Effect of feeding betaine hydrochloride and bypass fat supplement on feed intake, milk yield and physiological parameters in lactating buffaloes during heat stress

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Abstract: Present study examined the effect of feeding betaine hydrochloride (BH) and bypass fat (BF) in 24 early lactating buffaloes during May to July, 2018 in Nadiad district of Gujarat state. Buffaloes (30-35 days in milk) yielding 10-12 kg milk/d were divided into three groups of eight each based on milk yield, fat% and stage of lactation. Buffaloes in T1 group (control) were fed basal ration. In addition to basal ration, buffaloes in T2 group were fed daily 30 g BH + 100 g buffer; while buffaloes in T3 group were fed daily 30 g BH + 100 g buffer + 100 g BF for 60 days. Average thermal humidity index was 80.10 at 14:00 hr during the trial period. Study revealed that DMI improved (P=0.011) in T3 group as compared to control. Non-significant difference in milk yield was observed among the groups; however, reduction in milk yield was lower in T2 & T3 groups, as compared to control. Milk fat improved by 3.2% and 6.2% (P=0.002) in T2 and T3 groups, respectively. Rectal temperature (102.8, 102.7 vs 103.6 °F), respiration rate (46.0, 45.1 vs 60.1 breath/min.) and pulse rate (61.2, 58.5 vs 72.9 pulse/min.) at 14:00 hr were significantly (P<0.01) lower in buffaloes under T2 and T3 group as compared to T1 group. Average net daily income was increased by Rs. 36.02 and 47.43 in T2 and T3 group, respectively as compared to control.

Keywords: Betaine, Buffalo, Bypass fat, Heat stress, Milk yield

Introduction

Due to ongoing climate change, the climate of India has become increasingly volatile over the past several decades. There is accumulating empirical evidence that the changing environmental conditions are already adversely impacting the livestock productivity. Higher temperatures along with altered precipitation are likely to result in the problem of heat stress in dairy animals leading to decreased production. West et al. (2013) and Babinszky et al. (2011) reported lower feed intake by 5-20% and reduction in milk yield by 10-40% in dairy cows due to heat stress. Loss of productivity in dairy animals in India during heat stress is a well-known menace.

India possesses the world’s largest livestock population having 57% of the world’s buffalo (Bubalus bubalis) population. India is the largest milk producing country in the world and buffalo is the main milk producing animal contributing >50% of the total milk production in India. Buffaloes are more vulnerable to heat stress at high ambient temperature due to less number of sweat glands and black coat colour leading to loss in their productive efficiency (Upadhyay et al. 2008). Exposure of buffaloes to the hot conditions causes a series of changes in the biological functions that include decrease in feed intake, efficiency and utilization, disturbances in metabolism of water, protein, energy and mineral balances, resulting in impairment of productive and reproductive efficiencies (Das et al. 2014).

Productivity loss during heat stress period can be minimized by providing strategic feed supplement. The provision of nutritional supplements to ameliorate the effects of heat stress in dairy animals is an attractive method and is potentially the fastest and easiest option for milk producers. One such supplement that has been recently studied is the organic amino acid derivative; dietary betaine (DiGiacomo et al. 2014). Physiologically, mammals utilise betaine as a methyl donor able to participate in protein and lipid metabolism, or when not catabolised, betaine can be used as an organic cellular osmoprotectant (Fernández et al. 1998; Huang et al. 2007). In addition, use of bypass fat supplement in early lactating animals increases the energy density of the diet enabling the animals to meet their energy and essential fatty acid requirements expressing their milk production potential (Sirohi...
et al. 2010). Keeping this in mind, present work has been undertaken to evaluate the effect of supplementing betaine hydrochloride and bypass fat on feed intake, milk yield and physiological parameters of lactating buffaloes during summer season.

