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Profitability of Dorper Sheep Finished on Grass and Legume Diets in Taita Taveta and Makueni, Range Lands of Kenya

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Abstract

The nutrient content of ruminant feeds, especially crude protein, in the Arid and Semi-Arid Lands (ASALs) is insufficient to support maintenance and influence production. Therefore, ruminant supplementation with protein rich leguminous feeds that are cost-effective and easily accessible is strongly recommended for optimum ruminants' production. In a completely randomized experimental design, a group of 24 mass selected dorper sheep, with an average age of 10-13 months and average body weight of 22.6±2.4Kgs were assigned into the 6 diet experimental treatments of 4 animals each. The animals were dewormed prior to the start of the experiment. The study was carried on-farm and a control set up on-station. The results of a two-way analysis of variance on comparison of the sample means showed an on-farm average net weight gains (NWG) of African fox tail+Cow pea (4.5±1.2Kg) and African fox tail+Dolichos lab lab (3.2±0.4Kg) as the leading. The economic analyses showed that the diets composed of African fox tail+Cow pea and African fox tail+Dolichos lab lab had the best profitable returns of Ksh 106,267.0 and Ksh 55,026 respectively for 100 units' sheep establishment at the market live body weight price of Ksh 400/Kg. The on station performance was significantly higher, indicating a more promising returns under improved management.

Keywords: Profitability, grass, legume, daily weight gain, ASALs

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1. Introduction

In Kenya, the livestock sub-sector contributes about 10% of the country's Gross Domestic Product (GDP) and consequently 50% of the agricultural labor force. The livestock population is distributed all over the country with arid and semi-arid lands (ASALs) which constitute about 84% of country's land mass, hosting about 70% of the country's livestock (KCSAP/ELRP, 2023). Thus, making livestock keeping in the region the major economic activity. Ruminants in particular, rely heavily on roughages primarily derived from pastures, browse, fodders and crop-residues. The nutritional value of these feed sources is insufficient to support maintenance, let alone growth, milk and production. Thus, limiting the ruminant's reproductive abilities and production levels. This is demonstrated by poor daily weight gain, low meat production, low off-take rates, low conception and kidding rates, and high mortality (Behnke et at., 2011). This has led to low food and nutritional security, and consequently low livestock sub-sector potential impact on the country's economy. Accordingly, there is a need to greatly increase animal production and productivity. In the ASALs, crude protein has been found to be the most restrictive nutrient, particularly during dry seasons. Therefore, supplementation is strongly recommended if ruminants are to be optimally productive. Dietary supplements are known to increase consumption by increasing nitrogen supply to the rumen microorganisms. This has a beneficial impact on rumen microbial population and efficiency (Matthews et al., 2019). For smallholder ruminant producers in Kenya, protein source concentrates are either unavailable or too expensive. Availability of economical and easily accessible feeds that are high in both quantity and quality is a crucial factor in sustainable livestock production (Ephrem et al., 2015). The study objective was to determine the profitability of finishing ruminants and in particular dorper sheep in the ASALs using African fox tail and Bush rye grass basal diets with Cow pea and Dolichos lab lab legume.

2. Materials and Methods

2.1 Experimental animals, selection, management and treatment

Mass selection method was used to handpick 24 dorper sheep s with an average age of 10-13 months determined using recorded reports from farmers based on birth history and an average body weight of 22.6±2.4Kgs. The sheep were dewormed, and acclimatized for 7 days to the experimental diets and individual pens. A completely randomized experimental design (CRD) was used to group 24 mass selected dorper sheep and assigned into the experimental treatments of 4 animals each. A total of 6 diets were availed as follows; African fox tail, African fox tail+Cow pea, African fox tail+Dolichos lab lab, Bush rye, Bush rye+Cow pea and Bush rye+Dolichos lab lab. The feeds were chopped and offered ad-libitum, on a 3:1 grass and legume ratio (Abreu, et al, 2004). The diets were divided into two halves and offered twice a day. The utilized feeds were established on-farm and harvested at flowering stage (Kamalak et al, 2011), conserved by baling and stored. Water and mineral salt was provided ad-libitum. The experiment was conducted for a period of 90 days under on-farm and on-station (control) feedlot system.

