Research Article

Comparative Investigation of Feeding Habits and Apparent Digestibility of Maize, Millet and Sorghum Fodders in Sheep and Goat

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Abstract | A study was carried out to investigate the feeding behavior and performance of sheep and goat. The animals were fed on Maize, Sorghum, and Millet. For this purpose, a total of 90 animals (n=45 sheep) and (n=45 goats) were randomly assigned into six groups (n=15) each under 2x3 factorial arrangement. All groups of both species were fed maize, millet and sorghum randomly. Results indicated that goat spent more time to eat than sheep while sheep rumination time were noted significantly (*P<0.05*) higher in sheep compare to the goat. Meanwhile, drinking time was noted higher in sheep than goat. Moreover, goat exhibited higher resting, playing and other activities compared to sheep. Findings of dry matter intake (DMI), crude protein (CP) natural detergent fiber (NDF) and nutrient detergent fiber (NDF) were recorded significantly similar (P<0.05) in both species. Furthermore, digestibility of DM was observed similarly among two species while, digestibility of CP was recorded higher on millet fodder compare to other fodders. The digestibility of various nutrients such as CP, NDF and ADF were significantly higher (P<0.05) in sheep compared to goat. Daily weight gain, feed efficiency and cost of production were recorded similar in both species. Conclusively, both species of small ruminants showed significant weight gain and different feeding behavior of the consumption of various summer fodders.

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Introduction

In comparison to other ruminants, sheep and goat species are indigenous to tropical and subtropical environments generally performed better in terms of survival, reproduction, growth rate and milk production (Silanikove, 1997). Sheep and goat are the most important domestic animals of developing countries, including Pakistan, where approximately 95 percent of goat population is reared in various Agro-ecological zones of Africa and Asia to fulfill the public demand of animal food in term of meat and milk (Chowdhury and Mutalib, 2003). Small ruminant farming has economically viable business option for rural community of developing countries to generate the income and fulfill the food requirements (Nasrullah et al., 2015). Small ruminants play a significant role to fulfill the protein demand of growing human population (Arain et al., 2010 a, b, c). Small ruminants not only provide high quality nutrients such as meat, milk, fiber, skins and other by-products, but also contribute to fulfill the

public demand of animal slaughtered on social and religious occasions. Although the socioeconomic importance of sheep and goat species has been widely documented, the potential contribution inhibited by improper selection of potentially important breeds, poor feeding and management and inappropriate production system (Nasrullah et al., 2013). Sheep and goat are the preferred species of dry and warm regions of the world, including Pakistan (Salem and Smith, 2008). In Pakistan sheep and goat production system is still traditional, mostly animals are kept on grazing, fodders and forages (Nasrullah et al., 2015).

The production and availability of required fodder species for animal is influenced by several factors such as soil type, climate, availability of water and average rainfall (Thornton et al., 2009). However, the nutritional quality of fodder also affected due to seasonal changes. Like other South-Asian countries, Pakistan has two major seasons for the production of fodder crops i.e. winter and summer. The major winter fodders include *Trifolium alexandrium, Avena sativa* and *Brassica spp.* commonly known as (berseem, oats and mustard), while other fodders also contributed to fulfill the feeding requirements of animals such as *Trifolium resupinatum*, *Medicago sativa, Vicia species, Hordeum vulgare and Lolium perenne* also known as (shaftal, lucern, vetch, barley and rye grass). The fodders commonly cultivated and fed to the animals during summer season included *Coriandrum sativum, Vigna sinesis, Zea mays, Cyamopsis tetragonoloba, Sorghum bicolor and Pennisetum americanum* also called as (jantar, cowpeas, maize, guar, sorghum and millet) (Nasrullah et al., 2015). The domestic animals, including small ruminants are commonly grazed on these fodder to fulfill the maintenance, production and reproduction requirements. Previously published literature showed sufficient information regarding the nutritional value of fodders used for feeding small ruminant in not documented in Pakistan. Therefore, in the continuation of our previous study, current study was designed to evaluate the feeding behavior, digestibility and production performance of the local sheep and goat breeds fed on selected summer fodders.

Materials and Methods

Ethical statement

This animal study short title (Feeding behavior and digestibility of small ruminants) was carried out in Small Ruminant Research Center of Patoki campus, Punjab, Pakistan. The animals used in this study were housed and maintained according to the prior approval of ethical committee of the University of Veterinary and Animal Sciences (UVAS), Pakistan. All efforts were made to minimize animal suffering during entire period of experimental trial.

