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Effect of Diets with Varying Levels of Metabolizable Energy on Lactation Performance and Metabolic Profile of Buffaloes

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ABSTRACT

The present study was conducted to ascertain the effect of feeding varying level of metabolisable energy on the production performance and nutrient utilization of Murrah buffaloes. Sixteen advance pregnant Murrah buffaloes (40-50 d before parturition) were divided into three treatment groups on the basis of most probable production ability (MPPA), (2200±241) and lactation number (3.57±0.95). Duration of feeding trial was 130 days i.e. 40 days pre-partum to 90 days post-partum period. Treatment groups were fed 3 different diets as low metabolizable energy (LME), medium metabolizable energy (MME) and high metabolizable energy (HME), at 85%, 100% and 115% of ICAR, 2013 ME requirements respectively. Concentrate mixture, maize green and wheat straw were offered to individual animal as per experiment protocol. As per diet offered, ME intakes was higher in HME followed by MME and LME while metabolizable protein (MP) and crude protein (CP) intakes were similar in all experimental groups. Metabolic trial of 7 days duration was conducted at after 60 days of post-partum feeding and it was observed that apparent digestibility (%) of DM, organic matter (OM) and CP were statistically similar among groups. Neutral detergent fibre (NDF) digestibility was higher in HME group as compared to LME and MME. There was no significant change in blood biochemical profile i.e. NEFA, IGF-1, glucose, BUN, total protein, albumin, globulin, AST and IgG, on feeding different levels of metabolizable energy. The nitrogen balance was not affected by different levels of ME in the diet. HME group had significantly higher milk yield and FPCM (Kg/day). The outcome of the current study indicates that fat and protein corrected milk significantly improved at 115% higher ME with respect to ICAR, 2013 nutrient requirements.

Key words: Metabolizable energy; Metabolizable protein; Murrah buffalo; Nutrient Utilization; Metabolic Profile

INTRODUCTION

Buffaloes (*Bubalus bubalis*) occupy an important position among the domesticated livestock, with 105.3 million buffaloes, India contributes about 56.7% of the total world buffalo population. The Murrah is a popular buffalo breed in the tropics, having the highest potential to boost production from buffalo husbandry. To establish buffalo husbandry on a scientific basis for commercial purposes, there is a need to establish the nutrient requirements for buffalo to achieve full genetic potential.

The transition period for a Murrah buffaloes is critical period which is from 3 week pre-partum until 3 week postpartum (Esposito *et al.,* 2014). The term transition is to underscore the important physiological, metabolic, and nutritional changes occurring in this time frame. Imbalanced or deficient nutrition alone contributes more than 80% to the reproductive problems (Khan *et al.,* 2011). Among the all nutrients, energy, is one of the most critical nutrients which may affect production performance of buffaloes (Jabbar *et al.,* 2013). During transition period dairy animals require more energy than they are able to consume resulting in the NEBAL (energy expenditure is higher than intake then the energy balanced is negative) and the concomitant loss of body weight (Bell, 1995). Earlier studies (Grummer and Carroll, 1988; Gong *et al.,* 2002) reported that sufficient dietary energy is an important factor in lactating animals which may prevent metabolic disorders. There is need of refinement of nutrient requirement for buffaloes during transition period. There is paucity of data on effect of varying level of metabolisable energy intake on the productivity of buffaloes and impact of such variations on nutrient

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utilisation and metabolic status of animals. Keeping in view of above, the present study was planned to evaluate the effect of high and low energy intakes compared to ICAR, 2013 feeding recommendations on production performance, nutrient utilisation and blood biochemical profile of buffaloes on varying plane of metabolizable energy.

