection of common goat diseases and treated against internal and external parasites during quarantine time. In addition 15 days used as an adaptation period.

The experimental animals were randomly allocated into four treatment groups and each group contains six animals, then goats separated into their respective treatment groups and supplemented with individual pens. The treatment feed gradually introduced into the animals' ration after two-week adaptation period. The ration ingredients used in this experiment were pigeon pea hay, wheat bran, noug seed cake and salt mixture formulated based on the daily DM requirement of the animals; i.e. 3.0% of their body weight per head. All the experimental goats had got natural grass hay and water *ad libitum* throughout the experiment period.

Feed preparation

Pigeon pea leaves were harvested from Jari trial site of the center. The re-growths were harvested at about 50% flowering stage, air dried and stored for feeding trials. The grass was harvested

at 10% heading stage from the research center pasture area, dried and stored in recommended moisture content. Concentrate feeds were purchased from the factory and mixed according to the treatment settled. Samples of all feeds were taken and oven dried for 65°C for 72h to determine the dry matter percentage of the feeds.

Experimental design and treatments

The experiment was conducted in randomized complete block design (RCBD). Bucks were divided into 4 treatment groups and blocked in 6 by their live weight. Six bucks were randomly allocated to each treatment group on initial body weight basis. Feed allowed were adjusted weekly based on the weight gain of the animal and the *ad libitum* feed. The experiment was undertaken with the following treatments:

- T1=grass hay *ad libitum*+50% WB+50% Noug seed cake
- T2=grass hay *ad libitum*+50% WB+32.5% Noug seed cake+17.5% pigeon pea hay
- T3=grass hay *ad libitum*+50% WB+17.5% Noug seed cake+32.5% pigeon pea hay
- T4=grass hay *ad libitum*+50% WB+50% pigeon pea leaf hay on DM base.

Digestibility trial

The digestibility was done after the feeding trial completed. Samples of feces were dried and milled using a cross-beater mill through 1-mm sieve and kept in plastic bottles until analysis. Feces of experimental goats were put in refrigerator for nutrient determination until analysis. The animals were adapted to the attached fecal bags for three days followed by digestibility trial for seven days. The amount of voided feces per goat/day was weighed, subsampled 20% of the daily collected and 10% of the total sample were taken and placed in freezer at -20°C, pending analysis.

Thus, there were a total of 4 composite feed offer samples from each ingredient and from formulated feed and 4 refusal samples, which were collected from each animal separately and pool per treatment. The apparent digestibility coefficient (DC) was calculated as:

$$\text{Apparent Digestibility (\%)} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times 100$$

Cost benefit analysis

Before slaughtering of goats selling price of experimental goats were estimated and market price of goat meat was collected for the estimation of their selling price. The average market price used to find out the market values for the different treatment groups. Wheat bran, noug seed cake goat purchasing and pigeon pea collection and preparation cost considered as a variable cost for cost benefit analysis. The profit analyzed using the following equation [15]:

$$\Delta NI = \Delta TR - \Delta VC$$

where: NI=net income; T=total return; VC=variable cost.

Carcass evaluation

Carcass evaluation was done after the feeding and digestibility trials were done. All goats devoid of experimental feed for 16 hours weighed and slaughtered for carcass analysis. All goats were slaughtered for assessing carcass characteristics. Prior to slaughter, body weight was measured to determine the slaughter weight. The weights of edible and non-edible components of BW were recorded. Empty BW of each animal was determined by subtracting the weight of gut content from the slaughter weight. Dressing percentage was calculated as proportion of hot carcass weight to slaughter and empty BW. Hot carcass weight was computed by excluding the contents of thoracic, abdominal, and pelvic cavities, head, skin with feet, and tail of the animal. Each carcass was cut between the 12th and 13th ribs perpendicular to the backbone to measure the cross sectional area of the rib-eye muscle area.

