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Importance of roof modifications in animal housing and its impact on body measurements of Sahiwal calves during summer months in arid region of Rajasthan

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Abstract
The study was carried out at LRS Kodamdesar, Bikaner (Rajasthan) for the period of three months. Eighteen female Sahiwal calves of 6-12 months of age were selected and divided into three treatment groups i.e. T_0 (Control group having asbestos sheet as roof), T_1 (Thatch roof which is having thatch over asbestos sheet as modification) and T_2 (Agro-net roof which had Agro-net over asbestos sheet as a modification). All the three groups were managed under similar system of management. The daily recording of macro and microclimate i.e. temperature, relative humidity and THI was done twice in day at 9:00 am and 2:00 pm .The body measurement were recorded on weekly basis. The result showed that the mean temperature, relative humidity and THI at 9:00 am and 2:00 pm were significantly higher ($P<0.01$) in T_0 as compared to other two groups. All the body measurements were statistically higher in T_1 and T_2 as compare to T_0 but not significantly. Thus, from the overall result of the present research work, it may be concluded that thatch and agro-net can be used above the asbestos roof as roof modification in arid region as they are cost effective and had shown significant effect on microclimate inside animal house which ultimately leads to better growth of Sahiwal calves.

Keywords: Sahiwal calves, body measurements, temperature, microclimate and asbestos sheet

Introduction
India is a Tropical country which is characterized by high temperature and humidity. Extended periods of high ambient temperature along with high relative humidity compromise the ability of the dairy animals to dissipate excess body heat. Young animals with high body temperature exhibit lower DMI and growth with less efficiency, reducing profitability for dairy farms in hot, humid climate. The appropriate housing helps in enhancing heat losses from the animal body by providing desired microenvironment and maximize their production by protecting them from extreme climate. Roofing material in the animal shed is most critical factor which determines the cost of construction and micro-environment within the shed. Different variety of roofing materials are available in different climates which vary to a great extent in their thermal characteristics. Adam (2006) [1] and Badino (2007) [2] observed that the amount of reduction in radiant heat load and microenvironment inside the shed depends on the design and the material used for the roof. The quality of roof material decide the microclimate that should be light, strong, durable, weatherproof, bad conductor of heat and free from tendency to condense moisture inside. Asbestos sheets roofs are generally used at organized and commercial dairy farms as they are comparatively cheaper than RCC, durable than thatch, and have intermediate value of thermal conductivity (0.4 Kcal/m h ºC) (Sastry and Thomos, 2012) [9]. The major disadvantage of asbestos sheet is its radiation emission property, due to which it get heated up during peak hours of summer and then these sheets start emitting radiations which not only increase the surface temperature of animal but also change microclimate of the shed. Yazdani and Gupta, (2000) [11] reported that thatch is an excellent and cheap material to reduce the heat stress but is not durable. West, (2003) [10] observed that calves raised in a hot temperature of 27 °C gained 19 lbs less in three months than calves reared at a cooler temperature of 10 °C. Keeping the importance of housing and roof material in tropical country, the present study was undertaken to exploit positiveness of each roofing materials during summer months in arid region in Rajasthan.

Materials and Methods
The study was done at Livestock Research Station, Kodamdesar which is situated at an altitude

of 201 meters above the mean sea level in the Thar Desert, about 32 km away from the city of Bikaner in Rajasthan. For the study eighteen female Sahiwal calves of 6-12 months of age were selected and divided randomly into 3 groups and each group was allotted to the following housing conditions/treatments: T_0 Control (Asbestos roof) houses having covered area with asbestos cement sheet roofing, T_1 (Thatch roof house) having approximately 15 cm thick layer of khimp (*Leptadenia pyrotechnia*) was put on the asbestos roof as a roof modification and T_2 (Agro-net roof house) in which green and black coloured knitted fabric was put on the asbestos roof as roof modification. The work was carried out for a period of three months and all animals were kept for adaptation period of one week. The climatic conditions, feeding & management practices were same for all treatment groups.

Parameters to be studied: The following parameters were recorded during the experimental period:

Meteorological parameters: During the experimental trial temperature, relative humidity of macroclimate and microclimate was recorded at 9:00 am and 2:00 pm on daily basis and and Temperature Humidity Index (THI) was calculated as per Kiebler (1964) using the following formula.
THI=1.8Ta-(1-RH) (Ta-14.3)+32 (where Ta is ambient temperature in ^{O}C and RH is relative humidity as fraction of the unit).

Body morph metric traits: The body measurement i.e. body length, height at withers, hearth girth and paunch girth was also taken with the help of measuring tape on centimeter scale (cm) at weekly interval for each calf. Body measurement was taken when the calves were standing in a normal body posture. Body length of calves was measured by taking distance from the external occipital protuberance to the base of the tail in (cm). Height at withers was measured at highest point of body (from ground level to the point of wither in (cm). Heart girth was taken as smallest circumference immediately behind the elbow joint in (cm).Paunch girth was taken as smallest circumference immediately behind the abdomen in (cm).

Statistical analysis: The data for all measured variables were analyzed using one way ANOVA procedure of SPSS version 20 (SPSS for Windows, V 20.0; SPSS Inc., Chicago, IL, USA). The significant difference for the different variables was determined using Duncan Multiple Range Test of Significance.

Results and Discussion

The data on various parameters recorded during the present investigation have been statistically analyzed and the observed results are presented and discussed under the following headings:

Meteorological parameters

Temperature, Relative Humidity and THI of macro climate

The weekly macro climatic observations of environmental temperature, relative humidity and THI at 9:00 am and 2:00 pm were presented in Table 1. The overall temperature at 9:00 am and 2:00 pm was 29.284 ± 0.429 and 35.751 ± 0.457, respectively. The overall relative humidity at 9:00 am and 2:00 pm was 69.399 ± 1.676 and 46.389 ± 2.172, respectively. The THI value at 9:00 am and 2:00 pm was 80.11 ± 0.450 and 84.84 ± 0.43 respectively. The overall macro climatic conditions during experimental trail were very stressful to the animals which had deterimental effect on their growth and performance.

Table 1: Mean ± SE of Temperature, Relative Humidity and THI of macro climate

Weeks	Time	Temperature	Relative Humidity	THI
1	9:00 am	29.62 ± 1.05	73.29 ± 6.44	81.22 ± 0.89
	2:00 pm	36.23 ± 1.71	47.29 ± 6.52	85.65 ± 1.21
	Avg.	32.92 ± 1.33	60.29 ± 5.69	83.86 ± 0.95
2	9:00 am	31.67 ± 0.41	62.00 ± 2.27	82.40 ± 0.66
	2:00 pm	37.72 ± 0.51	36.86 ± 2.76	85.10 ± 0.53
	Avg.	34.70 ± 0.90	49.43 ± 3.89	84.14 ± 0.53
3	9:00 am	33.00 ± 0.62	56.43 ± 3.90	83.25 ± 0.26
	2:00 pm	40.00 ± 0.69	34.72 ± 2.69	87.22 ± 0.46
	Avg.	36.50 ± 1.07	45.58 ± 3.77	85.61 ± 0.46
4	9:00 am	30.00 ± 0.38	76.58 ± 1.84	82.32 ± 0.77
	2:00 pm	36.00 ± 1.00	56.43 ± 3.98	87.34 ± 0.86
	Avg.	33.00 ± 0.98	66.50 ± 3.50	85.13 ± 1.00
5	9:00 am	28.15 ± 0.46	77.58 ± 3.63	79.56 ± 0.46
	2:00 pm	33.72 ± 0.64	60.15 ± 3.28	84.95 ± 0.50
	Avg.	30.93 ± 0.86	68.86 ± 3.37	82.49 ± 0.58
6	9:00 am	28.58 ± 0.30	66.86 ± 1.35	78.71 ± 0.43
	2:00 pm	35.86 ± 0.14	40.72 ± 1.23	83.76 ± 0.30
	Avg.	32.22 ± 1.02	53.79 ± 3.73	81.71 ± 0.69
7	9:00 am	29.00 ± 0.53	66.72 ± 4.17	79.30 ± 0.67
	2:00 pm	34.29 ± 0.52	51.15 ± 3.86	83.95 ± 0.31
	Avg.	31.65 ± 0.82	58.93 ± 3.48	81.84 ± 0.78
8	9:00 am	29.29 ± 0.52	72.86 ± 2.61	80.65 ± 0.99
	2:00 pm	35.43 ± 0.72	50.29 ± 2.46	85.27 ± 1.22
	Avg.	32.36 ± 0.95	61.58 ± 3.57	83.30 ± 1.01
9	9:00 am	28.58 ± 0.43	76.00 ± 3.12	80.01 ± 0.58
	2:00 pm	34.29 ± 0.92	54.15 ± 2.71	84.55 ± 1.09
	Avg.	31.43 ± 0.93	65.08 ± 3.62	82.59 ± 0.85

