



Effect of fibre reinforced plastic (FRP) roof on performance of lactating Jakhrana does

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Received: 16 May 2020; Accepted: 12 July 2021

ABSTRACT

Present study investigated the use of fibre reinforced plastic (FRP) sheet roof as alternate roofing material in goat shelters. Twenty lactating goats, 10 each, housed under pen having cemented sheet roof (CR) and FRP sheet roof (PR) were managed uniformly during winter. Analysis of data revealed that microclimate and physiological responses of does were similar and does were equally comfortable. The milk yield was significantly lower up to 30 days, recorded lower trend up to 60 and 90 days of lactation in does housed under PR than does under CR. The overall mean weekly test day milk yield and body weight of does recorded under PR was significantly lower than does under CR. Results indicated that the provision of FRP roof as alternate roofing material in goat shelters in semi-arid areas may not be beneficial in increasing production of lactating goats during winter.

Keywords: Jakhrana goats, Milk yield, Physiological responses, Plastic roof, Winter

The importance of shelter for harnessing the full genetic potential of any livestock species in a commercial production system is inevitable. The goat rearing for livelihood and nutritional security purposes has been shifting gradually to specialized goat rearing on like production of young animals for rearing purposes as foundation stock, dairy goat rearing, broiler kid production for EID etc as Agri-business model on commercial scale from production of live animals to marketing of animals, raw milk and meat as well as marketing of its value added products. Accordingly, the goat rearing should be based on scientifically recommended rearing practices following welfare and animal ethics so as to take up the goat based business to export level in international markets. For this, permanent shelters with different facilities are needed for providing comfort so as to achieve optimum production from goat rearing. The importance of providing shelter to goats and its effect on production performance is well documented under different production systems (Shinde *et al.* 2004, Yadav *et al.* 2004, Patel *et al.* 2001, 2007, Singh *et al.* 2009, Rahman *et al.* 2013).

Among shelter structures, type of floor and roof play a major role in providing comfortable micro climate, welfare and better shed hygiene for clean milk production in dairy animals (Rahman *et al.* 2013). The provision of different floors using different materials in goat shelters on feed

intake, performance, welfare and worm load in goats have been reported by researchers (Bhakat and Nagpaul 2005, Kumari *et al.* 2013, Ramachandran *et al.* 2017, Ramachandran and Singh 2017, Singh *et al.* 2017, Ramachandran *et al.* 2019, 2020). However, the studies on effect of roofing materials on microclimate, welfare and performance of livestock in general and goats in particular are very limited (Bhakat and Nagpaul 2005, Patil *et al.* 2008, Rahman *et al.* 2013, Kumar *et al.* 2014). The common roofing material used in commercial large scale goat farm is corrugated cemented sheet which has the life of about 10–15 years. However, the goat farms in areas having the monkey menace problem are facing frequent damage especially in ridge of roof leading to rain water entry inside the shed. Therefore, there is a need to explore alternate roofing materials in goat farms and its effect on goat welfare and production. Though the lactation performance of goats under cemented sheet roofed shed is available (Prasad *et al.* 2005, Singh and Ramachandran, 2007, Singh *et al.* 2009, Ramachandran *et al.* 2019), the information on the performance of goats under the alternate roofing material comparatively is not available in literature. Therefore, the present study aimed to assess the provision of alternate roofing material using commonly available FRP sheets in goat pens on production performance of lactating Jakhrana goats which is one of the best milch breed of north-western India.

MATERIALS AND METHODS

Location and weather conditions: Study was conducted at the Experimental shed of the Animal Physiology and

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Reproduction Division of Central Institute for Research on Goats, Makhdoom (27°10'N latitude, 78°02'E longitude, 169 m above sea level altitude), Mathura, Uttar Pradesh, India which falls under semi-arid region of India. The mean maximum, minimum, daily temperature, dry and wet bulb temperature, relative humidity, vapor pressure, total rainfall, total sunshine and THI during experimental period (Oct-Feb) were 29.56±0.52, 11.43±0.43, 20.49±0.45, 22.56±0.49, 16.72±0.32°C, 59.28±1.35%, 14.05±0.60 mm Hg, 29.20 mm, 1061.6 h and 68.68±0.62, respectively. The THI, a measure of heat stress to animals, was calculated as per Marai *et al.* (2001). $THI = DB - \{(0.55 - 0.55 RH) (DB - 58)\}$ where DB, dry bulb temperature (°F) and RH, relative humidity (%). The obtained THI values were categorized as: <82, absence of heat stress; 82 to <84, moderate heat stress; 84 to <86, severe heat stress and over 86, extreme severe heat stress.