MATERIAL AND METHODS

The experimental protocols that were developed in this study fully complied with the ethical principles of animal experimentation prepared by Institutional animal ethic committee (IAEC)-NDRI.For the present experiment, sixteen advance pregnant Murrah buffaloes (40-50 d before parturition) were selected from the herd of Livestock Research Centre of Institute. The buffaloes were randomly divided into three treatment groups i.e. LME (n=5), MME (n=5) and HME (n=6) group on the basis of MPPA (2294, 2167 and 2155 in LME, MME and HME respectively), and lactation number (3.80, 3.41 and 3.52 in LME, MME and HME respectively).

$$\mathrm{MPPA} = \frac{u + nr}{1 + (n - 1)r\,(x + u)}$$

Where, u – population mean

r – Repeatability of lactation milk

x – Average of lactation yield

n - Number of lactation records

Total duration of the feeding trial was 130 days i.e. 40 days pre-partum to 90 days post-partum. The requirement of ME of experimental animals in the MME group were fulfilled as per ICAR, 2013 nutrient requirements, whereas animals in treatment group 1 (LME) and group 2 (HME) were fed a rations having 15% less and 15% more ME as compared to MME. The varying levels of energy were ensured by adjusting the energy content of 3 different concentrate mixtures which were otherwise iso-nitrogenous in nature. Concentrate mixture, green fodder (maize) and wheat straw was fed to the animals as total mixed ration (TMR), in varying ratio as per experiment protocol. Before the start of the experiment, all animals were properly de-wormed. The animals were fed twice a day and fresh clean water was made available.

Physical compositions of different concentrate mixture are presented in Table 1. Throughout the study period, the measured quantity of diet was offered daily in the morning and evening to individual animals and orts were collected the next morning to determine daily feed intake. The feed sample during pre and post-partum periods were collected weekly and composited every three weeks to analyze dry matter, crude protein, ash, and ether extract AOAC (2005), acid detergent fibre (ADF), neutral detergent fibre (NDF) and acid detergent lignin (ADL) (Van Soest *et al.,* 1991). Total digestible nutrients (TDN), digestible energy (DE), metabolizable energy (ME) and metablizable protein (MP) of the dietary samples were calculated as per NRC (2001).

The buffaloes were milked two times a day and daily milk production was recorded and samples were collected fortnightly for analysis of total solid, fat, solid

Table 1. Ingredient composition (% DM) of concentrate mixture used for different energy levels groups

Feed ingredient(%)	LME	MME	HME
Maize grain	24.0	34.0	39.0
Deoiled rice bran	24.5	16.5	12.0
Wheat bran	17.5	18.5	15.5
Mustard oil cake	-	12.0	10.5
Cotton seed cake	12.5	-	-
Soyabean meal	18.5	16.0	20.0
Mineral mixture	2.0	2.0	2.0
Salt	1.0	1.0	1.0
Total	100	100	100

not fat, and protein by using a Milk-O-Scan analyzer (Foss Electric, Conveyor 4000). The total solids in milk were calculated by the addition of milk fat% and SNF%. FPCM (Fat and Protein Corrected Milk) was calculated using Di Palo's equation (1992):

$$Y=1+0.01155\ [(X-40) + (Z-31)]$$

Where: Y is the quantity (kg) of FPCM equivalent to 1 kg of milk produced;

X and Z are the grams of fat and protein contained in 1 kg of milk produced

Blood samples were taken from the jugular vein using heparinized vacutainer in the morning before offering food. Plasma was obtained by centrifuging at 3,000×g for 10 min and frozen at -20ºC for later analysis of blood parameters. IgG and IGF-1 was quantified by Bioassay Laboratory technique ELISA kit (Cat no-E0010BO and E0016BO respectively) and based on the principle of competitive enzyme immunoassay technique. Blood urea nitrogen (BUN), aspartase aminotransfrase (AST), total protein, albumin and globulin were determined by using diagnostic reagent kit provided by Recombigen Laboratories Pvt. Ltd. (New Delhi).

After 60 days of post-partum feeding a metabolic trial was conducted for 7 days duration. Daily faeces of individual animals were collected for 24 h and pooled in plastic buckets covered with a lid, while urine was collected for 24 h and pooled in plastic cans. An aliquot of fecal sample for dry matter estimation (1/50) and N estimation (1/500 preserved in 20 % H_2SO_4) was collected daily from individual animal during the metabolic trial. Representative samples for urine was collected from individual animals from total urine collection of 24 hours. The urine samples was then pooled and preserved in plastic bottles containing 20 ml of 40% H_2SO_4. Samples of feed offered (wheat straw, green maize and concentrate mixtures) and orts were also collected daily, and representative samples were kept for dry matter (DM) estimation. Dried samples of faeces, feed offered, and orts were ground through a 1-mm sieve using a Wiley mill. Ground samples were stored in plastic containers and labelled for subsequent use in chemical and biochemical estimations.