10	9:00 am	29.08 ± 0.66	68.15 ± 2.09	79.63 ± 0.88
	2:00 pm	35.86 ± 0.55	44.43 ± 1.97	84.56 ± 0.74
	Avg.	32.47 ± 1.03	56.29 ± 3.57	82.50 ± 0.84
11	9:00 am	28.51 ± 0.33	67.72 ± 1.73	78.73 ± 0.57
	2:00 pm	34.43 ± 0.48	46.58 ± 1.51	83.22 ± 0.78
	Avg.	31.47 ± 0.87	57.15 ± 3.13	81.28 ± 0.75
12	9:00 am	27.58 ± 0.43	71.00 ± 1.69	77.79 ± 0.75
	2:00 pm	35.29 ± 0.42	41.86 ± 0.91	83.31 ± 0.60
	Avg.	31.43 ± 1.11	56.43 ± 4.15	81.11 ± 0.83
13	9:00 am	27.64 ± 0.28	67.00 ± 0.79	77.34 ± 0.59
	2:00 pm	35.65 ± 0.56	38.43 ± 1.32	83.02 ± 0.92
	Avg.	31.65 ± 1.15	52.72 ± 4.03	80.76 ± 0.83
0verall	9:00 am	29.28 ± 0.42	69.39 ± 1.67	80.11 ± 0.45
	2:00 pm	35.75 ± 0.45	46.38 ± 2.17	84.84 ± 0.43
	Avg.	32.51 ± 0.42	57.89 ± 1.85	82.84 ± 0.42

Micro climate

Temperature (^{O}C) of micro climate in different groups

The temperature of micro climate recorded under different shades during 13 weeks were presented in Table 2 and in Figure 1 and 2. The mean temperature at 9:00 am was highly significant ($P<0.01$) between different groups i.e. 26.95 ± 0.23, 27.58 ± 0.19 and 28.36 ± 0.22 in T_1, T_2 and T_0, respectively. Group T_0 had significantly higher ($P<0.01$) temperature as compared to other two groups. Also at 2:00 pm the overall mean temperature was highly significant ($P<0.01$) between groups i.e. 32.33 ± 0.4, 33.31 ± 0.41 and 34.78 ± 0.34 in T_1, T_2 and T_0, respectively.

The result revealed significantly higher temperature in T_0 (control roof) housing followed by T_1 and least in T_2. This might be due to the fact that thatch and agro-net over asbestos sheet in T_1 and T_2 groups act as thermal insulators as they had lower thermal conductivity which prevents solar radiations to penetrate the roof as compared to asbestos sheet alone in case of T_0.

Table 2: Mean ± SE of Temperature (^{O}C) of micro climate under different groups

Weeks	Time	Control (T_0)	Treatment (T_1)	Treatment (T_2)
1	9:00 am	28.56 ± 1.04	26.59 ± 0.72	28.19 ± 0.87
	2:00 pm	35.11 ± 1.91	32.36 ± 1.58	33.10 ± 1.75
	Avg.	31.84 ± 1.38	29.47 ± 1.16	30.64 ± 1.16
2	9:00 am	29.24 ± 1.55	28.40 ± 0.58	28.96 ± 0.57
	2:00 pm	$36.52 ± 0.47^{b}$	$33.17 ± 0.40^{a}$	$34.16 ± 0.40^{ab}$
	Avg.	32.88 ± 1.28	30.78 ± 0.74	31.56 ± 0.80
3	9:00 am	$31.88 ± 0.42^{b}$	$30.29 ± 0.42^{a}$	$31.24 ± 0.53^{ab}$
	2:00 pm	39.09 ± 0.75	37.00 ± 0.98	38.09 ± 0.91
	Avg.	35.48 ± 1.08	33.64 ± 1.06	34.66 ± 1.08
4	9:00 am	29.34 ± 0.54	28.21 ± 0.59	28.39 ± 0.53
	2:00 pm	34.76 ± 1.06	33.71 ± 1.43	34.23 ± 1.45
	Avg.	32.05 ± 0.94	30.96 ± 1.06	31.31 ± 1.10
5	9:00 am	$27.44 ± 0.30^{b}$	$25.64 ± 0.32^{a}$	$26.70 ± 0.35^{b}$
	2:00 pm	$32.73 ± 0.65^{b}$	$30.08 ± 0.86^{a}$	$31.44 ± 0.70^{ab}$
	Avg.	30.09 ± 0.81	27.86 ± 0.76	29.07 ± 0.76
6	9:00 am	$27.79 ± 0.21^{b}$	$27.26 ± 0.13^{a}$	$28.22 ± 0.11^{b}$
	2:00 pm	$34.92 ± 0.16^{b}$	$32.96 ± 0.14^{a}$	$33.37 ± 0.14^{a}$
	Avg.	31.35 ± 1.00	30.11 ± 0.80	30.79 ± 0.72
7	9:00 am	$28.21 ± 0.58^{b}$	$26.86 ± 0.55^{a}$	$27.25 ± 0.53^{ab}$
	2:00 pm	33.47 ± 0.62	30.94 ± 0.81	32.09 ± 0.80
	Avg.	30.84 ± 0.84	28.90 ± 0.74	29.67 ± 0.81
8	9:00 am	$28.35 ± 0.54^{b}$	$26.65 ± 0.47^{a}$	$27.29 ± 0.52^{ab}$
	2:00 pm	$34.66 ± 0.67^{b}$	$32.71 ± 0.61^{a}$	$33.38 ± 0.49^{ab}$
	Avg.	31.50 ± 0.97	29.68 ± 0.92	30.33 ± 0.91
9	9:00 am	28.02 ± 0.57	27.16 ± 0.52	27.44 ± 0.49
	2:00 pm	33.43 ± 1.00	30.70 ± 1.22	31.58 ± 1.02
	Avg.	30.72 ± 0.93	28.93 ± 0.80	29.51 ± 0.79
10	9:00 am	28.36 ± 0.68	26.60 ± 0.56	27.19 ± 0.68
	2:00 pm	$34.77 ± 0.58^{b}$	$32.09 ± 0.42^{a}$	$33.25 ± 0.55^{ab}$
	Avg.	31.57 ± 0.99	29.35 ± 0.83	30.22 ± 0.94
11	9:00 am	$27.73 ± 0.36^{b}$	$25.81 ± 0.54^{a}$	$26.02 ± 0.48^{ab}$
	2:00 pm	33.39 ± 0.39	31.87 ± 0.41	32.45 ± 0.32
	Avg.	30.56 ± 0.83	28.84 ± 0.90	29.23 ± 0.93
12	9:00 am	$26.71 ± 0.52^{b}$	$25.01 ± 0.55^{a}$	$25.61 ± 0.42^{a}$
	2:00 pm	$34.36 ± 0.33^{b}$	$31.71 ± 0.52^{b}$	$32.97 ± 0.44^{a}$
	Avg.	30.54 ± 1.10	28.36 ± 1.00	29.29 ± 1.06
13	9:00 am	27.01 ± 0.30	25.78 ± 0.95	26.05 ± 0.31
	2:00 pm	$34.79 ± 0.48^{b}$	$30.86 ± 1.14^{a}$	$32.93 ± 0.54^{ab}$

