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Effect of Dietary Sorbitol Supplementation on Performance of Crossbred Dairy Cattle during Winter Season in Jammu

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ABSTRACT

The effect of sorbitol supplementation on physiological, hemato-biochemical and milk production parameters was studied for a period of 12 weeks during winter on 12 crossbred dairy cattle, aged 4-5 years, average body weight 420-500 Kg and producing 10-15 kg of milk/day. The animals were randomly divided into two groups (T_1 and T_2) of six each. The T_1 group served as control and T_2 group was supplemented with sorbitol @100gm/animal/day. During the experiment, the minimum temperature, maximum temperature, wind velocity, Wind Chill Temperature (WCT) and Relative Humidity (RH) ranged from 8.00±0.44 to 15.29±0.42°C; 20.43±0.87 to 25.00±0.49°C, 2.42±0.37 to 4.48±0.77 km/hr, 5.67±0.51 to 13.68±0.62°C and 79.14±2.40 to 88.43±1.78%, respectively. Dietary supplementation of sorbitol significantly (P<0.05) increased the rectal temperature (°C) of T_2 (36.12±0.04, 38.03±0.11) over T_1 (35.86±0.04, 37.73±0.12) both at 6:00 hrs and 14:00 hrs. Glucose level (mg/dl) was significantly (P<0.05) higher in T_2 (69.60±0.38) than T_1 (68.07±0.20). Significantly (P<0.05) higher milk yield (Kg) was recorded in T_2 (9.60±0.28) than T_1 (8.31±0.27). The respiration rate, pulse rate, hemoglobin (Hb), packed cell volume (PCV), erythrocyte sedimentation rate (ESR), aspartate aminotransferase (AST), alanine aminotransferase (ALT), glutathione peroxidase (GPx) and superoxide dismutase (SOD),dry matter intake (DMI),water intake (WI), rumination number (R.No) did not differ significantly between T_1 and T_2. Thus it is concluded that, dietary supplementation of sorbitol to crossbred dairy cattle during winter has beneficial effect on increasing the rectal temperature, blood glucose level and milk production.

Key words: Crossbred cattle, Milk production, Physiological parameters, Sorbitol, Winter.

INTRODUCTION

Temperatures stress is a major contributor to economic loss of livestock production in temperate, sub-tropical and tropical region of the world. The Jammu region is characterized by summers which are hot and dry as well as hot and humid and severe cold winters, temperature dropping below 10°C. Cold stress, as it appears in the region, is a major challenge to the productivity of animals. Several studies have also indicated that the thermal environment of cattle influences animals production at effective ambient temperatures well above their estimated LCT (Schutz *et al.,* 2010; laer, 2015). Effective ambient temperature takes into an account both air temperature and the effect of wind chill and is quantified by means of the Wind Chill Temperature (WCT) Index. Effective ambient temperature is the actual temperature felt by the animal which may be very different from the air temperature (Aggarwal and Upadhyay, 2013). Angrecka and Herbut (2015) stated that apart from lower critical temperature, cold stress is also described with the help of the wind chill temperature (WCT) index. Cold stress increases maintenance requirement of the animals to maintain the body temperature and subsequent reduction in energy for tissue growth and production. Unless additional food energy is provided to compensate for increased energy demand, availability of metabolizable energy for productive process would be limited.

Sorbitol, a natural six-carbon polyalcohol serves as a source of energy yielding 2.6 kilocalorie per gram. It has been discovered that as much as at least about 50 weight per cent of the sorbitol, orally fed to the ruminant, passes through the rumen into the abomasum of the ruminant within about six to eight hours (Luhman, 2013). Supplementation of sorbitol increased the concentrations of plasma sugars in newborn calves (Becker *et al.,* 2000). Sorbitol has been reported to improve feed conversion in calves, finishing steers (Fontenot and Huchette, 1993) and bulls (Geay *et al.,* 1992) and milk production in cattle (Luhman, 2013). Heat stressed ruminants supplemented with sorbitol in the diet had higher milk yield and feed efficiency (Miller *et al.,* 2015). Sorbitol improves performance of cattle by providing added substrate used in gluconeogenesis because sorbitol is quickly converted to fructose and then to glucose. Since