Experimental design and housing

A total of 90 animals (n=45 sheep) and (n=45 goats) were used in this study. Approximate age of studied animals is 27 months ± 15 days, and weight 32.5 ± 3 kg. These Animals were bought to the University farm two weeks before in order to ensure the adaptation period. After two weeks the animals were randomly divided into six experimental groups with three replicates (n=5) in each, (Goat: A, B and C, and Sheep: D, E, and F). Maize, sorghum and millet fodders were fed to all groups of sheep and goat. Before starting research all necessary preventive and control measures such as vaccination, deworming, identification/tagging was performed during the adaptation period. All animals of individual replicates were kept in pens throughout the study period. Fresh water was available ad libitum. The chemical compositions of fodders used for current research are shown in Table 1.

Table 1: *Chemical composition of offered summer fodders.*

Fodders	DM%	CP%	NDF%	ADF%	Cal/g
Maize	23	7	64	49.8	3612
Millet	19	8	62	47	3755
Sorghum	31	4.5	65.5	46	3873

DM: Dry matter; CP: Crude Protein; NDF: Neutral detergent fiber.

Data collection and measurement

The measured amount of fodder was offered to the all groups on morning and evening and unconsumed fodder was again measured after 24 hours and calculate voluntary feed intake during entire research period. The body weight gain (BWG) of all animals was recorded initially and thereafter at fortnight intervals. For feeding behavior observation two animals from each experimental group of both species were selected. The feeding behavior observation was recorded thrice a week (Saturday, Monday and Thursday) at morning (8.00 am) after refreshing the daily feed. The parameters were noted during feeding behavior is time spent for eating, ruminating, drinking, resting, standing and playing up to 24 hours.

Digestibility trial

At the end of the feeding trial, one animal from each replicate were randomly selected from treatment groups for digestibility studies and kept in separate pens having the facility to free excess of feeding and watering. The total fecal collection method was used to asses' digestibility of experimental animals. The feces were collected up to five days. Total fecal outputs for each animal were weighed and mix thoroughly, then 25% of the sample was taken for dry matter (DM) determination. Fecal sample was dried followed by the method of Aregheore (1996) using forced convection oven at 70˚C for 24 hours.

Chemical composition of feed and fecal samples

The chemical analysis of fecal and feed samples was calculated according to the method of AOAC (2010). However, the ADF and NDF analysis was performed, followed the procedure of Van Soest et al. (1991).

Statistical analysis

The statistical comparison of the data SAS 9.1.3 statistical software was used. Mean comparisons of groups were measured by using two-way ANOVA technique under factorial arrangements. Whereas, difference among experimental groups were tested through LSD test as describe by Steel et al. (1997).

Results and Discussion

Eating behavior

The feeding behavior studies are important for the research of livestock husbandry to improve the management and production performance of domestic animals (Correia et al., 2015; de Carvalho et al., 2017). In the current study, specie based evaluation and comparisons were performed for eating behavior of sheep and goat. The Results of eating behavior of sheep and goat fed on summer fodder (maize, millet, sorghum) are shown in (Table 2a, b). The findings showed that the eating and rumination time comparatively higher ($P < 0.05$) in goat specie to the sheep. The results of the current study are consistent with the previously published study, who fed *Cyamopsis tetragonolba*, *Vignasinesis* and *Coriandrum sativum* to the sheep and goat (Nasrullah et al., 2013). However, another study showed that the similar time was spent for eating and rumination in both species (Van et al., 2002). This contradiction might be due to the type of fodder used for feeding, because the authors used whole sugarcane with or without concentrate. Morand-Feher et al. (1991), reported that generally goats have slow eating behavior as compare to sheep. Our study showed that the drinking and standing time were significantly ($P<0.05$) higher in sheep specie compare to the goats. However, time spent in resting and other activities such as playing with other animals were significantly different ($P<0.05$) among both species. These findings are in line with the previously published study of Keskin et al. (2005), who reported that goat specie required less time for drinking and standing, but spend more time for playing and resting in compression to the sheep. The eating behavior of sheep and goat different among the type of fodders, which might be due to palatability and nutritional value of the fodders. Dietary behavior of small ruminants is very complex when selecting the fodder depending on the palatability and the age of the fodder and physiological status of the animal. The study of Abijaoude et al. (1997), reported that goats have a strong ability to differentiate various fodders on the basis of the physical structure and palatability at the time of eating. Our results showed that the increase amount of fodders offered to the animal could improve the eating and ruminating times in studied animals. The findings of this study are consistent with the results of Santini et al. (1991). McSweeney and Kennedy (1992), reported that dry matter intake was lowered in goat than sheep, while spent more time to eat. This variation may be due to low palatability and coarseness of the fodder.