	Avg.	30.90 ± 1.11	28.32 ± 1.00	29.49 ± 1.00
0verall	9:00 am	28.36 ± 0.22^{b}	26.95 ± 0.23^{a}	27.58 ± 0.19^{ab}
	2:00 pm	34.78 ± 0.34^{c}	32.33 ± 0.40^{a}	33.31 ± 0.41^{b}
	Avg.	31.57 ± 0.91^{c}	29.64 ± 0.78^{a}	30.45 ± 0.82^{b}

Mean values between 9:00 am and 2:00 pm within the groups differ significantly ($P<0.01$).
Means bearing different superscript in a row differ significantly ($P<0.01$).

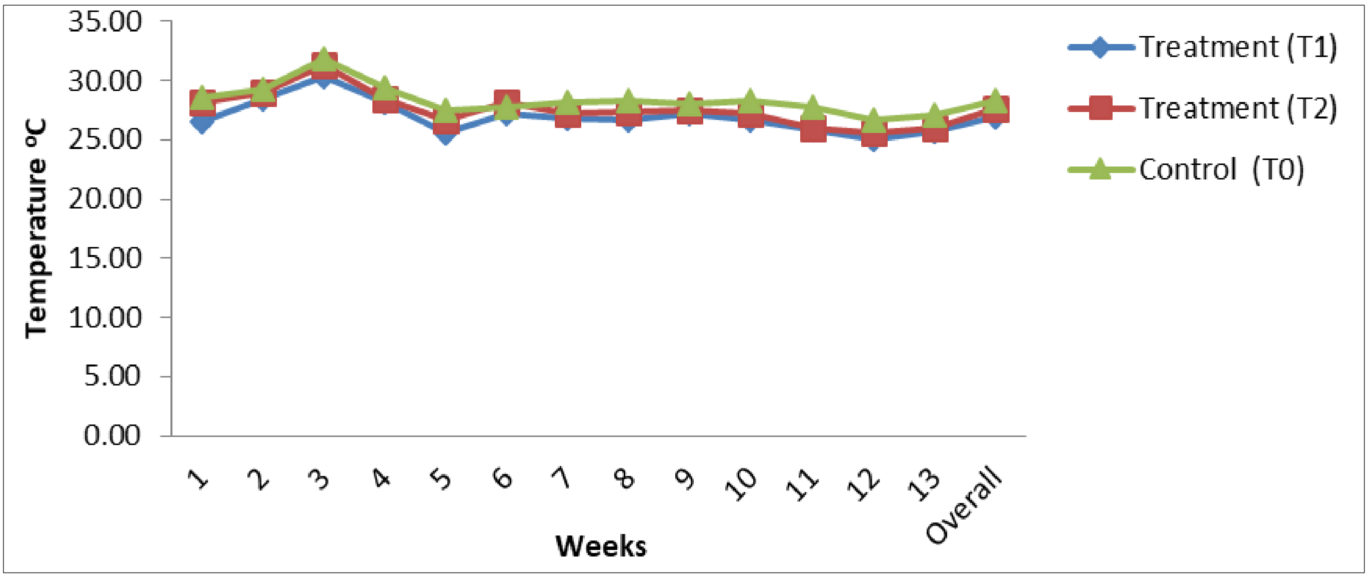

Fig 1: Temperature at 9:00 am (ºC) of micro climate under different groups

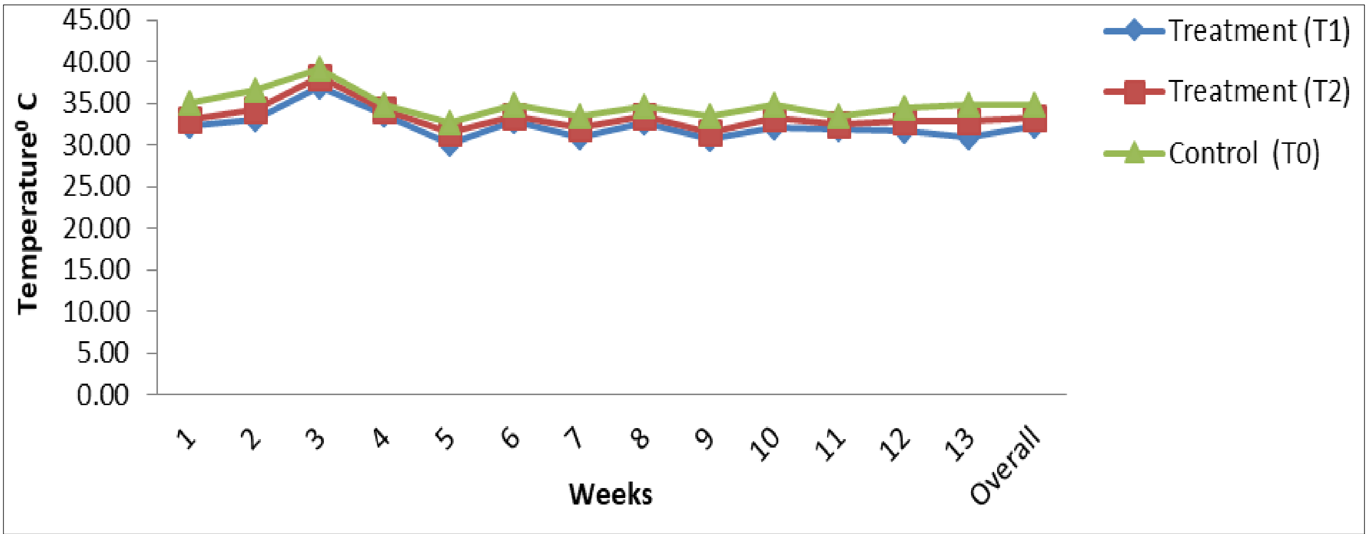

Fig 2: Temperature at 2:00 pm (ºC) of micro climate under different groups

Similar findings were reported by Yazdani and Gupta (2000) [11], Patil *et al.* (2014) [8], Kamal *et al.* (2014) [6] and Narwaria *et al.* (2017) [7] so they had suggested for improvement in existing roof structure through appropriate modifications, such as thatched asbestos roof, solar panels, polythene shade cloth, etc. as thatch and agro-net has lower thermal conductivity and are more efficient in maintaining comfortable microenvironment inside the animal shed than simple asbestos sheet.

