Original Article

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RESPONSE OF DIET SUPPLEMENTED WITH MUSTARD OIL ON PRODUCTION PERFORMANCE IN LACTATING MURRAH BUFFALOES

Aayush Yadav[1,*], Gandhi Prasad Lakhani[2], Biswajit Roy[2], Sudipta Ghosh[2], Aklank Jain[2], Ramesh Pratap Singh Baghel[3] and Bhavna Aharwal[2]

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ABSTRACT

The study determined the response of diet supplemented with mustard oil on production performance in lactating Murrah buffaloes at Livestock Farm, College of Veterinary Science and Animal Husbandry, NDVSU, Jabalpur, M.P., India. A total of 12 advance pregnant Murrah buffaloes were selected 21 days pre-partum and randomly allocated in 2 groups of 6 each: CON as control with basal diet + no oil and MO as treatment with basal diet + mustard oil supplementation 200 ml/animal/day. The trial was continued for 90 days post-partum. Significant positive response (%) in the daily milk yield, milk fat percent and 6% fat corrected milk yield by 8.10, 9.14 and 14.47, respectively was observed in MO in comparison to CON. Besides, there were insignificant findings for DMI, milk solid not fat, protein and lactose per cent, peak milk yield, persistency of lactation and predicted lactation yield (PLY) between the groups. The study affirms that supplementation of mustard oil improves the production potential of lactating Murrah buffaloes and could be recommended to dairy farmers during transition period and early lactation to earn profits.

Keywords: *Bubalus bubalis*, buffaloes, mustard oil, supplementation, Murrah, milk yield, fat corrected milk yield

INTRODUCTION

India inhabits 109.85 million buffaloes where buffaloes-in-milk contributes 49% of the total milk produced in the country. But as animal approaches parturition and early lactation, there is considerable decrease in dry matter intake and the dry matter intake becomes so insufficient that it fails to meet the energy requirements for maintenance and milk production, and the lactating animal's falls in negative energy balance (NEB) resulting in body weight loss and impaired production potential. The NEB and associated negative effects can be corrected by supplementation of fat source in the diets. In addition, there is an increasing public interest in manipulating the fatty acid profile of milk

[1]Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, Chhattisgarh Kamdhenu Vishvavidyalaya, Anjora, India, *E-mail: aayush.aayush091@gmail.com
[2]Department of Livestock Production and Management, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Jabalpur, India
[3]Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Jabalpur, India

fat more towards healthier unsaturated fatty acids. In this context, many sources of supplemental fat such as, palm oil (Kirovski *et al*., 2015), mustard oil (Kathirvelan and Tyagi, 2009), soybean oil (AlZahal *et al*., 2008) and linseed oil (Sultana *et al*., 2008), rich in unsaturated fatty acids have been fed to dairy animals and their effects on milk composition and milk yield have been investigated. Fat in the ration of early lactating dairy animals has often increased milk production due to increase in the energy density of ration, energy intake and improved efficiency of energy utilization (Guevara *et al*., 1992). The unsaturated fatty acids in the ration is found to reduce the proportions of saturated fatty acids in milk such as, myristic and palmitic acids, associated with cardiovascular ailments (Marin *et al*., 2011). Among vegetable oils, mustard oil is one of the traditionally used cheap sources of fat supplement that contains 60% MUFA and 21% PUFA (Wikipedia, 2020). But the exact information on the production performance of Murrah buffaloes supplemented with mustard oil is still not known. Therefore, an attempt was made to investigate the response of diet supplemented with mustard oil on production performance in lactating Murrah buffaloes.

MATERIALS AND METHODS

The planned study was conducted at Livestock Farm, Adhartal, College of Veterinary Science and Animal Husbandry, NDVSU, Jabalpur, MP, India. A total of twelve lactating Murrah buffaloes maintained in semi-intensive system of housing were selected based on similarity in age, body weight, parity and previous lactation yield and divided in two groups randomly and equally. Group 1 (CON) was control and animals were fed basal diet whereas, in Group 2 (MO; treatment) animals were fed basal diet supplemented with mustard oil 200 ml/animal/day. The study was conducted from 21 days pre-partum to 90 days post-partum. The experimental animals were stall fed as per body weight and production (ICAR, 2013). The basal diet of animals was kept similar for both the group’s i.e. a fixed quantity of chaffed green fodder and wheat straw was offered to the animals and concentrate consisting of 18% CP and 70% TDN was given at a scale of 1 kg per 2 kg milk production along with maintenance ration, except that in Group 2, mustard oil was mixed twice daily in concentrate in two equal divided dose. Half of the total required quantity of feed was offered daily at morning (5:30 am) and rest amount offered in the afternoon (3:00 pm). Water was made available to animals round the clock. The parameters studied were:

