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REGULAR ARTICLES

# Body weight change of Abergelle breed and Abergelle crossbred goats fed hay supplemented with different level of concentrate mixture

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## Abstract

The experiment was conducted at Sekota District using 36 intact yearling males of pure Abergelle breed and Abergelle crossbred goats (50%) with a mean live weight of 18.92 ± 0.72 kg (mean ± SE). The objective of the experiment was to evaluate the effect of different levels of concentrate mixture supplementation on feed intake, live weight gain, and economic gain of the breeds. Goats were blocked based on initial body weight and were randomly assigned to the dietary treatments. The experimental design was a 2 × 3 factorial in RCBD (randomized complete block design). The treatments included ad libitum feeding of local grass hay and supplementation with three levels (184, 368, and 552 g/day) of concentrate mixture. The experiment consisted of 90 days of feeding. Daily, total dry matter and CP (crude protein) intakes were affected by diet and genotype ($P < 0.01$). Significant decrease ($P < 0.001$) in hay intake was observed as the level of the supplement increased. Besides, substitution rate increased with increasing levels of supplementation. Average daily body weight gains were significantly impacted only by diet. Animals fed on 184 significantly lower weights, while nonsignificant difference was observed in live weight gain between 368 and 552 supplemented group. Supplementation of 368 concentrate mix significantly improved ($P < 0.05$) feed intake, daily weight gain, and feed conversion efficiency. Supplementation of 368 g/day had showed significantly higher net return for both goat breeds. However, the Abergelle breed was significantly better in net profit and sensitivity than the crossbreed. Both genotypes performed better with the diet containing 368 g/day than that with 184 and 552 g/day of concentrate supplementation.

**Keywords** Concentrate · Body weight · Abergelle · Barka · Goat

## Introduction

Sekota District is known by its goat production potential and as a regional government which categorizes to specialize on goat production. The feeding of livestock, mainly goats, which is based exclusively on range land, only allows their maintenance requirements, but in Sekota District, the presence of inconsistent and erratic rainfall distribution made feed availability and quality to be the bottlenecks for the livestock sector causing a regular suffer in scarcity of feed and large losses (50% deficient of their requirement). Consequently, in order to reach income levels of production, it is necessary to supplement animals that supply energy and protein to maintain milk and meat production at an income level.

Barka goat breed which are known in their fast growth and high milk yield have been introduced in lowland areas of Sekota District. Belay and Bewketu (2010) noted similar growth performance between Barka × Abergelle cross (50%) and Abergelle goat under on-farm condition. But two genotypes have not been compared and characterized in terms of growth, carcass, and meat quality under improved management, i.e., under concentrate supplementation and confined housing. Moreover, farmers and agricultural office experts perceive that Abergelle goats were not suitable for fattening and have low feed conversion efficiency. There is also no concentrate recommendation for both goat breed, and effect of breed and supplementation with concentrate mix on growth has not been done before. Therefore, this study was designed to alleviate the above problems with the objectives to valuate feed intake and body weight change of pure Abergelle breed and

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Abergelle-Barka crossbred goats consuming basal local grass hay and supplemented with different levels of concentrate mixture and to determine the economic feasibility.

## Material and method

### Study area

The study was conducted in Sekota District, Aybera site of Sekota Dryland Agricultural Research Center. The altitude of the research site ranges from 1340 to 2200 m above sea level (ZAD 1995). Annual rainfall ranges between 350 and 700 mm.

### Feeds and feeding management

Local hay was purchased from the farmers and manually chopped to a size of 3–4 cm to minimize selective feeding. The local grass hay was composed of *Cynodon dactylon* (locally called *Serdo*), *Hyperrhenia rufa* (locally called *yebetkidan sar*), and *Guizotia abyssinica* (locally called *Senbelet*) grass species. The concentrate feed was formulated by Akaki animal feed production private limited company which is located in Addis Ababa, Ethiopia. Local grass hay was fed at rate of 20% refusal of the previous day offer to ensure ad libitum feeding. The supplementary concentrate feeds (184, 368, and 552 g/day) were divided in two equal parts and were offered half at 8:00 a.m. in the morning and the rest half at 4:00 p.m. in the afternoon. These three supplementary concentrate feeds were offered as dry matter basis. All goats had free access to water and common salt (NaCl). The chemical compositions of the local grass hay and concentrate mixtures are indicated in Table 1.

### Experimental animals and their management

From each genotype, 18 intact yearlings of Abergelle and Abergelle-Barka cross (50%) goats were purchased from the market, with age based on dentition and the information obtained from the owners. During the quarantine period, the animals were dewormed with a broad-spectrum anti-helminthic (albendazole), sprayed with acaricide (diazzinole), and vaccinated against anthrax and pasteurelosis.