Relative humidity (%) of micro climate in different treatment groups

The relative humidity (%) under different shades during 13 weeks were presented in Table 3 and shown in Fig. 3 and 4. The RH at 9:00 am was 57.64 ± 0.60, 55.88 ± 0.52 and 62.99 ± 0.61 in T_1, T_2 and T_0, respectively. Similarly at 2:00 pm RH in T_1, T_2 and T_0 was 37.87 ± 0.59, 36.33 ± 0.40 and 41.61 ± 0.71, respectively. The table reveals that RH at 9:00 am was significantly higher ($P<0.01$) than at 2:00 pm irrespective of treatment which might be due to frequent water supply, washing of animal sheds in the morning and high micturition frequency of animals. At 9:00 am T_0 had significantly higher ($P<0.01$) RH followed by T_1 and least in T_2. At 2:00 pm significantly higher ($P<0.01$) RH was observed in T_0 as compared to T_1 and T_2.

Table 3: Mean ± SE of Relative humidity (%) of micro climate in different groups

Weeks	Time	Control (T_0)	Treatment (T_1)	Treatment (T_2)
1	9:00 am	62.43 ± 2.73	59.71 ± 2.60	57.43 ± 2.60
	2:00 pm	38.57 ± 3.86	36.43 ± 3.57	31.29 ± 2.12
	Avg.	50.50 ± 4.01	48.07 ± 3.86	44.36 ± 3.97
2	9:00 am	53.71 ± 1.80^{b}	50.14 ± 1.72^{ab}	47.86 ± 1.75^{a}
	2:00 pm	32.86 ± 2.41	31.29 ± 2.18	30.00 ± 2.08
	Avg.	43.29 ± 3.23	40.71 ± 2.94	38.93 ± 2.80
3	9:00 am	53.00 ± 3.11	49.29 ± 2.81	46.71 ± 2.21
	2:00 pm	33.57 ± 2.20	32.29 ± 2.13	30.57 ± 1.84
	Avg.	43.29 ± 3.26	40.79 ± 2.90	38.64 ± 2.63
4	9:00 am	70.14 ± 2.15^{b}	63.71 ± 1.77^{a}	64.43 ± 2.15^{ab}
	2:00 pm	52.14 ± 3.67	47.29 ± 3.29	47.71 ± 3.12
	Avg.	61.14 ± 3.23	55.50 ± 2.90	56.07 ± 2.95
5	9:00 am	69.71 ± 3.57	64.14 ± 3.08	62.71 ± 3.28
	2:00 pm	53.43 ± 2.09^{b}	46.43 ± 1.95^{a}	44.86 ± 1.84^{a}
	Avg.	61.57 ± 3.01	55.29 ± 3.02	53.79 ± 3.07
6	9:00 am	60.86 ± 1.35^{b}	56.00 ± 1.65^{a}	54.14 ± 1.58^{a}
	2:00 pm	35.57 ± 0.72^{b}	33.00 ± 0.44^{a}	31.86 ± 0.46^{a}
	Avg.	48.21 ± 3.58	44.50 ± 3.29	43.00 ± 3.19
7	9:00 am	60.71 ± 3.66	55.29 ± 3.59	53.71 ± 3.47
	2:00 pm	44.57 ± 3.12	39.57 ± 2.92	38.29 ± 2.83
	Avg.	52.64 ± 3.22	47.43 ± 3.11	46.00 ± 3.03
8	9:00 am	64.43 ± 2.01^{b}	56.86 ± 1.26^{a}	55.29 ± 1.29^{a}
	2:00 pm	43.71 ± 2.49	39.71 ± 2.83	38.00 ± 2.73
	Avg.	54.07 ± 3.26	48.29 ± 2.80	46.64 ± 2.80
9	9:00 am	68.29 ± 2.75^{b}	62.14 ± 2.48^{ab}	60.14 ± 2.44^{a}
	2:00 pm	48.86 ± 2.73	44.29 ± 2.49	42.57 ± 2.35
	Avg.	58.57 ± 3.27	53.21 ± 3.00	51.36 ± 2.93
10	9:00 am	62.43 ± 2.28^{b}	56.86 ± 2.35^{ab}	54.71 ± 2.52^{a}
	2:00 pm	41.00 ± 2.06	37.86 ± 2.20	36.29 ± 2.30
	Avg.	51.71 ± 3.32	47.36 ± 3.06	45.50 ± 3.04
11	9:00 am	64.00 ± 1.85^{b}	58.29 ± 2.11^{a}	56.00 ± 1.96^{a}
	2:00 pm	42.86 ± 1.47^{b}	38.14 ± 1.39^{a}	37.00 ± 1.50^{a}
	Avg.	53.43 ± 3.14	48.21 ± 3.05	46.50 ± 2.89
12	9:00 am	66.57 ± 1.57^{b}	60.14 ± 1.71^{a}	58.14 ± 1.64^{a}
	2:00 pm	38.00 ± 0.69	33.86 ± 0.55	32.71 ± 0.81
	Avg.	52.29 ± 4.05	47.00 ± 3.75	45.43 ± 3.63
13	9:00 am	62.57 ± 0.75^{b}	56.71 ± 0.57^{a}	55.14 ± 0.55^{a}
	2:00 pm	35.71 ± 1.51^{b}	32.14 ± 1.08^{a}	31.14 ± 0.74^{a}
	Avg.	49.14 ± 3.81	44.43 ± 3.46	43.14 ± 3.36
0verall	9:00 am	62.99 ± 0.61^{c}	57.64 ± 0.60^{b}	55.88 ± 0.52^{a}
	2:00 pm	41.61 ± 0.71^{b}	37.87 ± 0.59^{a}	36.33 ± 0.40^{a}
	Avg.	52.30 ± 3.00^{c}	47.76 ± 2.77^{b}	46.11 ± 2.73^{a}

Mean values between 9:00 am and 2:00 pm within the groups differ significantly ($P<0.01$).
Means bearing different superscript in a row differ significantly ($P<0.01$).

