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The Effects of Outdoor Housing and Cafeteria Feeding on Growth Performance and Feeding Behaviour of Awassi Lambs Kept in Hot Climate Condition

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Abstract: Study was carried out to determine the effects of shade allowance and cafeteria feeding on feeding behaviour of Awassi lambs kept in hot climate condition. The two housing methods indoor and outdoor and two feeding methods (single and cafeteria feeding) were tested (ISF, OSF, ICF and OCF). The thirty two lambs 3 months old male were divided into four groups and housed individually for 42 days. Results showed that daily gain, feed efficiency, the intake of water, protein, energy and fibre, the selection of energy, protein and fibre and water/feed ratio were affected by treatments ($p<0.05$). Indoor lambs, made a diet containing 29.27% B, 27.10% C, 11.63% CSM, 3.30% FFS, 19.17% A and 9.52% WB while outdoor ones made a diet having 24.75% B, 27.12 C, 9.60% CSM, 9.22% FFS, 16.12% A and 13.20% WB. Eating, drinking and standing were significant at ($p>0.05$) while ruminating and lying were significant at ($p<0.001$) respective groups ISF, OSF, ICF and OCF. In conclusion, single fed Awassi lambs kept in outdoor in hot climate showed less ruminating but more lying behaviour while given opportunity to choose a diet they ate more concentrate feed ingredients such as full fat soya and wheat bran without changing their behaviour patterns. Cafeteria feeding in lambs allows physiological arrangements against heat stress in outdoor housing condition by dietary self selection and by tuning respiratory and circulatory systems.

Key words: Awassi lambs, housing method, heat stress, behaviour, cafeteria feeding, opportunity

INTRODUCTION

High ambient temperature with high direct and indirect solar radiation, wind speed and relative humidity cause the effective temperature of the environment to often exceed the thermo neutral zone of the animals (5-25°C; McDowell, 1972), leading the heat stress (Bianca, 1962; Finch, 1984; Hayes *et al*., 2003). The effect of heat stress is also substantial in the subtropical-mediterranean zones and farm animals raised in this area are exposed annually for 3-5 months to considerable heat stress (Silanikove, 1992). The best recognized effect of raised body temperature is an adaptive depression of the metabolic rate associated with reduced appetite (Silanikove, 2000). There is a clear evidence that animals subjected to prolonged periods heat stress significantly reduce their dry matter intake (Thwaites, 1967; Abdel-Samee and Diel, 1998; Holst and Stanley, 2000; Beatty *et al*., 2006) and consequently, results in a fall in performance. Intake depression can be exacerbated by the consumption of diets containing a high percentage of roughage (Brink, 1975; Dixon *et al*., 1999).

Animals can successfully select a diet to meet their physiological and nutritional needs (Rose and Kyriazakis, 1991; Forbes, 1995; Sahin *et al*., 2001) to meet their nutritional requirements (Kyriazakis and Oldham, 1993; Arsenos and Kyriazakis, 1999). Recently, Gorgulu *et al*. (1996), Sahin *et al*. (2003) and Keskin *et al*. (2004) reported that Awassi lambs raised under a cafeteria feeding system successfully selected the diet to match their nutritional requirements and showed a performance similar to lambs raised under a conventional feeding system. However, the previous researcher have not been study enough the effect of environmental condition to diet choice in small ruminants.

There has been a limited study regarding the effect of environmental factors on behavioural and physiological responses of small ruminants. Previous feeding behaviour studies had been carried out in grazing conditions. However, it was not known how animals change their behavioural and physiological responses when given to live in house absolutely protected from sunshine in hot climate and also allowed to make their own diets from offered feed ingredients in these environmental conditions. Therefore, the current study was conducted to determine the effects of housing method and cafeteria feeding on growth performance and feeding behaviour of Awassi lambs kept in hot climate condition.

