Journal of Business and Entrepreneurship

[ISSN 2958-1125]
Volume: 03 Issue: 01 | December -2024

JBE

On-station development and testing of small ruminant feedlot finisher ration as an agribusiness for vulnerable groups in Kenya

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Cite this article in APA

Tabu, J., Syomiti, M., Magogo, J., Achieng', J. & Keya, G. (2024). On-station development and testing of small ruminant feedlot finisher ration as business for vulnerable groups in Kenya. *Journal of business and entrepreneurship, 3*(1), 54-62. https://doi.org/10.51317/jbe.v3i1.661

OPEN ACCESS
A publication of Editon Consortium Publishing (online)

Article history
Received: 28.10.2024
Accepted: 06.11.2024
Published: 20.12.2024

Scan this QR to read the paper online

Abstract

The study was carried out to formulate and test a cost-effective small ruminant feedlot finisher ration to reach a targeted market weight of 45–50 kg within 6 to 7 months as an agribusiness for vulnerable groups in Kenya. Thirty entire male Dorper-weaner lambs aged 3-4 months with an average initial body weight of 23.3 kg ± 2.4 were used in a controlled on-station feeding trial. Treatments were three energy levels (9.0, 10.0 and 11 MJ ME Kg-1 DM) and three crude protein levels (12, 14 and 16% DM), with Rhodes grass hay as the control diet in a Complete Randomized Design (CRD). One-way analysis of covariance (ANCOVA) for comparison of means of the response variables was conducted. ANCOVA results of the experimental rations and control showed that the feed intake (FI) was statistically significant for ration 8. Mean results indicated that TR8 had the highest average daily weight gain (ADG) mean and total weight gain (TWG). Significant peak final slaughter weights ($p<0.05$) in TR8 (46 kg), TR6 (43 kg) and ration 9 (41 kg) were observed at about 5-6 months old. Acceptable final slaughter weights were recorded in TR6, TR9 and TR8 rations. In conclusion, test ration with a combination of 11 MJ kg-1 DM of energy level and 14 per cent (TR8) had the highest ADG in the shortest period of 6 months old and can be recommended for adoption to finish Dorper sheep to reach market weight of up to 50 kg within 6-7 months old.

Key terms: Agribusiness, dorper sheep, finisher ration, Kenya

INTRODUCTION

Undernutrition, inadequate and/or fluctuating nutrient supply are major constraints limiting productivity of small ruminants (Balehegn et al., 2020; Salem & Smith, 2008). However, the Dorper sheep production system in Kenya is a promising agribusiness venture for vulnerable groups, Viz unemployed youths and women with potential for economic growth, particularly in arid and semi-arid areas (Kosgey et al., 2008). Extensive grazing is the predominant method for raising sheep and goats in the Rangelands of Kenya (Oyieng et al., 2021). The basic feeds used in these systems are forages of variable and inconsistent quantity and quality (Mwendia et al., 2018). More often, feeding practices do not meet the animal requirements, leading to low animal performance with respect to reproduction, growth and carcass quality (Mushi, 2004). It is a common observation to see animals taking too long to mature or reach market weight (Muigai, 2017; Salem & Smith, 2008). Intensive rearing of small ruminants in feedlots that can enhance fast growth rates due to proper feed supplementation is a fairly new concept in Kenya and has not been adequately emphasized by the authorities (Kenya Markets Trust, 2020).

Confining grazing animals for intensive management for fattening purposes, primarily for optimal growth and high weight gain, is necessary for the economic preparation of animals for slaughter (Gebremeskel & Kefeleg, 2011). Prasad et al. (1993) reported that commercial fat goat production under an intensive system of management with better genetic make-up was profitable, provided the cost of feed was minimized. In Pakistan, Talat (2006) reported that fattening sheep for 90–100 days could add 9–10 kg of weight per carcass and improve meat quality. Under a good feeding system, body weight gain can be improved from 60 to 80 g per day through an intensive feeding system (Hassan & Farhad, 2012). In Kenya, intensive sheep and goat rearing and finishing farms are limited. This may be attributed to a lack of sheep and goat finishing formulas in the market and a lack of expertise. This should be promoted as it opens opportunities for the availability of surplus males that could be raised for meat production in the country (Rakotoarisoa et al., 2015). Pastoral production systems in the ASALs contribute approximately 67 per cent of the red meat in Kenya (Juma et al., 2010). With the progressively rising demand for meat products, small ruminant production is a potential agribusiness for improving rural livelihoods (Koech et al., 2011)However, whereas many feed concentrates are available in the market for other animals, such as dairy and beef animals, supplementary feed packages are lacking in the market for sheep and goat rearing and finishing. This study seeks to address the urgent need to develop and make available specialized finishing rations for Dorper sheep in Kenya.