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ruminants depend upon gluconeogenic precursors (*i.e.*, propionate and amino acids) for their glucose needs, the gluconeogenic property of sorbitol could possibly provide ruminants an additional gluconeogenic precursor. Daniels *et al.* (1979) reported that calves intravenously infused with D-fructose within 12h of birth had a positive weight gain during the first week of life and resisted cold stress better than did untreated calves. Similarly, dietary sorbitol may be an effective supplementation to counteract the negative energy balance and thereby sustain production during the time of environmental stress. In view of the above fact, sorbitol was supplemented to crossbred dairy cattle during winter to counteract the negative energy balance and thereby sustain production during the time of environmental stress.

MATERIALS AND METHODS

Twelve lactating crossbred dairy cattle, 5-7 years of age and producing 10-15 Kg of milk were selected in the Instructional Livestock Farm Complex, College of Veterinary Science and Animal Husbandry, SKUAST-J, R.S. Pura, Jammu. The animals were randomly divided into two groups (T_1 and T_2) consisting of 6 animals in each group. The total duration of experiment was 12 weeks. All the animals were dewormed with broad spectrum anthelmintic before the beginning of the trial and maintained in a hygienic condition with uniform management practices throughout the experiment.

Feeding management

All animals were fed twice daily (early noon and evening) with dry roughages (wheat straw and rice straw), green roughages (barseem and oats) and concentrate mixture as per the schedule of the farm along with wholesome drinking water. In addition, sorbitol @ 100gm/animal/day was supplemented to the T_2 group.Sorbitol powder ($C_6H_{14}O_6$) manufactured by HiMedia Laboratories Pvt. Ltd was used for the experiment. The composition (%) of concentrate mixture was crushed maize 40%, wheat bran 17%, rice polish 10%, cotton seed cake 30%, mineral mixture 2% and salt 1%. Proximate composition of feeds and fodders were done as per the methods of A.O.A.C (1995) and represented in Table 1.

Housing management

The animals were housed in well-ventilated brick cemented house with cemented anti-slippery floor and gable type roof. The animals remained in the shed throughout the day and night. During extreme winter the windows were covered with curtains of plastic sheets.

Meteorological variables

Maximum and minimum temperature of the barn was recorded at 6:00 hrs and 14:00 hrs daily by using Six's thermometer in degree celsius (°C). The relative humidity % was recorded at 6:00 hrs using dry and wet bulb thermometer. Wind velocity was measured at 6:00 hrs with the help of anemometer and recorded as Km/hr. Wind Chill

Table 1: Proximate composition of feed and fodder (% on DM basis).

Attributes	Wheat straw	Rice straw	Barseem	Oats	Concentrate mix.
Dry matter	92.89	93.46	15.65	27.48	94.23
Moisture	7.11	6.54	84.35	72.52	5.77
Crude protein	3.67	2.49	15.45	9.97	21.62
Crude fiber	38.69	36.51	26.06	26.64	8.37
Ether extract	0.76	0.87	2.36	2.22	3.33
Total Ash	9.47	16.57	20.25	9.88	6.40
Acid insoluble ash	6.33	5.35	4.76	5.24	1.92
Nitrogen Free Extract	50.55	43.56	35.88	55.93	60.44

Table 2: Mean±SE microclimatic variables during the experimental period.