Table 1: The nutrient composition of single diet

Ingredients	Percentage
Barley (890 g DM, 2900 kcal ME, 110 g CP and 52 g CF kg^{-1})	40.00
Corn (890 g DM, 3000 kcal ME, 90 g CP and 28.5 g CF kg^{-1})	5.00
Wheat bran (890 g DM, 2200 kcal ME, 180 g CP and 110 g CF kg^{-1})	25.00
Cotton seed meal (900 g DM, 2100 kcal ME, 290 g CP and 190 g CF kg^{-1})	9.00
Full-fat soybean (900 g DM, 3200 kcal ME, 380 g CP and 50 g CF kg^{-1})	9.00
Alfalfa straw (870 g DM, 1800 kcal ME, 142 g CP and 190 g CF kg^{-1})	10.00
Vitamin and mineral mixture (obtained from commercial source)	2.00
Calculated composition per kg fresh diet	
ME (kcal)	2517.00
Dry Matter (DM) (g)	872.00
Crude Protein (CP) (g)	168.00
Crude Fiber (CF) (g)	90.32

MATERIALS AND METHODS

The thirty two 3 months old fat-tailed male Awassi lambs were used in this study at the Research Farm of Mustafa Kemal University, Antakya province, Turkey. Antakya is located between 36°N latitude and 36°E longitude in the Eastern mediterranean region where climatic conditions are hot and dry in summer and warm and rainy in winter.

At the beginning of the study, the lambs (n = 32) were numbered with ear tags and equally (eight lambs per group) allocated in the four groups Indoor-Single Feeding (ISF), Outdoor-Single Feeding (OSF), Indoor-Cafeteria Feeding (ICF) and Outdoor Cafeteria Feeding (OCF) with similar live weights (28.73, 28.85, 28.66 and 28.85 kg, p>0.05). Each lamb within each group was one replicate and housed individually within 100×120×120 cm sized pen in both housing area.

Each individual pen contained two plastic buckets one for a single feed (10 L capacity) and the other for water (15 L capacity). The pens of cafeteria animals contained seven plastic buckets (5 L capacity per bucket) for the main feed ingredients Barley (B), Corn (C), Wheat Bran (WB), Cotton Seed Meal (CSM), Full-Fat Soybean (FFS), Alfalfa straw (A) and water supply.

Control animals were fed *ad lib* a diet in mash form containing 168 g crude protein and 2517 kcal ME kg^{-1} (Table 1) which was prepared from the above ingredients while cafeteria animals were allowed free access to the same ingredients with added vitamin and mineral mixture (2% of total ingredients).

At the beginning of the study, feed ingredients were offered to cafeteria animals in the same position from left to right (alfalfa straw, barley, corn, wheat bran, cotton seed meal and full-fat soybean) in plastic buckets for

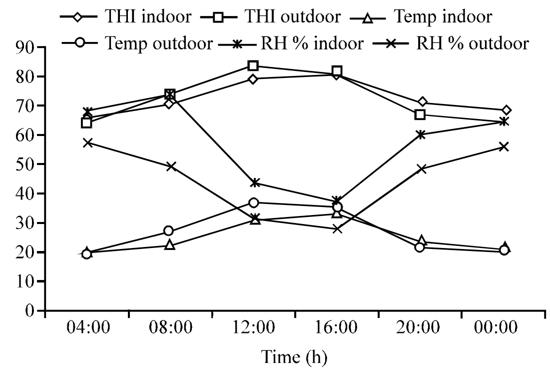

Fig. 1: Meteorological data

7 days to familiarize the metabolic consequences of feed ingredients. Feed and water intakes were determined daily (at 10:00) and lambs were weighed individually every fortnight.

The experiment lasted 42 days, from 31 August to 11 October 2007. The ambient temperature in pens were measured by using thermometer while humidity was measured by hygrometer once a week at the times 04:00, 08:00, 12:00, 16:00, 20:00 and 00:00 h for 6 weeks. Temperature-Humidity Index (THI) (Tucker *et al*., 2008) was used as indicators of thermal comfort and calculated as follows:

$$THI = (1.8\times T+32)-((0.55-0.0055\times RH)\times(1.8\times T-26))$$

Where:
T = Air temperature (°C)
RH = Relative Humidity (%)

The climate conditions of experimental unit were 26.25°C average temperature with 50.60% humidity. The detailed information regarding meteorological data shown in Table 2 and Fig. 1.

Relative humidity was lower outdoor area than indoor area due to wind. THI is commonly used as an indicator of the degree of climatic stress on animals where a THI of 72 and below is considered as no heat stress, 73-77 as mild heat stress, 78-79 as moderate and >90 as severe (Fuquay, 1981).

Each lamb was monitored behaviourally once a week for a period of 30 min at 10:00, 13:00, 16:00, 19:00, 22:00, 01:00, 04:00 and 07:00 h at 5 min intervals. After every 5 min, each lamb was monitored to determine its activity. The first seen activity was recorded as the determined activity as explained by Keskin *et al*. (2004). The recorded activities were eating, drinking, ruminating, standing, lying and others.