Nutrient intake

The results of dry matter (DM) and other nutrient intake of goats and sheep offered different fodders (maize, millet, and sorghum) are depicted in (Table 3). The DM, CP, NDF, ADF intakes were significantly higher ($P<0.05$) in goats compare to sheep. Similarly, higher nutrient intake of goat specie was reported by Gordon (2003). Amongst browsing and grazing of ruminant species, the spotted deer are more selective in grazing than sheep. In contrast, Hadjigeorgiou et al. (2001) reported the similar feed intake of temperate forages between sheep and fiber-producing goats. However, Osuga et al. (2008) fed browse foliages like (*A. brevispica, Z. mucronata, B. discolor, A. mellifera* and *M. angolensis*) to goats and sheep and concluded that goats had higher intakes of all the browse foliages than sheep. These findings are consistent to our study that goats had higher intake than sheep on all offered fodders. In present study goats and sheep preferred millet than sorghum and maize fodders, the

Table 2a: *Feeding behavior of goats and sheep fed different summer fodders.*

Specie	Eating min/24h			Ruminating min/24h			Drinking min/24h			Standing min/24h		
	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum
Goats	337.66^{b} ±1.45	324.66^{c} ±1.45	354.33^{a} ±1.76	407.33^{d} ±1.45	378.66^{e} ±1.85	436.33^{c} ±0.88	8.33^{c} ±0.33	7.66^{c} ±0.33	8.00^{c} ±0.57	300.0^{d} ±1.00	287.33^{e} ±1.20	275.33^{f} ±2.02
Sheep	310.00^{d} ±0.57	301.33^{e} ±1.45	322.33^{c} ±1.45	441.66^{b} ±1.20	405.00^{d} ±2.30	476.66^{a} ±0.88	10.00^{b} ±0.57	11.33^{b} ±0.33	13.00^{a} ±0.57	350.00^{a} ±0.57	337.66^{b} ±1.45	317.00^{c} ±1.15

Means having same superscript letters within row and columns are not different (P > 0.05).

Table 2b: *Feeding behavior of goats and sheep fed different summer fodders.*

Specie	Playing min/24h			Resting min/24h			Others min/24h		
	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum
Goats	44.66^{c}±1.45	51.33^{b}±0.33	36.66^{d}±0.88	265.0^{c}±0.57	322.00^{a}±1.15	256.33^{d}±1.20	77.00^{a}±1.00	68.33^{ab}±3.52	73.00^{a}±4.72
Sheep	34.00^{e}±0.57	54.00^{a}±0.57	25.33^{f}±0.88	244.66^{e}±1.20	290.00^{b}±1.15	223.66^{f}±0.88	49.66^{c}±0.66	40.66^{c}±2.02	62.00^{b}±3.60

Means having same superscript letters within row and columns are not different (P > 0.05).

Table 3: *Nutrient intake in goats and sheep fed different summer fodders.*

	DM (g/d)			CP (g/d)			NDF (g/d)			ADF (g/d)		
Specie	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum
Goats	1034.71^{b} ±4.95	1309.88^{a} ±14.41	704.47^{c} ±29.02	73.17^{b} ±1.93	112.84^{a} ±0.85	43.67^{c} ±1.18	659.11^{b} ±3.22	826.58^{a} ±22.54	451.98^{c} ±19.10	514.66^{b} ±2.48	613.57^{a} ±6.84	311.45^{d} ±13.47
Sheep	971.26 ^{b} ±29.35	1299.12^{a} ±36.19	641.83^{c} ±5.47	71.19^{b} ±1.86	111.39^{a} ±2.09	41.43^{c} ±0.19	671.35^{b} ±16.54	818.03^{a} ±21.08	410.48^{c} ±3.62	468.76^{c} ±15.29	604.19^{a} ±17.69	282.02^{d}± 2.57

Means having same superscript letters within row and columns are not different (P > 0.05). DM: Dry matter; CP: Crude Protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

Table 4: *Growth rate, cost of production in Sheep and Goats fed different summer fodders (Mean ± SE).*

Specie	Average daily gain (g)			Feed efficiency			Cost Rs/kg gain		
	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum
Goats	28.88^{a} ± 4.00	31.11^{a} ±5.87	32.22^{a} ±4.00	0.02^{b} ±0.00	0.01^{c} ±0.00	0.03^{a} ±0.00	192.84^{bc} ±24.45	298.45^{a} ±66.51	145.66^{c} ±17.93
Sheep	32.22^{a} ±2.93	31.11^{a} ±2.93	34.44^{a} ±2.93	0.02^{b} ±0.00	0.01^{c} ±0.00	0.03^{a} ±0.00	191.85^{bc} ±20.16	277.80^{ab} ±26.04	131.74^{c} ±0.61

Means having same superscript letters within row and columns are not different (P > 0.05).