Dry matter intake

Dry matter intake was calculated post-partum at fortnight intervals. Weighed quantities of concentrate, straw and green fodder were offered to animals and the leftover was collected next day in the morning and weighed. The leftover was subtracted from the initial feed supplied to know the feed intake of animal. The representative samples of concentrate mixture and roughage were taken in moisture cups and kept in the hot air oven at 100±2^{o}C for 24 h to obtain dry matter per cent. Later, per cent dry matter was multiplied with feed intake of animal to obtain dry matter intake of animal. The formula to calculate dry matter per cent is:

$$\text{Dry matter (\%)} = \frac{\text{Dry weight of sample (g)}}{\text{Fresh weight of sample (g)}} \times 100$$

Milk yield

The milk yield was recorded at fortnight intervals. Each animal was hand milked twice a day at 6:00 am and 4:00 pm to record the milk yield.

Milk composition

The milk components including fat, SNF, lactose and protein were recorded at fortnightly intervals. The representative milk samples of individual animals were collected from the milking bucket after complete milking of the individual animal. The milk samples were thereafter analysed by Lacto Plus (Ultrasonic auto milk analyser, Netco Pvt. Ltd.)

Fat corrected milk yield

The FCM yield was calculated at fortnight intervals. For the conversion of whole milk into 6% FCM yield, the equation derived by Rice (1970) was used.

$$6\%\ \text{FCM yield (kg)} = \frac{(0.4 \times \text{MY (kg)} + 15 \times \text{Fat (kg)})}{1.3}$$

Peak milk yield

Peak milk yield was calculated from the milk yield records of the experimental animals.

Predicted lactation yield

Predicted Lactation yield (305 days) was calculated by using ratio estimates of partial lactation of Murrah buffaloes (Thomas and Sastry, 2012). The lactation yield up to 12 weeks was multiplied by the corresponding ratio estimates of 2.8096 to obtain the predicted lactation yield.

Persistency of lactation

Persistency of lactation is defined as the milk yield at one test expressed as a percentage of milk yields at an earlier test, adjusted to 30 days interval between tests. Therefore, if two tests are exactly 30 days apart, persistency can be simply calculated as follows:

$$\text{Persistency of lactation (\%)} = \frac{\text{Milk (kg) at later test} \times 100}{\text{Milk (kg) at earlier test}}$$

Statistical analysis

Data were analysed using ANOVA (Snedecor and Cochran, 1994) and variances showing significant differences in ANOVA table were compared using Duncan’s Multiple Range Test (Steel and Toorie, 1980).

RESULTS AND DISCUSSIONS

Dry matter intake (DMI)

The fortnight average daily DMI of lactating Murrah buffaloes is presented in Table 1. A continuous increase in the DMI was observed in both the groups however, the overall average daily DMI (Kg/animal; CON: 19.60±0.44; MO: 19.41±0.48) varied insignificantly between the groups. In comparison to CON, MO exhibited 0.96 per cent decrease in DMI of animals. It is widely known that the animals in negative energy balance consume more DMI because of craving for more nutrients to support higher milk production. This was not seen in the present study as animals were not high yielders and the required energy for supporting milk production was met through the diet. This resulted in insignificant changes in DMI in present study. This may also be attributed to the short feeding period as seen in Holstein cows supplemented with rapeseed oil and soybean oil (Altenhofer *et al*., 2014) and small amount of oil supplementation as seen in Holstein dairy cows supplemented with flaxseed oil, soybean oil and oil from extruded soybeans 2% (Ye *et al*., 2009). In contrast, reports by Doreau and Chiliard (1997) showed a reduction in DMI of Holstein dairy cows supplemented with fish oil 300 ml/day for 12 weeks. This was due to the modifications caused by PUFA in the rumen environment and changes in the microbial population that resulted in decreased fibre digestibility and reduction in DMI. On the contrary, reports by Suharti *et al*. (2017) showed significant increase in the feed intake of Bali cattle supplemented with calcium soap-soybean oil 5%, indicating that Ca-soap soybean oil did not alter the palatability of ration.