Experimental animals, housing, feeding and management: Twenty pregnant Jakhra does (41.38±1.18 kg) were selected considering parity and previous lactation milk yield two weeks before expected date of kidding (-15 day pre-partum: -15 d PrP) for adaptation for the experimental conditions. The goats were randomly divided into two equal groups of 8 each and assigned to pen having either corrugated cemented sheet roof (CR) or FRP sheet roof (PR) in goat shelters. Each FRP sheet were 3.66 m × 0.91 m size, green colored with the thickness of 4–5 mm (mean 4.17 mm, average of 5 points in a sheet). The orientation of 18.29 m × 6.1 m shed is east west with open paddocks (18.29 m × 12.19 m) in south side. The height of shed is 3.5 m at centre and 2.7 m at eave. The goats of each group were reared separately in enclosures having two different roofs with the floor area of 55.74 m² under *ad lib.* group feeding and uniform management conditions up to 150 days postpartum (150 d PoP). The does were housed under covered area under roof round the clock, except they were allowed to roam freely in respective open paddocks during cleaning time. Does were offered *ad lib.* roughage (gram straw-*Cicer arietinum*, Arhar straw-*Cajanus cajan*), concentrate pellets and green fodder (cow pea-*Vigna sinensis*, berseem-*Trifolium alexandrinum*), and drinking water available 24 h. The experimental protocol was approved by the Institute Animal Ethics Committee.

Body weight and milk yield: The test day milk yield was recorded at weekly interval up to 150 d PoP at 8.00 AM and 3.30 PM for all the animals and milk yield was calculated for 30, 60, 90, 120 and 150 days of lactation. Live weight was recorded at 08.00 AM before feeding at fortnightly intervals using electronic weighing scale (Digicontrols Northern Pvt. Ltd., Noida, India) for two consecutive days and average values were considered to monitor body weight trend of goats during the trial.

Physiological variables: All measurements of physiological variables (RT, RR and HR) were done under relatively calm and quiet conditions at 2:00 PM at fortnightly intervals during the trial. The measurement of RT of kids was done using a digital clinical thermometer (Hicks, Hicks

Thermometers India Ltd.), inserted about 3–4 cm into the rectum for about 1 min and represented in °C. The RR was measured before the HR and RT. The HR (presented as beats per minute) and RR (presented as breath per minute) were recorded using a medical stethoscope (Amex Macro Tone Stethoscope) at the fourth left inter-costal space behind the animal's left elbow and above the animal's left elbow over a period of 1 min, respectively.

Statistical analysis: To account for multiple mean comparisons of variables associated with weather conditions, milk yield, body weight and physiological variables, an independent sample t-test or corresponding non-parametric test (Mann-Whitney U test) was performed. Variations were assessed by probability value (P) with the levels of significance $P < 0.05$ and a trend $P \leq 0.1$. Statistical analyses were performed with SPSS (version 20.0, SPSS Inc., Chicago, IL) software. Data are presented as a mean±standard error of the mean.

RESULTS AND DISCUSSION

The roof is the main shelter structure that protects animals directly from rain, sun rays and cold dews, and provides comfortable microclimate to animals. Since trial using FRP sheet roof in livestock shelter is not attempted so far, no published reports are available in literature regarding its effect on microclimate, physiological responses and production of livestock housed under them. The mean microclimatic conditions inside the two pens having different roofs during experimental period are presented in Table 2. The maximum, minimum and dry bulb temperature, relative humidity and THI were similar in pens having different roof indicating that the use of plastic roof in the recommended height in goat shelter in semi-arid conditions may not affect the microclimatic parameters during winter. This could also be due to long side of shed is totally kept open with facility of 100% cross ventilation during daytime and 2–10% cross ventilation during winter night hours using thatch panel sand gunny bags. The thumb rule for maintaining optimum productivity in goats during winter is that the minimum temperature inside shed should be above 10°C. The mean recorded minimum temperature of 12°C in experimental pens having two roofs indicates the proper winter care measures followed in ICAR-CIRG

Table 1. Composition of feedstuffs offered to the goats on dry matter basis

Parameter	Concentrate pellets*	Green fodder	Dry fodder
Organic matter	93.00	89.42	90.17
Crude protein	16.11	21.89	7.96
Ether extract	2.62	2.57	1.89
Neutral detergent fibre	27.44	46.51	58.14
Acid detergent fibre	9.02	33.47	43.51

*Contained: Maize grain 15, rice broken 15, barley grain 14, mustard cake 5, guar korma 5, deoiled rice bran 20, wheat bran 15, molasses 7, mineral mixture 2 and salt 1 part.

