

# Effect of Improved Shelter and Improved Nutrition on Wool Yield and Wool Quality of Magra Lambs in Two Lambing Seasons Under Arid Zone

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## Abstract

*In an attempt to assess the effect of improved nutrition and improved shelter either alone or in combination, an experiment was conducted at ICAR-ARC-CSWRI, Bikaner in two phases. In each phase, forty male Magra lambs of 15 days old age were taken from ARC-CSWRI, Bikaner; ten lambs in each group were used in a randomized block design upto the six month of age, born during season 1 and season 2. Performance of lambs were assessed by studying wool parameters. The obtained results of meteorological variables indicated that there was wide variation in temperature and THI. The results of greasy fleece yield was observed to be highly significant ( $P < 0.01$ ) due to main effect of season. Non-significant effect was observed on all parameters of wool quality. At the end, based on the performance of lambs, it appears that incorporation of both improved nutrition and improved shelter is a viable proposition for optimum wool production.*

**Keywords:** Greasy Fleece Yield, Improved Nutrition, Season



## Introduction

The productivity of small ruminant production in western Rajasthan is decreased by a variety of factors like low plane of nutrition, high environmental temperature and poor management. Among these factors, high environmental temperature is the major factor affecting animal's productivity and higher humidity aggravates the situation (Manish Kumar *et al.*, 2010). In the arid and semi-arid region of India, sheep are generally exposed to various climatic extremes like higher temperature, feed and water deprivation during grazing (Maurya *et al.*, 2004; Sejian *et al.*, 2010) hence in addition to heat stress and physical strain of grazing activity, the small ruminants are subjected to feed deficiency (Hooda and Naqvi, 1990). In these areas, there is wide variation in ambient temperature, which may elevate upto 49°C during summer and may decrease below 3°C during winter, therefore small ruminant kept on only grazing, expose to stress because of environmental and nutritional stressors (Maurya *et al.*, 2004). Extremes in the environmental conditions impose a great effect on physiology and productivity of farm animals (Singh and Upadhyay, 2009) Among these climatic component's ambient temperature, humidity, solar radiation, photoperiod and air movement are some important factors, which cause stress on production and reproductive efficiency of small ruminants (Marai *et al.*, 2008). Climate change affects the economic sustainability and productivity of small ruminant's production systems. The economic efficiency of sheep rearing is based on the optimum production of lambs with minimum mortality at the time of rearing. A high ambient temperature is the major limitation on production performance of animal in tropical and sub-tropical areas (Marai *et al.*, 1995, 2000; Shelton, 2000). This effect is enhanced when heat stress is associated by high ambient humidity (Marai *et al.*, 1997, 2000; Abdel-Hafez, 2002). In arid and semiarid regions, the effect of heat stress is accelerated by nutritional deficiency and water deprivation, which is due to lack of availability of feed and poor pasture conditions. Deficiency of adequate feed resources is also an important factor, which causes lower production, particularly in arid and semi-arid areas in the world (Salem and Smith, 2008; Kawas *et al.*, 2010). Therefore, heat stress in sheep may be mitigated by adopting various disciplinary approaches, which include nutritional strategies, housing management and health services (Collier *et al.*, 2003).