For the study of cervical (diameter of cervix) and uterine involution (diameter of both uterine horn) was checked by using Ultra Sonography technique (USG) (UST-8520-5 Aloka, probe-6.5 MHz, Japan) on days 7, 14, 21, 28, 35 and 42.

Statistical analysis

Data on various parameters (body weight, DMI, milk yield) were analyzed by one way ANOVA whereas blood biochemical parameters was assessed by repeated measures analysis of variance and further analyzed with regression procedure using method of Snedecor and Cochran (2004) and the Statistical Analysis System (2000). Data is presented as Mean ± SE. Differences with probabilities ($P<0.05$) were considered significant. The mathematical models used were *Yij*=

Table 2. Chemical composition of concentrate mixture, maize fodder and wheat straw

Chemical composition (g/kg)	Concentrate mixture			Maize(Green)	Wheat Straw
	LME	MME	HME		
Dry matter	891.7	896.8	895.3	215.0	908.9
Organic matter	923.0	928.4	929.6	897.1	885.4
Crude protein	191.6	195.5	197.8	84.0	3.40
Ether extract	32.0	33.0	34.0	13.3	9.90
Neutral detergent fiber	282.0	265.0	246.0	363.2	682.0
Metabolizable protein	128.9	123.5	128.4	65.0	0.0
Metabolizable energy (MCal/kg)	2.82	2.92	3.32	1.96	1.65

ME and MP were calculated as per method given by NRC (2001)

Table 3. Effect of feeding varying levels of ME on Nutrient intake of Murrah buffaloes

Parameters	LME	MME	HME
		Before calving	
Body weight (kg)	626.4±7.6	616.6±16.5	620.4±14.8
DM (g/ kg $W^{0.75}$)	90.66±0.44	91.32±1.16	91.74±0.78
CP(g/ kg $W^{0.75}$)	7.82±0.2	7.91±0.06	7.86±0.05
TDN (g/ kg $W^{0.75}$)	$40.32^{a}\pm0.37$	$45.50^{b}\pm0.18$	$48.53^{c}\pm0.77$
ME (KJ/ kg $W^{0.75}$)	$616.88^{a}\pm4.71$	$701.61^{b}\pm6.34$	$745.75^{c}\pm13.12$
MP (g/ kg $W^{0.75}$)	4.72±0.15	4.67±0.04	4.73±0.18
		After calving	
Body weight (kg)	570.8±4.8	560.3±9.6	574.2±4.8
DM (g/ kg $W^{0.75}$)	$127.97^{a}\pm1.79$	$128.06^{a}\pm1.11$	$135.86^{b}\pm1.22$
CP(g/ kg $W^{0.75}$)	14.72±0.18	14.62±0.19	14.90±0.20
TDN (g/ kg $W^{0.75}$)	$60.63^{a}\pm0.57$	$70.64^{b}\pm0.68$	$80.27^{c}\pm0.85$
ME (KJ/ kg $W^{0.75}$)	$936.40^{a}\pm7.62$	$1072.99^{b}\pm11.60$	$1205.70^{b}\pm12.72$
MP (g/ kg $W^{0.75}$)	7.80±0.48	7.77±0.38	7.53±0.36

$^{(a,b,c)}$ Means with a different superscripts in a row differ significantly (P<0.05)

μ+Ai+ei+Ti+(A X T)+eij and *Yi= μ+Ti+ei* for blood parameters and other parameters, respectively.

Where *Yij and Yi* is the dependent variable (BW; DMI; MY; Nutrient digestibility; Blood biochemical parameters etc), is the overall mean, *Ti* is the effect of *i*th treatment (LME, MME and HME), *Ai* is the fixed effect of *i*th treatment, ei is the variability within treatment group, eij is the variability from animal and time and is the residual error of the *i*th observation.

RESULTS AND DISCUSSION

The detail chemical composition of feed ingredients is presented in Table2. Body weight and intake of various nutrients before and after calving are presented in Table 3. CP and MP intakes were similar in all the groups. TDN and ME intakes significantly varied among treatment groups, being highest in HME followed by MME and LME groups respectively, as per feeding protocol. The apparent digestibility (Table 4) of DM, OM and CP was similar in all groups. The digestibility of EE, NDF and ADF was adversely affected in LME group. However the digestibility of EE, NDF and ADF were similar in HME and MME treatments groups. N excretion in faeces, nitrogen excretion via urine and N outgo in milk were not affected by the different levels of ME in diet (Table 5). Nitrogen balance (g/d) was statistically similar in all experimental groups.