Measurements and data collection

Intake, initial body weight, weekly body weight, final weight, necessary carcass measurement parameters, costs were collected and economic analysis was done to determine cost-effectiveness of the ration and economic return from forage based fattening. At the end of digestibility trial all goats were slaughtered based on the standard for carcass analysis. The supplementations were continued until all of the treatment group animals' attained live weight within the range of 25-30 kg [16]. The total amounts of feed offered and refused were daily measured to determine the quantity of feed intake throughout the experimental period.

Every morning the refusals were collected, weighed on individual bases; and the sample were bulked for laboratory analysis. During the feeding trial, body weight (BW) was measured every 7 day interval with suspended weight balance of 200 g precision after before the morning feed was offered. Feed conversion efficiency was calculated as the proportion of daily weight gain in gm and feed intake in gm. At the end of feeding trial, the value of each animal was estimated at the prevailing market price.

Feed chemical analysis

Before the treatment started for treatment adjustment and after the trail done feed chemical analysis for nutrient intake and digestibility. Samples of feed offered and refusals and feces were subjected to the analysis of DM, ash, and nitrogen [17] as well as neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) by the methods of [18]. The CP content was calculated by multiplying nitrogen content with a factor 6.25.

Statistical analysis

Table 1. Chemical composition (%) of experimental feeds used in the current study

Experimental feeds	DM	Ash	CP	NDF	ADF
Grass hay	89	12.3	9.6	64.44	30.2
Pigeon pea	89	10.1	24.5	53.33	29.29
Wheat bran	88	9.1	15.9	30.14	23.64
Nouge seed cake	89	10.1	31.9	42.2	30.27

DM=dry matter, CP=crude protein, NDF=neutral detergent fibre, ADF=acid detergent fibre

Dry matter and nutrient intakes

There were significant ($P<0.05$) differences in dry matter intake (DMI), crude protein, neutral detergent fiber and acid detergent fiber intake among the treatments (Table 2). The highest average DMI per day was recorded for T3 (902.3 g/Kg DM).

Data set from feed intake, body weight changes and carcass measurements in each treatment was analyzed using [19]. If there was significant difference between treatments at $P<0.05$, mean separation among treatments were done using the Tukey HSD Tests.

The model used was:

$$Y_{ijk} = \mu + B_i + T_j + e_{ijk}$$

where; Y_{ijk} =response variables such as average daily gain (ADG), DM intake, feed conversion efficiency (FCE), profits; μ =overall mean; B_i =block effect; T_j =effect of the j th dietary treatment; e_{ijk} =random error.

3. Results and discussion

Chemical composition of feeds

The chemical composition of grass hay and the supplements used in the current study was shown in Table 1. The concentrate feeds were low in fiber, rich in CP. The ADF and NDF content of wheat bran were lower than any of the other ingredients used to formulate the supplemental diet.

Dry matter and nutrient digestibility

Apparent DM digestibility coefficient (% DM) of Central Highland goat fed on a basal diet of grass hay and supplemented with pigeon pea leaves and concentrate mix was presented in Table 3. T2, T3 and T4 had higher CP, NDF and ADF apparent digestibility over T1 goat.

Table 2. Effect of experimental diets on feed intake (g/day) and growth performance of goats

Parameters	T1	T2	T3	T4	SEM	SL
T DMI (g)/d/head	722.2 ^b	783.3 ^b	902.3 ^a	786.4 ^b	22.48	***
TCPI (g)/d/head	119.0 ^c	142.6 ^b	160.5 ^a	139.2 ^b	5.28	***
T NDFI (g)/d/head	474.8 ^c	535.5 ^b	611.7 ^a	582.7 ^a	22.73	***
TADFI (g)/d/head	266.7 ^b	332.0 ^a	335.6 ^a	342.0 ^a	9.58	***
Initial Wt (kg)	21.6	21.2	21.3	21.6	1.12	ns
Final Wt (kg)	25.2	25.5	28.6	26.2	1.26	ns
Total Gain (kg)	3.0 ^b	4.9 ^{ab}	6.5 ^a	3.9 ^b	0.69	*
ADG (g)/d/head	35.7 ^b	58.5 ^{ab}	77.8 ^a	47.0 ^b	8.28	*
FCE	6.77	5.95	7.64	3.90	1.24	ns