Table 2: Meteorological parameters of indoor and outdoor housing areas (mean±SED)

		Indoor		Outdoor	
Traits	Hours	Mean	Range	Mean	Range
Air temperature (°C)	04:00	20.00±1.92	16-26.00	18.80±2.27	14-26
	08:00	22.25±3.49	19-28.50	26.85±1.54	22-32
	12:00	31.15±0.95	27-34.00	36.43±2.15	28-44
	16:00	32.83±0.70	30-35.00	35.17±0.65	34-48
	20:00	23.60±0.98	21-27.00	21.40±1.63	18-27
	00:00	21.40±1.54	18-26.00	19.68±2.00	16-26
Relative humidity (%)	04:00	67.80±9.85	29-83.00	57.00±9.26	28-83
	08:00	73.33±2.17	70-84.00	49.17±3.33	42-62
	12:00	43.33±3.52	30-52.00	31.67±2.70	20-38
	16:00	37.17±5.22	25-55.00	27.50±1.12	24-31
	20:00	60.00±8.69	29-76.00	48.40±8.62	29-72
	00:00	64.60±9.18	29-78.00	55.60±9.87	28-81
THI	04:00	65.60±2.84	60-76.00	63.60±3.01	57-74
	08:00	70.00±2.10	65-79.00	74.17±2.04	68-82
	12:00	78.83±1.27	74-82.00	82.83±2.80	73-93
	16:00	79.67±0.56	78-82.00	80.50±0.85	78-84
	20:00	70.60±1.70	68-77.00	66.60±1.96	63-74
	00:00	67.80±2.15	64-76.00	64.40±2.64	60-74

Additionally, Rectal Temperature (RT), Respiration Rate (RR) and Pulse Rate (PR) of lambs were determined at 07:00 am, 12:00 and 17:00 pm once a week. The rectal temperature was measured using digital thermometers (Omron MC-63, Omron Healthcare, Netherlands). Respiration rates were measured for 30" by counting thoracic and flank movements to detect clearly. Pulse rates were ascertained by use of a stethoscope through the ventral wall of the chest and also insertion time was 30".

In this study, two factors (two housing and two feeding methods) were tested in factorial experimental design. Data concerning growth, feed intake, diet selection and physiological values were analysed using MANOVA (Windows Version of SPSS, release, 10.01). Behavioural data were subjected to χ^2-test. Also the basal rate for single diet was compared as a pair by using one sample t-test in the same software. Means were ranked by using Duncan Multiple Range test.

RESULTS AND DISCUSSION

Table 3 shows that feed intake did not differ ($p>0.05$) between treatments. On the other hand, outdoor housing increase water intake, water/feed ratio, daily gain and feed efficiency while cafeteria feeding increased protein intake, energy intake and crude fibre intake ($p<0.01$). The higher rate of energy selection, protein selection and lower rate of fibre selection in outdoor cafeteria lambs indicated that outdoor cafeteria lambs preferred a high caloric and nitrogenous diet but less fibrous than other groups ($p<0.01$).

Figure 2 shows an insignificant difference in live weights between the experimental groups ($p>0.05$). Single

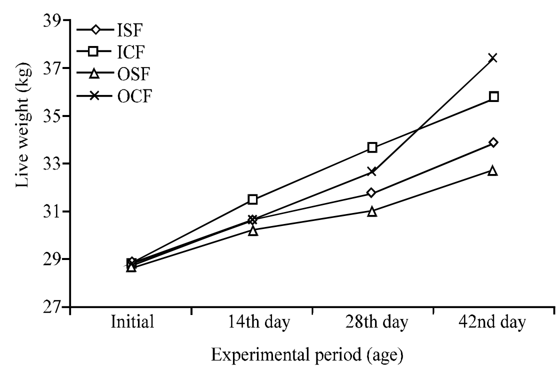

Fig. 2: Changes in live weight of experimental lambs

and cafeteria lambs kept in indoor and outdoor, reached 33.87, 35.72, 32.74 and 37.37 kg live weight, respectively at the end of the experiment ($p>0.05$). Outdoor cafeteria lambs tended to show better growth performance in comparison to other groups without statistical significance. Also there was difference between groups regarding daily gain during the experimental period ($p<0.01$). The less daily gain was monitored in indoor cafeteria group and higher daily gain was observed in outdoor cafeteria group. Thus, the better FCR was obtained in outdoor cafeteria group.