Table 2. Mean weather conditions of goat pens having different roof materials

Trial period	T _{max}		P value	T _{min}		P value	DBT		P value	RH		P value	THI		P value
	CR	PR		CR	PR		CR	PR		CR	PR		CR	PR	
16-Oct	37.77 ±0.44	37.95 ±0.33	0.746	20.34 ±0.66	19.9 ±0.63	0.637	31.56 ±0.41	31.69 ±0.37	0.814	47.98 ±2.34	47.31 ±2.27	0.839	80.01 ±0.71	80.08 ±0.68	0.943
16-Nov	31.57 ±0.25	32.22 ±0.29	0.1	12.82 ±0.34	12.85 ±0.29	0.94	26.99 ±2.39	24.81 ±0.32	0.37	50.26 ±1.76	50.17 ±1.76	0.972	74.32 ±3.13	71.46 ±0.40	0.366
16-Dec	23.92 ±0.50	24.68 ±0.58	0.326	9.13 ±0.40	9.31 ±0.42	0.762	18.05 ±0.42	18.17 ±0.42	0.838	70.88 ±2.85	69.87 ±2.89	0.804	63.15 ±0.57	63.29 ±0.57	0.86
17-Jan	21.63 ±0.57	22.89 ±0.65	0.148	7.76 ±0.61	8 ±0.63	0.783	16.37 ±0.37	16.47 ±0.36	0.845	72.74 ±2.19	72.39 ±2.31	0.912	60.95 ±0.56	61.09 ±0.55	0.852
17-Feb	28 ±0.74	28.91 ±0.64	0.355	10.54 ±0.37	10.43 ±0.39	0.843	21.6 ±0.53	21.82 ±0.52	0.767	54.8 ±2.30	54.77 ±2.22	0.994	67.45 ±0.61	67.76 ±0.60	0.724
Overall	28.57 ±0.53	29.32 ±0.50	0.304	12.14 ±0.43	12.06 ±0.40	0.978	22.91 ±0.69	22.59 ±0.48	0.701	59.48 ±1.34	59.04 ±1.34	0.816	69.18 ±0.88	68.74 ±0.61	0.882

CR, cemented sheet roofed pen; PR, FRP sheet roofed pen; T_{max}, maximum temperature (°C); T_{min}, minimum temperature (°C); DBT, dry bulb temperature (°C), RH, relative humidity (%); THI, temperature humidity index.

farm for maintaining optimum production level in goats.

Perusal of the physiological responses of does housed under different roofs (Table 3) revealed that all the does were equally comfortable under both roofs as reflected in non-significant ($P>0.05$) overall physiological responses of does during the trial. The similar physiological responses of does under both roofs confirm the similar comfortable microclimate recorded under pens having different roofs in the current study. The RR and RT of all does were within the normal range except the HR, which was slightly higher than the normal range indicating the higher metabolism for maintaining homeostasis during winter as well as during lactation period. Patil *et al.* (2008) reported similar HR values of 105–130 beats/min in kids raised under thatch and tin roofed pens. Further, authors reported that kids experienced higher RR under tin roof as compared to under thatch roof. Ramachandran and Singh (2017) reported non-significant difference of physiological responses in Jakhra kids reared on wooden slatted and soil floor in shed with

cemented sheet roof. Antil *et al.* (2019) reported that Barbari kids reared on plastic slat as bedding materials showed similar RR and lower HR as compared to soil floor. Ramachandran *et al.* (2020) opined that based on the recorded physiological responses, the kids reared on plastic slatted and soil floor in pen with cemented sheet roof were equally comfortable during hot dry and hot humid season and only the RR was significantly higher ($P<0.001$) in plastic floor as compared to soil floor (79.67 ± 4.50 vs 65.92 ± 2.91).