Period	Week	Min. Temperature (°C)	Max. Temperature (°C)	Wind velocity (Km/hr)	WCT (°C)	RH (%)
Dec	1	14.00±0.82	24.43±1.04	2.42±0.37	12.60±0.92	86.29±1.23
	2	13.86±1.08	21.14±0.74	4.48±0.77	11.46±1.37	86.14±2.93
	3	15.14±0.74	24.00±1.11	3.48±0.58	13.28±0.97	83.29±1.75
	4	12.86±0.40	22.00±0.87	3.59±0.43	10.72±0.41	84.14±2.82
Jan	5	9.57±0.65	20.43±0.87	2.84±0.48	7.58±0.73	88.43±1.78
	6	8.00±0.44	20.86±0.59	2.97±0.24	5.67±0.51	80.71±2.98
	7	8.86±0.86	23.71±0.52	2.92±0.58	6.77±0.88	83.00±1.00
	8	9.71±0.36	21.57±0.75	3.86±0.50	7.09±0.56	80.14±2.81
Feb	9	12.57±0.30	21.43±0.87	2.76±0.21	10.80±0.20	83.14±4.16
	10	10.86±0.46	24.00±0.44	2.72±0.28	8.96±0.59	79.14±2.40
	11	13.57±0.89	22.14±0.77	3.52±0.65	11.66±0.89	84.57±1.09
	12	15.29±0.42	25.00±0.49	2.96±0.48	13.68±0.62	83.14±1.45

Temperature (WCT) was calculated as per Tucker *et al.* (2007), by using the equation: WCT index = 13.2 + 0.6215 T_{air} -13.17$V^{0.16}$ + 0.3965 T_{air} $V^{0.16}$, where, T is the temperature of the air and V is the velocity of wind and recorded in ^{o}C.

Physiological parameters

Respiratory rate, pulse rate and rectal temperature of individual animals were recorded twice daily *viz*., 06:00hrs and 14:00hrs.Respiratory rate was recorded by observing flank movement for one minute and recorded as breath/ minute. Pulse rate was recorded from the coccygeal artery for one minute and recorded as beats/minute. The rectal temperature was recorded using a clinical thermometer in ^{o}C.

Hemato-biochemical parameters

Blood samples (10 ml/animal) were collected at monthly interval from the jugular vein using two different anticoagulant coated vacutainers. Ethylene diamine-tetra-acetic acid (EDTA) containing blood was used for the estimation of haematological parameters (Hb, PCV and ESR) by routine haematological methods. Plasma was collected from heparin containing blood by centrifugation at 3000rpm for 10 minutes and stored in eppendrof tube in deep freezer at -20^{o}C for biochemical parameters *viz*., AST and ALT. Analysis was done by using automated biochemistry analyser. Erythrocyte lysate was prepared on the same day for the analysis of oxidative enzymes *viz*., GPx and SOD. Estimation of GPx was done as per the method explained by Hafeman *et al*. (1974) and SOD using method of Marklund and Marklund (1974). Blood glucose level was estimated using digital glucometer (Dr.Morepen BG-03) at the time of blood collection.

Milk yield

Milk yield from individual animals were recorded twice daily *i.e*. 05:00 hrs and 016:00 hrs by using a weighing machine and expressed as Kg.

Dry matter intake (DMI), water intake (WI) and Rumination number

Dry matter intake (DMI) and water intake (WI) of the individual animal was recorded at monthly interval for three consecutive days. The amounts of feed were weighed before offering and residue were collected the next morning. The feed intake was calculated (on dry matter basis) by subtracting the amount of residue left from the amount of total feed offered. Similarly the water intake was estimated by subtracting the amount of residue left from the amount of total water offered. Rumination number (R.No/5min) was calculated by abdominal palpation method.

Data analysis

Experimental data were analyzed by one way ANOVA (Tukey's-b) as per the method described by Snedecor and Cochran (1994) using SPSS16.

Table 3: Physiological parameters of control and sorbitol treated group of crossbred dairy cattle (Mean±SE).