## Materials and Methods

Phased experiment was conducted on 15 days old male Magra lambs at the sheep farm of ARC-CSWRI, Bikaner. In phase-I, fifteen days old Magra lambs (n=40) born in autumn-winter season were used for study in a randomized block design up to the six month of age during the period from September 2016 to Feb-March 2017 i.e. Autumn-Winter season (Season-1) at ICAR-ARC-CSWRI and divided into four groups of ten lambs in each group (T<sub>1</sub>-T<sub>4</sub>). In Phase-II, similar experiment was followed with the lambs born in spring-summer season (Season-II) during the period from early February, 2017 to early August, 2017. Groups included T<sub>1</sub>-sole grazing with traditional shelter; T<sub>2</sub>-improved shelter with grazing; T<sub>3</sub>-improved nutrition and traditional shelter and T<sub>4</sub>- improved nutrition and improved shelter. The traditional shelter means an enclosure without roof structure under tree shade. Improved shelter was in the form of asbestos sheet-thatched roof. Additional protection was provided with curtains in winter period to save the lambs from direct cold waves. In groups of (T<sub>3</sub>-T<sub>4</sub>) varying plane of nutrition was supplemented with creep mixture @1% of their body weight from 15 days of age to weaning while multinutrient mixture @1% of their body weight was provided from weaning upto six month of age in both seasons. Lambs were kept in their respective sheds with their dams upto weaning and thereafter they were separated from their dams and let loose for 8 hours grazing in all groups. The lambs of all groups were supplemented with *ad lib* groundnut haulms during the whole trial. All experimental lambs reared under strict management and proper hygienic conditions throughout the study period. Deworming was carried out for both ecto and endoparasites using suitable anthelmintics before the beginning of the experiment.

Two digital data loggers were used to record air temperature and relative humidity inside and outside of the shed. The data logger was hanged at 1.5 meter above the ground in the middle of inside and outside the shed. Climatic variables were observed from September, 2016 to August, 2017. Temperature humidity index (THI) values were calculated from recorded meteorological variables as per formula given by Marai *et al.* (2007). The weight of greasy fleece yield (GFY) was recorded after complete shearing of lambs at the time of first shearing in both seasons. The wool samples for laboratory analysis were taken from mid-side region above the last pair of ribs. Each sample was collected as close to skin as possible, kept in zip lock polythene bags along with identification card. Thereafter, the wool samples for laboratory analysis were sent to Textile Manufacturing and Textile Chemistry Division of Central Sheep and Wool Research Institute, Avikanagar for quality analysis, which includes staple length, no. of crimps, medullation and fibre diameter.

## Statistical Analysis

The data obtained in the present experiment were analyzed statistically for main effect of treatment or season alone as well as interaction (Treatment x Season) in factorial design (4x2) as per Snedecor and Cochran (2004) and significance of mean differences was tested by Duncan's New Multiple Range Test (DNMRT) as modified by Kramer (1956).

## Results and Discussion

The monthly mean values of average temperature, relative humidity and temperature humidity index (THI) of different months of inside and outside shed of both seasons are presented under in Table 1. The monthly mean values of temperature, relative humidity and THI of daytime (7 a.m.-7 p.m.) and night time (7 p.m.-7 a.m.) during different months of inside and outside shed of both seasons are presented in Table 2.

**Table 1:** Monthly mean values of temperature, relative humidity and THI of season 1 and 2 (inside and outside shed)

Period (Months)	Average Temperature (°C)		Average Relative Humidity (%)		Average THI	
	In	Out	In	Out	In	Out
<b>Season 1</b>						
September	31.65	32.33	49.63	49.16	28.94	29.49
October	27.8	27.81	44.83	45.64	25.56	25.6
November	19.31	19.01	43.27	44.95	18.45	18.22
December	18.76	17.87	48.62	48.05	18.06	17.31
January	14.73	12.84	65.3	65.51	14.72	13.02
Feb.-Mar. (up to 5th march)	18.59	20.19	42.91	39.07	17.74	19.05
<b>Season 2</b>						
February (From 12 <sup>th</sup> Feb.)	20.64	21.88	33.65	33.47	19.16	19.95
March	25.26	26.15	33.43	33.83	22.96	23.67
April	32.84	33.31	23.45	23.8	28.47	28.84
May	34.96	34.93	32.41	33.82	30.61	30.66
June	34.44	34.52	49.43	49.63	31.26	31.32
July-Aug (Up to 12th Aug.)	32.58	32.44	59.47	59.5	30.29	30.17

**Table 2:** Monthly mean values of temperature, relative humidity and THI of day and night of season 1 and 2 (inside and outside shed)