The mean milk yield of goats housed under two roofs is given in Table 4. The milk yield of does housed under plastic roofed pen was significantly ($P=0.025$) lower than does under cemented roofed pen up to 30 days of lactation. Similarly, does housed under plastic roof recorded lower trend of milk yield than cemented roof up to 60 days ($P=0.074$) and 90 days ($P=0.098$). Similarly, the morning and evening milk yield of does housed under plastic roofed pen was also significantly lower up to 30 days of lactation

Table 3. Mean physiological responses of Jakhra does housed under goat pens having different roofing materials

Fortnight postpartum	Respiration rate (breathes/min)		P value	Heart rate (beats/min)		P value	Rectal temperature (°C)		P value
	CR	PR		CR	PR		CR	PR	
1	45.00±6.33	49.80±5.08	0.731	113.00±2.01	104.80±4.41	0.562	39.10±0.03	39.08±0.05	0.108
2	37.60±5.86	36.80±3.36	0.345	100.20±2.80	101.20±3.59	0.907	38.94±0.06	39.00±0.01	0.829
3	33.40±1.23	29.40±1.52	0.591	99.80±3.61	114.60±2.11	0.056	38.96±0.02	38.98±0.03	0.002
4	26.60±1.66	29.60±1.22	0.03	102.60±3.48	107.40±3.21	0.163	38.42±0.25	39.00±0.00	0.324
5	22.40±1.60	24.00±1.19	0.219	84.80±2.44	91.20±3.57	0.433	38.40±0.09	38.22±0.11	0.156
6	25.40±1.52	26.00±2.17	0.072	107.20±3.71	100.80±4.84	0.823	38.35±0.10	38.06±0.11	0.308
7	28.40±1.39	26.00±1.61	0.424	114.40±5.21	104.80±4.08	0.274	38.08±0.06	38.16±0.07	0.164
8	23.80±1.85	28.80±2.97	0.016	105.20±2.98	100.80±3.31	0.17	38.07±0.05	38.28±0.06	0.337
9	28.00±2.39	26.40±2.15	0.478	96.40±3.34	101.40±5.35	0.624	38.98±0.08	39.05±0.05	0.438
Overall	30.07±2.65	30.76±2.36	0.415	102.62±3.29	103.00±3.83	0.689	38.59±0.08	38.65±0.06	0.849

CR, cemented sheet roofed pen; PR, FRP sheet roofed pen.

Table 4. Mean milk yield (L) of Jakhrana does housed under pens having different roofing materials

Days of lactation/ Type of roof	Milking time	Milk yield (L)		P Value
		Cemented sheet roof	FRP sheet roof	
Up to 30 days	Morning	21.18±1.73	16.33±0.99	0.025
	Evening	9.64±0.94	7.17±0.56	0.036
	Total	30.82±2.61	23.49±1.48	0.025
Up to 60 days	Morning	45.67±3.39	37.52±2.95	0.087
	Evening	19.16±1.56	15.13±1.29	0.061
	Total	64.83±4.85	52.65±4.21	0.074
Up to 90 days	Morning	67.51±4.43	56.42±4.88	0.100
	Evening	27.60±1.86	22.69±2.01	0.091
	Total	95.11±6.06	79.11±6.86	0.098
Up to 120 days	Morning	89.84±5.40	76.92±7.48	0.179
	Evening	37.40±2.12	30.71±2.96	0.082
	Total	127.24±7.22	107.63±10.41	0.139
Up to 150 days	Morning	112.12±6.22	98.33±9.96	0.255
	Evening	46.60±2.54	38.51±3.81	0.094
	Total	158.72±8.34	136.84±13.75	0.190

and showed lower trend showed 60 and 90 days of lactation. However, the milk yield up to 120 and 150 days of does under both the roofs were statistically similar, though does under plastic roof yielded almost 20 litre lower than cemented sheet roof.

The results obtained on lactation performance in the present study were in agreement with the previous findings in dairy goat breeds on different shelter structures (Rai and Singh 2006, Singh *et al.* 2009, Ramachandran *et al.* 2019). However, the lower (Shinde *et al.* 2004, Yadav *et al.* 2004, Singh and Ramachandran, 2007, Mirzaei *et al.* 2011) and higher (Upadhyay *et al.* 2013) milk yield in goats than the current study was reported by previous researchers in different goat breeds under varied system of rearing. Patil *et al.* (2008) opined that covering the roof with a thatch materials proved beneficial and resulted significantly ($P<0.01$) higher body weight gains in Osmanabadi kids over to tin roofing. Kumar *et al.* (2014) observed significantly ($P<0.010$) higher body weight in kids reared under the roof shed painted with black colour on top and white colour inside along with hydrated lime mixed bedding material than the kids under roof shed painted with black colour on top only and roof without colour.

Table 5 depicts the weekly trend of test day milk yield of does under two roofs. The overall mean weekly test day milk yield of does recorded under plastic roof (0.917 L/goat/day) was significantly lower ($P< 0.001$) than does under cemented sheet roof (1.061 L/goat/day). The analysis of data indicated that the milk production of goats housed under plastic roof was significantly lower ($P< 0.05$) than does reared under cemented sheet roof up to third week of lactation. Thereafter, milk yield of does were statistically similar level. The milk composition of does housed under plastic roof also showed lower trend as compared cemented sheet roof.