**Table 1** Chemical compositions of local grass hay and concentrate mixtures (g/kg)

| Type of feed | DM | OM | CP | NDF | ADF | ASH |
|---|---|---|---|---|---|---|
| Local grass hay | 900 | 800 | 79 | 620 | 420 | 100 |
| Concentrate mix | 920 | 830 | 159 | 236 | 170 | 90 |

*DM* dry matter, *OM* organic matter, *CP* crude protein, *NDF* neutral detergent fiber, *ADF* acid detergent fiber

### Experimental design and treatments

The experimental treatment arrangement was a 2 × 3 factorial in a randomized complete block design (RCBD) with six replications. Factor A had two levels which were Abergelle pure breed and Abergelle 50% × Barka 50% crossbreed. Factor B had three levels which were supplementation levels (184, 368, and 552 g) of concentrate. The experimental animals were blocked on the basis of their initial body weights. The average initial body weights of pure Abergelle breed goats were 17.16, 17.72, and 17.4 kg for the supplementation levels of 184, 368, and 552 g, respectively. Similarly, the average initial body weights of the crossbreed goats were 19.97, 19.93, and 21.4 kg for the supplementation levels of 184, 368, and 552 g, respectively (Table 2).

### Feeding trial

The feeding trial lasted 105 days considering a conditioning period of 15 days initially and 90 days trial. The offered feeds and refusals were weighted daily for each goat. A sample of the feed offered was measured once in the week. Body live weight of the goats was measured every 15 days in the morning when goats had no access to feed. Average daily weight gain was calculated as the difference between final and initial body live weight divided by 90 days. Feed conversion efficiency was calculated by average daily gain (ADG) divided by daily total DM intake.

### Chemical analysis

The samples were mixed and taken to Debri Birhan Agricultural Research Center and partially dried at 60 °C in air-forced oven for 72 h and ground to pass through a 1-mm sieve and kept in airtight containers until chemical analysis. The ground samples were analyzed for DM, ash and nitrogen (N) by the procedure of AOAC (1990), and neutral and acid detergent fiber (ADF) by Van Soest et al. (1991).

### Economic analysis

Partial budget analysis was performed using the procedure of Upton (1979). The costs of depreciation of barn, utensils, and the value of dung were not included. The feed, hired labor, load and unload, transport, and medicament costs were considered as total variable cost. Net return was calculated by subtracting total variable cost (TVC) from total return (TR). Marginal rate of return (MRR) measures the increase in net return (ΔNR) associated with each additional unit of expenditure (ΔTVC). The MRR was calculated by dividing the unit

**Table 2** Experimental treatments

| Treatments | Breed | Concentrate mix level | Basal diet |
|---|---|---|---|
| 1 | Abergelle | 184 g | Ad libitum local grass hay |
| 2 | Abergelle | 368 g | Ad libitum local grass hay |
| 3 | Abergelle | 552 g | Ad libitum local grass hay |
| 4 | Abergelle × Barka cross (50%) | 184 g | Ad libitum local grass hay |
| 5 | Abergelle × Barka cross (50%) | 368 g | Ad libitum local grass hay |
| 6 | Abergelle × Barka cross (50%) | 552 g | Ad libitum local grass hay |

The species composition of the local grass hay was *Cynodon dactylon*, *Hyparrhenia rufa*, and *Guizotia abyssinica*

of change of net return (ΔNR) to the unit of change of expenditure (ΔTVC). Sensitivity analysis was also done to capture the likely change in prices of input (feed) and fattened goat.

### Statistical analysis

Data were analyzed using the General Linear Model procedure of SAS (2002). Means were compared by Duncan's Multiple Range Test (Duncan 1955). Index was also used for identifying of preferred treatment.

The model used was:

$$Y_{ijk} = \mu + T_i + B_k + G_j + T^*G_{ij} + e_{ijk.}$$

where

| | |
|---|---|
| $Y_{ijk}$ | Response variable |
| $\mu$ | Overall mean |
| $T_i$ | Concentrate effect (3 levels) |
| eijk | Residual error |
| $B_k$ | Block effect (3 blocks) |
| $G_j$ | Effect of breed |
| $T^*G_{ij}$ | Interaction effect of breed and concentrate |

## Results

### Chemical composition of treatment feeds

The crude protein (CP) content of the concentrate mix and the local grass hay were 159 and 79 g/kg, respectively. The chemical compositions of the local grass hay and concentrate mixture feeds are indicated in Table 1.

### Feed intake

The genotype and level of concentrate supplementation had significant effect ($P < 0.05$) in all parameters measured (Tables 3 and 4). The supplement dry matter intake (compared to the total dry matter intake) of the concentrate feed levels of 184, 368, and 552 g/day were 25.3, 41.4, and 56.8%, respectively, for the pure Abergelle breed goats. Similarly, for the crossbred goats were 23.98, 40.1, and 55.8%, respectively.