2.2 Study site

The study was conducted in Makueni and Taita Taveta arid and semi-arid (ASAL) counties of Kenya, located in ecological zone IV. The zone has moderate climates and distinct seasons with a bimodal rainfall pattern experienced in March, April and May (long rains) and October, November and December (short rains) seasons, with an average annual rainfall of <700 mm (Government of Kenya, 2018). The short rains are more reliable (Government of Kenya, 2018).

2.3 Data collection and analysis

Data on the cost of production of the different feed crops was collected during the establishment periods. Included, cost of buying seeds, land preparation, planting, weeding, harvesting and labor. The average variable cost of unit feed production (AVCf) was calculated as the quotient of the aggregate total variable costs incurred along the crop lifespan in seasons (n) over the aggregate estimated seasonal yields.

$$AVCf = \frac{\sum_{i=1}^{n} season\ cost}{\sum_{i=1}^{n}\ season\ yield} \qquad (1)$$

The feed daily intake (DI) was calculated by subtracting the average daily feed refusal from the average daily feed offered.

$$DI = \frac{\sum_{i=1}^{n}(Feed\ offered - Refus\quad)}{n=90} \qquad (2)$$

Where, the numerator is the cumulative absolute feed intake within the finishing period in days (n).

Measurements on the daily body weight were taken using an electronic weighing scale and entered in MS Office Excel work sheet. The average daily weight gain (NWG) was determined as the difference between the final and initial/previous live body weight (LBW_i-LBW_0). A two-way analysis of variance (ANOVA) statistics was used to compare the sample means and test for significant differences between the treatments and LSD significance difference post hoc test used to separate significant differences (P<0.05), using SPSS software version 22. The results were presented in tables.

Profitability analysis of sheep finishing was computing using the gross margin (GM) analysis. Where, GM was determined by calculating the difference between the total revenue (TR) and total variable cost (TVC) incurred within the finishing period. The following formula defines this calculation.

$$GM=TR-TVC \qquad (3)$$

Where, the gross margin (GM) is calculated as the difference between the total revenue (TR) and the total cost of variable inputs (TVC). The revenue and cost variables were then computed as;

TR= Q*P. Where Q, the quantity is the product of net weight gain (NWG) per sheep for Y number of sheep (NWG_iY)in kilograms and P, the live weight price per kilogram (LWP).

Therefore; $TR = NWG_iY.LWP$ (4)

While, $TVC = \sum_{j=1}^{n} X_j C_j$ the aggregation of inputs j→n of X units per cost C. The inputs included the cost of various inputs such as feed, labor and 10% of total variable cost (TVC) miscellaneous. (5)

Thus, *GM* was calculated as, $GM = NWG_i Y.LWP - \sum_{j=1}^{n} X_j C_j$ (6)

Other profitability metrics used included return on investment (ROI) and benefit cost ratio (BCR).

Where *ROI* was calculated as; $ROI = \left(\frac{GM}{TVC}\right) x100$ (7)

While *BCR* was calculated as; $BCR = \frac{TR}{TVC}$ (8)

Where, BCR> 1 suggested that the investment was economically viable

Additionally, a linear model with intercepts was employed to predict the gross margin (GM) as a function of (NWG) in sheep and the unit cost of feed (CF) cultivated on-farm. Labor costs and other miscellaneous production factors were held constant and excluded from the model since they were static. The model's parameters include coefficients β_1 and β_2, representing the impact of NWG and CF respectively, on the gross margin. The error term (ε) accounts for unobserved factors, and β_0 is the intercept term.