The effect of different ME levels on milk yield

Table 4. Effect of feeding varying levels of ME on digestibility of nutrients (%) in Murrah buffaloes

Particular	LME	MME	HME
DM (%)	62.77±0.76	65.28±1.47	65.15±1.32
OM (%)	67.93±1.17	67.35±1.48	70.53±1.29
CP (%)	63.14±1.36	64.38±2.35	65.39±1.29
EE (%)	$67.94^{a}\pm0.90$	$71.70^{b}\pm0.95$	$72.92^{b}\pm1.11$
NDF (%)	$50.31^{a}\pm1.16$	$52.82^{ab}\pm1.74$	$55.65^{b}\pm0.94$
ADF (%)	$31.86^{a}\pm0.97$	$35.39^{b}\pm1.15$	$35.37^{b}\pm0.83$

$^{(a,\,b)}$ Means with a different superscripts in a row differ significantly (P<0.05)

Table 5. Effect of feeding varying levels of ME on nitrogen balance (g/day) during digestibility trial in Murrah buffaloes

Particulars	LME	MME	HME
N intake	292.91±7.04	280.82±5.54	294.46±9.30
N in feces	109.17±11.95	102.11±19.41	103.89±13.83
N in Urine	100.02±6.74	100.26±15.81	102.99±4.54
N in milk	60.91±4.63	55.24±4.06	61.74±1.19
N outgo	270.11±6.43	257.62±6.85	268.63±10.57
N balance	22.8±2.39	23.2±3.56	25.83±2.18

and composition is presented in Table 6. Significantly higher milk production (kg/day) was observed in the HME (10.97) in comparison to LME (10.42). The FPCM (kg/day) was significantly higher in HME (14.00) as compared to LME (13.42) and MME (13.37). The milk components of i.e. total solid, fat, solid not fat and protein did not vary on feeding rations with varying ME level.

The result of metabolic profile pertaining to immunity is depicted in Table-7. IGF-1 (ng/ml) and IgG (µg/ml) were similar on feeding varying ME rations. BUN (mg/dl), total protein (mg/dl), albumin (mg/dl), globulin (mg/dl) and AST (U/L) concentrations were also similar in different treatment groups.

The calf mortality was not observed in MME and HME group whereas two calf mortality were there in LME. Calf birth weight was 35.2, 32.5 and 33.66 in LME, MME and HME, respectively. Period required for complete uterine involution was 50, 47 and 47 days in the LME, MME and HME groups respectively, which was higher in LME group. This may be due to incidences of metritis in LME group.

McNamara *et al.* (2003) found that feeding of diets high in energy density pre-partum improved transitional success. In the present study feeding of high energy diet in pre-partum improved postpartum DMI (Fig 1) of HME group than LME and MME group. Similarly, dry matter intake in the ruminants was increased by energy concentration in the diets (Nair *et al.* 2004; Gaafar *et al.* (2011). In contrast to our result, Wang *et al.* (2010), reported that animal fed high energy diets during pre-partum period had lower DMI compared with those on lower energy diets and Aghaziarati *et al.* (2011) reported that varying energy density, did not affect the DM intake. In the present study high energy density might have resulted in improvement in DMI. CP and MP intakes were not affected due to variations in ME levels. In the present study digestibility of EE, NDF and ADF were improved in high energy diet group than low energy diet group whereas DM, OM and CP remained similar in all experimental group (Table-4). Higher NDF levels diets are associated with depressed NDF and DM digestibility (Ahmed *et al.,* 2014; Tjardes *et al.,* 2002).