Period (Months)	Temperature (°C)				Relative Humidity (%)				THI			
	Day		Night		Day		Night		Day		Night	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
<b>Season 1</b>												
September	35.06	37.01	28.22	27.67	40.9	37.86	58.38	60.44	31.24	32.58	26.42	26.02
October	30.72	31.32	24.81	24.23	37.88	37.82	51.84	53.55	27.54	28.01	23.23	22.78
November	20.44	21.04	18.18	16.97	41.5	41.39	45.06	48.52	19.34	19.82	17.53	16.55
December	23.17	24.96	14.3	10.73	37.65	33.72	59.85	62.64	21.39	22.65	14.3	11.13
January	17.95	17.24	11.48	8.39	58.26	54.83	72.45	76.32	17.44	16.78	11.71	8.82
Feb.-Mar.	20.92	24.35	16.27	16.04	37.95	31.66	47.83	46.44	19.65	22.2	15.95	15.77
<b>Season 2</b>												
February	23.17	25.38	18.11	18.39	27.87	25.9	39.43	41.04	21.09	22.63	17.22	17.27
March	29.06	31.52	21.52	20.84	26.17	24.62	40.65	42.98	25.68	27.47	20.19	19.68
April	37.14	38.9	28.54	27.71	18.18	17.22	28.79	30.44	31.35	32.59	25.4	24.81
May	38.9	39.14	30.97	30.68	25.61	27.24	39.44	40.6	33.23	33.55	27.84	27.66
June	37.28	37.84	31.6	31.2	41.98	41.5	56.91	57.8	33.14	33.56	29.29	28.99
July-Aug	34.54	34.87	30.61	30	52.56	52.17	66.39	66.83	31.56	31.82	28.91	28.39

The mean values of greasy fleece yield (GFY) at the time of first shearing of different treatment groups of experiment are presented in Table 3. Due to main effect of treatment, the mean values of greasy fleece yield of

lambs at the time of first shearing were recorded 430.79±34.39 g in T<sub>1</sub>, 431.00±37.65 g in T<sub>2</sub>, 500.00±38.31 g in T<sub>3</sub> and 521.50±50.59 g in T<sub>4</sub> group. Likewise, as a resultant to the main effect of season, the mean values of greasy fleece yield of lambs in season 1 and season 2 were recorded 368.42±21.03g and 568.38±27.11 g. Due to interaction, mean values of greasy fleece yield in season 1 and season 2 were recorded 344.44±29.40 and 508.50±48.85 g in T<sub>1</sub>, 350.00±47.73 and 512.00±47.44 g in T<sub>2</sub>, 388.89±51.22 and 600.00±33.66 g in T<sub>3</sub> and, 390.00±40.69 and 653.00±72.85 g in T<sub>4</sub> group. The statistical analysis of variance due to main effect of treatment and interaction (Treatment x Season) revealed no significant effect on greasy fleece yield at the time of first shearing, whereas, due to main effect of season revealed highly significant (P<0.01) effect. Due to main effect of treatment, the highest per cent (21.16%) increase in greasy fleece yield was recorded in lambs of group T<sub>4</sub> followed by 16.27 % in T<sub>3</sub> and 0.23 % in T<sub>2</sub> over control group. Likewise, due to main effect of season, the increase in greasy fleece yield of lambs by 54.27 % was noticed in season 2 over season 1. The mean values of wool quality of lambs under different treatment groups of experiment presented in Table 3.