$GM = \beta_0 + \beta_1 NWG + \beta_2 CF + \cdots + \varepsilon.$ *Excl. Price and other costs* (9)

3. Results and Discussions

3.1 Cost of feed production

Livestock feeds play a crucial role in the cost of livestock production. The type, quality and availability of feeds can significantly influence the overall expenses incurred by livestock producers.

Table 2: Unit cost of feed production

Type	Crop	Seasonality	AVCf_kg "Ksh"	AVCf_bale (15kg)	Market price*
Grass	African fox tail	Perennial	6.3	94.0	250
Grass	Bush rye	Perennial	5.1	77.0	250
Legume	Dolichos lab lab	Annual	9.6	144.2	350
Legume	Cow pea	Annual	9.9	149.1	350

**Author livestock feed market survey, 2023.*

Perennially growing crops had a lower unit cost of production. This is due to one off costs of production incurred only in the first season and exempted in the subsequent seasons. The cost of growing the feeds was however generally relatively cheaper than the market buying price. Generally, on farm feed production reduced the cost of feed by 61.3%. Thus minimized the cost of production and maximized on the profits. The feed quality is also guaranteed.

3.2 Animal performance

The feeding diets included; African fox tail (AF), African fox tail+Cow pea (AF+Cow), African fox tail+Dolichos lab lab (AF+Dol), Bush rye (Br), Bush rye+Cow pea (Br+Cow) and Bush rye+Dolichos lab lab (Br+Dol).

Table 3: Animal weight growth

Diet	Unit NWG (Kg)- On-farm	Unit NWG (Kg)- On station (Control)	On-farm*On station Sig
AF+Cow	4.5±1.2[a]	4.8±0.1[a]	NS
AF+Dol	3.2±0.4[ab]	4.7±0.2[a]	*
Br+Cow	3.0±0.4[ab]	3.7±0.3[ab]	*
Br+Dol	2.5±0.2[ab]	3.5±0.2[ab]	*
AF	1.0±0.1[b]	1.3±1.1[b]	*
Br	-1.5±0.1[c]	-0.9±0.1[c]	NS

*Column means with different letter superscript are significantly different at p<0.05, *Treatment and control means significantly differed, NS= Not significant*

The effective average animal daily feed intake was 0.85kgs, which represented an average dry matter intake (DMI) of 3.4±0.16 percent of the animal live body weight. The results compared well with Holden et al, 2023) findings, that found out an animal effective dry matter intake of 3%. Legume supplementation increased (P<0.05) animal dry matter intake (DMI), metabolisable energy (ME), crude protein (CP) and digestibility and consequently animal performance (Mukiti, 2023) as compared with the control as indicated by laboratory proximate results shown in table below. The on station performance was significantly higher, indicating a more promising returns under improved management.

Table 4: Nutritive composition of diets used in feeding experiment

Diet	% DMI	ME (MJ/kg)	CP g/kg	CF g/kg	NDF g/kg	ADF g/kg
AF+Cow	3.1[d]	8.2[a]	72.3[a]	435.4[a]	770.5[a]	471.4[a]
AF+Dol	3.0[d]	8.7[b]	81.8[b]	482.6[b]	726.6[b]	427.9[b]
Br+Cow	3.0[d]	7.5[ab]	60.7[c]	448.3[c]	730.7[c]	443.6[c]
Br+Dol	2.9[d]	8.3[a]	166.1[bc]	441.9[bc]	715.4[bc]	468.8[bc]
AF	2.7[e]	8.2[a]	43.8[ab]	358.9[ab]	773.1[ab]	553.7[ab]
Br	2.4[e]	7.7[c]	54.9[ac]	424.5[ac]	751.7[ac]	493.8[ac]

Column mean with different letter superscript are significantly different at p< 0.05.