Table 6. Effect of feeding varying levels of ME on Milk yield and milk composition of Murrah buffaloes

Parameters	LME	MME	HME
Milk yield (Kg/day)	10.42^{a}±0.10	10.60^{ab}±0.13	10.97^{b}±0.10
FPCM (Kg/day)	13.42^{a}±0.14	13.37^{a}±0.16	14.00^{b}±0.13
FPCM (Kg/kg DMI)	0.89±0.09	0.90±0.01	0.88±0.09
TS (%)	17.22±0.09	17.40±0.10	17.53±0.15
Fat (%)	7.02±0.08	7.09±0.07	7.04±0.06
SNF (%)	10.19±0.04	10.27±0.14	10.49±0.10
Protein (%)	3.87±0.05	3.97±0.14	3.88±0.03

$^{(a,b,c)}$ Means with a different superscripts in a row differ significantly (P<0.05)

Table 7. Effect of different levels ME on Metabolic profile in Murrha buffaloes

Parameters	LME	MME	HME
BUN (mg/dl)	13.22±0.29	13.38±0.26	13.53±0.30
TP (mg/dl)	6.94±0.14	6.86±0.16	7.32±0.13
Albumin (mg/dl)	2.7±0.12	2.94±0.14	3.18±0.11
Globulin (mg/dl)	4.17±0.13	3.91±0.15	4.14±0.12
AST (U/L)	37.07±1.80	35.17±1.80	34.21±1.64
IgG (µg/ml)	37.30±2.39	35.17±2.39	39.33±2.18
IGF-I (ng/ml)	112.19±3.15	114.83±3.15	122.52±2.88

El-Ashry *et al.* (2003) and Gaafar *et al.* (2011) observed that buffaloes fed the highest energy level recorded the highest digestibility of ether extract. Ether extract content was relatively high in HME and source of additional fat was oilseed cakes and cereals grain, mainly through concentrate mixture, which is more digestible. This might be the reason for better digestibility of ether extract.

In the present study increased ME intake (Table-3) in HME group, might have contributed to improved milk yield. These results are in agreement with Patton *et al.* (2006), who reported that increasing the dietary energy up to recommended level within 1st month of lactation enhanced the milk yield. Broderick (2003) reported that increasing the dietary protein and energy gave the linear increase in the milk yield. However, in contrary to present study, Jabbar *et al.* (2013) observed that feeding 20% above NRC recommended levels did not show changes in milk yield, but feeding 20% below NRC recommendation there was detrimental effect on milk production. In the present study the milk components were not influenced by varying dietary energy levels. The results are in agreement with the findings of Aghaziarati *et al.* (2011) who concluded that enriched dietary energy and protein did not affect milk fat and protein. Likewise, Mustafa *et al.* (2017) also reported that milk production and composition were not affected by feeding an energy-rich diet (added dietary fat) to dairy animals. However, in contrast to our result Bovera *et al.* (2002) and by Gaafar *et al.* (2011) observed increase in milk protein on feeding high energy content diet. The FPCM yield in HME group was better than LME and MME groups, but FPCM yield per kg of DMI did not vary among the different dietary groups. In support with our findings Bovera *et al.* (2002) reported that feeding higher energy diet lead to higher FPCM yield compared to energy deficient diet and Gaafar *et al.* (2011) reported that high energy diet significantly improved 7 % FCM yield.

In the present study difference in dietary energy content did not affect IGF-1 and IgG levels of transitional buffaloes. In contrast to our result, Mustafa *et al.* (2017) observed that lower IgG levels in low energy fed group. The AST (U/L) in all the groups was similar (Table-7) and within the physiological limits; hence, no impairment in liver function is observed in all the groups. It was also observed that blood urea level was not affected by different energy levels this may also be due to feeding of iso-nitrogenous diet to all experimental groups. However, Bovera *et al.* (2002) found that blood urea concentration was higher in group which was supplied higher energy and protein in their total ration.

Improved nutrition of the late-gestation cow has been postulated to reduce the incidence of reproductive issues (Goff, 2006). Earlier reports (Qureshi and Ahmad 2008; Khan *et al.,* 2011) indicated a mean post-partum uterine involution time of 34.30±1.33 days in dairy buffaloes. In our study the involution time is on higher side to above reported results. Miettinen (1990) reported that in dairy cows, a low energy level in early puerperium delayed uterine involution and onset of ovarian activity and prolonged service period. The birth weight calves is within the normal limits and no variation was observed.

CONCLUSIONS

It was concluded that increasing energy supplementation at 15% higher than ICAR-2013 feeding recommendation may improve the FPCM yield and fiber digestibility with no adverse effect on blood biochemistry and DM digestibility in Murrah buffaloes.

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