LITERATURE REVIEW

The livestock sub-sector in Kenya plays a significant role in the economy, contributing about 10 per cent to the Gross Domestic Product (GDP). The sub-sector accounts for over 30 per cent of the farm-gate value of agricultural commodities and employs over 50 per cent of the agricultural labour force (KALRO, 2023). Additionally, with respect to livestock products marketing, meat production is the largest livestock enterprise, with an annual output of approximately 702,090 MT valued at KES. 278.9 billion, followed by milk production at 4.1 million MT, valued at KES. 182 billion. Additionally, other livestock products such as wool, hides and skins, and beeswax bring in an additional KES. 28 billion.

The bulk of red meat comes from beef cattle, followed by small ruminants, with 67 per cent being sourced locally and 33 per cent imported, mostly through porous borders. The capital value of the national animal resource base for the sub-sector is valued at KES. 795 billion, while the total annual value of primary and value-added products and livestock by-products from all the livestock supply chains is estimated at KES 1,448 billion (USAID-KAVES, 2017). The livestock population is distributed all over the country, with ASAL hosting the majority. The ASAL comprises 23 counties covering an area of 506,534 square kilometres of land, supporting 80 per cent of the national ruminant population. Over 60 per cent of the country's livestock herd, particularly cattle, small ruminants and camels, are under extensive production systems in the ASALs.

The Non-ASAL consists of 24 counties that cover an area of 62,605 square kilometres of land, constituting about 10 per cent of Kenya's landmass, and is home to about 20 per cent of the national livestock ruminant

population (GoK, 2022a). Feed and nutrition insecurity is a major hindrance to livestock production and productivity in Kenya. Feed and nutrition insecurity exists when all livestock, at all times, have physical, social and economic access to an adequate quantity and quality of feed that meets their dietary requirements and preferences and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and productive life (KALRO, 2023). Small ruminants are finished in feedlots to meet market requirements earlier and because pasture may not be sufficient enough for cattle to develop consistent meat quality and quantity due to environmental factors such as drought. Research findings by Deneke (2022) indicate that livestock feedlot systems minimize soil and nutrient loss from bare ground (prevent erosion), prevent grazing of dry pastures that results in bare ground, allow grazing to be deferred at the break of season, and allow pastures to reach optimal density. It also prevents the animals from 'chasing the green pick' and expending more energy after the daybreak. Feedlots support maximal growth and weight gain through a high-energy diet of grains and legumes, such as corn and lucerne (GoK, 2022a; GOK, 2022b).

METHODOLOGY

Study Area

The experiment was carried out at KALRO Buchuma Sheep, Goat and Camels Research Station. The research centre is located in Taita Taveta County, about 60 km east of Voi town along the Mombasa Nairobi highway. The centre lies approximately 400 meters above sea level, with an average annual rainfall of 560 mm. The current feeding experiment was carried out between May and July 2021.

Description of the Experimental Animals, Health, Feeding and Housing Management

Fifty entire male uncastrated Dorper sheep weaners aged between 3-4 months were used in the on-station feeding trial. The experimental animals were purchased from agro-pastoral farmers in Narok County, Kenya. The animals were ear-tagged and quarantined for a period of 7 days for acclimatization with the new area, housing, and test rations. During the acclimatization period, the animals were treated with a broad-spectrum antiparasitic agent (Ivermectin) against internal and external parasites. They were also vaccinated against common sheep diseases in Taita Taveta County, *viz*., sheep pox, pasteurollosis and anthrax. The experimental animals were managed in individual pens/stalls measuring 0.70 m x 1.70 m as recommended housing space for small ruminants (Mushi, 2004) with a 2-hour sunlight allowance between 9 and 10 o'clock in the morning hours. The animals were fed daily about 3 per cent of their LBW (Souza et al., 2013). The offered feeds were adjusted to allow for 5 per cent feed refusals during the acclimatization period. Weighing of the experimental animals was done weekly using a digital weighing scale after an overnight fast. The formulated test diets were offered twice a day at 8:00 and 16:00 h in two equal portions. Feed refusals were collected, weighed and discarded before the morning meal. Water and mineral salts were provided ad libitum.