### Live body weight change

Final body weight, feed conversion efficiency, and feed conversion ratio were significantly affected ($P < 0.001$) by

**Table 3** Dry matter intake (g/day) of pure Abergelle and Abergelle-Barka crossbred goats

| Variables | Genotype | Level of supplementation | | | Genotype | | Significance level | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 184 g (±SD) | 368 g (±SD) | 552 g (±SD) | Abergelle (±SD) | Cross (±SD) | Diet | Genotype | Interaction |
| Hay DM intake | Abergelle | $541^{a}_{(\pm 94)}$ | $515^{a}_{(\pm 94)}$ | $366^{b}_{(\pm 94)}$ | $474^{b}_{(\pm 94)}$ | $511^{a}_{(\pm 84)}$ | *** | * | NS |
| | Cross | $573^{a}_{(\pm 84)}$ | $546^{a}_{(\pm 84)}$ | $416^{b}_{(\pm 84)}$ | | | *** | | |
| Concentrate DM intake | Abergelle | $183^{c}_{(\pm 151)}$ | $363^{b}_{(\pm 151)}$ | $482^{a}_{(\pm 151)}$ | $343^{b}_{(\pm 151)}$ | $357^{a}_{(\pm 172)}$ | *** | * | NS |
| | Cross | $181^{c}_{(\pm 172)}$ | $365^{b}_{(\pm 172)}$ | $524^{a}_{(\pm 172)}$ | | | *** | | |
| Total DM intake | Abergelle | $725^{b}_{(\pm 81)}$ | $878^{a}_{(\pm 81)}$ | $848^{a}_{(\pm 81)}$ | $817^{b}_{(\pm 81)}$ | $868^{a}_{(\pm 101)}$ | *** | ** | NS |
| | Cross | $753^{b}_{(\pm 101)}$ | $911^{a}_{(\pm 101)}$ | $940^{a}_{(\pm 101)}$ | | | *** | | |
| % of live body weight | Abergelle | $3.5_{(\pm 0.1)}$ | $3.6_{(\pm 0.1)}$ | $3.6_{(\pm 0.1)}$ | $3.6^{b}_{(\pm 0.1)}$ | $3.2^{a}_{(\pm 0.2)}$ | NS | * | NS |
| | Cross | $3.3^{a}_{(\pm 0.2)}$ | $3^{b}_{(\pm 0.2)}$ | $3.2^{ab}_{(\pm 0.2)}$ | | | ** | | |

Means in the same row with different superscripts differ significantly

*NS* not significant, *DM* dry matter

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

**Table 4** Nutrient intake (g/day) of Abergelle breed and Abergelle × Barka crossbred goats

| Variables | Genotype | Level of supplementation | | | Genotype | | Significance level | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 184 g/day (±SD) | 368 g/day (±SD) | 552 g/day (±SD) | Abergelle (±SD) | Cross (±SD) | Diet | Genotype | Interaction |
| CP intake in hay | Abergelle | $43^{a}_{(\pm 8)}$ | $41^{a}_{(\pm 8)}$ | $29^{b}_{(\pm 8)}$ | $37^{b}_{(\pm 8)}$ | $40^{a}_{(\pm 6)}$ | *** | * | NS |
| | Cross | $45^{a}_{(\pm 6)}$ | $43^{a}_{(\pm 6)}$ | $33^{b}_{(\pm 6)}$ | | | *** | | |
| CP intake in concentrate | Abergelle | $29^{c}_{(\pm 24)}$ | $58^{b}_{(\pm 24)}$ | $77^{a}_{(\pm 24)}$ | $55^{b}_{(\pm 24)}$ | $57^{a}_{(\pm 28)}$ | *** | * | NS |
| | Cross | $29^{c}_{(\pm 28)}$ | $58^{b}_{(\pm 28)}$ | $83^{a}_{(\pm 28)}$ | | | *** | | |
| Total CP intake | Abergelle | $72^{c}_{(\pm 18)}$ | $98^{b}_{(\pm 18)}$ | $106^{a}_{(\pm 18)}$ | $92^{b}_{(\pm 18)}$ | $97^{a}_{(\pm 21)}$ | *** | *** | NS |
| | Cross | $74^{c}_{(\pm 21)}$ | $101^{b}_{(\pm 21)}$ | $116^{a}_{(\pm 21)}$ | | | *** | | |
| % of live body weight | Abergelle | $3.5_{(\pm 0.1)}$ | $3.6_{(\pm 0.1)}$ | $3.6_{(\pm 0.1)}$ | $3.6^{b}_{(\pm 0.1)}$ | $3.2^{a}_{(\pm 0.2)}$ | NS | * | NS |
| | Cross | $3.3^{a}_{(\pm 0.2)}$ | $3^{b}_{(\pm 0.2)}$ | $3.2^{ab}_{(\pm 0.2)}$ | | | ** | | |

Means in the same row with different superscripts differ significantly

*NS* not significant, *CP* crude protein

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

genotype (Table 5). However, initial body weight, total gain, and average daily gain were not significantly affected ($P > 0.05$) by genotype. Total weight gain and average daily gain were significantly increased ($P < 0.01$) as the feed amount increased from 184 to 368 g as DM basis, but there was no significant difference when increased to 552 g as DM basis for both breeds (Table 5). Thus, 368 g concentrate per day per head was the optimum level of supplement for fattening for the two breeds (Figure 1).

## Regression analysis

The regression between ADG and daily crude protein intake (DCPI) of the two goat breeds was found to be linear (Figs. 2 and 3). The $R^2$ of ADG and DCPI for pure Abergelle breed was 0.72 and for the crossbreed was 0.60 which indicates that there is a high correlation between ADG and DCPI for both breeds of goats. The slope of the regression analysis shows purebred (0.5974) has shown better performance in the feed utilization (better in feed conversion efficiency and percentage of live body weight change) than crossbred goats (0.3244). The relationship between ADG and DCPI was found to be highly significant ($P < 0.001$) for Abergelle goat breed. Similarly, the relationship between ADG and DCPI for crossbred goat had shown a significant difference ($P < 0.05$).