Daily milk yield

The fortnight average daily milk yield of lactating Murrah buffaloes is presented in Table 1. The milk yields increased up to 4th fortnight and thereafter decreased gradually. The overall average daily milk yield varied significantly between the groups and was highest in MO (8.54±0.06) than CON (7.90±0.06) by 8.10%. The significant positive response in milk yield might be due to sufficient energy intake i.e. more availability of energy per unit DMI resulting in increased efficiency of energy utilization for milk production in comparison to CON (Ranjan et al., 2012; Guevara *et al*., 1992). Later, Khalil et al. (2012) mentioned improved feed conversion ratio of milk production in Holstein cows supplemented with 5% calcium salts of fatty acids. It has also been suggested that the maximum milk production response to fat supplementation is not achieved until cows are in positive energy balance (Skaar *et al*., 1989). It resembles the present study where buffaloes were not high yielders and under negative energy balance. Significant increase in milk yield of Murrah buffaloes supplemented with mustard oil 2% was also reported by Kathirvelan and Tyagi (2009) and credited to the higher energy density of ration. Increase in the milk yield of MO by 8.10% in present study in comparison to 7.27% in Holstein cows supplemented with monensin and soybean oil 1.7 to 3.4% (AlZahal *et al*., 2008) and 7.30% in Holstein cows supplemented with protected fat 10 g/lit milk (Gowda *et al*., 2013) indicates usefulness of pre- and post-partum feeding in eliciting higher milk production response than feeding alone in early lactation or post-partum. On the contrary, Veira *et al*. (2001) reported decline in milk production of mid-lactating Holstein cows supplemented with 3% soybean oil which is in support with the present findings of reduction in milk yield from 5th fortnight onwards. This may have been due to the depression in diet digestibility due to impaired rumen function caused by higher levels of oil intake (i.e. >5% of DMI). In contrast, Hervas *et al*. (2008) failed to observe effects on milk production of mid-lactating Spanish Assaf ewes supplemented with 6% sunflower oil for 4 weeks due to no negative effects of the sunflower diet on rumen process. Meanwhile, less milk yield in CON in present study is attributed to the non-availability of fat supplements in the ration.

Milk composition

The fortnight average milk fat percent of lactating Murrah buffaloes is presented in Table 1. A continuous increase in the milk fat per cent was observed in both the groups. The overall average milk fat percent varied significantly between the groups and was highest in MO (7.52±0.01) than CON (6.89±0.01) by 9.14%. The fat in milk is the variable component unlike SNF, protein and lactose. The significant positive response on milk fat percent corroborates with the results of Madan *et al*. (2013) in Murrah buffaloes supplemented with protected fat 200 g/animal/day and, Mele *et al*. (2008) in Saanen goats supplemented with soybean oil 100 g/day. This may have been due to the increase in plasma concentration of very low-density lipoprotein triglyceride on supplementation of fat source in diet, increasing their uptake by the mammary gland with inhibition of short chain fatty acid synthesis and consequent changes in milk fatty acid composition, leading to increase in the milk fat (Palmquist and Jenkins, 1980). On the contrary, Renno *et al*. (2014) observed milk fat depression (MFD) in Holstein cows supplemented with soybean oil and calcium salts of unsaturated fatty acids 30 g/kg on dry matter basis and stated that, diets containing additional fatty acid sources suffer from incomplete rumen biohydrogenation that reduces Δ9-desaturase enzyme activity responsible for synthesis of fatty acids. A similar report on MFD was presented by Schroeder *et al*. (2004) where reduction in rumen fibre digestibility as a negative effect of fat supplementation resulted in reduction in the proportions of acetate to butyrate ratio, the main precursors of milk fat production. In contrast, Ranjan *et al*. (2012) failed to observe effects on milk fat per cent in lactating Murrah buffaloes supplemented with bypass fat 100 to 200 g/day on dry matter intake basis.