Materials and methods

Location, animals and dietary treatments

Present study was undertaken during summer months (18th May to 28th July 2018) at an organized dairy farm of Dumral village in Nadiad district of Gujarat. Twenty-four early lactating (30-35 days in milk) buffaloes were divided into three groups of eight each, based on milk yield (10-12 kg/d), fat (6.8-6.9%) and stage of lactation (2-4 lactations). Buffaloes in control group (T1) were fed basal diet comprising of 6-7 kg concentrate, 20 kg green fodder and 4.0 kg dry fodder (NRC, 2001). In addition to basal diet, animals in T2 group were supplemented daily 30 g BH and 100 g buffer; and buffaloes in T3 group were supplemented daily 30 g BH, 100 g buffer and 100 g BF for 60 days. Buffer contained 49 g sodium bicarbonate, 21 g magnesium oxide and 30 g potassium chloride. Bypass fat was procured from M/s. Berg Schmidt Indian Pvt ltd, Pune.

Temperature and humidity

Ambient temperature and relative humidity were recorded twice daily at 09:00 and 14:00 hrs in buffalo shed during the trial period. Daily maximum and minimum ambient temperatures were recorded and calculated thermal humidity index (THI) as per the equation

\[ \text{THI} = 0.72 \left( T_{db} + T_{wb} \right) + 40.6; \]

where \( T_{db} \) is the temperature of the dry bulb and \( T_{wb} \) is the temperature of the wet bulb (NRC 1971).

Feed, fodder and milk analyses

The chemical composition of feeds and fodder offered to buffaloes during the trial period was carried out as per AOAC (2005). All buffaloes were hand milked twice daily (06:00 and 18:00 hrs) and individual milk yield was recorded. The milk samples were collected at weekly intervals from individual buffaloes during both milking time. After proper mixing, pooled milk samples (100-150 ml) from each buffalo were collected and analysed for fat, SNF, protein and lactose contents by an automatic milk analyzer. Average feeding cost and realization receipt from the sale of milk was calculated based on the current market prices.

Physiological parameters

Rectal temperature, respiration rate and pulse rate were recorded twice daily at 09:00 and 14:00 hrs for 2 consecutive days in every week. The rectal temperature (°F) was recorded using a digital thermometer by inserting 3 inches in the rectum for about 2 min. The respiration rate per minute was recorded by counting the movement of flank, i.e. one outward and inward movement considered as one respiration. The pulse rate per minute was counted by palpating coccygeal artery.

Statistical analysis

Data were analysed using one-way ANOVA with SPSS package programme (SPSS 9.00 software for Windows, SPSS Inc., Chicago, IL) as per Snedecor and Cochran (1994). When F-test was significant (P<0.05), Turkey’s test was utilized to compare significant difference (P<0.05) among the groups.

Results and discussion

Chemical composition

Analysis of feeds and fodder offered to buffaloes in all three groups is given in Table 1. Bypass fat (Bergafat) contained 99% total fat (min.). Fatty acid composition contained about 77.22% palmitic acid (C16:0), 1.21% myristic acid (C14:0), 5.14% stearic acid (C18:0), 12.49% olic acid (C18:1n9c), 2.56% linoleic acid (C18:2n6c) and 0.35 arachidic acid (C20:5).

Weather conditions

The weather conditions during the experimental period (18th May to 28th July, 2018) were typically hot. The average ambient air temperature at 9.00 and 14.00 hrs during the experimental period was 32.03 ± 0.40 °C and 36.13 ± 0.96 °C, respectively. Whereas, average humidity at 9.00 and 14.00 hrs was 70.90 ± 1.40% and 60.71 ± 2.44%, respectively. The average calculated THI was 70.22 ± 0.65 and 80.10 ± 1.07 units at 9.00 and 14.00 hrs, respectively during the trial period. The maximum THI was recorded at initial period (0 week) of experiment (85.24).

Dry matter intake

It is well known that dairy animal reduces its feed intake during the heat stress as a thermoregulation effort to prevent an excessive increase in body temperature via decreasing its heat production. West et al. (2013) reported that feed intake reduced by 5-20% in dairy cows due to heat stress.