^{ab} means within a row not bearing a similar superscript letter significantly differ. *=(P<0.05); **=(P<0.01); NS=not significant; SEM=standard error of the mean; SL=significant level; T1=grass hay ad libitum+100% Noug seed cake, T2=grass hay ad libitum+65% Noug seed cake+35% pigeon pea hay, T3= grass hay ad libitum+35% Noug seed cake+65% pigeon pea hay, T4=grass hay ad libitum+100% pigeon pea leaf hay on DM base; DMI=Dry Matter Intake, CPI=Crude Protein Intake, NDFI=Neutral Detergent Fiber, ADFI=Acid Detergent Fiber, ADG=Average Daily Gain and FCR=Feed Conversion Ratio.

Table 3. Effect of dietary treatments on DM nutrient digestibility on Central Highland goat fed on a basal diet of grass hay and supplemented with pigeon pea leaves and concentrate mix

Digestibility (%)	T1	T2	T3	T4	SEM	SL
DM	67.95	67.72	70.50	69.27	0.83	ns
CP	68.09 ^b	71.24 ^a	72.44 ^a	72.54 ^a	1.09	*
NDF	62.64 ^b	67.91 ^a	67.81 ^a	68.94 ^a	1.06	***
ADF	53.24 ^c	63.32 ^a	58.61 ^b	60.83 ^{ab}	1.37	***

^{A, b, c} means within a row not bearing a similar superscript letter significantly differ. *=(P<0.05); **=(P<0.01); ns=not significant; SEM=standard error of the mean; SL=significant level; T1= grass hay ad libitum+100% Noug seed cake, T2=grass hay ad libitum+65% Noug seed cake+35% pigeon pea hay, T3=grass hay ad libitum+35% Noug seed cake+65% pigeon pea hay, T4=grass hay ad libitum+100% pigeon pea leaf hay on DM base.

Weight gain and feed conversion efficiency

There was a significant difference (P<0.05) among treatments on average daily weight gain and total weight change in the present study (Table 2). T3 gained the highest ADG and TWG, which was 77.8 g/day and 6.5 kg/84 days, respectively it may be due to higher DM and CP intake recorded under this treatment.

Carcass characteristics

All Caracac parameters statically had no significant difference (p>0.05) (Table 4). However, the result revealed that Slaughter weight (SW), Hot Carcass Weight (HCW) and Empty Body Weight (EBW) of Central Highland goats feed pigeon pea and concentrate mix result were comparable and greater than other similar studies in Ethiopia.

Table 4. Carcass characteristics of Central highland goat feed pigeon pea and concentrate mix

Parameters	T1	T2	T3	T4	SEM	SL
Hind quart (kg)	4.2	4.4	4.6	4.5	0.22	ns
Fore quart (kg)	6.2	6.2	7.2	6.4	0.48	ns
Leg (kg)	3.5	3.6	3.8	3.7	0.21	ns
Loin (kg)	0.76	0.78	0.80	0.75	0.06	ns
Leg+Shoulder+Neck (kg)	4.2	4.1	4.7	4.2	0.32	ns
Rib+Chest (kg)	2.1	2.1	2.4	2.2	0.19	ns
Thin cut (g)	684.5	645.5	629.2	568.2	54.78	ns
Rib eye area (cm ²)	11.3	11.4	11.2	12	6.88	ns

Means within a row not bearing a similar superscript letter significantly differ. *=(P<0.05); **=(P<0.01); ns=not significant; SEM=standard error of mean; SL=significant level; T1=grass hay ad libitum+100% Noug seed cake, T2=grass hay ad libitum+65% Noug seed cake+35% pigeon pea hay, T3= grass hay ad libitum+35% Noug seed cake+65% pigeon pea hay, T4=grass hay ad libitum+100% pigeon pea leaf hay on DM base.