Attributes	Time	Group	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	Overall mean
RR	6:00hrs	T_1	22.00±0.68	20.33±0.76	21.00±0.73	19.83±0.40	18.67±0.49	18.00±0.45	19.33±0.49	20.67±0.71	22.00±0.63	21.17±0.60	23.00±0.52	23.33±0.88	20.96±0.50
		T_2	22.50±0.96	20.67±1.14	21.50±0.99	20.17±0.54	19.00±0.58	19.33±0.56	19.67±0.80	20.83±0.65	22.67±0.71	21.33±0.92	23.17±0.48	23.50±0.76	21.36±0.45
	14:00 hrs	T_1	27.00±0.37	25.50±0.72	26.33±0.67	26.00±0.58	25.17±0.87	24.00±0.26	24.50±0.43	24.83±0.70	26.17±0.48	25.67±0.80	27.17±0.87	27.50±0.76	25.94±0.32
		T_2	27.17±0.60	25.67±0.56	26.50±0.62	26.17±0.79	25.50±0.99	24.33±0.56	24.83±0.70	25.00±0.45	26.67±0.49	25.83±0.60	27.33±0.92	27.67±0.88	26.17±0.31
PR	6:00hrs	T_1	62.00±0.93	63.17±0.83	62.67±0.88	63.50±0.72	64.17±0.60	65.00±0.86	63.50±0.67	62.50±0.99	61.83±0.48	62.17±0.70	61.53±0.48	61.33±0.71	62.72±0.31
		T_2	61.67±0.56	63.00±0.58	62.33±0.67	63.17±0.83	63.83±0.75	64.67±0.71	62.83±0.60	62.17±0.60	61.50±0.76	62.00±0.58	61.50±0.76	61.17±0.79	62.40±0.30
	14:00 hrs	T_1		72.17±0.79	71.83±0.70	72.17±0.70	72.50±0.67	73.17±0.87	72.67±0.71	72.33±0.67	72.00±0.68	72.83±0.79	71.33±0.71	70.33±0.76	71.96±0.24
		T_2	71.33±0.80	72.00±0.73	71.50±0.56	71.67±0.92	72.00±0.93	72.83±0.95	72.33±0.95	72.17±0.79	71.83±0.75	72.50±0.76	71.17±0.65	70.17±0.40	71.69±0.22
RT	6:00hrs	T_1	35.78±0.07	35.73±0.10	36.08±0.10	35.60±0.10^{a}	35.55±0.07^{a}	35.47±0.06^{a}	35.58±0.06^{a}	35.67±0.11^{a}	36.07±0.09^{a}	35.73±0.09	36.18±0.12	36.40±0.13	35.86±0.04^{a}
		T_2	35.93±0.09	35.87±0.06	36.17±0.09	35.95±0.12^{b}	35.87±0.08^{b}	35.82±0.07^{b}	35.93±0.10^{b}	36.10±0.09^{b}	36.45±0.10^{b}	36.28±0.17	36.50±0.10	36.63±0.19	36.12±0.04^{b}
	14:00 hrs	T_1	37.80±0.18^{x}	37.77±0.22	37.80±0.15	37.37±0.17	37.32±0.07	37.25±0.20	37.43±0.19	37.65±0.17	37.73±0.12	37.48±0.18	37.90±0.24	38.75±0.23	37.73±0.12^{x}
		T_2	38.30±0.13^{y}	38.22±0.10	38.27±0.21	37.78±0.23	37.70±0.19	37.63±0.26	37.72±0.17	37.77±0.19	37.93±0.14	37.67±0.16	38.12±0.17	38.90±0.14	38.03±0.11^{y}

RESULTS AND DISCUSSION

Microclimatic variables

During the experiment the range of minimum and maximum temperature was 8.00±0.44°C to 15.29±0.42°C and 20.43±0.87°C to 25.00±0.49°C. The relative humidity (%) ranged from 79.14±2.40 to 88.43±1.78, wind velocity from and2.42±0.37 to 4.48±0.77 Km/hrand WCT from 5.67±0.51°C to 13.68±0.62°C, respectively (Table 2).

The present result showed that the range of WCT inside the shed was below the comfort zone for crossbred dairy cattle reported by different authors. The comfort zone of crossbred dairy cattle reported by Roenfeldt (1998) and Yasothai (2014) is between 18-27°C and 65-75° F, respectively. This indicated that the effective ambient temperature during the period of experiment was below the comfort zone of the animals.

