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Influence of Prepartum Plane of Nutrition on Nutrient Utilization and Performance in Murrah Buffaloes

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ABSTRACT

Maternal nutritional status pre-partum acts as a determining factor not only for the health status of the off-spring but also, for production yield of upcoming lactation phase, thereby feeding during this time period is of utmost importance. The present study investigated the effect of feeding a high plane of nutrition to prepartum Murrah buffaloes on the birth weight of calves and their performance, nutrient utilization, and blood metabolites. Forty pregnant Murrah (4 months before parturition) buffaloes were divided into four experimental groups based on parity, previous lactation yield and body weight as control. Based on the ICAR (2013) requirements for metabolizable protein (MP) and metabolizable energy (ME), four dietary treatments were formulated: (i) a control ration as per ICAR (2013); (ii) a high metabolizable energy (HME) ration containing 30% more ME; (iii) a high metabolizable protein (HMP) ration with 40% more MP; and (iv) a high metabolizable energy and protein (HMEMP) ration with 30% higher ME and 40% higher MP than the ICAR (2013) recommendations. A feeding trial was conducted using these rations until the date of parturition. Concentrate mixture, green fodder (maize) and dry roughage (wheat straw) were offered to individual animal as per experimental protocol. Dry matter intake and metabolizable energy intake were significantly ($P<0.05$) higher for HMEMP, followed by HMP, HME and control group. Average daily body weight gain of pre-partum dams was higher ($P<0.05$) in HMEMP that is 946.08 g/d, followed by HME (761.67 g/d) and HMP (753.17g/d), with lowest for control group (576.08 g/d). It was observed that digestibility coefficients (%) of dry matter, organic matter, ether extract, neutral detergent fibre and acid detergent fibre were higher ($P<0.05$) in groups HMP, HME and HMEMP as compared to the control. It was concluded that group fed HMEMP diet i.e., an additional 40% protein and 30% energy above ICAR, 2013 requirements during last four months of pregnancy resulted in higher body weight gain and better nutrient digestibility compared to groups fed individual diets having high levels of energy (HME) or protein (HMP).

KEYWORDS: Birth weight, Digestibility, P of nutrition, Prepartum buffaloes, Transition nutrition

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INTRODUCTION

Buffaloes are considered the main dairy animal in India, contributing 49% to the country's total milk production (BAHFS, 2019). Murrah leads as the prominent buffalo breed in the country, followed by Mehsana, Surti and Jaffarabadi (Breedwise report of Livestock and Poultry, 2022). Lower birth weight leads to a delay in puberty (generally attained at the age of 34 months in Murrah buffaloes) and retarded performance as the growth of calves depends on birth weight. If the mother is severely underfed during the last three months of pregnancy, it might affect the young, causing death in utero or reducing viability at birth (Mc Donald, 2002, Wallace et al.1999, Godfrey and Barker, 2000). Therefore, balanced feeding taking into account proper nutrition over and above maintenance is of utmost necessity during this phase.

However, experimental studies that substantiate that feeding of higher energy and protein than that recommended by ICAR (2013) during advanced pregnancy might be valuable are sparse. The present study, therefore, aims at monitoring the influence of feeding higher levels of dietary protein and dietary energy than the recommendation of ICAR (2013) during the last trimester of pregnancy on nutrient utilization in buffaloes and the birth weight of their calves.

MATERIALS AND METHODS

Forty Murrah buffaloes in the last trimester (6 months) of pregnancy were randomly distributed into four groups (n=10) based on parity, lactation number and body weight as T1 (Control), T2 (HME), T3 (HMP) and T4 (HMEMP), respectively to minimize variation between the groups. The control group animals were fed as per the ICAR (2013) feeding standards for late gestation. Buffaloes in the HME group received 30% more metabolizable energy (ME) than the ICAR (2013) recommendation, while protein and other nutrients were provided as per the standard. In the HMP group, animals were fed 40% more metabolizable protein (MP), with energy and other nutrients aligned with ICAR (2013). The HMEMP group received both 30% higher ME and 40% higher MP, while other nutrients were maintained as per the standard guidelines. The increase in ME and MP levels in the treatment groups was based on the ICAR (2013) recommendations for late gestation in buffaloes, which served as the baseline. Treatment diets were formulated by increasing the energy and/or protein levels above these reference values to evaluate the physiological response of buffaloes to enhanced nutrient intake during the last four months of pregnancy. Based on ME and MP values four concentrate mixtures were prepared, and four different freshly prepared total mixed ration (TMR) were offered twice a day. The physical compositions of different concentrate mixtures are presented in Table 1. Fresh drinking water was provided ad libitum four times daily.