Experimental Feeds Formulation Procedures and Ingredients Used in the Ration

Feedsoft® Professional feed formulation software (10.1 Edition) was used to formulate the experimental TMR rations. The main feed ingredients used in the feed formulations were as follows: Protein sources: cotton seed cake, sunflower cake, and lucerne hay; energy sources: wheat bran, maize germ, whole maize, molasses and Rhodes grass hay; other feed additives: minerals and mineral premixes, and aflatoxin binder.

All the ingredients were weighed using a digital weighing scale based on specific test rations. The mixing of the ingredients was done manually on a black polythene paper gauge 60. The energy and protein concentrates were purchased from a large-scale agro-dealer (Crop Ways Feeds Ltd.) in Thika. The roughages (Rhodes grass and Lucerne hay) for TMR formulation were purchased from the Dairy Research Institute, KALRO Naivasha. The roughages were chopped into about 1-2 cm using a forage chopper prior to manual mixing with selected energy and protein concentrates (mentioned above).

Experimental Design and Treatments

The experimental design was a Complete Randomized Design (CRD), with a single factor (test ration) replicated five times and blocked by the experimental animals' live weight and body condition. Treatments consisted of three energy levels: 9.0, 10.0 and 11 MJ

ME/Kg DM, and three CP levels (12, 14 and 16% DM), with Rhodes grass hay as the control diet (Table I and II). The response variables in this study were Voluntary feed intake, growth performance measurement, Total weight gains (TWG), Average daily gain (ADG), and final slaughter/market weights after the end of the feeding experiment. As shown in Table 1.

Table 1: Formulation of the TMR Diet Fed to the Experimental Weaner Dorper Sheep

Treatment no.	Energy levels	Crude protein levels
	(MJ ME /Kg DM)	(%DM)
TR1	9.0	12
TR2	9.0	14
TR3	9.0	16
TR4	10.0	12
TR5	10.0	14
TR6	10.0	16
TR7	11.0	12
TR8	11.0	14
TR9	11.0	16
TR0 (Control)	5.0	7.0

TR1= (9 MJ Kg^{-1} DM; 12% CP (Crude Protein)	TR6= (10 MJ Kg^{-1} DM; 16% CP)
TR2= (9 MJ Kg^{-1} DM; 14% CP	TR7= (11 MJ Kg^{-1} DM; 12% CP)
TR3= (9 MJ Kg^{-1} DM; 16% CP	TR8= (11 MJ Kg^{-1} DM; 14% CP)
TR4= (10 MJ Kg^{-1} DM; 12% CP	TR9= (11 MJ Kg^{-1} DM; 16% CP)
TR5= (10 MJ Kg^{-1} DM; 14% CP	TR0= (5.0 MJ Kg^{-1} DM; 7.0 % CP)

Data Collection

Data was collected on voluntary feed intake, average daily weight gain (ADG (Kg/day), Total weight gain (TWG) and final slaughter/market weight. All data on weight was collected using the digital weighing machine. Voluntary feed intake (VFI) was estimated by the arithmetic difference between the amount offered and the amount refused after each meal. The daily intake was thus calculated as the summation of morning and afternoon leftovers minus the total feed offered per day.

Response Variables Calculations

Voluntary feed intake= Arithmetic difference between amount offered and the amount refused after each meal.

Average daily weight gain (ADG) was collected weekly and body weight changes of animals was calculated as;

Average daily weight gain (ADG (kg/day) =

$$\frac{\text{Final weight (kg)-Initial weight)}}{\text{Number of days in experiment.}}$$

While, Total weight gain (TWG) =Final LWT gain (kg) - initial weights.

Statistical Analysis

The collected data were subjected to analysis of Covariance (ANCOVA) using General Linear Model (GLM) procedure of statistical analysis system (SAS, 2003) with (test rations) as the main effect in the model and the animal performance (Feed intake, ADG, TWG, and final slaughter/market weight) as the dependent variables.

The mathematical model used for data analysis was:

$Y_{ijk} = \mu + t_i + e_{ijk}$,

Where;

Y_{ijk} = Response variables (ADG (kg Day^{-1}, daily feed intake and targeted final market weights)

μ = Overall mean,

t_i = Treatment/Ration effect (T_0, T_1, T_2, T_3, T_4.....T_9)

e_{ijk} = Random error.