Physiological parameters

The effect of sorbitol supplementation on physiological parameters was assessed in crossbred dairy cattle. At 6:00hrs, the range of rectal temperature (°C) recorded throughout the experiment were subnormal in both T_1 (35.47±0.06 to 36.40±0.13) and T_2 (35.82±0.07 to 36.63±0.19), while at 14:00 hrs the values of RT were within the normal range in both the groups. The overall mean RT of T_2 (36.12±0.04; 38.03±0.11) was significantly (P<0.05) higher than T_1 (35.86±0.04; 37.73±0.12) both at 6:00 hrs and 14:00 hrs (Table 3). Supplementation of sorbitol increased the RT in the T_2 is because of sorbitol served as a source of energy. Similar findings were reported by Daniels *et al.* (1979) and Keller *et al.* (1998) for calves. The overall mean of respiration rate (Table 3) were higher in T_2 than T_1 both at 6:00 hrs and 14:00, but no significant difference has been observed indicating that sorbitol supplementation did not significantly affected the respiration rate. No significant effect of sorbitol supplementation was observed on overall mean pulse rate (Table 3).

Hemato-biochemical parameters

Sorbitol supplementation increased the overall mean of hematological parameters *viz.,* Hb, PCV and ESR (Table 4) in T_2 but no significant difference has been observed between T_1 and T_2 indicating that there is no significant effect of sorbitol supplementation on the hematological parameters studied. The overall mean values of AST (IU/L) and ALT (IU/L) were lower while the overall mean of oxidative enzymes *viz.*, SOD (U/mg) and GPx (U/mL) were higher in T_2 than T_1 but analysis revealed no significant difference between T_1 and T_2 (Table 4). Significantly (P<0.05) higher blood glucose level (Table 4) was observed in T_2 (69.60±0.38 mg/dl) than T_1 (68.07±0.20 mg/dl) which confirmed that dietary supplementation of sorbitol significantly increases the blood glucose level . This is in accordance with the finding of Neil *et al*. (1961) in pregnant goats and Brenner and Kolb (1977) in cattle. Higher blood glucose in sorbitol treated group might be due to the enzymatic oxidation of sorbitol to fructose leading to glucose production as reported by (Blakley, 1951) or could be due to the possibility of sorbitol serving as a glucose precursor in ruminants as reported by Boyles (1993). Miller *et al*. (2015) stated that adding sugar alcohol (sorbitol) to the diet of ruminants may alter liver metabolism to increase glucose or may act as an alternative of glucose for peripheral tissues metabolism or may affect endocrine control of metabolism to spare glucose, or combination thereof.

Milk production

The overall mean±SE (Table 5) milk yield (MY) of T_2 (9.60±0.28) was significantly (P<0.05) higher than T_1 (8.31±0.27). Higher milk production in the T_2 might be due to sorbitol supplementation which is in accordance to the

Table 4: Hemato-biochemical parameters of control and sorbitol treated group of crossbred dairy cattle (Mean±SE).

Attributes	Groups	December	January	February	March	Overall
Hemoglobin	T_1	11.08±0.37	11.25±0.15	11.38±0.27	11.47±0.22	11.16±0.15
	T_2	11.15±0.23	11.30±0.29	11.43±0.18	11.52±0.16	11.21±0.15
Packed cell volume (%)	T_1	33.02±0.57	33.25±0.63	33.55±0.71	33.89±0.75	33.21±0.15
	T_2	33.12±0.93	33.30±0.94	33.62±0.73	34.03±0.70	33.30±0.16
Erythrocyte sedimentation rate (mm/24hrs)	T_1	3.10±0.19	3.31±0.16	2.89±0.32	2.73±0.24	2.97±0.10
	T_2	3.16±0.20	3.34±0.26	2.92±0.25	2.81±0.27	3.02±0.09
Aspartate amino transferase (IU/L)	T_1	86.30±0.41	84.97±0.78	82.86±0.77	82.29±0.93	85.10±1.23
	T_2	86.23±0.96	84.75±0.99	82.77±0.84	82.38±0.69	85.02±1.21
Alanine amino transferase (IU/L)	T_1	28.65±0.56	31.62±0.90	33.10±0.99	35.20±0.54	31.15±0.62
	T_2	28.59±0.78	31.54±0.58	32.95±0.53	35.12±0.75	31.06±0.61
Superoxide dismutase (U/mg of protein)	T_1	15.36±2.74	14.15±3.23	18.77±3.62	19.94±2.94	17.15±1.06
	T_2	17.25±2.76	16.81±2.08	19.55±3.35	20.78±2.21	18.69±0.74
Glutathione peroxidase (U/mL)	T_1	4.51±0.67	3.52±0.63	5.40±0.77	5.88±0.86	4.82±0.40
	T_2	5.43±0.87	4.42±0.94	5.51±0.90	6.12±0.82	5.33±0.28
Glucose (mg/dl)	T_1	67.67±0.80	68.00±0.86	68.83±0.60	68.50±0.85	68.07±0.20[a]
	T_2	69.33±0.71	70.50±0.76	71.17±0.98	69.17±0.70	69.60±0.38[b]

