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Research Article

Effect of feeding different levels of forages and concentrate ration on production performance, serum biochemical and hematological profile in Ghaljo sheep (*Ovis aries*)

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Abstract

Adequate provision of nutritious diet can help improve the production performance of sheep. This study aimed to explore optimal production performance in Ghaljo sheep feeding different levels of forages and concentrate ration. Nine healthy sheep were divided into three groups. The control group was fed on an exclusively forage-based diet (wheat straw, sorghum and millet), Concentrate-supplemented diet (C-33) group on 33% concentrate with 67% forages and C-67 group on 67% concentrate with 33% forages. The average weight gain was significantly greater in animals fed on concentrate-supplemented diet (C-33 group: 13.9±1.0 Kg; C-67 group: 13.0±0.9 Kg) than an exclusively forage-based diet (10.1±0.9 Kg, p=0.007). The feed efficiency of animals fed on concentrate-supplemented diet (C-33 group: 7.3±0.4; C-67 group: 7.5±0.1) was superior to an exclusively forage-based diet (8.4±0.2, p=0.003). The total serum protein levels (C-33 group: 7.4±0.3 g/dL; C-67 group: 7.1±0.3 g/dL; Control group: 6.5±0.3 g/dL, P=0.009) were significantly higher with concentrate-supplemented diet. While, serum urea levels were significantly different between all study group (C-67 group: 15.6±1.3 mg/dL; C-33 group: 13.7±0.5 mg/dL; Control group: 12.2±0.4 mg/dL, p=0.007). The highest return on investment (26%) was seen in animals fed on a diet comprising 33% concentrate ration with 67% forages. In conclusion, concentrate-supplemented diet significantly improves weight gain and feed efficiency in sheep. Diet comprising 33% concentrate ration with 67% forages on dry matter basis are recommended for optimal growth and economic returns without adverse effect on animal health.

Keywords: Economics; Feed Efficiency; Pakistan; Production; Sheep; Weight Gain

Introduction

Livestock sector has a vital role in ensuring food security by fulfilling the ever-increasing demand for animal proteins [1, 2]. For this reason, short-cycle animals such as sheep and goat etc. demanding low investment and relatively easy management practices for rearing are of particular

importance [2]. Livestock is the largest sub-sector of agriculture in Pakistan contributing about 61.9% in agriculture segment and 14% in gross domestic products. The livestock segment has achieved a growth rate of more than 3.26% during 2021-2022 and more than eight million families in rural areas of Pakistan are involved in livestock production, deriving up to 40% of their total income [3].
Ruminants including sheep have the unique ability to survive harsh environmental conditions and food shortages. For this reason, they are the preferred rearing animals in arid, semi-arid and dry hilly areas and are of central economic importance for most people of these areas [2, 4]. The estimated population of sheep in Pakistan is 31.9 million heads; they are reared for mutton, wool, milk and hide production. In 2021-2022, Pakistan has produced 765,000 tons of mutton, 47,900 tons of wool, 41,000 tons of sheep milk and 3,548 numbers of skin [3, 5].
The selection of efficient breeds along with adequate quality and quantity of feed is of prime importance in commercial livestock production. The provision of balanced and nutritious feed promotes the growth and health of animals, thereby improving their productive efficiency [1, 2, 5]. Moreover, efficient feeding also minimizes the adverse environmental impact of farming [6]. Although sheep are highly adaptive to stay alive under limited feed conditions (up to 50%), the deficiency of such nutrients often leads to sub-optimal production/reproductive performance and increases the likelihood of various diseases [1, 7]. Sheep in arid, semi-arid and dry hilly regions often experience feed scarcity and they mostly thrive on natural grasses and/or shrubs. These grasses have high neutral detergent fiber (NDF) on one side and low digestibility, metabolizable energy, protein content, minerals and vitamins on other the side, which are insufficient to meet the nutrient requirements of sheep [4, 8, 9]. In addition to free grazing, limited supplementation with concentrate ration (which is rich in protein) significantly improves the production performance with no detrimental effects on body [4, 10, 11].
Blood is an important indicator of health and nutritional status of an animal [12, 13]. The hematological and serum biochemical profiles can quickly and reliably provide information regarding the physiological, nutritional and pathological status of an animal and its significance has been well documented in literature for multiple animals including sheep [2, 9]. Under nutrition significantly reduces the levels of various hematological parameters (hemoglobin, White Blood Cells, hematocrit) and serum biochemical markers (total protein and triglycerides). While, the level of liver enzymes including alanine aminotransferase (ALT), aspartate aminotransferase (AST) and blood urea increases following restricted diet [7]. Moreover, the serum albumin and creatinine can be used as markers for protein metabolism in sheep [6].
In terms of breed, sheep are extremely diverse, accounting for nearly 25% of all mammalian breeds [5]. Among 30 or more breeds of sheep in Pakistan, seven or more are native to different regions of Khyber Pakhtunkhwa province [14]. The Ghaljo breed, native to Kohat Division of Khyber Pakhtunkhwa has been scarcely reported in the literature. Therefore, this study is aimed to explore the effect of feeding different levels of forages and concentrate ration on production performance, blood profile and economics in Ghaljo sheep.