**Table 3:** Effect of different treatment groups on wool yield and wool quality in two lambing seasons

Treatment groups		Wool yield (g)	Fiber diameter (μ)	Hetero fibers (%)	Hairy fibers (%)	Medullation (%)	Crimps (per cm)	Staple length (cm)
Treatment	Season	Interaction (Treatment X Season)						
T <sub>1</sub>	1	344.44±29.4	34.16±3.38	13.26±2.81	37.53±13.39	50.79±11.94	1.45±0.27	4.66±0.59
T <sub>2</sub>	1	350.00±47.73	31.46±1.65	20.65±3.77	30.00±7.71	50.73±11	1.11±0.06	5.36±0.72
T <sub>3</sub>	1	388.89±51.22	30.68±2.53	12.53±3.47	29.46±11.96	42.00±13.35	1.38±0.26	3.90±0.4
T <sub>4</sub>	1	390.00±40.69	27.74±1.6	21.06±4.24	18.39±4.57	39.46±7.77	1.36±0.1	4.28±0.52
T <sub>1</sub>	2	508.50±48.85	35.28±2.81	21.26±2.86	37.00±6.1	58.26±6.5	1.03±0.27	4.70±0.86
T <sub>2</sub>	2	512.00±47.44	34.82±2.62	24.67±3.86	30.86±6.74	55.53±9.44	1.31±0.2	4.80±0.54
T <sub>3</sub>	2	600.00±33.66	32.10±1.62	20.73±1.3	33.20±6.13	53.93±5.2	1.43±0.16	4.90±0.25
T <sub>4</sub>	2	653.00±72.85	30.52±1.63	14.26±2.53	24.93±9.51	39.20±11.35	1.71±0.31	4.86±0.48
Main Effect of Treatment								
T <sub>1</sub>		430.79±34.39	34.72±2.08	17.26±2.31	37.26±6.94	54.53±6.53	1.24±0.19	4.68±0.49
T <sub>2</sub>		431.00±37.65	33.14±1.56	22.66±2.63	30.43±4.83	53.13±6.88	1.21±0.1	5.08±0.43
T <sub>3</sub>		500.00±38.31	31.39±1.44	16.63±2.21	31.33±6.36	47.96±7.04	1.41±0.15	4.40±0.28
T <sub>4</sub>		521.50±50.59	29.13±1.17	17.66±2.59	21.66±5.09	39.33±6.48	1.54±0.16	4.57±0.35
Main Effect of Season								
Season 1 (S1)		368.42 <sup>a</sup> ±21.03	31.01±1.22	16.88± 1.89	28.85±4.86	45.75±5.27	1.33±0.09	4.55±0.29
Season 2 (S2)		568.38 <sup>b</sup> ±27.11	33.18±1.12	20.23±1.55	31.50±3.48	51.73±4.24	1.37±0.12	4.82±0.27

Means with different superscripts in a column differ significantly

Due to main effect of treatment, the mean values of fiber diameter of wool of lambs at first shearing were recorded 34.72±2.08 μ in T<sub>1</sub>, 33.14±1.56 μ in T<sub>2</sub>, 31.39±1.44 μ in T<sub>3</sub> and 29.13±1.17 μ in T<sub>4</sub> group. Likewise, due to main effect of season, the mean values of fiber diameter of wool of lambs during season 1 and season 2 were recorded 31.01±1.22 and 33.18±1.12 μ. Further, due to interaction (Treatment x Season), the mean values of fiber diameter of wool of season 1 and season 2 were recorded 34.16±3.38 and 35.28±2.81 μ in T<sub>1</sub> (Control), 31.46±1.65 and 34.82±2.62 μ in T<sub>2</sub>, 30.68±2.53 and 32.10±1.62 μ in T<sub>3</sub> and, 27.74±1.60 and 30.52±1.63 μ in T<sub>4</sub> group. The statistical analysis of variance due to main effect of treatment or season alone and interaction (Treatment x Season) revealed no significant effect on average fiber diameter of wool. Due to main effect of treatment, the mean values of hetero fibers of wool of lambs were recorded 17.26±2.31% in T<sub>1</sub>, 22.66±2.63% in T<sub>2</sub>, 16.63±2.21% in T<sub>3</sub> and 17.66±2.59% in T<sub>4</sub> group. Likewise, due to main effect of season, the mean values of hetero fibers of wool of lambs in season 1 and season 2 were recorded 16.88±1.89 % and 20.23±1.55 %. Further, due to interaction (Treatment x Season), the mean values of hetero fibers of wool of season 1 and season 2 were recorded 13.26±2.81 and 21.26±2.86 % in T<sub>1</sub> (Control), 20.65±3.77 and 24.67±3.86 % in T<sub>2</sub>, 12.53±3.47 and 20.73±1.30 % in T<sub>3</sub> and, 21.06±4.24 and 14.26±2.53 % in T<sub>4</sub>. The statistical analysis of variance due to main effect of treatment or season alone and interaction (Treatment x Season) revealed no significant effect on average per cent hetero fibers of wool. Due to main effect of treatment, the mean values of hairy fibers of wool of lambs were recorded 37.26±6.94 % in T<sub>1</sub>, 30.43±4.83 % in T<sub>2</sub>,