FINDINGS AND DISCUSSIONS

Growth performance trials

Results on average daily feed intake, average daily gain (ADG), and total weight gain of experimental Dorper sheep are shown in Table 2. A significant difference ($p<0.05$) was observed in feed intake among the treatment groups. In comparison with other experimental rations and the control, significant differences in feed intake (1.72 kg sheep-1 day-1) were observed in ration TR6. However, this did not translate to high-growth performance parameters such as ADG and TWG. The results revealed that the best ($p<0.05$) performing test ration in terms of ADG (0.31 kg day-1), and TWG (26.5 kg) was ration TR8.

Table 2: Feed Intake, Average Daily Gain and Total Gain (Mean ± Standard Deviation) of Dorper Sheep on Different Experimental Finisher Ratio

Treatment	Mean Feed Intake (Kg/day)	ADG (Kg/day)	Total Wt gain (Kg)	Final slaughter/ Market Wt. (Wk 10)	Final slaughter/ Market Wt. (Wk 12)
TR0	0.73^{j}±0.26	0.089^{j}±0.19	6.83^{j}	29.5^{j}±0.23	29.17^{j}±0.12
TR1	1.33^{i} ±0.24	0.128^{i}±0.19	9.8^{i}	38.17^{i}±0.64	36.17^{i}±0.93
TR2	1.36^{h}±0.23	0.148^{g}±0.11	11.67^{g}	39.0^{h}±0.49	39.33^{h}±0.40
TR3	1.51^{f}±0.18	0.145^{h}±0.14	11.17^{h}	40.8^{g}±0.15	40.83^{g}±0.14
TR4	1.59^{d}±0.22	0.171^{f}±0.19	13.17^{f}	43.7^{d}±0.37	42.5^{e}±0.14
TR5	1.62^{c}±0.34	0.193^{e}±0.16	14.83^{e}	42.0^{f}±0.64	41.83^{f}±0.03
TR6	1.70^{a}±0.19	0.271^{d}±0.27	20.83^{d}	47.2^{b}±0.01	46.83^{b}±0.87
TR7	1.42^{g}±0.21	0.277^{c}±0.29	21.33^{c}	42.2^{e}±0.09	44^{d}±0.39
TR8	1.65^{b}±0.17	0.357^{a}±0.47	27.50^{a}	48.8^{a}±0.32	49.83^{a}±0.38
TR9	1.56^{e}±0.22	0.294^{b}±0.24	22.67^{b}	45.2^{c}±0.65	46.3^{c}±0.79

^{a,b,c} Means with different superscripts in a columns differ significantly

Similar results on feed intake were reported by Sheridan et al. (2003) who documented an average feed intake for Dorper sheep ranging between 1.74-1.89 kg/lamb/day with Lucerne-based finisher diets of the same nutrient composition as Ration T8 (11 MJ kg-1DM and 14% CP) This means animal on ration 8 gained more weight per unit of feed consumed, thus reaching the market weight on a short period in return, that can give farmer high profit. However, these values disagree with previous findings by Van de Vyver et al. (2013), who reported lower DM intakes ranging from 0.91-1.37 kg/lamb/day for Merino sheep offered similar diets. Merino is mainly kept for wool production, with lower growth rate characteristics and low feed intake as compared to Dorper, which is mainly kept for meat. The findings on ADG resemble those by (Price et al., 2009) f 0.28-0.34 kg/day, while (Brand et al., 2001) found lower daily gains of 0.23-0.27 kg/day with feedlot finisher rations of similar nutrient composition.