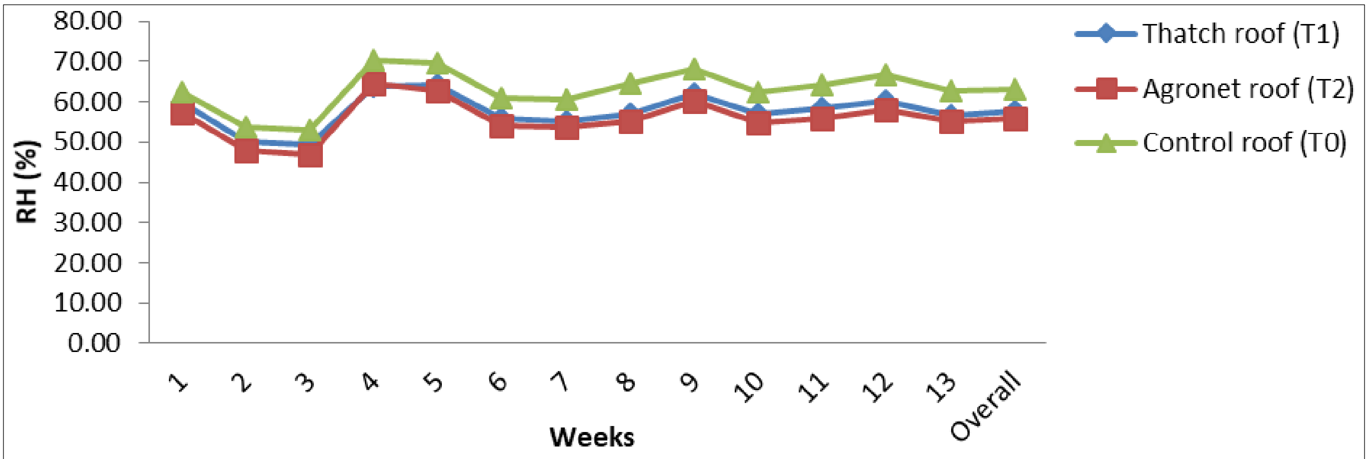

Fig 3: Relative humidity (%) at 9:00 am of micro climate under different groups

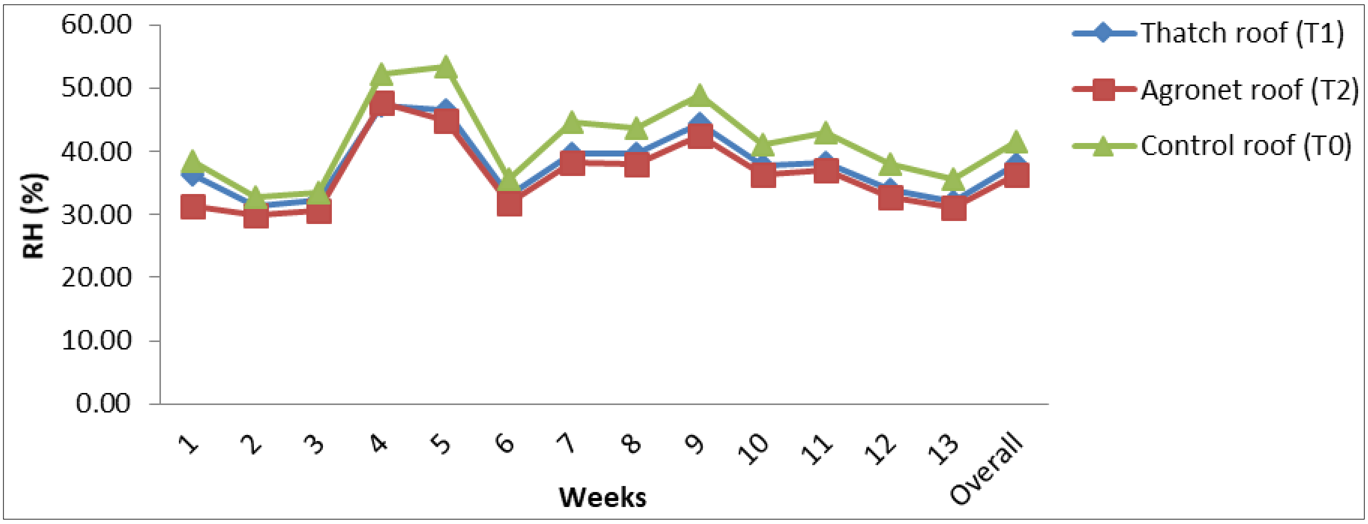

Fig 4: Relative Humidity (%) at 2:00 pm of micro climate under different groups

Temperature humidity index of micro climate under different treatment groups.

The THI at 9:00 am and 2:00 pm on weekly interval under different shades during the experimental period were presented in Table 4 and shown in Fig. 5 and 6. The overall THI at 9:00 am was highly significant (P<0.01) between group i.e. lowest in T_1 (75.15 ± 0.30), followed by T_2 (75.78 ± 0.22) and maximum in T_0 (77.84 ± 0.29). Similarly at 2:00 pm also highly significant difference (P<0.01) between groups which was 78.95 ± 0.46, 79.85 ± 0.41 and 82.65 ± 0.34 in T_1, T_2 and T_0, respectively. The result indicates that the THI at 9:00 am was significantly lower (P<0.01) than THI at 2:00 pm in all the three groups due to high temperature. At 9:00 am non-significantly higher THI was observed under T_2 as compared to T_1 but THI under control is significantly higher (P<0.01) than the two treatments. However at 2:00 pm highly significant (P<0.01) THI was observed in T_0 followed by T_2 and least in T_1. This might be due to fact that thatch and agro-net over the asbestos sheet were able to reduce the solar radiation to penetrate the shade as compared to asbestos sheet alone in control roof. High environmental temperatures along with high relative humidity exert more stress than either of them alone and their combined effect is known as THI which is used to measure heat stress in animals. Higher THI leads to heat stress in animals which have adverse effect on their growth.

The observed result were similar to findings of Jat *et al.* (2005) [4] who observed higher THI in loose house covered with asbestos sheet causes thermal stress, whereas, lower THI is observed in thatch and mud roof house which creates better microenvironment during rainy season and Derensis and Scaramuzzi (2003) [3] who found out that the environmental temperature, radiant energy, RH and wind speed all contribute to the degree of heat stress in animals.

Table 4: Mean ± SE of Temperature Humidity Index of micro climate under different groups

Weeks	Time	Control (T_0)	Treatment (T_1)	Treatment (T_2)
1	9:00 am	78.00 ± 1.01	74.91 ± 0.90	76.83 ± 1.04
	2:00 pm	82.41 ± 1.54	78.77 ± 1.32	78.66 ± 1.40
	Avg.	80.63 ± 1.03^b	77.17 ± 0.88^a	78.06 ± 0.87^a
2	9:00 am	77.72 ± 1.36	76.09 ± 0.81	76.48 ± 0.72
	2:00 pm	82.82 ± 0.77^b	78.74 ± 0.65^a	79.59 ± 0.83^a
	Avg.	80.65 ± 0.97^b	77.63 ± 0.61^a	78.27 ± 0.73^a
3	9:00 am	81.12 ± 0.54^b	78.41 ± 0.33^a	79.20 ± 0 .35^a
	2:00 pm	85.89 ± 0.53^b	83.23 ± 0.84^a	84.04 ± 0.63^a
	Avg.	83.85 ± 0.68^b	81.10 ± 0.79^a	81.90 ± 0.79^a
4	9:00 am	80.32 ± 0.54^b	77.73 ± 0.55^a	78.09 ± 0.63^a
	2:00 pm	84.78 ± 1.04	82.45 ± 1.51	83.19 ± 1.49
	Avg.	82.79 ± 0.78	80.31 ± 0.98	80.89 ± 1.02
5	9:00 am	77.41 ± 0.41^b	74.09 ± 0.59^a	75.44 ± 0.58^a
	2:00 pm	82.33 ± 1.01^b	77.69 ± 1.11^a	79.14 ± 0.92^a
	Avg.	80.09 ± 0.76^b	76.09 ± 0.76^a	77.50 ± 0 .71^a
6	9:00 am	76.74 ± 0.27^b	75.37 ± 0.36^a	76.41 ± 0.42^{ab}
	2:00 pm	81.57 ± 0.26^b	78.83 ± 0.22^a	79.07 ± 0.34^a
	Avg.	79.60 ± 0.70^b	77.42 ± 0.46^a	78.02 ± 0.47^a
7	9:00 am	77.31 ± 0.77^b	74.73 ± 0.60^a	75.06 ± 0.50^a
	2:00 pm	81.62 ± 0.41^b	77.64 ± 0.65^a	78.78 ± 0.59^a
	Avg.	79.68 ± 0.65^b	76.34 ± 0.56^a	77.11 ± 0.61^a
8	9:00 am	78.03 ± 0.93^b	74.64 ± 0.60^a	75.31 ± 0.91^a
	2:00 pm	82.93 ± 1.24^b	79.78 ± 0.65^a	80.25 ± 0.83^{ab}
	Avg.	80.80 ± 1.00^b	77.47 ± 0.56^a	78.04 ± 0.94^{ab}
9	9:00 am	78.09 ± 0.71	76.02 ± 0.70	76.15 ± 0.69
	2:00 pm	82.39 ± 1.23^b	78.12 ± 1.43^a	78.92 ± 1.17^{ab}