Materials and Methods

Study design

A three-month randomized controlled trial was conducted at the Arid Zone Small Ruminants Research Institute in Kohat, Khyber Pakhtunkhwa. A total of nine healthy Ghaljo sheep of similar age and weight were randomly distributed into three experimental groups (three animals per group). The control group was fed on an exclusively forage-based diet (wheat straw, sorghum and millet) as per common feeding practice. The C-33 group was fed on a diet comprising 33% concentrate ration with 67% forages. Whereas, the C-67 group fed on a diet comprising 67% concentrate ration with 33% forages as shown in (Fig. 1).

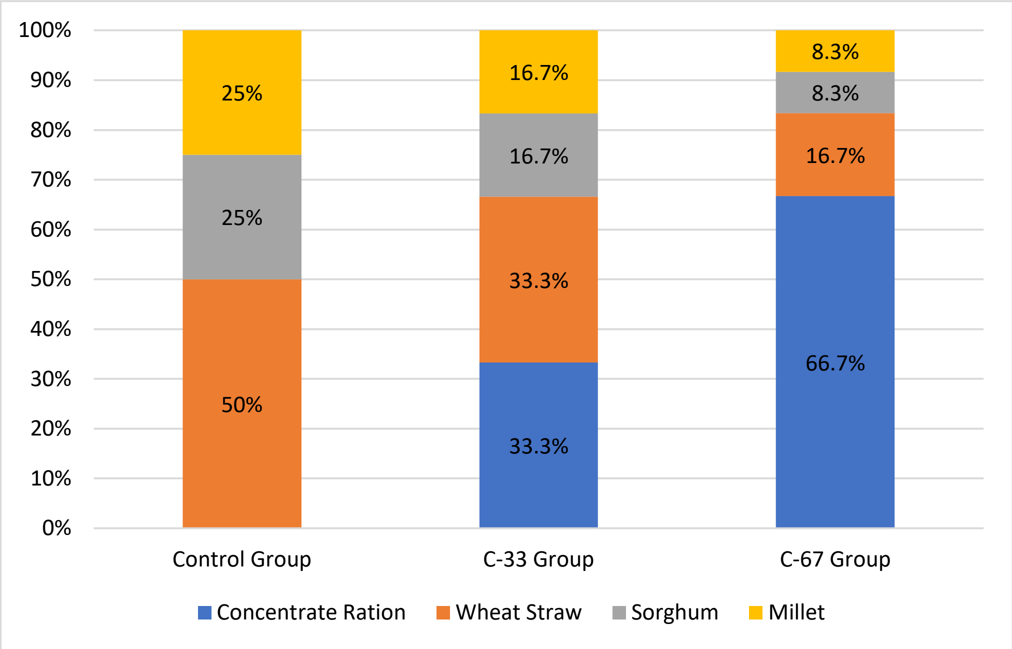

Figure 1: **Composition of experimental diets**

The proximate and aflatoxin B_1 profile of concentrate ration (dry matter: 91.7%, ash: 9.3%, crude protein: 15.8%, Aflatoxin B_1: 15ppb), wheat straw (dry matter: 94.9%, ash: 9.0% and crude protein: 4.9% and Aflatoxin B_1: 12ppb), sorghum (dry matter: 20.8%, ash: 8.0% and crude protein: 5.4% and Aflatoxin B_1: 05ppb) and millet (dry matter: 20.6%, ash: 6.9% and crude protein: 6.9%, Aflatoxin B_1: 08ppb) were fed to animals. The feed was offered twice daily (morning and evening) with an additional two hours of field grazing inside the institute and clean water was available ad-libitum. The experimental animals were treated with Vorcid® Drench (Oxfendazole, Triclabendazole) followed by 21 days of adaptation period before the commencement of trial.