The fortnight average SNF, protein and lactose per cent in the milk of lactating Murrah buffaloes is presented in Table 1 The overall average SNF (CON: 9.84±0.09; MO: 9.61±0.12), protein (CON: 3.82±0.03; MO: 3.76±0.04) and lactose (CON: 5.18±0.05; MO: 5.06±0.07) percent in the milk were similar in both the groups. The insignificant findings in present study are strengthened by declarations of Kirovski et al. (2015) in Holstein cows supplemented with palm oil 300 g/cow/day and Sulatana *et al*. (2008) in Holstein dairy cows supplemented with calcium salts of soybean oil and linseed oil fatty acids 1% on dry matter basis and attributed to the lower dose of oil supplementation in the diet. No variations in findings may also be justified by the widely known fact that the milk SNF, protein and lactose are the non-variable components in milk. Various researchers also observed reduction in milk protein per cent on addition of fat sources in diet. Jenkins (1993); DePeters and Cantt (1992) related this to the side-effect of oil supplementation on the microbial fermentation and subsequent decline in availability of microbial protein reaching the small intestine. This declines the uptake of microbial protein and other amino acids from intestine by mammary gland and thus fails to synchronize with the higher milk volume synthesis, causing dilution of milk protein.

6% Fat corrected milk yield (FCMY)

The fortnight average daily 6% FCMY of lactating Murrah buffaloes is presented in Table 1. The 6% FCMY increased up to 4th fortnight and thereafter decreased gradually. The overall average values (Kg/animal/day) varied significantly between the groups and were highest in MO (10.84±0.08) than CON (9.47±0.08) by 14.47%. The significant increment in 6% FCMY is credited to the simultaneous increase in average daily milk yield and milk fat yield in the oil supplemented group over Control group. The findings are consistent with the discoveries of Rohila *et al*. (2016) in early lactating Murrah buffaloes supplemented with bypass fat 100 to 150 g/day/animal, reporting 4.61 to 10.53% increase in 6% FCMY, and Gandra *et al*. (2014) in Simmental dairy cows supplemented with ricinoleic acid from castor oil 2 g/animal/day, suggesting increased productive efficiency of animals as a probable reason of increase in 3.5% FCMY, despite of no effects on DMI of animals. The increase in productive efficiency could be partially explained by an improvement in the efficiency of energy utilization, attributed to lower energy loss as heat and methane, a direct use of long chain fatty acids for milk fat secretion and, a higher efficiency of ATP production from long chain fatty acids than acetate (Gransworthy, 1997; Chilliard, 1993). Besides, no response on 4% FCMY was observed in crossbred lactating cows supplemented with rumen protected calcium salts of rapeseed oil 20 g/kg milk/day for 90 days (Subrahmanyeswar et al., 2019). It was also reported that fat corrected milk production was lower in mid-lactating cows than early lactating cows (Schroeder *et al*., 2004).

Peak milk yield

The peak milk yield (litres) was highest in MO (10.76±0.50) than CON (10.42±0.58) by 3.26%; however it was attained (days) earlier in CON (51.33±4.71) than MO (61.5±6.13) by 10.17 days. Both the groups varied insignificantly. The insignificant findings are in contrast with the findings of Teh *et al*. (1994) who reported no significant response of rumen-inert fat supplementation 3 to 9% in Alpine does on the time of peak production. Besides, statistically higher peak yield in MO may have been achieved due to the increased energy density of ration and improved efficiency of utilization of energy, resulting in reducing the deleterious effects of negative energy balance and stress during early lactation and increasing the milk yield and milk fat content. The results confirm with the outcomes of Parihar *et al*. (2018) in Gir and Sahiwal supplemented with mustard oil and molasses 200 g/animal/day for 90 days, Ranjan et al. (2012) in lactating Murrah buffaloes supplemented with bypass fat 100 to 200 g/day on dry matter intake basis and Tyagi *et al*. (2010) in crossbred cows supplemented with bypass fat 2.5% on total dry matter intake basis. Contributing to this segment, Anitha *et al*. (2011) correlated peak yield with the BCS of Murrah buffaloes and recommended maintenance of BCS at calving at 2.50 to 3.99 with ideal score of 3.50 to 3.99, for better reproductive and productive performance of Murrah buffaloes. In the present study, average BCS of CON (2.92±0.20) and MO (2.83±0.25) at calving was above 2.5 and could be a reason for higher but insignificant peak yield in both the groups.

