Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; Sp 10(1): 08-11
Received: 26-10-2020
Accepted: 07-12-2020

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Effect of meteorological variables on milk production in lactating buffaloes fed on linseed oil and whole linseed

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Abstract
A study was conducted to find out the effect of meteorological variables (*i.e.* temperature, humidity, wind velocity, day length and temperature humidity index) on milk production in lactating buffaloes fed on linseed oil and whole linseed. Eighteen lactating Murrah buffaloes were divided into three equal groups (T_0, T_1 and T_2) considering their body weight (516.50±9.53 kg), milk production (7.55±0.3 kg), fat (6.67±0.29 %) and stage of lactation (2 weeks post-partum). Buffaloes in all the three groups were fed a similar mixed basal diet, comprising of wheat straw, green fodder and concentrate. Buffaloes in T_0 group were fed total mixed basal diet, comprising of wheat straw, green fodder and concentrate (69.03:30.97; roughage: concentrate ratio) to fulfill nutrient requirement of animals. The treatments consisted of basal ration supplemented with 250 g/d of linseed oil (T_1), or supplemented with 570 g/d of whole linseed (T_2). The feeding of experimental diets was started at 15 days postpartum and total experimental feeding done for 60 days. However, the data were recorded for the period of 180 days. Meteorological variable were recorded daily at the livestock farm during the experimental period. It was be concluded that rise in atmospheric temperature and humidity ultimately increases the temperature humidity index (THI) which affect the feed intake, heat dissipation and other physiological processes, thereby creating conditions of stress on milk yield.

Keywords: Buffaloes, humidity, lactating, milk yield, temperature and temperature humidity index

Introduction
India has one of the highest livestock populations in the world. Fifty percent of the buffaloes and twenty percent of the cattle in the world are found in India, most of which are milch buffaloes and cows. India is world leader in milk production for the past fifteen years with 187.74 million tonnes of milk production in 2018-19 (BAHS, 2019) [3]. Buffaloes play a major role in providing nutritional and livelihood security for millions of rural households in India. Buffaloes contribute 49.20% of total milk production in India and average yield per in-milk buffalo was 5.23 kg/day. Fifty percent of the buffaloes in the world are found in India. Madhya Pradesh bestowed with vast livestock population with an account of 40.63 million and ranks 3rd in India with total milk production of 159.11 lakh MT in 2018-19.

One of the major challenges being faced in buffalo farming is thermal stress. Thermal stress is a major limiting factor in buffalo production under tropical and subtropical climate and also during the summer season in temperate region. Bioenergetics, performance and well-being of buffaloes are affected by thermal stress. Heat stress may adversely affect milk production, reproductive and general health of the buffaloes (Kadzere *et al*., 2002; West, 2003 and Hansen, 2007). Wolfenson *et al*. (2000) [9, 20, 21] stated that over half of the world's bovine population is located in the tropical regions and it has been reported that about 60 percent of the dairy farms around the world faces economic losses due to the thermal stress. In addition, heat stress may also adversely affect the fertility of buffales in summer by poor signs of oestrus due to a reduction in estradiol secretion from the dominant follicle developed in a low luteinizing hormone environment (DeRensis and Scaramuzzi, 2003) [6]. Drop in conception rates may occur upto 20-27% in summer (Chebel *et al*., 2004; Lucy, 2002 and Rawat *et al*., 2014) [5, 10, 13]. The present study was conducted to find out the effect of different meteorological variables on milk production in lactating buffaloes fed on linseed oil and whole linseed.

Material and methods
The present study was conducted to find out the effect of meteorological variables on milk production fed with linseed and linseed oil in lactating buffaloes in Jabalpur district of Madhya Pradesh (India).

For this purpose, eighteen lactating buffaloes were divided into three equal (T_0, T_1 and T_2) considering their body weight (516.50±9.53 kg), milk production (7.55±0.3 kg), fat (6.67±0.29 %) and stage of lactation (2 weeks post-partum). Buffaloes in all the three groups were fed a similar mixed basal diet, comprising of wheat straw, green fodder and concentrate. Chemical composition of concentrate mixture (T_0, T_1 and T_2), berseem and wheat straw has been estimated as per standard methods (AOAC, 2012) [2] and are presented in Table 01. Concentrate mixture were offered to the experimental buffaloes according to the level of milk production to meet the maintenance and milk production requirements (ICAR, 2013) [7]. Buffaloes in T_0 group were fed total mixed basal diet, comprising of wheat straw, green fodder and concentrate (69.03:30.97; roughage: concentrate ratio) to fulfill nutrient requirement (ICAR, 2013) [7] of animals. The treatments consisted of basal ration supplemented with 250 g/d of linseed oil (T_1), or supplemented with 570 g/d of whole linseed (T_2). The feeding of experimental diets was started at 15 days postpartum and total experimental feeding done for 60 days. However, the data were recorded for the period of 180 days. The buffaloes were housed in a well-ventilated shed having cemented floor with individual feeding and watering arrangement. They were dewormed before start of the experiment and standard managemental practices will be followed in the shed. In morning and evening, buffaloes were offered weighed quantity of concentrates at the time of milking followed by roughage (dry + green) feeding. The animals were let loose for about 1-2 hours daily in the surrounded paddock for exercise. Clean fresh water was made available *ad libitum*.