Assessment of feed intake and production performance

The feed intake of each animal was noted on daily basis and data pertaining to live animal body weight was collected on weekly basis. The body condition score of experimental animals was assessed on the first and last day of the trial. The feed efficiency was estimated in terms of feed conversion ratio (FCR) using the following equation:

$$\text{Feed Efficiency} = \frac{\text{Feed Intake in Kgs (Dry Matter Basis)}}{\text{Weight Gain (Kgs)}}$$

Assessment of serum biochemical and hematological profile

For serum biochemical profile, whole blood samples (~3ml) was collected on fortnight basis from each animal using a disposable syringe (Nipro®, Indonesia) in accordance with standard protocols. The blood samples were immediately transferred to a gel and clot activator tube (Xinle®, China) and transported to laboratory in a blood transport cooler for analysis. The serum was extracted within one hour of sample collection and all biochemical tests were performed with a semi-automatic chemistry analyzer (Chem-o-Test Vet®, Germany) using reagent kits (MTI Diagnostics®, Germany) for glucose, cholesterol, calcium, ALT, total protein, and urea as per manufacturer's protocol. Similarly, whole blood samples (~3ml) were collected on fortnight basis from each animal using a disposable syringe (Nipro®, Indonesia) in accordance with standard protocols for hematological profile. The blood samples were immediately transferred to Ethylene di-amine tetra acetic acid (EDTA) tube (Xinle®, China), gently mixed for few seconds and transported to laboratory in blood transport cooler for analysis using an automatic hematology analyzer (URIT-2900VetPlus®, China) as per standard protocols.

Assessment of economics

In order to estimate the profit for each animal, the total investment, including value of each animal at baseline and cost of feed consumed throughout the study period was subtracted from value of each animal at the end of trial as follows:

$$\text{Profit} = \text{Final Value of Animal} - (\text{Value of Animal at Baseline} + \text{Total Feed Cost})$$

The initial and final value of each animal was estimated on the basis of carcass yield (60% of live body weight) and prevailing market rates for mutton. Whereas, return on investment (profit/ cost) was estimated for all groups using the following equation:

$$\text{Return on Investment} = \frac{\text{Profit}}{\text{Total Investment}} \times 100$$

Statistical analysis

All statistical analyses were performed with IBM SPSS Statistics (v21). The continuous variables are presented as mean ± standard deviation (SD) and one-way ANOVA with Tuckey's post-hoc analysis was performed to compare the study groups for different variables. A p-value of <0.05 is considered statistically significant.

Results

Feed Intake, body weight gain, feed efficiency and body condition score

Although, the intake of fresh feed was significantly higher in control group and C-33 group when compared with C-67 group (p=0.015). However, no significant differences were observed with respect to feed intake on dry matter basis among the study groups. The average animal weight gain in animals fed on concentrate-supplemented diet (C-33 group: 13.9 ± 1.0 Kg; C-67 group: 13.0 ± 0.9 Kg) was significantly greater than animals fed on an exclusively forage-based diet (10.1 ± 0.9 Kg, p=0.007). The feed efficiency of animals fed on concentrate-supplemented diet (C-33 group: 7.3 ± 0.4; C-67 group: 7.5 ± 0.1) was significantly better when compared with an exclusively forage-based diet (8.4 ± 0.2, p=0.003). The average body condition score was not remarkable between the study groups as shown in (Table 1).

Serum biochemical profile

The (Table 2) presents the serum biochemical profile comprising glucose, cholesterol, calcium, ALT, total protein and urea of study animals. We observed significant differences with respect to total serum protein and serum urea levels between the experimental groups. The total serum protein level of animals fed on concentrate-supplemented diet (C-67 group: 7.4 ± 0.3 g/dL; C-33 group: 7.1 ± 0.3 g/dL) was significantly greater than animals fed on an exclusively forage-based diet (6.5 ± 0.3 g/dL, P=0.009). The serum urea levels of all study groups were significantly different from each other (p=0.007). The highest serum urea levels were observed in animals of C-67 group (15.6 ± 1.3 mg/dL) followed by animals in the C-33 group (13.7 ± 0.5 mg/dL) and control group (12.2 ± 0.4 mg/dL).