The proportional intakes of feed ingredients by lambs are shown in (Table 4). Cafeteria lambs selected different level of feed ingredients than single diet depending on housing method. Indoor cafeteria lambs selected diet including 29.27% B, 27.10% C, 11.63% CSM, 3.30% FFS, 9.52% WB and 19.17% A straw while outdoor cafeteria ones selected diet including 24.75% B, 27.12% C, 9.60% CSM, 9.22% FFS, 13.20% WB and 16.12% A straw. The proportional dietary choices of FFS and WB was significantly higher in outdoor cafeteria lambs compared

Table 3: Daily food intake and performance traits of lambs

Housing methods	Indoor		Outdoor			p-values		
Feeding methods	Single	Cafeteria	Single	Cafeteria	SEM	HM	FM	HM×FM
Feed intake (g)	1120.95	1248.95	1168.57	1253.45	25.13	0.801	0.067	0.873
Water intake (g)	4045.11	4065.00	4415.53	4746.93	81.38	0.001	0.295	0.130
Water/feed ratio	0003.61	3.29	3.77	3.82	0.06	0.009	0.315	0.169
Daily gain (g)	0127.55	119.04	163.51	202.91	11.26	0.007	0.450	0.246
FCR	0010.04	11.16	8.18	6.73	0.67	0.022	0.901	0.329
Protein intake (g)	0188.32	235.40	196.32	241.89	6.48	0.631	0.000	0.880
ME intake (g)	0002.82	3.19	2.94	3.26	0.06	0.630	0.022	0.931
CF intake (g)	0101.24	114.73	105.54	111.42	2.33	0.915	0.046	0.416
Protein selection	0168.00	189.22**	168.00	192.44**	2.56	-	-	-
ME selection	0002.52	2.55**	2.52	2.60**	0.01	-	-	-
CF selection	0090.32	92.34**	90.32	88.57**	0.75	-	-	-

Table 4: The proportional content of feed ingredients in single diet or diets made by lambs subjected to indoor and outdoor housing (mean±SED (%))

Feeding methods	Single feeding	Cafeteria feeding (Lambs-made diet)		
Housing methods	(Man-made diet)	Indoor	Outdoor	p-value[a]
Feed ingredients/diets				
Barley (B)	40	29.27±1.82*	24.75±2.43*	0.32
Corn (C)	5	27.10±2.08*	27.12±2.13*	0.95
Cotton Seed Meal (CSM)	9	11.63±0.92*	9.60±1.92*	0.42
Full-Fat Soybean (FFS)	9	3.30±0.85*	9.22±0.82*	0.00
Wheat Bran (WB)	25	9.52±1.02*	13.20±1.11*	0.01
Alfalfa hay (A)	10	19.17±1.40*	16.12±1.86*	0.25

[a]Shows the significance in differences between the diets selected by the lambs; *Denotes the difference between the diets selected by lambs and single diet based on one sample t-test ($p<0.05$)

Table 5: The proportional count of behavioural elements in accordance with the pooled observations (mean (%))

Treatments/behavioural elements	Indoor single feeding	Outdoor single feeding	Indoor cafeteria feeding	Outdoor cafeteria feeding	p-value[a]
Eating	19.21	19.97	18.02	18.75	0.454
Drinking	1.40	1.04	1.43	1.25	0.675
Ruminating	11.96	6.65	11.25	11.28	0.000
Lying	24.18	32.76	28.47	28.08	0.000
Standing	40.57	37.45	38.45	37.06	0.880
Others	2.68	2.13	2.38	3.58	0.001
Total scans in percentage	100.00	100.00	100.00	100.00	-

[a]Shows statistical significance between treatments

to indoor ones (p = 0.00 and 0.01, respectively). Table 5 and Fig. 3a-c shows the percentage count of eating, ruminating, standing and lying behaviour of lambs on time basis in a day. Table 5 shows that lambs showed similar eating, drinking, standing behaviours irrespective to treatments. Eating were 19.21, 19.97, 18.02 and 18.75% ($p>0.05$), drinking were 1.40, 1.04, 1.43 and 1.25% ($p>0.05$), ruminating were 11.96, 6.65, 11.25 and 11.28% ($p<0.001$), lying were 24.18, 32.76, 28.47 and 28.08% ($p<0.001$), standing were 40.57, 37.45, 38.45 and 37.06% ($p>0.05$) respective groups ISF,OSF, ICF and OCF.