Meteorological variable (temperature, humidity, wind speed, day length and THI) were recorded daily at the livestock farm during the experimental period and were compiled on fortnightly basis. The maximum and minimum thermometers were used for the measurement of maximum and minimum temperature. Wet bulb and dry bulb thermometers are used for the calculation of air humidity. Robinson's cup anemometer is used for the measurement of wind velocity. Campbell Stoke's sunshine recorder is used for the measurement of day length (hrs). Temperature humidity index (THI) was calculated using the formula given by Mader *et al.* (2006) [11] as below:

$$\mathrm{THI} = (0.8 \times \mathrm{T}) + [(\mathrm{RH} \div 100) \times (\mathrm{T} - 14.4)] + 46.4$$

Where, THI = temperature humidity index, T = average temperature (°C) and RH = relative humidity

Milk production of individual animal is recorded daily (morning and evening) and are compiled on fortnightly basis. The data obtained during the experiment were analyzed by Randomised Block Design (RBD) method as described by Snedecor and Cochran (1994) [17] with SPSS software (14.1 version).

Table 1: Chemical composition of concentrate mixtures, berseem and wheat straw on dry matter basis (%)

Particulars	Concentrate mixture			Berseem	Wheat straw
	T_0	T_1	T_2		
Moisture	6.72	6.76	6.87	13.35	90.86
OM	90.35	90.60	90.79	88.35	91.11
CP	19.89	19.78	20.02	15.90	3.29
EE	4.53	4.59	4.57	2.20	1.39
CF	6.82	6.56	6.71	20.55	35.79
Ash	9.65	9.40	9.21	11.65	8.89
NFE	59.11	59.67	59.49	49.70	51.64

Results and discussion

The concentrate mixture, berseem (*Trifolium alexandrinum*) and wheat straw offered to the experimental animals were analysed for proximate composition (% DM basis) are presented in Table 01. The moisture content of concentrate in T_0, T_1 and T_2 diets were 6.72, 6.76 and 6.87%; OM: 90.35, 90.60 and 90.79%; CP: 19.89, 19.78 and 20.02%; EE: 4.53, 4.59 and 4.57%; CF: 6.82, 6.56 and 6.71%; total ash 9.65, 9.40 and 9.21% and NFE: 59.11, 59.67 and 59.49%, respectively. The moisture percentage in berseem and wheat straw were 86.65, 9.14; OM: 88.35, 91.11; CP: 15.90, 3.29; EE: 2.20, 1.39; CF: 20.55, 35.79; total ash 11.65, 8.89 and NFE: 49.70, 51.64, respectively. The proximate composition (% DM basis) of concentrates in T_1 and T_2 diets did not vary as compare to concentrate used in T_0 (control) diet. Similar to our findings Sharma *et al.* (2007) and Tewatia *et al.* (2014) [15, 18] also reported similar values for the chemical composition of concentrate mixtures in their studies. Similarly, proximate composition (% DM basis) of berseem and wheat straw were also in accordance (Anonymous, 2012) [1] to values given in nutritive value of commonly available feeds and fodders in India.

The meteorological variables (*i.e.* maximum temperature, minimum temperature, average temperature, humidity, wind velocity, day length and THI) were recorded and are presented on fortnightly basis (Table 02), also the milk yield of experimental buffaloes were recorded and presented on fortnightly as T_0, T_1 and T_2 groups (Table 03).

Table 2: Average meteorological variables during the study

Periods	Temperature (°C)			Humidity (%)	Average wind velocity (km/h)	Day length (hrs.)	THI
	Max.	Min.	Average				
1st fortnight	30.20	16.20	23.27	42.73	6.33	11.10	68.97
2nd fortnight	28.73	14.13	21.57	43.53	5.60	10.64	66.90
3rd fortnight	25.93	13.80	19.97	40.67	6.07	11:06	64.64
4th fortnight	23.31	10.63	16.97	36.25	5.50	10.43	60.89
5th fortnight	25.87	14.00	19.67	37.30	6.87	10.48	64.09
6th fortnight	25.90	14.30	19.90	41.00	8.13	10.80	64.52
7th fortnight	28.47	16.67	22.47	34.60	8.40	11.15	67.19
8th fortnight	30.23	18.69	24.38	34.54	10.77	11.32	69.33
9th fortnight	31.47	20.27	24.93	30.87	9.93	11.53	69.60
10th fortnight	35.94	24.44	29.91	22.06	10.19	12.11	73.75
11th fortnight	40.93	29.93	35.10	12.80	10.20	12.31	77.13
12th fortnight	39.50	29.50	34.20	20.00	10.27	12.50	77.13