Hematological profile

The present study observed no significant differences with respect to white blood cells (WBCs) count, red blood cells (RBCs) count, hemoglobin content, hematocrit and platelets count among the experimental animals over the course of the study duration as shown in (Table 3).

Economics

The economic evaluation of feeding forages with or without concentrate ration is presented in (Table 4). Although, supplementation of forage-based diet with concentrate ration increases the feed cost, but animals fed on concentrate-supplemented diet performed better than animals fed on an exclusively forage-based diet (wheat straw, sorghum and millet). The highest return on investment (26%) was observed for animals fed on diet comprising 33% concentrate and 67% forages (wheat straw, sorghum and millet). Whereas, 20% return on investment was recorded for animals fed on diet comprising 67% concentrate with 33% forages and an exclusively forage-based diet.

Table 1: Feed intake, feed efficiency, weight gain and body condition score of experimental animals

Groups	Total Feed Intake (Kg) (Mean ± SD)		Live Animal Weight (Kg) (Mean ± SD)			Feed Efficiency	Body Condition Score (Mean ± SD)		
	Fresh Feed	**DM-Based Feed**	**Initial Weight**	**Final Weight**	**Weight Gain**		**Initial BCS**	**Final BCS**	**BCS Gain**
C-33%	240.5 ± 29.9a	103.4 ± 12.9	27.4 ± 9.1	41.2 ± 10.0	13.9 ± 1.0a	7.3 ± 0.4a	3.2 ± 0.3	4.2 ± 0.3	1.0 ± 0.0
C-67%	172.9 ± 12.1b	99.10 ± 6.90	31.4 ± 19.7	44.4 ± 20.5	13.0 ± 0.9a	7.5 ± 0.1a	3.5 ± 0.5	4.3 ± 0.3	0.8 ± 0.3
Control	249.8 ± 26.6a	84.90 ± 9.00	26.2 ± 2.6	36.3 ± 2.80	10.1 ± 0.9b	8.4 ± 0.2b	3.3 ± 0.6	4.0 ± 0.5	0.7 ± 0.3
p-value	0.015	0.134	0.87	0.761	0.007	0.003	0.702	0.579	0.296

Kg: Kilogram, DM: dry matter, BCS: body condition score, SD: standard deviation

Table 2: **Serum biochemical profile of experimental animals**

Groups	Glucose (mg/dL)		Cholesterol (mg/dL)		Calcium (mg/dL)		Alanine Aminotransferase (U/L)		Total Protein (g/dL)		Urea (mg/dL)	
	Initial	**Final**	**Baseline**	**Final**	**Baseline**	**Final**	**Baseline**	**Final**	**Baseline**	**Final**	**Baseline**	**Final**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Control	71.9 ± 7.7	61.5 ± 10.3	62.3 ± 3.1	61 ± 4	11.7 ± 0.4	12 ± 0.5	29 ± 1.7	31.7 ± 3.2	6.4 ± 0.2	6.5 ± 0.3 **a**	13.6 ± 0.3	12.2 ± 0.4 **a**
C-33	79.7 ± 2.6	60.9 ± 8.7	59.7 ± 7	65 ± 10.5	12.2 ± 0.4	11.9 ± 0.2	29 ± 2.6	31.3 ± 1.5	6.6 ± 0.1	7.1 ± 0.3 **b**	13.5 ± 1.2	13.7 ± 0.5 **b**
C-67	72.5 ± 12.2	56.6 ± 2.6	62 ± 4.6	63 ± 7.5	11.9 ± 0.4	11.8 ± 0.2	31 ± 2	29.3 ± 1.5	6.7 ± 0.3	7.4 ± 0.3 **b**	14.3 ± 0.8	15.6 ± 1.3 **c**
P Value	0.493	0.72	0.795	0.827	0.377	0.729	0.471	0.436	0.329	0.009	0.463	0.007