## Economic analysis of the feeding trials

Economic analysis (per goat) for pure Abergelle and Abergelle × Barka (50%) cross goats is reported in Table 6. The net return from the pure breed goat was 0.7 USD per head more than the crossbred goats.

**Table 5** Live body weight change of pure Abergelle and Abergelle × Barka (50%) crossbred goats

| Variables | Genotype | Supplementation level | | | Genotype | | Significance level | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 184 g/day (±SD) | 368 g/day (±SD) | 552 g/day (±SD) | Abergelle (±SD) | Cross (±SD) | Diet | Genotype | Interaction |
| Initial weight (kg) | Abergelle | $17.16^{a}_{(\pm 0.3)}$ | $17.72^{a}_{(\pm 0.3)}$ | $17.40^{a}_{(\pm 0.3)}$ | $17.42_{(\pm 0.3)}$ | $20.43_{(\pm 0.8)}$ | NS | NS | NS |
| | Cross | $19.97_{(\pm 0.8)}$ | $19.93_{(\pm 0.8)}$ | $21.4_{(\pm 0.8)}$ | | | NS | | |
| Final weight (kg) | Abergelle | $20.83^{b}_{(\pm 1.9)}$ | $24.40^{a}_{(\pm 1.9)}$ | $23.76^{a}_{(\pm 1.9)}$ | $22.99^{b}_{(\pm 1.9)}$ | $27.12^{a}_{(\pm 1.3)}$ | ** | *** | NS |
| | Cross | $24.63^{b}_{(\pm 1.3)}$ | $27.37^{ab}_{(\pm 1.3)}$ | $29.38^{a}_{(\pm 1.3)}$ | | | * | | |
| Total gain (kg/90 days) | Abergelle | $4.33^{b}_{(\pm 1.3)}$ | $6.68^{a}_{(\pm 1.3)}$ | $6.36^{a}_{(\pm 1.3)}$ | $5.79_{(\pm 1.3)}$ | $6.68_{(\pm 1.8)}$ | * | NS | NS |
| | Cross | $4.67^{b}_{(\pm 1.8)}$ | $7.4^{a}_{(\pm 1.8)}$ | $7.98^{a}_{(\pm 1.8)}$ | | | * | | |
| Average daily gain (g/days) | Abergelle | $48.14^{b}_{(\pm 14)}$ | $74.22^{a}_{(\pm 14)}$ | $70.66^{a}_{(\pm 14)}$ | $64.34_{(\pm 14)}$ | $74.37_{(\pm 20)}$ | * | NS | NS |
| | Cross | $51.85^{b}_{(\pm 20)}$ | $82.59^{a}_{(\pm 20)}$ | $88.67^{a}_{(\pm 20)}$ | | | * | | |
| Feed conversion efficiency | Abergelle | $0.089^{b}_{(\pm 0.1)}$ | $0.143^{a}_{(\pm 0.1)}$ | $0.194^{a}_{(\pm 0.1)}$ | $0.142^{a}_{(\pm 0.1)}$ | $0.084^{b}_{(\pm 0)}$ | ** | *** | NS |
| | Cross | $0.068_{(\pm 0)}$ | $0.09_{(\pm 0)}$ | $0.096_{(\pm 0)}$ | | | NS | | |
| Feed conversion ratio | Abergelle | $10.83^{a}_{(\pm 2.8)}$ | $7.12^{b}_{(\pm 2.8)}$ | $5.23^{b}_{(\pm 2.8)}$ | $7.7^{b}_{(\pm 2.8)}$ | $12.86^{a}_{(\pm 2.9)}$ | ** | *** | NS |
| | Cross | $16.2_{(\pm 2.9)}$ | $11.51_{(\pm 2.9)}$ | $10.89_{(\pm 2.9)}$ | | | NS | | |