31.33±6.36 % in T<sub>3</sub> and 21.66±5.09 % in T<sub>4</sub> group. Likewise, as a resultant to the main effect of season, the mean values of hairy fibers of wool of lambs in season 1 and season 2 were recorded 28.85±4.86 % and 31.50±3.48 %. Further, due to interaction, the mean values of hairy fibers of wool of lambs of season 1 and season 2 were recorded 37.53±13.39 and 37.00±6.10 % in T<sub>1</sub>, 30.00±7.71 and 30.86±6.74 % in T<sub>2</sub>, 29.46±11.96 and 33.20±6.13 % in T<sub>3</sub> and, 18.39±4.57 and 24.93±9.51 % in T<sub>4</sub> group.

The statistical analysis of variance due to main effect of treatment or season alone and interaction (Treatment x Season) revealed no significant effect on mean per cent hairy fibers of wool. Due to main effect of treatment, the mean values of medullation of wool of lambs were recorded 54.53±6.53 % in T<sub>1</sub>, 53.13±6.88 % in T<sub>2</sub>, 47.96±7.04 % in T<sub>3</sub> and 39.33±6.48 % in T<sub>4</sub> group. Likewise, due to main effect of season, the mean values of medullation of wool of lambs in season 1 and season 2 were recorded 45.75±5.27 % and 51.73±4.24 %. Further, due to interaction (Treatment x Season), the mean values of medullation of wool of season 1 and season 2 were recorded 50.79±11.94 and 58.26±6.50 % in T<sub>1</sub> (Control), 50.73±11 and 55.53±9.44 % in T<sub>2</sub>, 42.00±13.35 and 53.93±5.20 % in T<sub>3</sub> and, 39.46±7.77 and 39.20±11.35 % in T<sub>4</sub> group. The statistical analysis of variance due to main effect of treatment or season alone and interaction (Treatment x Season) revealed no significant effect on mean of per cent medullation of wool. Due to main effect of treatment, the mean values of number of crimps of wool of lambs were recorded 1.24±0.19 per cm in T<sub>1</sub>, 1.21±0.10 per cm in T<sub>2</sub>, 1.41±0.15 per cm in T<sub>3</sub> and 1.54±0.16 per cm in T<sub>4</sub> group. Likewise, due to main effect of season, the mean values of number of crimps of wool of lambs in season 1 and season 2 were recorded 1.33±0.09 and 1.37±0.12 per cm. Further, due to interaction, the mean values of number of crimps of wool of lambs were recorded 1.45±0.27 and 1.03±0.27 per cm in T<sub>1</sub>, 1.11±0.06 and 1.31±0.20 per cm in T<sub>2</sub>, 1.38±0.26 and 1.43±0.16 per cm in T<sub>3</sub> and 1.36±0.10 and, 1.71±0.31 per cm in T<sub>4</sub> group. The statistical analysis of variance due to main effect of treatment or season alone and interaction (Treatment x Season) revealed no significant effect on average number of crimps of wool fiber. Due to main effect of treatment, the mean values of staple length of wool of lambs were recorded 4.68±0.49 cm in T<sub>1</sub>, 5.08±0.43 cm in T<sub>2</sub>, 4.40±0.28 cm in T<sub>3</sub> and 4.57±0.35 cm in T<sub>4</sub> group. Likewise, due to main effect of season, the mean values of staple length of wool of lambs in season 1 and season 2 were recorded 4.55±0.29 cm and 4.82±0.27 cm. Further, due to interaction (Treatment x Season), the mean values of staple length of wool of season 1 and season 2 were recorded 4.66±0.59 and 4.70±0.86 cm in T<sub>1</sub>, 5.36±0.72 and 4.80±0.54 cm in T<sub>2</sub>, 3.90±0.40 and 4.90±0.25 cm in T<sub>3</sub> and, 4.28±0.52 and 4.86±0.48 cm in T<sub>4</sub> group. The statistical analysis of variance due to main effect of treatments and interaction (Treatment x Season) revealed no significant effect on average staple length of wool.