It was found that the temperature humidity index greatly affect the production performance of lactating buffaloes fed on linseed and linseed oil. Temperature humidity index (THI) indicates the quantum of heat stress on buffaloes which includes the effect of meteorological variables like temperature and humidity. This index has been developed as a weather safety index to control and minimize the heat stress-related losses (Wiersma, 1990) [19]. Highest milk production was found when temperature humidity index (THI) was 60.89 (4th fortnight) and when the temperature heat index (THI) was increased the milk production was decreased accordingly. The lowest milk production was observed when temperature humidity index (THI) was 77.13 (12th fortnight). The decrease in milk yield from 4th fortnight to 12th fortnight was 32.95, 33.85 and 33.40% in T_0, T_1 and T_2, respectively. No significant difference was observed in milk yield of buffaloes and in the percent reduction in milk yield from peak yield during the experiment between treatments. Similar to present findings, Seerapu *et al*. (2015) [14] found that average milk yield (kg/day) was significantly ($p<0.001$) higher in the group in which the foggers and fan were used. This might be due to lowering of thermal stress in buffaloes housed in foggers, fans and foggers plus fans fitted houses, resulting in increased feed and water intake and increased milk yield. The effects of cooling on increasing milk yield might be due to change in body temperature and diurnal rhythm (Singh *et al*., 2003) [16] or by restoring feed intake is corroborating to our study. The lowest milk production of the experimental buffaloes was reached at last week of April during the experiment. This was due to increased THI of the experimental period which was responsible for reduced feed intake, which could directly affected the milk production in the experimental buffaloes. This is added that, reduction in milk yield may also be due to declining phase of lactation. Barash *et al*. (2001) [4] found a reduction in milk yield of dairy cows subjected to high THI and suggested that part of energy cost for milk yield is diverted towards maintaining body temperature.

Zimbelman *et al*. (2009) [22] stated that milk production of the cows in environmental chambers started to decline when temperature heat index (THI) was 65 or higher. In another study, Ravagnolo *et al*. (2000) [12] reported that decreased milk yield was observed when average temperature heat index (THI) was 70 or above.

Table 3: Milk production of experimental buffaloes

Periods	T_0	T_1	T_2
1st fortnight	$7.93^{BCD} \pm 0.86$	$7.91^{BCDE} \pm 0.49$	$7.84^{BCD} \pm 0.74$
2nd fortnight	$8.40^{ABC} \pm 0.37$	$8.33^{ABCD} \pm 0.40$	$8.44^{ABC} \pm 0.65$
3rd fortnight	$8.52^{AB} \pm 0.38$	$8.59^{ABC} \pm 0.79$	$8.59^{ABC} \pm 0.92$
4th fortnight	$9.59^{A} \pm 0.47$	$9.63^{A} \pm 0.65$	$9.58^{A} \pm 0.29$
5th fortnight	$8.85^{AB} \pm 0.76$	$8.79^{AB} \pm 1.06$	$8.75^{AB} \pm 0.41$
6th fortnight	$8.58^{AB} \pm 0.49$	$8.60^{ABC} \pm 0.28$	$8.65^{AB} \pm 1.08$
7th fortnight	$8.31^{ABC} \pm 0.66$	$7.39^{BCDE} \pm 0.80$	$7.29^{BCD} \pm 1.27$
8th fortnight	$7.94^{BCD} \pm 1.12$	$8.02^{BCD} \pm 0.70$	$8.09^{ABC} \pm 0.79$
9th fortnight	$7.67^{BCD} \pm 0.86$	$7.59^{BCDE} \pm 1.06$	$7.79^{BCD} \pm 0.71$
10th fortnight	$7.21^{BCD} \pm 0.91$	$7.15^{CDE} \pm 0.92$	$7.19^{BCD} \pm 0.75$
11th fortnight	$6.83^{CD} \pm 1.17$	$6.92^{DE} \pm 1.16$	$6.88^{CD} \pm 1.33$
12th fortnight	$6.43^{D} \pm 1.15$	$6.37^{E} \pm 0.95$	$6.38^{D} \pm 1.02$

Means bearing different superscripts A, B, C, D, E (column) differ significantly ($p<0.05$)

Conclusion

Different meteorological variables such as high ambient temperature, relative humidity, wind velocity, day length and temperature humidity index (THI) etc. greatly affect the animal's production performance. On the basis of present study, it may be concluded that the rise in atmospheric temperature and humidity ultimately increases the temperature humidity index (THI) which affect the feed intake, heat dissipation and other physiological processes, thereby creating conditions of stress on milk yield. To avoid the stress due to high temperature humidity index (THI) in lactating buffaloes the foggers and fan may be used in animal shed or house. However, further research is needed in this subject.

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