Non-carcass components

Table 5 shows non-carcass components of Central Highland goats fed pigeon pea leaves and concentrate mixture. The effects of feeding pigeon

pea and concentrate mix were no significant difference ($p>0.05$) for all non-carcass/offal parameters except blood, which was recorded 1042 g (T1) and 1036 g (T3).

Table 5. Non carcass components of Central Highland goats fed pigeon pea and concentrate mix under intensive management

Parameters	T1	T2	T3	T4	SEM	SL
Edible offal						
Kidney (g)	77.7	87.1	82.7	83.7	19.93	Ns
Head (g)	1449.5	1365.8	1548.8	1505.8	71.65	Ns
Liver with bile (g)	536.8	544.2	534.6	469.7	28.67	Ns
Heart (g)	131.0	130.6	143.2	122.1	8.48	Ns
Empty gut (g)	825.8	867.6	857.5	846.4	29.09	Ns
Blood (g)	1042.5 ^a	969.1 ^{ab}	1036.5 ^a	898.9 ^b	37.02	*
Total edible offal	4063.3	3964.5	4203.4	3976.7	0.182	Ns

^{ab}means within a row not bearing a similar superscript letter significantly differ. *=($P<0.05$); **=($P<0.01$); ns=not significant; SEM=standard error of mean; SL=significant level; T1= grass hay ad libitum+100% Noug seed cake, T2=grass hay ad libitum+65% Noug seed cake+35% pigeon pea hay, T3=grass hay ad libitum+35% Noug seed cake +65% pigeon pea hay, T4=grass hay ad libitum+100% pigeon pea leaf hay on DM base.

Number of days required to attain market weight and economic analysis

The study revealed that Central highland goat managed under intensive management achieved market weight requirement within 84 days of feeding trail followed 15-day adaptation of newly introduced feed.

The chemical composition of grass hay, which was harvested from the research center pasture land, contained relatively better quality which contained CP higher than the minimum of 70 g/kg DM, CP required to support optimal microbial activity in the rumen [20]. The CP content of the grass hay is comparable with the report of [21], which was recorded 9.9 to 10.1%. But Noug seed cake contains higher Cp content 31.9% than the report of [21] which was reported 28.9%. Based on its CP content, the grass hay used in this experiment could support adequate rumen microbial function or maintenance requirement of an adult ruminant and may also support optimum DM intake, since roughage feeds with more than 70–80 g CP/kg DM do not depress intake and digestibility of feeds [22].

The higher crude protein intake also recorded under T3 (160.5g). Goats used this study daily consume a higher dry matter amount which was compared Nutrient intakes were of experimental goats shown an increment until the protein supplement Noug with a similar study done on three Ethiopia indigenous goat feed hay and

concentrate mixture [20]. The present study confirmed that daily DMI proportion to live weight of the Central Highland goat was within the range of 2.6–3.2% reported for Small East African goat and their crosses with Norwegian goat fed hay and supplemented with concentrate[23]. Average DMI (902.3 g) per day was greater than the result obtained from Boer x Woyto-Guji Crossbred Goats supplement with Commercial Concentrate with *Acacia nilotica* Pod Meal which was recorded 822.09 g [24].

On the other hand, this study confirmed that dried pigeon pea leaves had a potential to substitute noug seed cake up to 65%; which was agreed with other studies in Ethiopia supplementation of dried pigeon pea leaves has resulted in an increase in weight gain of kids [25]. The DM digestibility in this study were 67.72–70.50%, which was agreed with the study reported on Boer x Woyto-Guji Crossbred Goats supplemented with *Acacia nilotica* Pod Meals within the range of 45.02–69.89% [24]; but this study obtained better DMD% than the report on the Napier supplement with molasses protected palm kernel cake and soya waste four goat 64.1% (Mohammed et al. 2013). However, the cp (71.24-72.54) digestibility was smaller than the result reported from Boer x Woyto-Guji Crossbred Goats supplemented with *Acacia nilotica* Pod Meals (83.06) which was reported by [24] and for Central Highland goat fed concentrate mix which was 74.9 [26].