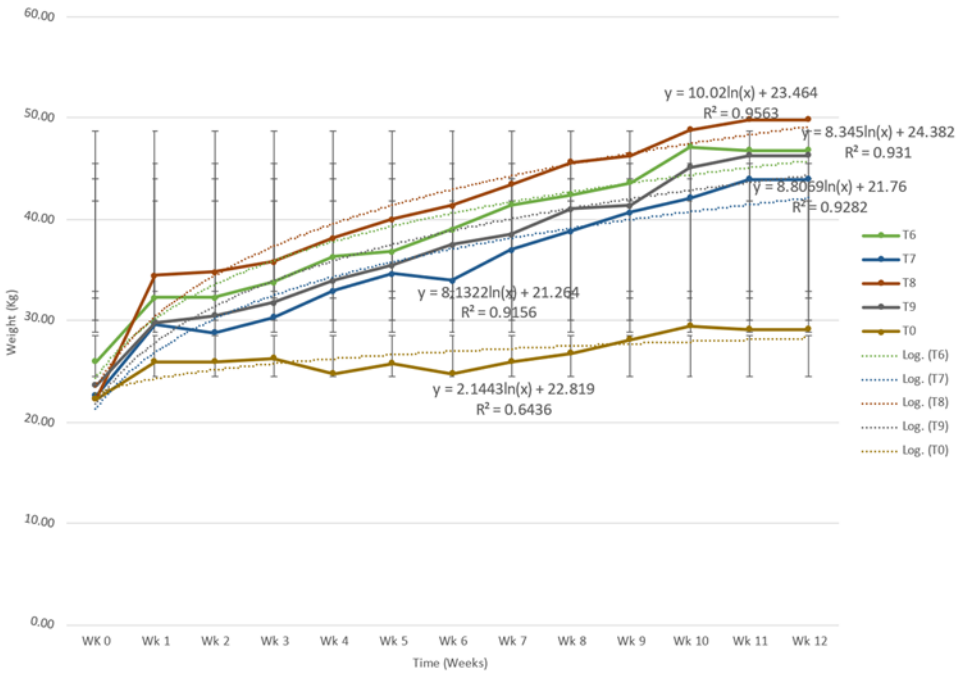

Figure 2: Weekly Growth Performance of Dorper Sheep on Four Best-Bet Experimental Finisher Rations

The variation in feed intake and ADG in this study can be linked to the chemical composition and the physical form of the different test finisher rations for the experimental Dorper weaner sheep. The Dorper sheep is a hardy South African composite breed, derived from a cross between the Black-headed Persian and the Dorset Horn. It is a potential breed for feedlot production (Sheridan et al., 2003). These two factors (chemical composition and the physical form of test finisher rations) may have influenced the level of feed intake of the Dorper weaner sheep, with more feed nutrients for production, such as putting on muscles for enhanced growth rate.

Figure 2 shows the weekly final weight gains of experimental Dorper sheep. Significant ($p<0.05$) peak final slaughter weight in rations TR8, TR6 and TR9 (48, 47 and 45 kg, respectively) were observed at the age of about 5-6 months old. Acceptable slaughter weights of 46-50 kg were recorded in ration TR8, TR6 and TR9 (50, 48 kg, 46 kg, respectively) as compared to the control (29kg) in the final week 12 finishing period. Dorper sheep receiving ration TR8 reached the highest ($p<0.05$) slaughter weight (50 kg) at about 7 months old post-weaning. However, from physical observations, Dorper sheep receiving ration 8 exhibited a high degree of fat deposition post the age of 6th (sixth) months old. Ration TR6 gave finished sheep with proportional good body conformation and with less fat deposition (physical judging) past this age (6 months old). Although an increase in total weight gains (Figure 2) is recorded with an increase in days in the feedlot in this study, this may negatively affect the enterprise profitability and meat quality. Figure 3 shows the weekly weight gains of experimental Dorper sheep on various finisher test rations.