Means in the same row with different superscripts differ significantly

*NS* not significant

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

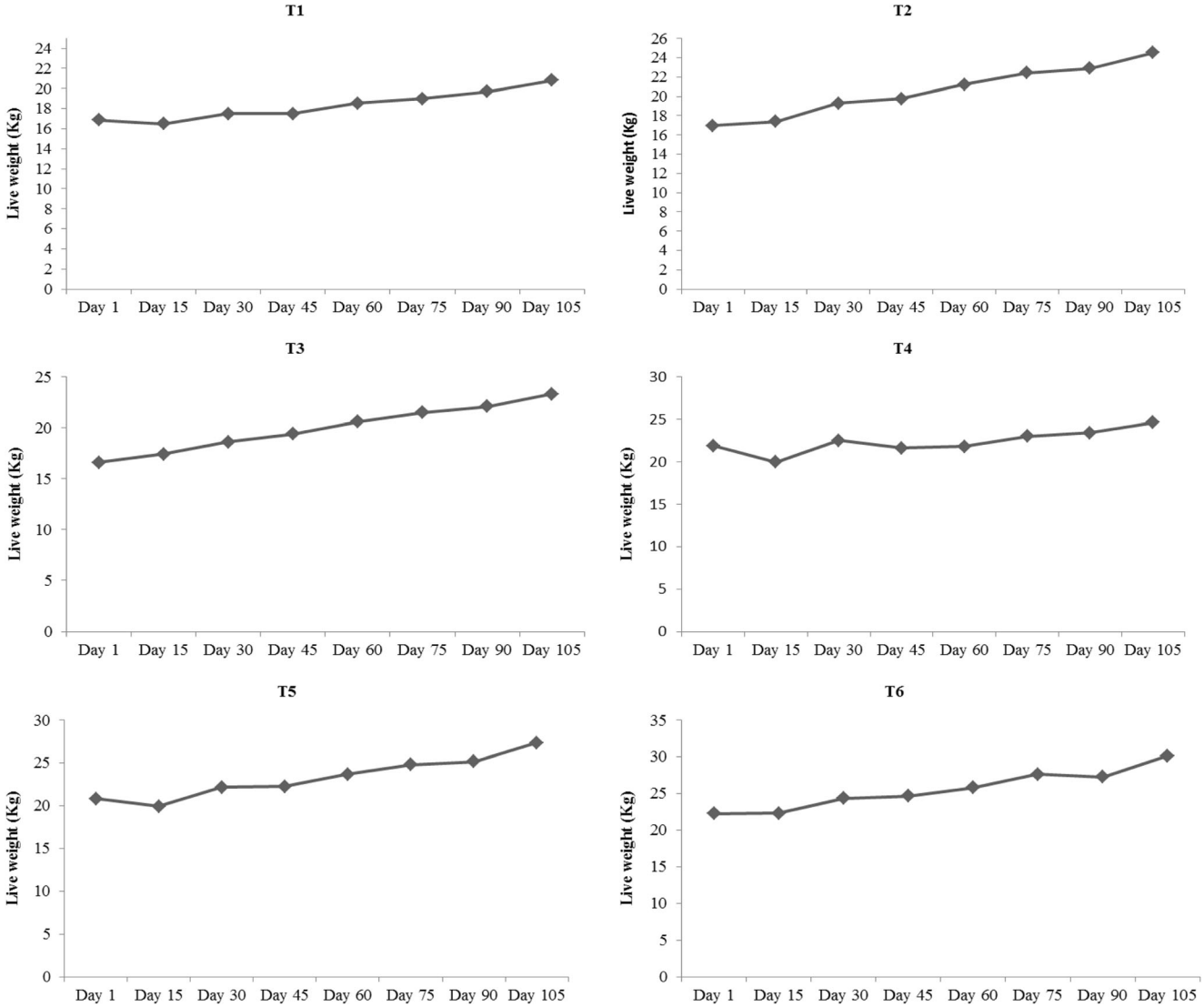


**Fig. 1** Live body weight of Abergelle and Abergelle × Barka (50%) cross goats across the feeding period for each of the feed treatments. T1 Abergelle goat breed fed with 184 g/day ($\mu \pm SD = 18.3\ kg \pm 1.49$), T2 Abergelle goat breed fed with 368 g/day ($\mu \pm SD = 20.6\ kg \pm 2.68$), T3 Abergelle goat breed fed with 552 g/day ($\mu \pm SD = 19.9\ kg \pm 2.34$), T4 Barka × Abergelle crossbred goat fed with 184 g/day ($\mu \pm SD = 22.4\ kg \pm 1.39$), T5 Barka × Abergelle crossbred goat fed with 368 g/day ($\mu \pm SD = 23.3\ kg \pm 2.46$), T6 Barka × Abergelle crossbred goat fed with 552 g/day ($\mu \pm SD = 25.6\ kg \pm 2.73$). Where $\mu$ = mean weight of each weight day the goats and SD = standard deviation

## Discussion

### Chemical composition of treatment feeds

The CP content of the concentrate mix was 15.9% of DM, which was lower than CP content reported by Belay (2008) and Ameha et al. (2008), 23.63% and 21.6%, respectively. This is because of high proportion of corn and wheat bran in the ration preparation of the factory.

The local hay CP content was similar to Daubenmire (1972) reported CP content of natural stands of *Hyperrhenia rufa* (7.4%). It is higher than the CP content reported by Lulseged and Jamal (1989) which is 6.6% in the Ethiopian highlands. The CP content of the local grass hay fulfills the minimum requirement for optimum rumen function (7%) (Van Soest 1982).