This study confirmed that Central highland goats gain a best average daily BW when compared with similar breed treated under the supplement of concentrate feed were recorded 54.0 g/day and 32.1 g/day for 50% Boer goat cross with CHG and pure CHG, respectively [26]. In addition, the result was higher than the previous study 42.1 g/day reported for central highland goat feed concentrate mixture [20] which was reported ADG 33–49 g/day for Harrege Highland goats fed different levels of leftover khat. Better performance in daily BW gain in goats supplemented with concentrate might be due to higher CP intake from the supplements [21].

The total body weight change recorded through 84 day feeding period in the current study was at T3 (6.5 kg); which was in line with the result obtained from Boer x Woyto-Guji Crossbred Goats supplemented with *Acacia nilotica* Pod Meals was of 6.25 kg [24]. Feed Conversion Efficiency (FCE) of Central Highland goats treated under this study was no significant difference between treatments ($P>0.05$). The result of this study contained FCE ranges from 3.9 to 7.64 which were within the range of 3.7-7.8 [27].

According to Belay and Mengestie (2013) [28], Central Highland goat feed concentrates mix gained HCW (12.5 kg) was agreed with the current study (11.1-12.3 kg) but EBW (24.9 kg) gained were greater than the current study (20.42-22.28 kg). The effects of concentrate and pigeon pea dried leaves had no significant effect on DP when expressed as percentage of empty and slaughter weight. The average DP as percentage of empty weight of Central Highland goats in this study (54.25-54.94) was comparable to the report of [20] three Ethiopian indigenous goat breeds fed concentrate mix which recorded within the range of 51.2-54.4%, but greater than 49.3-51.2 and 40.5 for Sidama and Central Highland goats, respectively [21, 28].

Rib eye area of the current study was higher than the report of Central highland goat Bati type feed concentrate mix (6.9 cm²).

According to the report of [20], larger rib-eye area is associated with higher production of lean in the carcass and higher lean to bone ratio. This indicates high proportion of lean in the current carcass. The number of days goats took to reach disagreed with the result of intact yearling afar

goats under semi-intensive feeding management supplemented with concentrate mix and lucinea leaf which needs 168 days [16] fed the same breed. This may be due to small feed intake, the difference in nutrient composition and different management system. But this result agreed with most of feeding trial done on most goat breeds for instant [28]; they reported goat attained market weight within 84 days.

The net income calculated from the total cost and total revenue obtained from the sale of goat. Feeding of yearling Central Highland goat with a proportion of 65% dried pigeon pea leaves and 35% of Noug seed cake as a protein source and wheat bran as an energy source for grass hay as a basal diet, confirmed that the highest net income was recorded (254.84 ETB); which was comparable with fattening Afar goat kids by supplementing 25% wheat bran and 75% *Leucaena* leaf, hay mixture after grazing brought the highest net income (244.45 ETB) [16]. The non-edible carcass components result was comparable with the result of similar breed feed concentrate mix 1010 g [26].

4. Conclusions

The study confirms that Central Highland goats managed under intensive condition fed a maximum 3.1% DM of their body weight daily. So, goats fed higher energy levels recorded higher weights and carcass yields. Central highland goat recorded under this study was under recorded acceptable rib eye area which indicates a quality carcass production. Based on the current finding, Central Highland Goat supplement with 65% of pigeon pea and 35% of Noug seed cake as protein supplement mix with wheat bran, which contribute 50% from daily supplementation requirement, should be recommended. It is better to carry out an onfarm trial using the above feeding regime to exploit the potential of Central Highland Goats in the area. Further research on meat quality analysis should done for goats fed hay as a basal diet and supplement with pigeon pea dried leaves.

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