Results of present findings showed that the calculated temperature humidity index (THI) for both seasons was observed to be in wide variation, which were either higher or lower than recommended values *i.e.* <22.2 is absence of heat stress, 22.2 to < 23.3 is moderate heat stress, 23.3 to < 25.6 is severe heat stress and 25.6 and more is extreme severe heat stress as reported for sheep by Marai *et al.* (2007). Looking into the results of meteorological variables of day-night it is indicated that there was diurnal variation in temperature and THI, when animals were exposed to severe climatic stress in almost all daytime hours in extreme summer and in almost all night time hours during extreme winter. Wide variation in temperature and THI as evident from present findings indicated that lambs were under stress during various months of both seasons of study period. Looking into the results of main effect of season, it is indicated that there was significantly better greasy fleece production at first shearing in lambs born during spring-summer season in comparison to those of autumn-winter season, which is in accordance with Gupta *et al.* (2015) who reported that greasy fleece weight of September clip was observed significantly higher than March clip. The results of present study are well supported by Tomar *et al.* (2000b) and Arora *et al.* (2007). Safari *et al.* (2005) and Akhtar *et al.* (2014) also stated that there is effect of different environmental factors on wool yield. However, on contrary Kumar *et al.* (2006) observed non-significant effect of season of shearing in avikalin sheep. Due to main effect of treatment, there was better greasy fleece production in treatment groups, though it was statistically non-significant. Higher greasy fleece yield was obtained on supplementation of concentrate in treatment groups as the level of nutrition affects the wool production and efficiency (Dunlop *et al.*, 1966; Dolling and Piper 1968; Ferguson 1972).

Further, the findings are well supported with the results of Naqvi and Rai (1990) who reported that as the level of concentrate feeding increased from restricted to *ad libitum* resulted in improved greasy fleece yield of sheep. The non-significant variations in wool quality due to main effect of season was observed in present study, are in accordance with findings of Bottomley, (2001) and Yeates *et al.* (2013) who reported that environmental factors could cause a number of faults in wool, which influences the value of the fleece. Further, Ryder (2000) and Hutchinson (1999) stated that seasonal cycles of annual rhythm of wool growth rate are controlled by day length

and concluded that any change in day length could be the important factor for wool growth. Due to main effect of season, no significant trend in fibre diameter was observed, though it was numerically higher during season 2 over season 1. The results of fiber diameter, due to main effect of season are in agreement with Das *et al.* (2014). The results of staple length and crimp/cm were found statistically non-significant between seasons. Due to main effect of treatment, there was no significant reduction in fibre diameter and medullation, which was in partial agreement with Saroj (2016) who reported significant decrease in fibre diameter and medullation in Marwari sheep with improved nutrition. However, on contrary Karim *et al.* (2001), and Singh and Sankhyan (2003) stated increment in fibre diameter on supplementation of concentrate. Non-significant effect was observed on staple length and number of crimps/cm due to main effect of treatment in the present study, is in well accordance with Kumawat (2016) and Saroj (2016).

## Conclusion

Wool production is adversely affected by nutritional challenges and also by environmental stress, especially in arid and semi-arid regions of our country. It can be concluded from the present study that wool production of lambs can be improved by providing improved nutrition and improved shelter in thermal and nutritional stresses.

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## Conflict of Interests

There is no conflict of interest.