	Avg.	80.49 ± 0.93^{b}	77.23 ± 0.80^{a}	77.72 ± 0.72^{a}
10	9:00 am	77.77 ± 0.91^{b}	74.57 ± 0.87^{a}	75.10 ± 0.88^{a}
	2:00 pm	82.51 ± 0.70^{b}	78.71 ± 0.71^{a}	79.78 ± 0.88^{a}
	Avg.	80.49 ± 0.82^{b}	76.91 ± 0.78^{a}	77.72 ± 0.84^{a}
11	9:00 am	77.08 ± 0.36^{b}	73.66 ± 0.68^{a}	73.68 ± 0.42^{a}
	2:00 pm	81.19 ± 0.72^{b}	78.50 ± 0.64^{a}	78.98 ± 0.65^{a}
	Avg.	79.44 ± 0.65^{b}	76.38 ± 0.80^{a}	76.63 ± 0.80^{a}
12	9:00 am	75.93 ± 0.91	72.75 ± 0.65	73.36 ± 0.63
	2:00 pm	81.41 ± 0.39	77.56 ± 0.63	78.78 ± 0.57
	Avg.	79.22 ± 0.88	75.60 ± 0.81	76.54 ± 0.82
13	9:00 am	75.86 ± 0.46	73.43 ± 1.33	73.62 ± 0.41
	2:00 pm	81.45 ± 0.70^{b}	76.31 ± 1.05^{a}	78.45 ± 0.7^{a}
	Avg.	79.18 ± 0.93^{b}	75.19 ± 0.90^{a}	76.44 ± 0.78^{ab}
0verall	9:00 am	77.84 ± 0.26^{b}	75.15 ± 0.25^{a}	75.78 ± 0.23^{a}
	2:00 pm	82.65 ± 0.26^{c}	78.99 ± 0.32^{a}	79.85 ± 0.29^{ab}
	Avg.	80.59 ± 0.25^{b}	77.34 ± 0.24^{a}	78.11 ± 0.24^{a}

Mean values between 9:00 am and 2:00 pm within the groups differ significantly (P<0.01).
Means bearing different superscript in a row differ significantly (P<0.01).

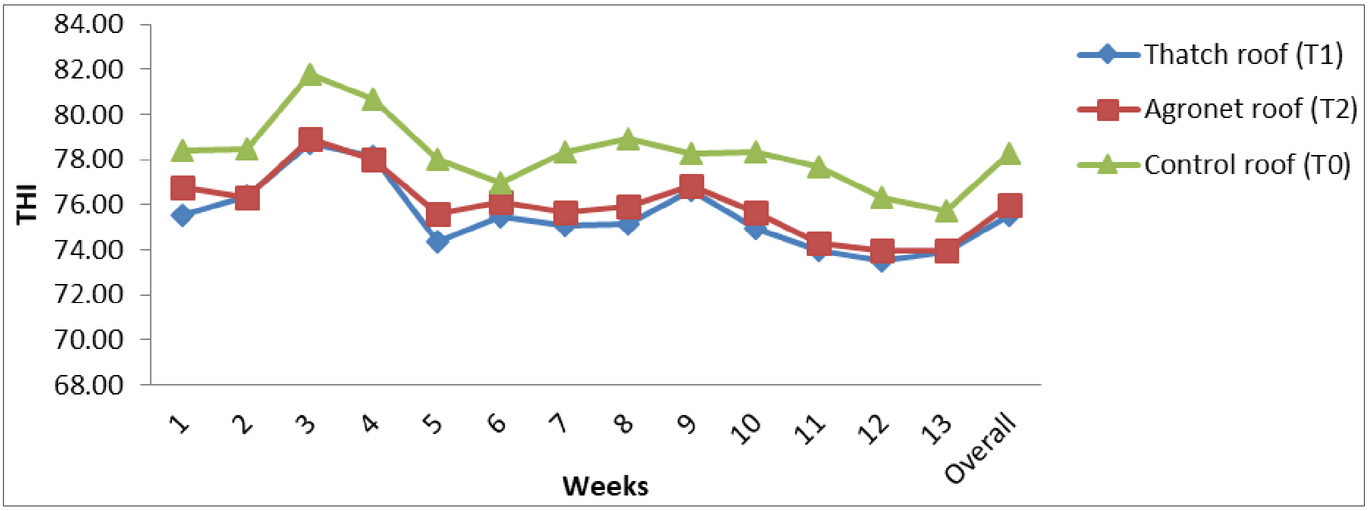

Fig 5: Temperature Humidity Index at 9:00 am of micro climate under different groups

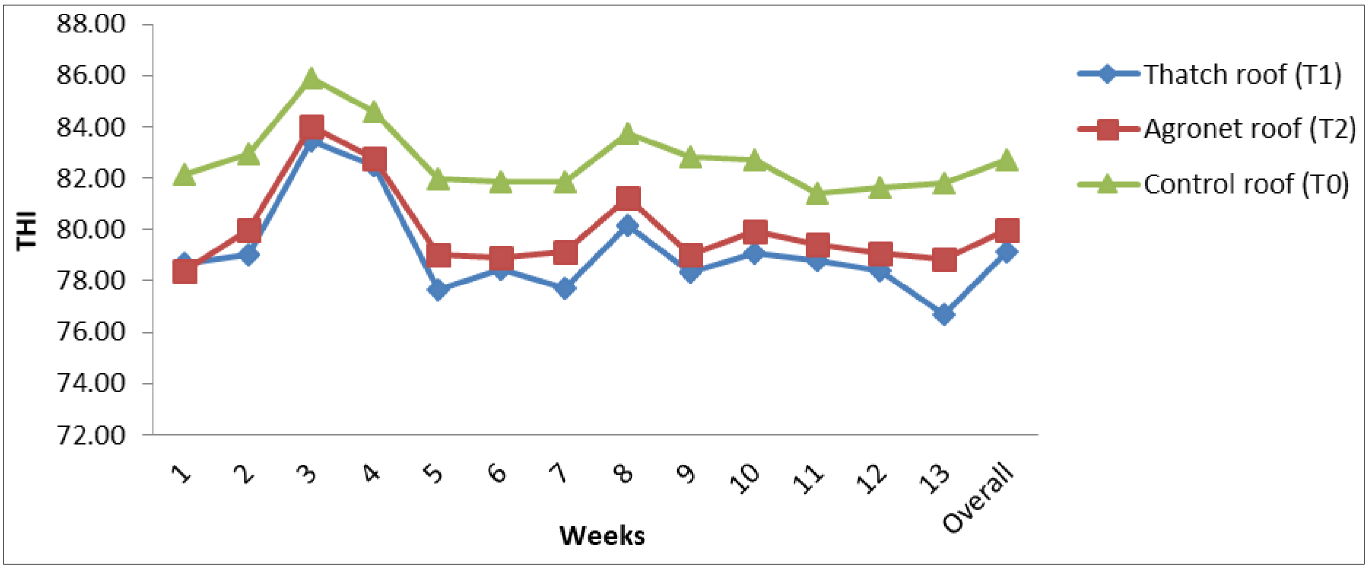

Fig 6: Temperature Humidity Index at 2:00 pm of micro climate under different groups

Body measurement

All the body measurement such as body length, height at wither, heart girth and paunch girth of sahiwal calves were presented in Table 5,6,7 and 8 and depicted in Fig. 7, 8, 9 and 10.