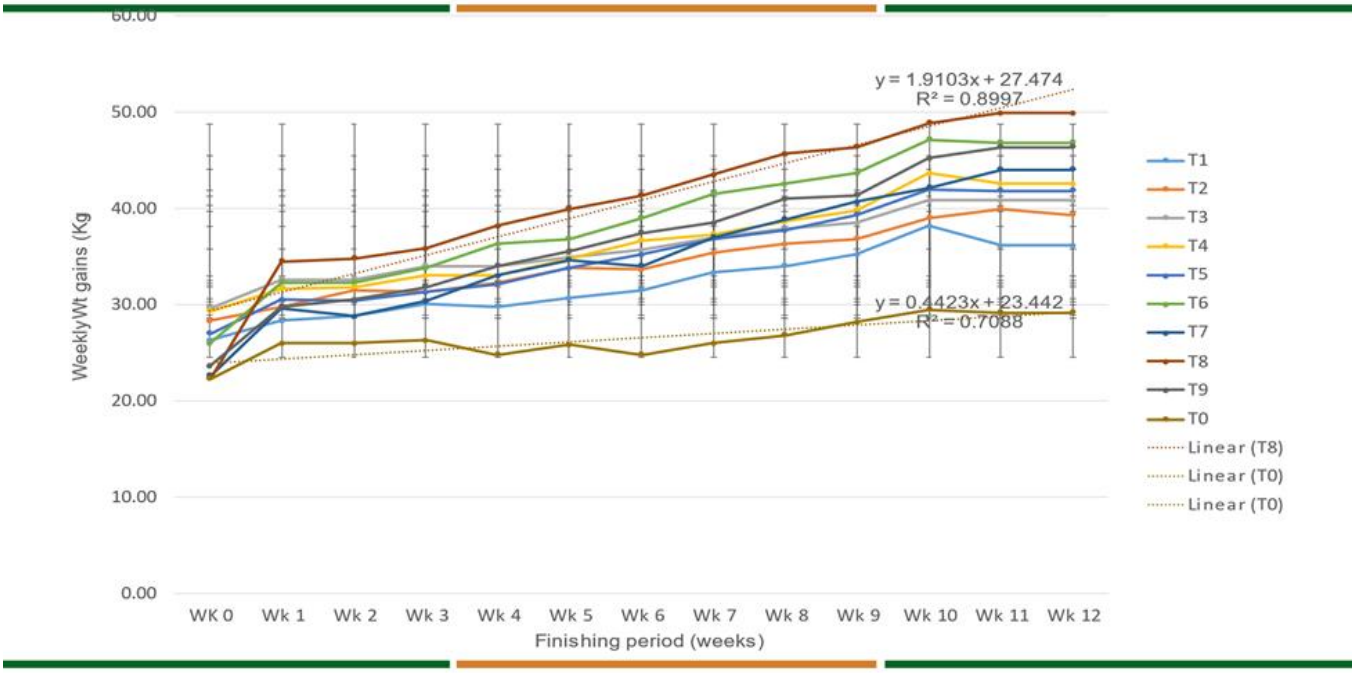

Figure 3: Weekly market weight gains of experimental Dorper Sheep on various finisher test rations

Correlation Analysis

A correlation analysis was conducted to describe the relationship between feed intake, slaughter/total weight and ADG (Table IV). Results of correlation analysis indicated that average daily gain (ADG), total weight gain (TWG) and feed intake (FI) were highly positively correlated. The correlation between ADG and TWG (r=0.985), ADG and FI (r=0.794), and TWG and FI (r=0.820) were positively highly correlated. With these results, ADG, TWG and FI can be used to predict the Dorper sheep feedlot profitability.

Table 3: Correlation Analysis of Response Variables

Variable / Statistics	Average Daily Gain	Total Weight Gain	Feed Intake
Average Daily Gain	1.000	.985	.794
Total Weight Gain		1.000	.820
Feed Intake			1.000

CONCLUSION AND RECOMMENDATIONS

Conclusion: Current research findings from this research work conclude that the rearing period from birth to marketing of Dorper sheep can be shortened from 1.5-2 years old to 6.5 months only. This, in turn, can increase the rate of returns and farm enterprise profitability. Experimental animals on ration TR 8 reached far beyond the targeted market/slaughter weight of 45 kg within 6 months, followed by TR6. Ration 8 emerged as the most performing in terms of growth performance, both rations (TR6) and (TR 8) can be recommended for dissemination and adoption among smallholder pastoral Dorper sheep livestock.

Recommendations: To validate the results obtained from the on-station experiment, it is critical to conduct additional experiments using Ration 8 and Ration 6, particularly on-farm; this is because there are circumstances where on-station research outputs could be technically feasible but not profitable or viable under on-farm conditions. Training and capacity development for the pastoralists in small ruminant feedlotting and formulation of ration 8 and ration 6 is required to enable better animal husbandry practices, feedlot management, feed formulation and small ruminant health management. We should package capacity development programs to target the youths and women who make up the majority of the population. The training needs to focus on practical applications of knowledge and skills.

Acknowledgement

The authors of this manuscript wish to thank the Climate Smart Agricultural Productivity Project (CS APP) under the EU AgriFI Kenya project for funding this study. Special appreciation to the National Project Coordinator (NPC, CS APP) for effective coordination of the project, close watch of the whole project implementation cycle via monitoring and evaluation, and timely disbursement of funds. Much appreciation to the Director General for guaranteeing a good working environment in the Research Centre. Other KALRO Buchuma and Matuga Research Centres research and technical teams for great effort in designing, data collection and monitoring of the Dorper sheep feeding experiments.

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