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## References

1. Abdel-Hafez, M. A. M. (2002). Studies on the reproductive performance in sheep. Ph.D. thesis. Faculty of Agriculture, Zagazig University, Zagazig, Egypt.
2. Akhtar, M., Javed, K., Abdullah, M., Mirza, R. H. and Elzo, M. A. (2014). Environmental factors affecting greasy wool yield traits of buchi sheep in Pakistan. *The Journal of Animal and Plant Sciences*, 24(3): 685-692.
3. Arora, A. L., Prince, L. L. L. and Mishra, A. K. (2007). Performance evaluation of Jaisalmeri sheep in farmers' flocks. *Indian Journal of Animal Sciences*, 77: 759-762.
4. Bottomley, G. A. (2001). Weather conditions and wool growth. University of New England Publishing Unit, Armidale. 115-125.
5. Collier, R. J., Coppola, C. and Wolfgram, A. (2003). Novel approaches for the alleviation of climatic stress in farm animals. *Interactions between climate and animal production. EAAP Technical Series*, (7): 61-71.
6. Das, A. K., Chakraborty, D., Kumar, N., Gupta, P., Khan, N. N. and Bukhari, S. (2014). Effects of non-genetic factors on performance traits of Kashmir Merino sheep. *Indian Journal Animal Research*, 48(2): 106-108.
7. Dolling, C. H. S. and Piper, L. R. (1968). Efficiency of conversion of food to wool. III. wool production of ewes selected for high clean wool weight and of random control ewes, on restricted and unrestricted food intakes, in pens. *Australian Journal of Agricultural Research*, 19(6): 1009-1028.
8. Dunlop, A. A., Dolling, C. H. S. and Carpenter, M. T. (1966). Efficiency of conversion of food to wool at two nutritional levels by three Merino strains. *Australian Journal of Agricultural Research*, 17: 81-89.
9. Ferguson, Ka. (1972). The nutritional value of diets for wool growth. *Proceedings of the Australian Society of Animal Production*, 9: 314-320.
10. Gupta, J. P., Pandey, D. P., Panchasara, H. H. and Shah, R. R. (2015). Non-genetic factors affecting greasy fleece weight in patanwadi sheep. *The Indian Journal of Small Ruminants*, 21(1): 100-102.