Body length (cm): The total gain in body length of Sahiwal calves in T_1, T_2 and T_0 groups were 15.45 ± 1.22, 15.80 ± 0.58, and 15.33 ± 1.163 cm, respectively. The body length was not significant between the groups.

Height at wither (cm): The total gain in height at wither in T_1, T_2 and T_0 groups were 11.77 ± 2.01, 11.40 ± 2.11 and 10.58 ± 2.20 cm, respectively which vary non-significantly.

Hearth girth (cm): The total gain in hearth girth in T_1, T_2 and T_0 groups were i.e 19.84 ± 1.101, 20.22 ± 1.681 and 19.02 ± 1.598 cm, respectively which vary non-significantly between groups.

Paunch girth: The total gain in paunch girth of calves in T_1, T_2 and T_0 group were 29 ± 1.817, 28.62 ± 2.14 and 25.74 ± 2.317 cm, respectively. Thatch and agro-net roof housed animals have slightly higher gain in paunch girth as compared to control roof housed but not significantly.

The overall results of the body measurements showed that there were non-significant changes in body measurements of Sahiwal calves reared under different roof modification systems. All the body measurement showed an increasing trend with advancement of age and increase in body weight. All the body measurements are non-significantly higher in T_1 and T_2 might be because of better growth in calves due to comfortable micro environment in these treatment groups and along with gain in body weight, skeletal growth of calves occur with age.

Similar findings were observed by Kamal *et al. (*2013) [5] who reported that the inter group differences of chest girth and height at withers were found to be non-significant (P<0.05) throughout the period of growth but there was significant difference in body length.

Table 5: Mean ± SE of Weekly Body Length (cm) of Sahiwal calves in different groups

Week	Control (T_0)	Treatment (T_1)	Treatment (T_2)
Initial	79.60 ± 2.33	80.39 ± 1.30	80.88 ± 2.01
1	80.50 ± 2.33	81.42 ± 1.31	81.75 ± 1.95
2	81.67 ± 2.41	83.25 ± 1.38	83.14 ± 2.07
3	82.34 ± 2.89	84.34 ± 1.43	84.5 ± 2.145
4	83.52 ± 2.98	85.52 ± 1.48	85.84 ± 2.20
5	86.39 ± 2.26	86.57 ± 1.49	87.12 ± 2.41
6	86.74 ± 2.71	87.72 ± 1.57	88.12 ± 2.37
7	88.55 ± 2.44	88.65 ± 1.68	89.60 ± 2.42
8	89.85 ± 2.38	90.62 ± 2.27	90.49 ± 2.42
9	90.97 ± 2.45	92.07 ± 2.31	91.94 ± 2.37
10	91.57 ± 2.51	92.72 ± 2.48	93.29 ± 2.41
11	92.55 ± 2.54	93.71 ± 2.47	94.52 ± 2.37
12	94.00 ± 2.70	95.09 ± 2.42	96.09 ± 2.42
13	94.92 ± 2.68	95.84 ± 2.38	96.67 ± 2.43
Total Gain	15.33 ± 1.16	15.45 ± 1.22	15.80 ± 0.58

Non-significant

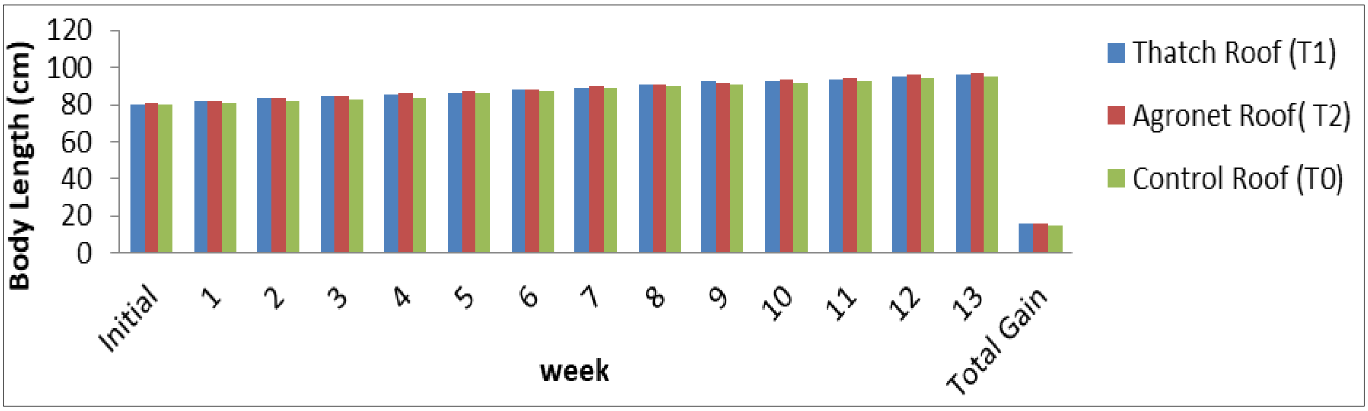

Fig 7: Weekly Body Length (cm) of Sahiwal calves in different groups

Table 6: Mean ± SE of weekly Height at wither (cm) of Sahiwal calves in different groups

Week	Control (T_0)	Treatment (T_1)	Treatment (T_2)
Initial	95.34 ± 2.52	93.65 ± 2.01	96.44 ± 2.12
1	96.12 ± 2.56	94.42 ± 2.00	97.14 ± 2.16
2	97.25 ± 2.59	96.5 ± 2.003	97.80 ± 2.19
3	98.12 ± 2.56	97.50 ± 1.99	97.04 ± 2.99
4	98.87 ± 2.60	98.34 ± 1.97	97.90 ± 3.07
5	100.02 ± 2.62	99.22 ± 2.01	100.89 ± 2.03
6	100.52 ± 2.69	99.84 ± 2.10	101.37 ± 2.08
7	101.29 ± 2.58	100.75 ± 2.07	102.49 ± 2.08
8	102.14 ± 2.66	101.42 ± 2.03	103.60 ± 2.09
9	103.25 ± 2.72	102.82 ± 2.16	104.42 ± 2.04
10	103.89 ± 2.76	103.59 ± 2.16	105.45 ± 2.15
11	104.67 ± 2.85	104.55 ± 2.20	105.47 ± 2.39
12	105.35 ± 2.77	105.09 ± 2.29	107.25 ± 2.03
13	105.92 ± 2.71	105.42 ± 2.39	107.84 ± 2.12
Total Gain	10.58 ± 2.20	11.77 ± 2.01	11.40 ± 2.11

Non-significant

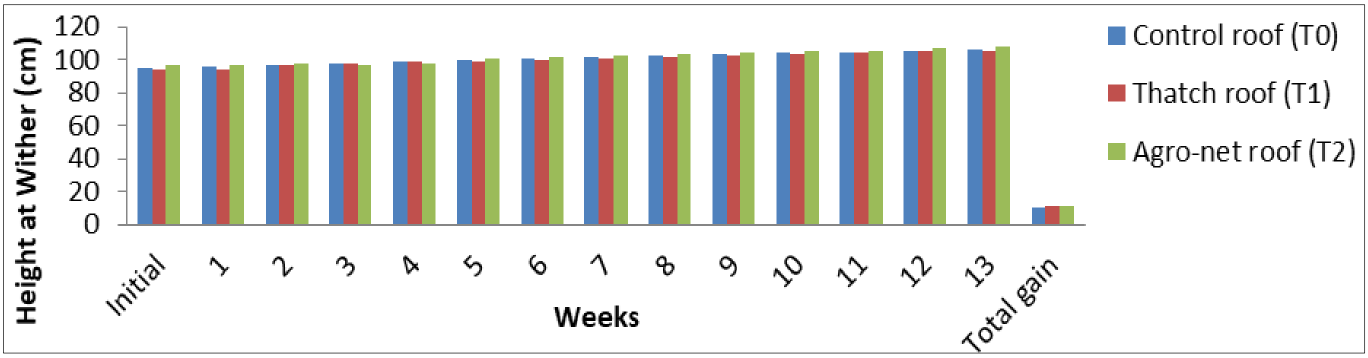

Fig 8: Weekly Height at wither (cm) of Sahiwal calves in different groups

Table 7: Mean ± SE of weekly Hearth girth (cm) of Sahiwal calves in different groups