### Feed intake

The supplement DM intake of 184, 368, and 552 g/day were 25.3, 41.4, and 56.8% (purebred) and 23.98, 40.1, and 55.8% (crossbred) of total dry matter intake, respectively. Indeed, Topps (1997) indicated there is an increase in basal diet intake, as supplement is less than 30–40% of the total DM intake. Accordingly, in the current study,

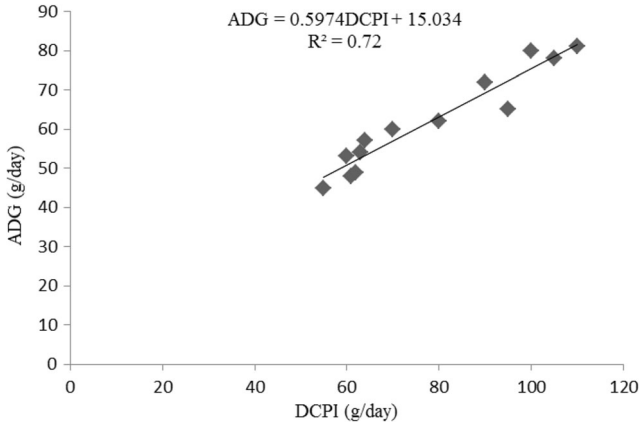


**Fig. 2** Regression of DCPI on ADG of Abergelle goat breed supplemented with graded levels of concentrate. The mean daily weight gain and standard deviation for each daily CP intake was 64.34 g (± 14)

there was a reduction in the intake of the basal diet as the concentrate level increased. The finding is in agreement with Marques et al. (2014) who indicate concentrate supplementation increases feed intake of Moxoto goats. In contrast to this finding, there were no effects of diet on DM intake in Omani goats (Mahgoub et al. 2005). Similarly, the current study disagrees with the study of Chanjura et al. (2007) who report there is no significant difference in DM intake among different level of concentrates. In the study, the total DM intake of goats on the basis of the percent of body weight were within the range of indigenous meat goat breeds, 2–6% as reported by ARC (1980). The total DM intake of both breeds was higher than Bati, short-eared Somali, and Hararghe highland breeds as reported by Dereje et al. (2016). The result contrasts with the report of Kumari et al. (2012) who indicated there is no significant difference in feed intake among different level of concentrate supplementation.

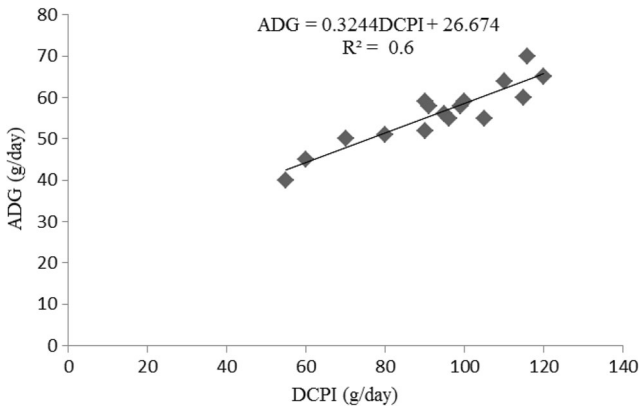


**Fig. 3** Regression of DCPI on ADG of crossbred goat supplemented with graded levels of concentrate. The mean daily weight gain and the standard deviation for each daily CP intake was 74.37 g (± 20)

## Live weight change

The result of the study is in line with Marques et al. (2014) who indicated concentrate supplementation positively influences the performance of the animals, providing greater live body weight gain. The result disagrees with the report of Simret Betsha (2005) that 200 and 400 g/day supplementation is not statistically significant in weight gain of Somali goats. It is lower than pure Mubende goat (90 g/day) in Uganda supplemented 1.4 kg/day of concentrate mix (Denis 2010). Final live weight and ADG attained in this study were higher than yearling Central Highland (18.38 kg and 34.7 g/day) and Afar (17.95 kg and 36.7 g/day) (Ameha et al. 2008). This illustrates the relative potential of Abergelle and Abergelle × Barka crossbred goats as meat-producing animals.

The percentage of live body weight change of Abergelle breed goat was significantly higher ($P < 0.05$) than Abergelle × Barka crossbred goat. This is in line with Dereje et al. (2016) who indicated small-eared Somali goats, though smaller in size, are capable of producing comparable weight gain compared to Bati goats. The total live weight gain and average daily live weight gain were not significantly affected ($P > 0.05$) by genotype. The extra weight gain of Abergelle × Barka crossbred goats over Abergelle goats might be due to their increased DM and protein intakes. This agrees with the report of Zahraddeen et al. (2008) who indicated the daily weight gain of Red Sekoto, Sahel, and West African dwarf goat breeds revealed non-significant breed effect. It is also supported by the findings of Lu and Potchoiba (1990) who reported ADG was similar between Alpine and Nubian goat breeds.

## Regression analysis

The $R^2$ of ADG and DCPI for pure Abergelle breed was 0.72, and for the crossbreed was 0.60 which indicates the correlation displayed between ADG and DCPI was high for both breeds of goats. The relationship between ADG and DCPI was highly significant for Abergelle breed ($P < 0.001$) and significant for crossbred goat ($P < 0.05$). The pure breed was better correlated with DCPI than crossbreed since the $R^2$ for pure breed ($R^2 = 0.72$) is higher than the crossbred ($R^2 = 0.60$). This result is similar with the report of Abebe (2011).