Value with different superscript differ significantly (P<0.05).

Table 5: Milk production (Kg) of control and sorbitol treated group of crossbred dairy cattle (Mean±SE).

Treatments	1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	Overall
T_1	10.02±0.12^a	9.95±0.36^a	9.48±0.36^a	7.54±0.20^a	5.85±0.46	4.42±0.32^a	5.33±0.47	6.01±0.41	8.93±0.24^a	8.08±0.40	9.00±0.33^a	10.21±0.54^a	8.31±0.27^a
T_2	10.45±0.36^b	10.05±0.33^b	10.79±0.33^b	9.84±0.45^b	7.68±0.60	5.60±0.34^b	6.08±0.52	6.92±0.55	10.64±0.20^b	9.41±0.50	11.46±0.84^b	12.49±0.60^b	9.60±0.28^b

Values with different superscript differ significantly (P<0.05) between the columns.

Table 6: Dry matter intake (Kg) and water intake (Liter) and Rumination number (R.No/5min) of control and sorbitol treated group of crossbred dairy cattle (Mean±SE).

	Group	December	January	February	March	Overall
Dry matter intake	T_1	12.70±1.21	13.16±0.83	13.34±0.78	12.22±0.52	12.80±0.36
	T_2	12.98±0.59	13.64±0.49	13.52±0.54	13.31±0.97	13.25±0.27
Water Intake	T_1	8.83±0.48	9.00±0.63	8.50±0.72	8.00±0.63	8.57±0.28
	T_2	9.17±0.31	9.33±0.56	9.17±0.31	8.83±0.48	9.10±0.17
Rumination number	T_1	44.81±1.48	43.42±1.18	43.27±1.07	42.98±1.18	44.09±0.53
	T_2	45.19±0.40	45.69±1.11	45.23±1.31	44.45±1.58	45.15±0.47

finding of Luhman (2013) and Miller *et al*. (2015) who reported that feeding of sugar alcohol to the ruminants significantly increases milk production. Lister and Smithard (1984) suggested that rapid absorption of sugar alcohols occurs through the rumen epithelium. *In vitro* evidence suggests that sorbitol can shift the fermentation pattern within the rumen of sheep towards more propionate (Poutiainen *et al*., 1976), which could enhance hepatic gluconeogenesis. Sorbitol might have impacted rumen papillae growth, enhancing papillae size and number (McFadden *et al.,* 2007) for increased propionate absorption during lactation (Goff and Horst, 1997) and thereby increasing net energy supply for milk production.

Dry matter intake (DMI), water intake (WI) and Rumination number

The DMI, WI and R.No (Table 6) did not differ significantly between the T_1 and T_2 showing that sorbitol supplementation had no significant effect on the behavioral parameters studied.

CONCLUSION

Supplementation of sorbitol to lactating dairy crossbred cattle @ 100 g per day increased the rectal temperature, blood glucose and milk production as compared to the control group during winter which might because sorbitol is a source of energy and increases the energy density of the ration. Thus it can be concluded that sorbitol can be supplemented during winters to maintain thermal comfort of the animal and optimize the milk production.

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