In our study, initial dry matter intake (DMI) in all three groups were similar (14.05, 14.19 and 14.16; P=0.231). However, during the trial period, DMI reduced by 1.86, 1.71 and 1.42 kg in T1, T2 and T3 groups, respectively (Table 2). Despite reduction in all three groups, DMI in T3 group was significantly higher (P=0.011) by 4.51% as compared to control group, which indicates that the heat stress has less effect on DMI in T3 group as compared to control (Figure. 1). Non-significant improvement in DMI was observed in T2 group as compared to T3 group. Marai and Habeeb (2010) reported that the reduction in DMI is the most important effect of heat stress in tropical and sub-tropical conditions. Increased heat load decreases nutrient uptake in almost all species and in case of cattle, the nutrient uptake decreases upto
about 30% of dry matter intake (Rhoads et al. 2013; Wheelock et al. 2010). A decrease in the dry matter intake in dairy cattle was found on exposure to heat stress (Rhoads et al. 2009). High environmental temperature reported to reduce feed intake in Friesian heifers (Smith et al. 2013).

Milk yield

As the lactation progress, milk production decline in all animals, but reduction in milk yield was less in treatment groups as compared to control group; may be due to supplementation of BH and BF in buffaloes. Milk yield was higher (P=0.334) by 5.69 and 6.73% in T2 and T3 group, respectively as compared to T1 group. The average milk fat in T1, T2 and T3 was 6.93, 7.15 and 7.36%, respectively, which showed that the BH and BF supplementation in concentrate mixture of lactating buffaloes (T2 and T3) increased (P=0.002) fat content of milk as compared to control group (T1).

Marai et al. (2009) recorded lower milk yield in buffaloes during summer than spring and winter seasons and decline in milk yield as a direct result of high environmental temperature. Wang et al. (2010) reported that by adding 100 or 150 g of anhydrous betaine significantly improved milk yield and fat during the early lactation of Holstein dairy cows. Zhang et al. (2014) studied that the addition of up to 15 and 20 g/day betaine caused milk yield to increase by 29.16 and 28.87 vs. 27.70 kg/d (control), respectively. Bouraoui et al. (2002) found that daily THI is negatively correlated with milk yield and observed that increasing THI value from 68 to 78 decrease milk production by 21% and DMI by 9.6%. Aggarwal and Singh, (2006) also reported that milk yield decreases by 0.41 kg/cow/d for each point increase in the THI values above 69.0. In our study also, we observed weekly inter-relationship between THI and daily milk yield of buffaloes during the whole trial period (Figure 2).

Economics

Daily feeding cost of ration was Rs. 209.59, 223.30 and 234.71 in T1, T2 and T3 groups, respectively which was significantly higher (P=0.001) in T2 and T3 groups as compared to T1 group. Higher feeding cost in experimental group was mainly due to the higher DMI and addition of supplemental cost. However, daily realizable receipt (Rs./head) from the sale of milk was higher by 9.12 and 13.30% (P=0.037) in T2 and T3 groups, respectively as compared to T1 group. Cost benefit ratio (net income per unit feeding cost) was found to be higher in T2 (1.67) and T3 (1.63) groups, as compared to T1 (1.60) group. Thus, net daily income of farmer increased by Rs. 36.02 and 47.43 per animal after supplementation
Physiological parameters

The rectal temperature and respiration rate is recognized as an important measure of physiological status as well as ideal indicator for assessment of stress in dairy animals. Rectal temperature is generally considered to be a useful measure of body temperature and changes in rectal temperature indicates changes of a similar magnitude in deep body temperature (Ganaie et al. 2013). In our study, supplementation of BH, buffer and BF helped to reduce heat stress in buffaloes. Average rectal temperature (103.6, 102.8, 102.7 °F; P=0.01), respiration rate (60.1, 46.0, 45.1 per min; P=0.01) and pulse rate (72.9, 61.2, 58.5 per min; P=0.01) were significantly lower at 14:00 hr in T₂ and T₃ groups as compared to control group (Table 3). Physiological parameters indicate that the buffaloes in control group were more prone to heat stress as compared to supplemental groups. Gaughan et al. (2005) suggested that the addition of exogenous osmolytes significantly reduce the rectal temperature, and increases the feed intake and heat endurance of buffaloes during heat stress. The results of our study showed that the rectal temperature significantly declined with BH and BH with BF supplemented groups. This trend might be related to the function of BH, which helps animals to alleviate heat stress.