The slope of the regression analysis showed purebred goats (slope—0.5974) was better performed in feed utilization (better in feed conversion efficiency and percentage of live body weight change) than the crossbred goats (slope—0.3244). The ADG per unit of daily CP intake was higher for the purebred goats than crossbred goats, i.e., with intake of one more unit of CP, the purebred goats will gain more weight (0.5974) than

**Table 6** Economic analysis (per goat) for pure Abergelle and Abergelle × Barka (50%) cross goats in USD (2012 academic year)

| Variables | Genotype | Level of supplementation | | | CV | Genotype | | | Level of significance | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 184 g | 368 g | 552 g | | Pure | Cross | CV | Diet | Genotype | Interaction |
| Total cost of feed | Abergelle | $4.5^{b}$ | $6.7^{a}$ | $0.3^{a}$ | 5.0 | $5.8^{b}$ | $6.7^{a}$ | 4.3 | *** | ** | NS |
| | Cross | $5.1^{c}$ | $7^{b}$ | $0.4^{a}$ | 3.2 | | | | *** | | |
| Total cost of transport | Abergelle | $1.6^{c}$ | $2.9^{b}$ | $3.6^{a}$ | 3.1 | $2.7^{b}$ | $4.4^{a}$ | 3.8 | *** | ** | NS |
| | Cross | $3.3^{c}$ | $4.6^{b}$ | $5.3^{a}$ | 3.1 | | | | *** | | |
| Labor cost | Abergelle | 2.9 | 2.9 | 2.9 | 0 | 2.9 | 2.9 | 0 | NS | NS | NS |
| | Cross | 2.9 | 2.9 | 2.9 | 0 | | | | NS | | |
| Total cost of medicament | Abergelle | 0.2 | 0.1 | 0.1 | 3.5 | 0.1 | 0.1 | 2.9 | NS | NS | NS |
| | Cross | 0.1 | 0.1 | 0.1 | 0 | | | | NS | | |
| Total variable cost | Abergelle | $9.2^{c}$ | $12.1^{b}$ | $13.3^{a}$ | 8.5 | $11.5^{b}$ | $14.6^{a}$ | 6.3 | *** | ** | NS |
| | Cross | $11.9^{c}$ | $15.1^{b}$ | $16.9^{a}$ | 2.5 | | | | *** | | |
| Purchased price | Abergelle | 21 | 22.2 | 21.6 | 22.4 | 21.6 | 25.9 | 15.8 | NS | NS | NS |
| | Cross | $25^{b}$ | $24.9^{b}$ | $27.9^{a}$ | 7.5 | | | | *** | | |
| Total cost | Abergelle | $30.2^{b}$ | $34.3^{a}$ | $35^{a}$ | 27.3 | $33.1^{b}$ | $40.5^{a}$ | 20.4 | ** | * | NS |
| | Cross | $36.8^{c}$ | $40^{b}$ | $44.8^{a}$ | 5.4 | | | | *** | | |
| Sold price | Abergelle | $30.9^{b}$ | $36.6^{a}$ | $35.9^{a}$ | 27 | $34.5^{b}$ | $41.1^{a}$ | 23.8 | ** | * | NS |
| | Cross | $37^{b}$ | $41.1^{ab}$ | $45.2^{a}$ | 8.3 | | | | *** | | |
| Net return | Abergelle | $0.7^{b}$ | $2^{a}$ | $1^{b}$ | 37.2 | $1.2^{a}$ | $0.5^{b}$ | 15.2 | * | * | NS |
| | Cross | 0.1 | 1 | 0.5 | 453.1 | | | | NS | | |
| Annual rate of return | Abergelle | $0.5^{b}$ | $1.2^{a}$ | $0.6^{b}$ | 38.0 | 0.7 | 0.7 | 102 | * | NS | NS |
| | Cross | 0.1 | 1.3 | 0.6 | 533.4 | | | | NS | | |
| Marginal rate of return | Abergelle | – | 0.02 | −0.03 | | −0.01 | −0.01 | | | | |
| | Cross | – | 0.02 | −0.03 | | | | | | | |

Means in the same row with different superscripts differ significantly

*NS* not significant

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

crossbred goats (0.3244). This indicates the potential of Abergelle goats to produce more weight gain from the feed offered relative to their body size or weight than the crossbred goats. This is in line with the finding of Dereje et al. (2016) in his report on the comparison of small-eared Somali goats and Bati goats.

## Economic analysis of the feeding trials

The higher net return in 368 g/day group for the purebred goat was due to the lower cost of feed per live weight gain. This indicates that goats have marginal body weight gain with respect to feed intake (more efficient and less costly) and earn better net return at this rate. Generally, the difference in net return was in a similar trend with body weight gain. The result of this study suggested that supplementation of local hay with 368 g DM level of concentrate mix was potentially more feasible and economically beneficial than the other level of supplements for both breeds.

In conclusion, Abergelle × Barka crossbred goats had higher dry matter hay intake, total dry matter intake, and similar average daily gain and lower feed efficiency than pure Abergelle goat breed. The pure Abergelle goat breed had significantly higher net profit and sensitivity than Abergelle × Barka crossbred goats. Pure Abergelle and Abergelle Barka crossbred goats had a similar biological performance under the feeding regime used in this study, and it appeared that both breeds perform better in the diet containing the 368 g/day level of concentrate mixture. So it is recommended that supplementation of 368 g/day concentrate feed would be both biologically and economically the optimum level for both goat breeds for fattening practice.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethics approval** All procedures performed in the study involving animals were in accordance with the ethical standards of the institution or practice at which the study was conducted.