Week	Control (T_0)	Treatment (T_1)	Treatment (T_2)
Initial	106.90 ± 1.50	105.75 ± 2.77	100.79 ± 4.15
1	107.92 ± 1.51	106.92 ± 2.86	103.45 ± 3.22
2	109.52 ± 1.57	108.59 ± 2.92	104.92 ± 3.29
3	110.75 ± 1.62	109.75 ± 2.96	106.17 ± 3.18
4	112.00 ± 1.67	111.39 ± 3.09	107.54 ± 3.32
5	113.50 ± 2.36	113.17 ± 2.99	109.29 ± 3.27
6	114.39 ± 2.27	114.25 ± 2.97	108.17 ± 3.38
7	115.87 ± 2.31	115.92 ± 3.06	111.5 ± 3.452
8	117.89 ± 2.50	117.49 ± 3.19	112.57 ± 3.80
9	119.09 ± 2.55	118.92 ± 3.13	114.55 ± 3.60
10	121.25 ± 3.03	120.67 ± 3.16	116.35 ± 3.81
11	122.42 ± 2.69	122.55 ± 3.35	118.00 ± 3.86
12	124.10 ± 2.78	124.34 ± 3.44	119.82 ± 4.07
13	125.92 ± 2.96	125.59 ± 3.46	121.00 ± 4.08
Total Gain	19.02 ± 1.59	19.84 ± 1.10	20.22 ± 1.68

Non-significant

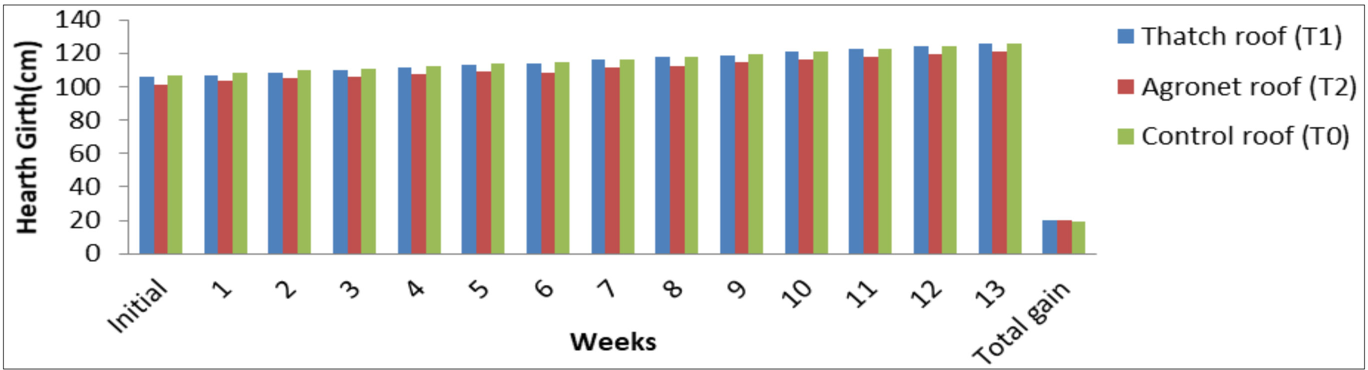

Fig 9: Weekly Hearth girth (cm) of Sahiwal calves in different groups

Table 8: Mean ± SE of weekly Paunch girth (cm) of Sahiwal calves in different groups

Week	Control (T_0)	Treatment (T_1)	Treatment (T_2)
Initial	112.44 ± 1.68	111.55 ± 3.22	107.17 ± 3.07
1	114.34 ± 1.64	113.42 ± 3.19	109.39 ± 3.19
2	115.94 ± 1.91	115.29 ± 3.14	111.59 ± 3.21
3	118.05 ± 1.87	117.74 ± 3.21	113.92 ± 3.27
4	120.24 ± 2.04	120.25 ± 3.36	116.47 ± 3.27
5	123.29 ± 2.59	123.50 ± 3.19	119.59 ± 3.48
6	125.39 ± 2.52	125.80 ± 3.21	122.80 ± 3.25
7	128.25 ± 2.78	128.89 ± 3.06	125.62 ± 3.23
8	131.15 ± 3.00	131.22 ± 3.11	128.24 ± 3.11
9	132.54 ± 2.69	134.17 ± 2.96	130.09 ± 3.01
10	134.67 ± 2.88	135.74 ± 2.87	129.79 ± 4.55
11	136.75 ± 3.06	139.29 ± 2.86	131.84 ± 4.26
12	137.00 ± 3.585	140.92 ± 4.19	134.47 ± 4.20
13	138.17 ± 3.621	141.84 ± 4.22	135.79 ± 4.01
Total gain	25.74 ± 2.31	30.29 ± 1.81	28.62 ± 2.14

Non-significant

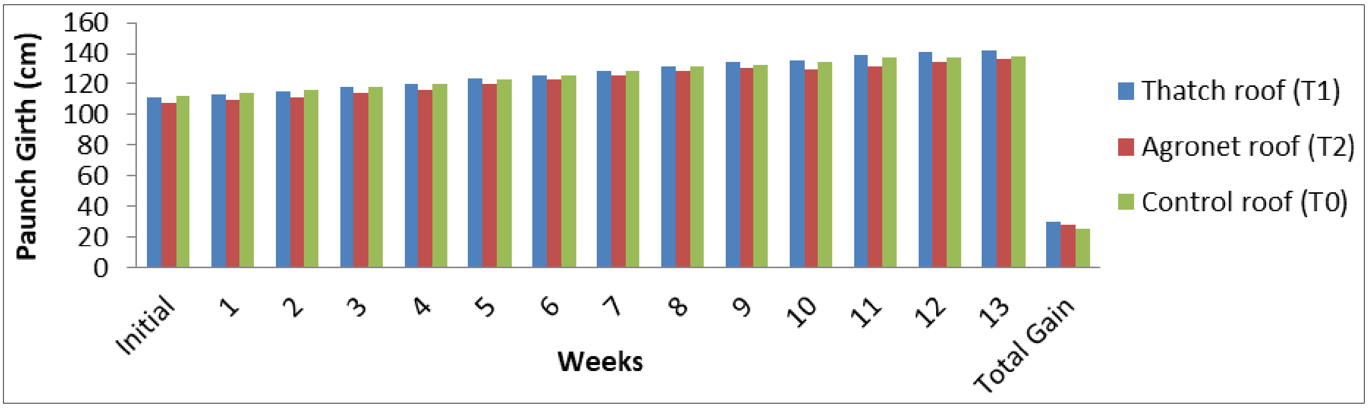

Fig 10: Weekly paunch girth (cm) of Sahiwal calves in different groups

Conclusion

The overall result clearly demonstrate that, improvement in existing roof structure through appropriate modifications, such as thatch and agro-net can be used above the asbestos roof in arid region during summer months as they are cost effective and significantly reduce THI inside animal shed which ultimately leads to better growth of Sahiwal calves.

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