Table 2 Effect of feeding betaine and bypass fat on feed intake, milk yield and economics

| Parameters                              | T₁     | T₂     | T₃     | SEM   | P value |
|-----------------------------------------|--------|--------|--------|-------|---------|
| Feed intake                             |        |        |        |       |         |
| Initial DMI (kg/d)                      | 14.05  | 14.19  | 14.16  | 0.09  | 0.231   |
| DMI (kg/d) after 60 days of trial       | 12.19ᵇ | 12.48ᵇ | 12.74ᵇ | 0.09  | 0.011   |
| Milk yield and composition              |        |        |        |       |         |
| Initial milk yield (kg/d)               | 12.85  | 12.78  | 12.81  | 0.22  | 0.326   |
| Milk yield (kg/d) after 60 days         | 11.59  | 12.25  | 12.37  | 0.23  | 0.334   |
| Fat (%)                                 | 6.93ᵇ  | 7.15ᵇ  | 7.36ᵇ  | 0.06  | 0.002   |
| SNF (%)                                 | 9.15ᵇ  | 9.36ᵇ  | 9.34ᵇ  | 0.04  | 0.038   |
| Protein (%)                             | 3.40   | 3.42   | 3.45   | 0.01  | 0.222   |
| Lactose (%)                             | 5.24   | 5.29   | 5.30   | 0.02  | 0.439   |
| Economics                               |        |        |        |       |         |
| Daily feeding cost (Rs./head)           | 209.59ᵇ| 223.30ᵇ| 234.71ᵇ| 2.50  | 0.001   |
| Realizable receipt from sale of milk (Rs./head/d) | 545.39ᵇ| 595.13ᵇ| 617.95ᵇ| 11.77 | 0.037   |
| Average gross income (Rs/head/d)        | 335.81 | 371.83 | 383.24 | 10.93 | 0.242   |
| Cost benefit ratio                      | 1:1.60 | 1:1.67 | 1:1.63 |       |         |

abcMeans bearing different superscripts in a row differ significantly (P<0.05)
of BH alone and along with BF in T₂ and T₃ group over T₁ group, respectively.

Fig. 2 Inter-relationship between THI and milk yield
Table 3 Physiological parameters of buffaloes

| Attribute                | Time (hrs) | T1         | T2         | T3         | SEM  | P value |
|--------------------------|------------|------------|------------|------------|------|---------|
| Rectal temperature °F    | 9.00       | 101.5      | 101.3      | 101.6      | 0.08 | 0.398   |
| Rectal temperature °C    | 9.00       | 28.5       | 28.2       | 28.1       | 0.01 | 0.007   |
| Respiration rate (breath/min.) | 14.00 | 60.1a      | 46.0a      | 45.1a      | 1.60 | 0.01    |
| Pulse rate (Pulse/min.)  | 9.00       | 56.7       | 55.0       | 55.0       | 0.63 | 0.346   |

abcMeans bearing different superscripts in a row differ significantly (P<0.05)

Conclusions

Study indicates that supplementation of betaine hydrochloride, buffer and bypass fat in the ration of buffaloes improved dry matter intake, milk production as well as its component and also helped in maintaining crucial physiological parameters of buffaloes during hot condition. This supplementation during summer season increases the net daily income of farmer by 14% in comparison to control.