Persistency of lactation (POL)

The POL (%) was higher in CON (91.21±2.16) than MO (86.42±4.09) by 5.54%. Both the groups varied insignificantly. The insignificant outcome may be due to the short observation period of 90 days and if the observation was carried for a longer period, it could have provided a different picture of POL. Meanwhile, various studies have reported increase in POL. In this context, Shelke et al. (2012) monitored persistency of milk production for 120 days of lactation after cessation of rumen protected fat and protein supplementation to Murrah buffaloes and revealed that the persistency of milk production can be maintained until the end of lactation through supplementing fats in diets as it reduces the detrimental effect of post-calving stress and negative energy balance on animals. Similar outcomes were also reported by Tyagi et al. (2010); Sampelayo et al. (2004) on supplementation of protected fat where, protected fat not only increased the milk yield but the effects persisted even after the supplement was withdrawn in cows and goats.

Predicted lactation yield (305 days; PLY)

The PLY (305 days; lit/lactation/animal) based on 90 days lactation yield was statistically similar in both the groups but higher in MO (2159.98±59.68) than CON (1999.95±85.67) by 8%. The statistically higher PLY in MO is due to higher milk yield, as compared to CON. As previously discussed, higher milk yield could be either due

Table 1. Fortnight production performance (Mean ± SE) of lactating Murrah buffaloes.

Parameters	CON							MO						
	Fortnights							Fortnights						
	1	2	3	4	5	6	Avg	1	2	3	4	5	6	Avg
DMI (Kg/animal/day)	16.80±0.71	18.07±0.57	20.32±1.25	20.37±1.26	20.90±0.99	21.33±0.78	19.60±0.44	17.77±1.38	18.48±1.19	19.10±0.98	20.04±0.96	20.25±1.42	20.81±1.22	19.41±0.48
Milk yield (lit/animal/day)	6.23±0.17	8.10±0.10	8.51±0.11	8.81±0.13	8.20±0.13	7.60±0.12	7.90[a]±0.06	6.50±0.16	8.50±0.12	9.20±0.08	9.64±0.08	9.10±0.12	8.30±0.05	8.54[b]±0.06
Fat (%)	6.19±0.02	6.70±0.04	6.96±0.01	7.10±0.01	7.19±0.01	7.20±0.01	6.89[a]±0.01	7.30±0.01	7.45±0.01	7.50±0.01	7.55±0.04	7.62±0.05	7.70±0.02	7.52[b]±0.01
SNF (%)	10.21±0.13	9.65±0.30	9.81±0.19	10.09±0.19	9.73±0.17	9.55±0.21	9.84±0.09	9.57±0.26	9.66±0.13	9.68±0.28	9.31±0.42	9.77±0.26	9.67±0.28	9.61±0.12
Protein (%)	3.99±0.05	3.75±0.12	3.83±0.07	3.94±0.07	3.80±0.06	3.72±0.08	3.82±0.03	3.72±0.09	3.78±0.07	3.78±0.09	3.63±0.16	3.82±0.09	3.78±0.10	3.76±0.04
Lactose (%)	5.42±0.08	5.10±0.17	5.18±0.10	5.35±0.09	5.13±0.08	5.03±0.10	5.18±0.05	5.05±0.15	5.08±0.10	5.10±0.15	4.88±0.24	5.15±0.13	5.09±0.16	5.06±0.07
6% FCMY (kg/animal/day)	6.95±0.18	9.49±0.11	10.23±0.15	10.73±0.16	10.08±0.15	9.34±0.14	9.47[a]±0.08	8.07±0.20	10.70±0.16	11.64±0.10	12.24±0.10	11.64±0.16	10.69±0.07	10.84[b]±0.08

[a and b] Average values with different superscript differ significantly within rows ($P<0.05$). DMI: Dry matter intake; FCMY: Fat corrected milk yield.

to increased energy intake, improved efficiency of utilization of energy or lower stress during early lactation, as observed by Parihar *et al*. (2018) in Gir and Sahiwal cattle supplemented with mustard oil and molasses 200 g/animal/day. The PLY is correlated with the BCS of animals. It is said that the animals with low BCS i.e. 2 at calving fails to achieve their PLY and those with BCS 2.5 or above yielded more than their PLY (Moira et al., 1978). The animals in present study, at calving, were maintained above BCS 2.5 (CON: 2.92±0.20; MO: 2.83±0.25). This could be a reason for better PLY in both the groups, although varying insignificantly.

CONCLUSION

The inclusion of 200 gram/day of mustard oil in diets of lactating Murrah buffaloes improved the production performance (milk production, fat per cent and 6% fat corrected milk yield) and the energy balance, without posing any risk to health and welfare of animals. This may alleviate consequences of negative energy balance and become a promising supplement in ruminant nutrition.

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