SD: Standard deviation

Table 3: **Hematology profile of experimental animals**

Groups	WBCs ($x10^3/\mu L$)		RBCs ($x10^6/\mu L$)		Hemoglobin (g/dL)		Hematocrit (%)		Platelets ($x10^3/\mu L$)	
	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final	Baseline	Final
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Control	6.4 ± 0.9	6.1 ± 1	12.9 ± 0.7	13 ± 0.3	12.7 ± 0.8	12.4 ± 0.7	35.3 ± 1.2	36.2 ± 1.1	931 ± 54.6	926.3 ± 25.8
C-33	6.2 ± 0.7	6.4 ± 0.7	12.5 ± 1	13.2 ± 0.4	12.8 ± 0.4	12.8 ± 0.3	34.7 ± 1.2	36.9 ± 0.9	920 ± 38.4	960.7 ± 47.5
C-67	6.9 ± 0.9	6.2 ± 0.5	13 ± 0.5	13.6 ± 0.9	12.6 ± 0.7	12.6 ± 0.2	35.7 ± 1.7	38.2 ± 2.2	899 ± 48.1	933.7 ± 42.6
P Value	0.5	0.8	0.6	0.4	0.9	0.6	0.6	0.2	0.6	0.5

WBCs: White blood cells, RBCs: Red blood cells, SD: standard deviation

Table 4: **Economic evaluation of concentrate supplementation in sheep**

Groups	C-33%	C-67%	Control
Animal initial Value*	14,778	16,974	14,148
Total Feed Cost (PKR)	2,893	2,994	2,187
Total Initial Cost (PKR)	17,671	19,968	16,335
Animal final Value*	22,262	23,972	19,591
Profit (PKR)	4,591	4,004	3,256
Income/Cost (%)	126	120	120
Profit/Cost (%)	26	20	20

*Market value/ carcass yield of animals are calculated per 60 percent of live body weight

Discussion

The present study observed highest weight gain in Ghaljo sheep fed with a diet containing 33% concentrate ration and 67% forages (wheat straw, sorghum and millet) as compared with a diet containing 67% concentrate ration and an exclusively forage-based diet. The feed efficiency of a diet containing 33% concentrate ration and 67% concentrate ration was superior to an exclusively forage-based diet. Feeding sheep with a concentrate-supplemented diet resulted in higher serum protein and serum urea levels when compared to an exclusively forage based diet, but their levels did not exceed the normal range for these parameters. Economic evaluation revealed that feeding a diet containing 33% concentrate ration with 67% forages (wheat straw, sorghum and millet) results in highest return on investment as compared with a diet containing 67% concentrate with 33% forages or an exclusively forage-based diet.

No significant differences were observed between the study groups with respect to feed intake on dry matter basis. However, intake of fresh feed was significantly lower for C-67 group primarily because of high proportion of concentrate ration (which has relatively low moisture content than forages) in their diet. Further, we observed no impact of concentrate ration and/or high protein diet on intake of feed. Previous studies have reported varied results on impact of diet containing concentrate ration and/or high crude protein levels on feed intake. Some studies have reported no significant impact of feeding concentrate and/or crude protein rich diets on feed intake in ruminants [15-17]. Whereas, others have reported higher feed intake in ruminants fed on a diet containing high concentrate (up to 40%) and/or protein content [10, 18, 19]. Lower dry matter intake in ruminants has also been reported with concentrate-supplemented diets because of lactic acidosis, which is a common manifestation of concentrate-supplemented diet [20]. The contrasting evidence on impact of concentrate and/or protein -rich diet on feed intake may be attributed to differences in nature/ composition of concentrate diet, breed or type of experimental animals, geographical location, and seasonal variations.

The animals fed on concentrate-supplemented diet achieved significantly greater weight gain as compared with animals fed on an exclusively forage-based diet. The average weight gain in C-33 group (13.9 ± 1.0 Kg) and C-67 group (13.0 ± 0.9 Kg) was significantly greater than animals in the control group (10.1 ± 0.9 Kg, p=0.007). Higher weight gains with concentrate-supplemented diet can be attributed to ample availability of nutrients, energy, dietary proteins, minerals and vitamins required for optimal production performance [18, 21-24]. It has also been reported that concentrate supplementation with forages improves the overall digestibility of nutrients [25]. Moreover, lower weight gain in animals fed exclusively on a forage-based diet may be attributed to poor profile of forages with respect to digestibility, metabolizable energy, protein content, minerals and vitamins, which are often insufficient to meet nutritional requirements for optimal growth of sheep [4, 8, 9, 26].