Single fed lambs when kept outdoor showed lower ruminating activity than those of indoors but showed the more lying behaviour ($p<0.01$). Figure 3a-c shows that the time dependent ruminating, drinking and lying behaviours of experimental animals. Single fed indoor lambs showed more ruminating behaviour in early morning. Drinking behaviour was not affected by treatment except at 16:00 in outdoor cafeteria fed lambs. These lambs showed more drinking activity than other treatment groups. Outdoor single fed animals showed more lying behaviour during the period of 13:00-16:00 h.

This study was conducted to investigate the relationship between the housing condition and cafeteria feeding with respect to growth performance, diet selection and physiological status. Outdoor cafeteria lambs tended to show better growth performance in comparison to other groups without statistical significance. Also the better FCR was obtained in outdoor cafeteria group. It might be explained by:

- Water intake
- Air circulation
- Dietary self selection

Outdoor housing increased water intake. Sheep consume less water per unit of dry matter intake than cattle but the intake increases with an increase in ambient temperature. Sheep consume 2 kg water/kg DM at temperatures between 0 and 15°C. This ratio increases to

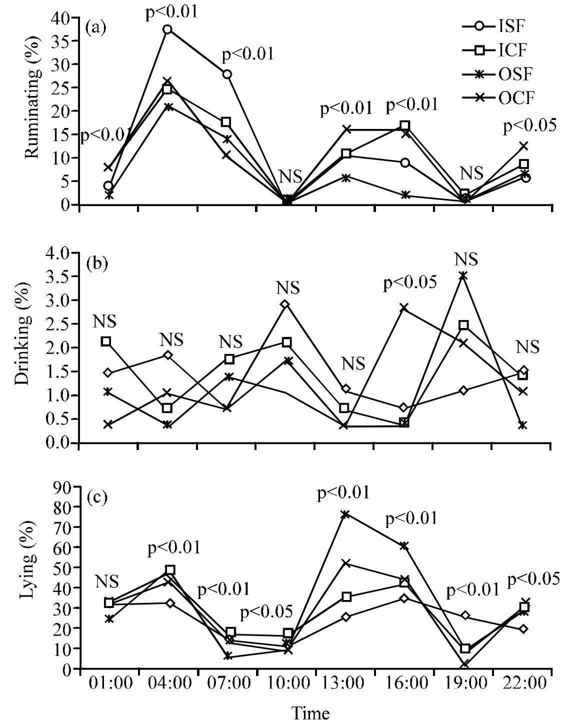

Fig. 3a-c: Ruminating, drinking and lying behaviour of experimental lambs

3:1 at temperatures above 20°C (Conrad, 1985). As shown in Table 5, all animals consume water at above 3:1 water: food ratio. Water intake was significantly higher at 11:00-15:00 and 15:00-19:00 than 7:00-11:00 and in the summer than during winter (Marai *et al*., 1997, 2000). In the present study, outdoor cafeteria lambs showed more drinking behaviour at 19:00 while indoor single fed lambs showed more drinking behaviour than the other group of lambs. In the present study, indoor housing subjected lambs more heat stress due to lack of air circulation than outdoor ones. Outdoor cafeteria lambs showed drinking behaviour about 20 times more than indoor ones at 16:00.

The air circulation and consuming the high proportion of full fat soya and wheat bran may cause the higher rate of drinking. Outdoor cafeteria lambs chose less barley and alfalfa hay and more full fat soya and wheat bran compared to indoor cafeteria lambs. This might be explained that outdoor lambs tried to reduce body heat by consuming concentrate feed which was not cause fermentative heat in their rumen.

Indoor lambs showed higher incidence of eating behaviour rather than that of the other groups. Feed refreshing was at 10:00 during the experiment period. Therefore, refreshing feed increased eating activity at that time in lambs ($p<0.01$). As reported previously studies, eating activity were higher in early morning (at 07:00) and late evening time (19:00). Generally, sheep tend to forage very early in the morning and again late in the evening with periods of grazing, resting and rumination during the day (Sutherland, 1967). They do not eat in the hottest part of the day (Johnson, 1987). Indoor animals ruminated more than outdoor ones since their diet contained more fibrous ingredients. Outdoor lambs either in single and cafeteria fed did not stand up as much as indoor ones. They do not need to stand up due to wind at outsite of barn. Indoor lambs had to stand up in order to help in dissipating body heat since THI was high as a result of lack of wind indoor housing condition. Heat lost by the skin dependent partly on the temperature gradient between skin and air and solid objects. Air velocity is one of the important factors influencing evaporative heat transfer. Ittner *et al*. (1951) reported that the reduced skin and body temperatures were obtained by increasing the air velocities over pigs and cattle subjected to high ambient temperatures.