Rahman *et al.* (2013) reported higher milk yield in lactating Alpine × Beetal crossbred goats reared on elevated

wooden floor with thatched roof as compared to pen having concrete floor with concrete roof (1.47±0.07 vs 1.37±0.05) during summer season. Ramachandran *et al.* (2019) also reported that the weekly trend of test day milk yield of Jakhrana lactating does in 1.114±0.12 and 1.358±0.12 L/goat/day, respectively reared on slatted and soil floor which is slightly higher than the present level of milk yield in Jakhrana goats.

Table 5. Weekly trend of test day mean milk yield of Jakhrana does housed under pens having different roofing materials

Weeks postpartum/ Type of roof	Milk yield (L/day/doe)		P value
	Cemented sheet roof	FRP sheet roof	
1	0.997±0.07	0.793±0.05	0.034
2	0.912±0.07	0.654±0.06	0.012
3	1.056±0.11	0.801±0.06	0.049
4	1.167±0.14	0.907±0.09	0.126
5	1.152±0.11	0.931±0.09	0.330
6	1.172±0.11	1.001±0.09	0.224
7	1.192±0.09	0.974±0.11	0.141
8	1.065±0.06	0.987±0.11	0.548
9	1.109±0.07	0.905±0.11	0.124
10	0.928±0.06	0.856±0.10	0.558
11	0.986±0.06	0.828±0.08	0.117
12	0.997±0.07	0.896±0.08	0.358
13	1.052±0.06	0.930±0.11	0.348
14	1.021±0.06	0.856±0.12	0.249
15	1.100±0.09	0.976±0.15	0.479
16	1.104±0.08	0.965±0.09	0.256
17	1.086±0.08	1.102±0.09	0.890
18	1.026±0.07	0.968±0.12	0.689
19	1.064±0.07	0.984±0.14	0.617
20	1.035±0.08	0.987±0.11	0.731
21	1.073±0.07	0.945±0.11	0.341
22	1.048±0.08	0.989±0.12	0.693
23	1.069±0.10	0.843±0.12	0.592
Overall	1.061±0.02	0.917±0.02	< 0.001

Table 6. Mean body weight of Jakhrana does housed pens having different roofing materials

Fortnight postpartum	Cemented sheet roof	FRP sheet roof	P value
-1 PrP	42.83±1.68	39.93±1.62	0.230
1	35.25±0.93	32.50±1.22	0.090
2	34.70±1.02	32.64±1.24	0.215
3	35.18±1.09	33.29±1.13	0.246
4	35.64±1.01	34.22±1.32	0.401
5	35.92±1.21	33.89±1.30	0.268
6	36.32±1.11	34.94±1.34	0.438
7	37.98±1.20	36.31±1.71	0.433
8	39.62±1.25	37.68±1.93	0.410
9	40.29±1.41	38.52±2.00	0.480
Overall	37.37±0.45	35.39±0.52	0.004

The mean body weight of pregnant does housed under pens having cemented and plastic roofs two weeks before expected date of kidding was 42.83±1.68 and 39.93±1.62 kgs, respectively, which were statistically similar (Table 6). As expected, the body weight of does under both roofs immediately after kidding were significantly reduced by about 7.5 kg which was due to weight of kids and expelled placenta and other amniotic fluids from reproductive tract. The similar body weight loss of 4–6 kg in dairy goats (Sahlu, 1995), 7.5–9.5 kg in Jakhrana goats (Ramachandran *et al.* 2019) was also reported after kidding. The body weight during first fortnight only showed trend of significant difference (P=0.090) reflecting the higher body reserve mobilization for milk production resulting in negative energy balance. However, the overall body weight of does under plastic roof were significantly lower (P=0.004) than the does under cemented sheet roof.

Findings of the study suggested that the provision of FRP roof as alternate roofing material in goat shelters in semi-arid areas may not be beneficial in increasing production of lactating goats during winter. This warrants further studies in goat shelters using FRP sheets as roofing materials in summer and rainy season before meaningful recommendation.

ACKNOWLEDGEMENTS

The authors are grateful to ICAR for providing financial support through AICRP on Plastic Engineering in Agricultural Structures and Environment Management Project for taking up this research work and Director of the Institute for extending the support to carry out this study. The technical assistance rendered by Sh. Ranjeet Singh, Sh Dinesh Bhatt and Sh Chandra Mohan is gratefully acknowledged.

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