11. Hooda, O. K. and Naqvi, S. M. K. (1990). Effect of thermal load and feed restriction on the relative adaptability of Malpura and Avikalin sheep in semi-arid region. *Indian Journal of Animal Science*, 60: 608-611.
12. Hutchinson, J. C. D. (1999). Photoperiodic effects on hair and wool growth of domestic animals. In: *Progress in Biometeorology*, Division B, 1(2): 47-60. Swets and Zeitlinger, Amsterdam.
13. Kawas, J. R., Andrade-Montemayor, H. and Lu, C. D. (2010). Strategic nutrient supplementation of free-ranging goats. *Small Ruminant Research*, 89(2): 234-243.
14. Karim, S. A., Parthasarathy, S., Santra, A. and Sharma, V. K. (2001). Wool yield and fibre characteristics of intensively fed lambs. *Indian Journal of Small Ruminants*, 7(1): 25-27.
15. Kramer, C. Y. (1956). Extension of multiple range tests to group means with unequal numbers of replications. *Biometrics*, 12(3): 307-310.
16. Kumar, S., Arora, A. L., Prince, L. L. L. and Singh, V. K. (2006). Effect of non-genetic factors on greasy fleece yield in Avikalin sheep under semi-arid condition of Rajasthan. *Indian Journal of Animal Sciences*, 76: 557-559.
17. Kumawat, S. (2016). Study on production performance of Magra lamb under different supplementary feeding in arid zone. M.V.Sc. thesis. Rajasthan University of Veterinary and Animal Sciences, Bikaner.
18. Manish kumar, Jindal, R., Nayyar, S and Singla, M. 2010. Physiological and biochemical responses in Beetal goats during summer season. *Indian Journal of Small Ruminants* 16: 255-257.
19. Marai, I. F. M., Bahgat, L. B., Shalaby, T. H. and Abdel-Hafez, M. A. (2000). Fattening performance, some behavioral traits and physiological reactions of male lambs fed concentrates mixture alone with or without natural clay under hot summer of Egypt. *Annals of Arid Zone (India)*, 39: 449-460.
20. Marai, I. F. M., El-Darawany, A. A., Fadiel, A. and Abdel-Hafez, M. A. M. (2007). Physiological traits as affected by heat stress in sheep. *Small Ruminant Research*, 71:1-12.
21. Marai, I. F. M., El-Darawany, A. A., Fadiel, A. and Abdel-Hafez, M. A. M. (2008). Reproductive performance traits as affected by heat stress and its alleviation in sheep. *Tropical and Subtropical Agroecosystems*, 8: 209-234.
22. Marai, I. F. M., Habeeb, A. A. M., Daader, A. H. and Yousef, H. M. (1995). Effects of Egyptian sub-tropical conditions and the heat stress alleviation techniques of water spray and diaphoretics on the growth and physiological functions of Friesian calves. *Journals of Arid Environments*, 30: 219-225.
23. Marai, I. F. M., Shalaby, T. H., Bahgat, L. B. and Abdel-Hafez, M. A. (1997). Fattening of lambs on concentrates mixture diet alone without roughages or with addition of natural clay under subtropical conditions of Egypt. Growth performance and behaviour. In: *Proceedings of International Conference on Animal Production & Health, Dokki, Cairo, Egypt*.
24. Maurya, V. P., Naqvi, S. M. K. and Mittal, J. P. (2004). Effect of dietary energy level on physiological responses and reproductive performance of Malpura sheep in the hot semi-arid region of India. *Small Ruminant Research*, 55: 117-22.
25. Naqvi, S. M. K. and Rai, A. K. (1990). Effect of nutritional stress on wool yield, characteristics and efficiency of feed conversion to wool. *Livestock Research for Rural Development*, 2(2): 61-66.
26. Ryder, M. L. (2000). Coat structure and seasonal shedding in goats. *Animal Production*, 8: 289-302.
27. Safari, E., Fogarty, N. M. and Gilmour, A. R. (2005). A review of genetic parameter estimates for wool, growth, meat and reproduction traits in sheep. *Livestock Production Science*, 92: 271-289.
28. Salem, H. B. and Smith, T. (2008). Feeding strategies to increase small ruminant production in dry environments. *Small Ruminant Research*, 77(2): 174-194.
29. Saroj (2016). Effect of supplementary feeding on production performance of Marwari lambs in arid zone of Rajasthan. M.V.Sc. thesis. Rajasthan University of Veterinary and Animal Sciences, Bikaner.
30. Sejian, V., Maurya, V. P. and Naqvi, S. M. K. (2010). Adaptive capability as indicated by endocrine and biochemical responses of Malpura ewes subjected to combined stresses (thermal and nutritional) under semi-arid tropical environment. *International Journal of Biometeorology*, 54: 653-661.
31. Shelton, M. (2000). Reproductive performance of sheep exposed to hot environment. *Sheep Reproduction in Hot and Arid Zones*, 155-162.
32. Singh, N. P. and Sankhyan, S. K. (2003). Effect of supplementary concentrate on growth, wool yield and quality in fine wool sheep. *Animal Nutrition and Feed Technology*, 3(2): 189-193.
33. Singh, S. V. and Upadhyay, R. C. (2009). Thermal stress on physiological function, thermal balance and milk production in Karan Fries and Sahiwal cows. *Indian Veterinary Journal*, 86:141-144.
34. Snedecor, G.W. and Cochran, W.G. (2004). *Statistical methods*. 8<sup>th</sup> Edn., Oxford and IBH publishing company, Kolkata

35. Tomar, A. K. S., Mehta, B. S. and Gurmej, S. (2000). Greasy fleece production and factors affecting it in Bharat Merino sheep under semi-arid climate of Rajasthan. *Indian Journal of Animal Sciences*, 70(1): 96-97.
36. Yeates, N. T. M., Edey, T. N. and Hill, M. K. (2013). *Animal science: Reproduction, climate, meat, wool*. Elsevier.

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