In terms of feed efficiency, animals fed on a concentrate-supplemented diet (feed conversion ratio of C-33 group is 7.3 ± 0.4 and C-67 group is 7.5 ± 0.1) outperformed animals fed on an exclusively forage-based diet (8.4 ± 0.2, p=0.003). The highest feed efficiency (i.e, lowest feed conversion ratio) was observed for animals fed on a diet containing 33% concentrate ration and 67% forages (7.3 ± 0.4) followed by animals fed on a diet containing 67% concentrate ration and 33% forages (7.5 ± 0.1). Whereas, significantly poor feed efficiency was observed for animals fed on an exclusively forage-based diet (8.4 ± 0.2, p=0.003). Our findings are also supported by previous studies which have concluded that feeding concentrate-supplemented diet (50 - 70% concentrate ration) improves feed efficiency in sheep [18, 20, 27].

The level of total serum protein and serum urea was significantly higher in animals fed on a concentrate-supplemented diet (the level of total serum protein for C-33 group is 7.1 ± 0.3 g/dL and C-67 group is 7.4 ± 0.3 g/dL) as compared with animals fed on an exclusively forage-based diet (6.5 ± 0.3 g/dL, p=0.009). This study observed similar increase in total serum protein levels in animals fed on a diet containing different levels of concentrate to forages ratio i.e. 33% concentrate and 67% concentrate. Notably, the levels of total serum protein were within the normal range (6 – 8 g/dL), which indicate that diets comprising up to 67% of concentrate ration are well tolerated by Ghaljo sheep [28]. Similar increase in total serum protein following a concentrate-supplemented diet in sheep has also been reported by previous studies [2, 29, 30]. It has been reported that total serum protein is a marker for protein reserves in the body and higher levels of total serum protein indicate improved intake and digestibility of proteins in diet [31, 32].

The level of serum urea was significantly higher in animals fed on different levels of concentrate-supplemented diets as compared with animals fed on an exclusively forage-based diet (p=0.007). The highest increase in serum urea level was observed for animals fed on diet containing 67% concentrate ration with 33% forages (15.6 ± 1.3 mg/dL) followed by animals fed on diet containing 33% concentrate ration with 67% forages (13.7 ± 0.5 mg/dL). Whereas, lowest levels of serum urea were observed for animals fed on an exclusively forage-based diet (12.2 ± 0.4 mg/dL). Despite the higher levels of serum urea in animal fed on concentrate-supplemented diet, the levels of serum urea did not exceed the upper limit for serum urea (normal range is 8 – 20 mg/dL) in sheep [28]. Urea is a metabolic by-product of proteins, which may be associated with increased intake, and metabolism of dietary proteins. The higher levels of serum urea in animals fed on a concentrate-supplemented diet may be attributed increased intake and digestibility of dietary protein **[2, 33, 34]**. Further, no significant increases in serum hepatic enzymes were observed which indicates that feeding diet comprising up to 67% concentrate ration are well tolerated by Ghaljo sheep.

The overall cost of feed was considerable lower in animals fed on an exclusively forage-based diet, but animals fed on a concentrate-supplemented diet performed better than an exclusively forage-based diet **[27, 35]**. The highest return on investment (26%) was noted for animals fed on a diet comprising 33% concentrate ration with 67% forages (wheat straw, sorghum and millet). Whereas, the return on investment (20%) was similar between animals fed on a diet comprising 67% concentrate ration with 33% forages (wheat straw, sorghum and millet) and an exclusively forage-based diet (wheat straw, sorghum and millet). Animals fed on a diet containing 67% concentrate with 33% forages performed better in terms of weight gain, but its cost was considerable higher than an exclusively forage-based diet.

Conclusion

The findings of this study indicate that concentrate-supplemented diet can significantly improve the production performance i.e., weight gain and feed efficiency of sheep without any adverse effect on their overall health. It is recommended that sheep should be fed on a diet comprising 33% concentrate ration and 67% forages (wheat straw, sorghum and millet) on dry matter basis for optimal growth and economic returns in commercial production.

Author's contributions

Conceived and designed the experiments: S Khan, SU Hayat, F Shahzadi, F Khan & AH Khan, Performed the experiments: S Khan, F Shahzadi, SU Hayat, F Khan & HA Majid, Analyzed the data: SU Hayat, F Khan & AH Khan, Contributed reagents/ materials/ analysis tools: M Iqbal, RJ Afridi & S Khan, Wrote the paper: SU Hayat, F Khan, F Shahzadi & S Khan.

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