Outdoor lambs were usually lying down on the floor at 13:00 and 16:00 h. They did not need to stand up to dissipate body heat due to air circulation in outdoor. Outdoor cafeteria lambs preferred lower fibrous feed ingredients. Highly fibrous material, release much heat during the process of fermentation. This heat increment exacerbates the heat load of the animal by increasing the internal heat load (Beede and Collier, 1986; Goetsch and Johnson, 1999; West, 1999). Adding fat to the diet increases energy density and lowers total heat increment thereby reducing body heat load (Beede and Shearer, 1991). Outdoor lambs increased to consume high fat contained feed ingredients full fat soya and corn when given to them a choice but decreased barley and wheat bran.

According to Table 6, outdoor or indoor lambs tuned their body heat by dietary arrangement, pulse rate and respiration rate. The RT was markedly lower at 08:00 than at 12:00 and 16:00. The RR was higher in outdoor lambs than indoor ones ($p<0.01$). The RR can be an indicator of heat stress (Habeeb *et al*., 1992). Sheep loose approximately 20% of total body heat via respiratory moisture in a neutral environmental temperature (12°C). With regard to the effect of humidity when a load of high relative humidity was superimposed upon as already high ambient temperature, there was a further increase in respiratory frequency in sheep. This was related to an increase in the perception of warmth (Marai *et al*., 2002). The PR reflects primarily the homeostasis of circulation along with the general physiologic status. The rate increases on exposure to high environmental temperature (Aboul-Naga, 1987).

Table 6: The differences of rectal temperature (RT, °C), respiration (RR, breath min^{-1}) and pulse rate (PR, beat min^{-1}) of groups in a day

Physiological parameters per lambs	TMR indoor	Cafeteria indoor	TMR outdoor	Cafeteria outdoor	Significance
RT 07:00 am	39.35±0.11	39.39±0.05	39.30±0.11	39.10±0.04	NS
12:00 am	39.56±0.04	39.54±0.09	39.62±0.05	39.55±0.06	NS
17:00 pm	39.77±0.06	39.69±0.06	39.80±0.05	39.80±0.05	NS
RR 07:00 am	40.33±1.95^{a}	44.83±2.59^{a}	41.50±1.63^{a}	51.50±1.97^{b}	**
12:00 am	75.00±3.79^{a}	74.00±4.88^{a}	83.83±4.98^{ab}	97.17±6.97^{c}	**
17:00 pm	81.83±5.47^{a}	72.50±5.47^{a}	82.50±3.26^{a}	101.67±5.99^{b}	**
PR 07:00 am	81.50±3.25^{a}	98.50±2.63^{ab}	91.50±3.05^{b}	105.50±3.22^{c}	**
12:00 am	108.33±2.16^{a}	109.33±2.29^{a}	126.83±2.59^{b}	124.17±2.99^{b}	**
17:00 pm	105.50±2.71^{a}	105.17±3.08^{a}	115.83±3.55^{b}	120.67±3.95^{b}	**

**$p<0.01$, NS: Not Significant; $^{a-c}$: Values marked with different letters in line are significantly different

As the ambient temperature increases, the PR as well as the circulation of blood increase to transfer from the core to the periphery. During the day, the PR was significantly higher in outdoor lambs compared to indoor lambs. Earlier work with Awassi lambs (Bhattacharya and Hussain, 1974) found that RR, PR and RT significantly increased at high temperatures and that the effect was most pronounced when lambs were consuming diets consisting of a high proportion of roughage. However, in the present study, cafeteria feeding allowed lambs to arrange their physiological status by dietary self selection.

CONCLUSION

In the study, single fed Awassi lambs kept in outdoor in hot climate showed less ruminating but more lying behaviour while given opportunity to choose a diet they ate more concentrate feed ingredients such as full fat soya and wheat bran without changing their behaviour patterns. Cafeteria feeding in lambs allows physiological arrangements against heat stress in outdoor housing condition by dietary self selection and by tuning respiratory and circulatory systems.

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