Table 5: *Nutrient digestibility % in Sheep and Goats fed different summer fodders (Mean ± SE).*

	DM			CP			NDF			ADF		
Specie	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Sorghum
Goats	53.40^{a} ±0.87	50.53^{a} ±1.07	52.43^{a} ±1.65	59.55^{c} ±1.39	70.05^{a} ±1.02	66.68^{b} ±0.75	52.95^{c} ±0.73	56.02b^{c} ±0.87	56.15b^{c} ±1.42	46.36^{bcd} ±0.97	44.15^{dc} ±1.42	52.72^{a} ±1.68
Sheep	53.94^{a} ±1.70	50.09^{a} ±1.10	51.23^{a} ±1.69	66.41^{b} ±0.91	67.93^{a} ±0.80	62.43^{c} ±1.08	61.16^{a} ±1.98	58.94^{ab} ±1.30	54.14^{c} ±1.51	42.32^{d} ±1.73	47.63^{bc} ±1.80	51.01^{ab} ±1.66

Means having same superscript letters within row and columns are not different (P >0.05). DM: Dry matter; CP: Crude Protein; NDF: Neutral detergent fiber; ADF: Acid detergent fiber.

results are line with the findings of Hadjigeorgiou et al. (2003), who reported that goats and sheep have a similar pattern of preference for forages with a wide range of chemical characteristics. Meanwhile, another study contradicts our finding and not supported the suggested differences regarding the preferences of CP and fiber intake of forages in both species (Domingue et al. 1991).

Efficiency of body weight gain

The results of the body weight gain (BWG) of both species fed different summer fodders are shown in Table 4. The average body weight gain was noted similar in all experimental groups fed different summer fodders. The results of the current study are consistent with the findings of our previous study (Nasrullah et al., 2013). However, performance and weight gain efficiency were noted higher in sheep as compare to the goat specie. Previously published study reported that the growth rate of Boer goat was lower than sheep (Van Niekerk and Casey, 1988). These findings are consistent with the results of the current study. In another study reported that the average growth rate was higher in lambs compare to kids under similar stall-feeding conditions (Sormunen-Cristian and Kangasmaki, 2000). The efficiency among fodders was significantly different ($P< 0.05$), whereas the performance of goats and sheep was similar ($P> 0.05$) fed same fodders. Normally feed efficiency is different in goats and sheep. In the current study, feed efficiency was recorded similar in both species. This might be attributed due to the type, quality and palatability of fodders, preference of both species and dry matter digestibility. The feeding cost was higher on millet, maize and sorghum in goats and sheep respectively. This cost was similar in maize and sorghum while on millet was different in goats and sheep. The cost of production Pk. Rs/kg was similar significantly ($P> 0.05$) among both species. The production cost is generally higher in sheep as compare to goats. In our study production cost of goats was higher might be due to aggressive behavior, fighting and playing activities.

Nutrient digestibility

The results of nutrient digestibility of sheep and goat fed different fodders of the summer season are presented in Table 5. The digestibility DM was recorded similarly ($P> 0.05$) in all experimental groups. Whereas, digestibility of CP was found higher in millet than other fodders while, the digestibility CP, NDF and ADF were found higher ($P<0.05$) in sheep as compare to the goats. Earlier literature is also in line with our findings (Brown and Johnson, 1985; Brown, 1982; Larbi et al., 1991). However, Lamba and Rajora (2002), reported that dry matter and CP digestibility were lower in sheep (71.4%) than goats (74.0%) while, the crude fiber digestibility was higher in sheep (74.2%) than the goats (71.4%). Furthermore, Santra et al. (2002), studied that the digestibility of NDF and ADF were significantly higher in goats compare to the sheep.

Conclusions and Recommendations

We conclude that both species of small ruminants showed different behavior on the consumption of various fodder such as maize, millet and sorghum. In both species observed marginal weight gain among all fodders used in the current study. The selected fodders are palatable for sheep and goats, however, for feedlot fattening and milk production offer such fodders without concentrate are not recommended.

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Author's Contribution

Nasrullah: Conceived the idea and data collection.
Ahmad Nawaz Khoso: Design Methodology.
Jamila Soomro: Did SPSS.
Illahi Bakhash Marghazani: Revised English language.
Masood-ul-Haqkakar: Technical Input.
Abdul Hameed Baloch: Overall Management.
Sarfaraz Ahmed Brohi: Data entry.
Muhammad Asif Arain: Critically revised and formatting for publication.

Conflicts of interest

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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