The basal diets of African fox tail and bush rye exhibited the lowest nutritional values, leading to correspondingly lower net weight gains. The significantly (*p< 0.05)* low CP, high fiber and low ME suggested low quality of the grasses which negatively affected performance of the sheep (Milis, 2008).

3.3 Profitability of sheep finishing in Taita Taveta (on-farm) and Makueni (on-station) sites

The profitability indices of the sheep finishing are as determined and shown in the tables below;

Table 5: Break even quantity (BEQ)

Diet	Unit feed cost	Labor cost	Other cost	Revenue	BEQ	BCR (>1)	Viability
*AF+Cow	565.3	10,500	10%	1,800.0	10.0	1.0	Viable
**				1,920.0	9.0	1.0	
*AF+Dol	558.4	10,500	10%	1,280.0	18.0	1.0	Viable
**				1,880.0	9.0	1.0	
*Br+Cow	500.9	10,500	10%	1,200.0	18.0	1.0	Viable
**				1,480.0	13.0	1.0	
*Br+Dol	500.9	10,500	10%	1,000.0	26.0	1.0	Viable
**				1,400.0	14.0	1.0	
*AF	482.6	10,500	10%	400.0	1,000.0	0.7	NV
**				520.0	1,000.0	1.0	
*Br	390.7	10,500	10%	-600.0	1,000.0	-1.4	NV
**				-360.0	1,000.0	-0.8	

*Market live body weight price of Ksh 400/kg (Author livestock market survey, 2023). NV= Not Viable. *On-farm treatment, **On-station treatment (Control).*

African fox tail+Cow pea and African fox tail+Dolichos lab lab diets showed the best efficient scale. African fox tail and Bush rye basal diets had the highest break even quantities and were not viable. The cost of feed production translated to an estimated average of 74% of the total variable cost of production. The primary cost in a feedlot production system is linked to feeding expenses (Sitorski, 2019).

Table 6: Profitability case at 100 units

Diet	TVC	Revenue	GM	BCR (>1)	ROI	Rank
*AF+Cow	73,733.0	180,000.0	106,267.0	2.4	1.4	1
**		192,000.0	118,267.0	2.6	1.6	
*AF+Dol	72,974.0	128,000.0	55,026.0	1.8	0.8	2
**		188,000.0	115,026.0	2.6	1.6	
*Br+Cow	66,649.0	120,000.0	53,351.0	1.8	0.8	3
**		148,000.0	81,351.0	2.2	1.2	
*Br+Dol	66,649.0	100,000.0	33,351.0	1.5	0.5	4
**		140,000.0	73,351.0	2.1	1.1	

**On-farm treatment, **On-station treatment (Control).*

African fox tail+Cow pea and African fox tail+Dolichos lab lab diets showed the highest returns respectively, with a BCR of 2.4-2.6 and 1.8-2.6 and ROI of 1.4-1.6 and 0.8-1.6 both. This indicated that, there was an exceeding positive return on revenue and profit for every shilling invested as cost.

3.1 GM deterministic model

The GM model was as shown in table and equation below;

Table 7: GM coefficients

Model	Standardized Coefficients Beta	t	Sig.
(Constant)		-.795	.430
NWG	1.036	2393.055	.000
Cost of feed	-.080	-184.411	.000

$GM=\beta_0+1.036NWG+-0.80CF$

Both weight gains (influenced by the diets) and cost of feed significantly affected the enterprise gross margins. An increase in a unit of NWG and cost of feeds, influenced GM by 1.036 and -0.080 effect respectively. This indicated that, a unit Ksh increase in ration cost of production would be earnt by a complementary increase of 77.2g units of NWG.

4. Conclusion

On-farm feed production was more cost proficient than buying from the market and thus more farmer profit maximizing. A cost effective legume selection was also an essential consideration for the enterprise. Additionally, the breed and genetics of the animal influences feed efficiency, carcass merit and economic benefits significance. Thus it's fundamental to select the right breeds whether buying the animal or raising it from home.

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