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References

Aggarwal A, Singh M (2006) Effect of water cooling on physiological responses, milk production and composition of Murrah buffaloes during hot-humid season. Indian J Dairy Sci 59 (4): 386-389
AOAC (2005) Official Methods of Analysis of the Association of Official Analytical Chemists. 18th edn. (AOAC International: Gaithersburg, Maryland, USA)
Babinszky L, Halas V, Verstegen MWA (2011) Impacts of climate change on animal production and quality of animal food products. In: Climate Change - Socioeconomic Effects. Kheradmand, H. (Ed.), In Tech (Europe). ISBN: 978-953-307-411-5
Bouraoui R, Lahmar M, Majdoub A, Djemali M, Belyea R (2002) The relationship of temperature-humidity index with milk production of dairy cows in a Mediterranean climate. Animal Research (51): 479-491
Das KS, Singh JK, Singh G, Upadhyay RC, Malik R, Oberoi PS (2014) Heat stress alleviation in lactating buffaloes: Effect on physiological response, metabolic hormone, milk production and composition. Indian J Anim Sci (84): 275-280
DiGiacomo K, Warner RD, Leury BJ, Gaughan CJB, Dunshea FR (2014) Dietary betaine supplementation has energy-sparing effects in feedlot cattle during summer, particularly in those without access to shade. Anim Prod Sci (54): 450-458
Fernández C, Gallego L, Lopez-Bote CJ (1998) Effect of betaine on fat content in growing lambs. Anim Feed Sci Tech (73): 329-338
Ganaie AH, Shanker G, Bumla NA, Ghasura RS, Mir NA (2013) Biochemical and physiological changes during thermal stress in bovines. J Vet Sci Technol (4): 126-131

Gaughan J, Cadogan D, Cawdell-Smith A, Roft I (2005) Improved heat tolerance of cattle by dietary supplementation with osmolytes. Asia Pac J Clin Nutr (14): 123
Huang QC, Xu ZR, Han XY, Li WF (2007) Effect of betaine on growth hormone pulsatile secretion and serum metabolites in finishing pigs. J Anim Physiol Anim Nutr (91): 85-90
Marai IFF, Haeed AAM (2010) Buffalo’s biological functions as affected by heat stress- A review. Livest Sci (127): 89-109
Marai IFF, Daader AH, Soliman AM, El Menshawy SMS (2009) Non-genetic factors affecting growth and reproduction traits of buffaloes under dry management housing (in sub-tropical environment) in Egypt. Livestock Research for Rural Development (21): 3
NRC (1971) A guide to environmental research on animals. National Academy of Sciences, Washington, DC
NRC (2001) Nutrient requirements of dairy cattle. 7th edn. National Academy Press, Washington DC
Rhoads ML, Rhoads RP, VanBaale MJ, Collier RJ, Sanders SJ, Weber WJ, Crooker BA, Baumgard LH (2009) Effects of heat stress and plane of nutrition on lactating Holstein cows: I. Production, metabolism, and aspects of circulating somatotropin. J Dairy Sci (9):986-997
Rhoads RP, Baumgard LH, Suagee JK, Sanders, SR (2013) Nutritional interventions to alleviate the negative consequences of heat stress. Adv Nutr (4): 267-276
Sirohi SK, Walli TK, Mohanta RK (2010) Supplementation effect of bypass fat on production performance of lactating crossbred cows. Indian J Anim Sci (80): 733-736
Smith DL, Smith T, Rude BJ, Ward SH (2013) Comparison of the effects of heat stress on milk and component yields and somatic cell score in Holstein and Jersey cows. J Dairy Sci (96): 3028-3033
Snedecor GW, Cochran WG (1994) Statistical Methods. 8th ed., Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.
Upadhyay RC, Singh SV, Ashutosh (2008) Impact of climate change on livestock. Indian Dairyman (60): 98-102
Wang C, Liu Q, Yang WZ, Wu J (2010) Effects of betaine supplementation on rumen fermentation, lactation performance, feed digestibilities and plasma characteristics in dairy cows. J Agr Sci (148): 487-495
West JW, Mullinix BG, Bernard JK (2013) Effects of hot, humid weather on milk temperature, dry matter intake, and milk yield of lactating dairy cows. J Dairy Sci (86): 232-242
Wheelock JB, Rhoads RP, Van Baale MJ, Sanders SR, Baumgard LH (2010) Effects of heat stress on energetic metabolism in lactating Holstein cows. J Dairy Sci (93): 644-655
Zhang L, Ying SJ, An WJ, Lian H, Zhou GB, Han ZY (2014) Effects of dietary betaine supplementation subjected to heat stress on milk performances and physiology indices in dairy cow. Genet Mol Res (13): 7577-7586