## References


Abebe Hailu, 2011. Supplementation of concentrate mixture on feed intake, body weight and carcass characteristics of Washera sheep, Ethiopia, (unpublished MSc thesis, Haramaya University). PP. 1–64.

Ameha Sebsibe, Casey N H, Van Niekerk W. A, Azage Tegegne, Coertze, R.J., 2008. Growth performance and carcass characteristics of three Ethiopian goat breeds fed grain less diets varying in concentrate to roughage ratios. South African Journal of Animal Science, 37, 221–232.

AOAC (Association Cofficial Analytic Chemists).1990. Official methods of analysis 15th ed, AoAC, inc.Arlington, Virginia, U.S.A., 1298p.

ARC, 1980. The Nutrient Requirements of Ruminant Livestock. Technical review by an Agricultural Research Council Working party published on behalf of the Agricultural Research Council (ARC) by the Common Wealth Agricultural Bureaux, Famham Royal, England, pp. 114–151.

Belay Derebe, 2008. Growth, Reproductive Performance and Carcass Characteristics of Abergelle and Central Highland Goat types under Traditional and Slightly Improved Management in Sekota District, (unpublished MSc thesis, Haramaya University). PP. 1–77.

Belay Deribe and Bewketu Amare, 2010. Report of Sekota Dry Land Agriculture Research Center, Waghimra, Sekota, Ethiopia.

Chanjura, P., W.Ngampongsai and M. Wanapat, 2007. Effect of replacing ground nut with cassava chip in concentrate on feed intake, nutrient utilization, rumen fermentation characteristics and microbial populations in goats. *Journal of Animal Science*, 20: 1557–1566.

Daubenmire, R., 1972. Ecology of *Hyparrhenia rufa* in dried Savanna in north western Costa Rica *Journal of applied Ecology,* 9, 11–23.

Dereje Taddesse, Megistu Urge, Getachew Animute and Yoseph Mekasha, 2016. Growth and carcass characteristics of three indigenous Ethiopian goats fed concentrate at different concentration levels. *Springer plus*, 5:414.

Denis Asizua, 2010. Effect of feeding system on the performance of finishing Ankola cattle and Munbende goats, unpublished MSc thesis, Makerere University). PP.1–77.

Duncan, D. B., 1955. Multiple range and multiple F tests. Biometrics, 11, 1–42.

Kumari N., R. Reddy, M. Blummel, D. Nagalakshmi, T. Monik, S. Reddy and R. Reddy, 2012. Growth performance and carcass characteristics of growing ram lambs fed sweet sorghum bagasse-based complete rations varying in roughage to concentrate ratios. International crop research institute for the semi-arid tropics, Patancheru, India.

Lu CD and Potchoiba MJ, 1990. Feed intake and weight gain of growing goats fed diets of various energy and protein levels. Journal of Animal Science, 68 (6):1751–9.

Lulseged Gebre-Hiwot, Jamal Mohammed, 1989. The status of livestock pastures and forage research and development in Ethiopia. In: Proceedings the workshop held at Addis Ababa, Ethiopia, PP., 101–113.

Mahgoub, O., Lu, C.D., Hameed, M.S., Richie, A., Al-Halhali, A.S., Annamalai, K., 2005. Performance of Omani goats fed diets containing various metabolizable energy densities. *Small Ruminant Reseach.,* 58, 175–180.

Marques T., D. Medeiros, G. Costa, D. Carvalho, D. Araujo and C. Torreao, 2014. Performance and carcass traits of Moxoto goats supplemented on native pasture under semi-arid conditions. *Revista Brasileira De Zootecnia*, 43 (3): 151–159.

SAS (Statistical Analysis System), 2002. Statistical Analysis System (SAS) Institute, Inc.cary, NC. Science. Uppsala, Sweden.

Simret Betsha, 2005. Supplementation of graded levels of peanut cake and wheat bran mix on the utilization and carcass parameters of Somali Goats. An MSc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia

Topps, J H., 1997. Urea or biuret supplements to low protein grazing in Africa. *World Animal Review*, 3, 14–18.

Upton, M., 1979. Farm management in Africa: The principle of production and planning. Oxford University Press, Oxford. 282–298.

Van Soest, P. J., 1982. Nutritional ecology of the ruminant. O and B Books Inc. Corvallis, Oregon, USA, pp. 154–220

Van Soest, P.J., B.J. Robertson, B.A Lewis, 1991. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science.,* 74, 3583–3597.

ZAD (Zone agricultural development office), 1995. Annual report of Waghimra Zone Agricultural Office, Sekota, Ethiopia. 56p.

Zahraddeen D, ISR Butswat and ST Mbap, 2008. Evaluation of some factors influencing growth performance of local goats in Nigeria. African Journal of Food Agriculture Nutrition and Developemt, Vol.8 (4). 464–479.