Table 1. Ingredients and their proportions in the concentrate mixture

Ingredients (kg/100 kg)	Control	HME	HMP	HMEMP
Maize grain	20.0	56.0	16.0	39.0
Oats grain	18.0	7.00	20.00	14.00
SBM	2.00	7.00	9.00	16.00
Wheat bran	40.00	9.00	25.00	5.00
DORB	15.00	0.00	15.00	2.00
MOC	0.00	9.00	0.00	6.00
GNC	2.00	0.00	12.00	8.00
Prilled fat	0.00	9.00	0.00	7.00
Mineral mixture	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
CP%	14.22	14.07	19.80	19.80
ME (Mcal/kg)	2.70	3.55	2.76	3.41
MP%	8.85	9.42	12.14	12.61

A metabolism trial was conducted around one month before expected date of parturition to determine the nutrient digestibility and nitrogen balance. For suitable aliquoting of biological samples representative samples of feed offered, faeces voided, and urine excreted were collected (Schneider and Flatt, 1975). The samples were analyzed for proximate composition (AOAC, 2005), cell wall fractions (Van Soest et al., 1991) and fiber bound protein fractions such as NDF and ADF bound CP (NDICP and ADICP) (Licitra et al., 1996). Total-N content of urine samples were estimated (AOAC, 2005). The TDN, DE and ME value of the fodders was estimated using chemical composition based formulae suggested by NRC (2001) The average of two days was considered as body weight of that fortnight. Difference of body weight for each fortnight was considered as body weight changes for that fortnight. After proper restraining, blood samples were collected from the jugular vein for immunoglobulin analysis at monthly intervals before feeding. The proximate analysis of the feed, leftover residues, and faecal samples was done to assess their chemical composition (AOAC, 2005) and cell wall constituents (Van Soest et al., 1991). Measured amount of TMR was offered and on the next day collection of residue was done for individual animal on daily basis. DMI was recorded daily by subtracting residual/left-over DM from the quantity of DM offered.

Plasma total immunoglobulin was estimated by zinc sulphate turbidity method (Mc Ewan and Fisher, 1970) Reagents: Zinc sulphate, fetal calf serum, Rabbit gamma globulin Test reagent: 4.1 ml of 5% zinc sulphate solution was taken and final volume was made upto 1 litre with double distilled water. Principle: Albumins, alpha-globulins, beta-globulins and gamma-globulins are the four major classes of protein present in the blood. These proteins have differential precipitability in various concentration of salt such as ammonium sulphate or sodium sulphate. The zinc sulphate turbidity test is based on the principle given by McEwen and Fisher, (1970). Zinc sulphate at a specific concentration precipitates the gamma globulin, this creates a turbidity which is proportional to the quantity of gamma globulin in the sample and can be quantified in the spectrophotometer at 460nm.

Analysis of data assimilated through measurement of various parameters (body weight, DMI) was conducted by one way ANOVA method of Snedecor and Cochran (2004) using the Statistical Analysis System (2012) and presented as average mean ± pooled standard error of means (SEM). 5 % level of probability ($P<0.05$) was considered statistically significant.

RESULTS AND DISCUSSION

The detailed chemical composition of feed ingredients is presented in Table 2. Dry matter intake (DMI) and digestibility coefficients of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fibre (NDF) and acid detergent fibre (ADF) are illustrated in Table 3. The DMI in HMEMP (13.98 kg/d) was higher ($P<0.05$), than HMP (13.36 kg/d), followed by HME (12.39 kg/d) and control (12.21 kg/d). From the third fortnight onwards, the dry matter intake increased in all four groups, however, it gradually decreased around the last fortnight of pregnancy.

Table 2. Chemical composition of feeds and fodder (On DM basis)

Particular	DM	OM	CP	EE	NDF	ME (MJ/kg)	MP (%)
Roughage							
Maize fodder	18.46	89.25	10.83	2.01	60.67	7.98	7.15
Oat fodder	16.55	90.91	11.83	2.20	42.06	9.26	8.52
Sugargraze	26.13	90.25	10.08	2.07	58.56	7.86	6.88
Berseem	14.62	88.04	17.24	1.82	53.78	8.26	12.58
Wheat straw	90.15	89.0	3.42	1.01	76.73	5.55	0.92
Energy and protein sources							
Soybean meal	91.10	91.68	46.75	0.99	19.18	13.62	28.07
Maize grain	90.99	98.03	9.76	5.20	17.93	13.11	7.53
Wheat bran	90.14	95.57	14.34	2.07	38.99	11.24	9.28
De-oiled rice bran	92.09	90.7	17.69	1.03	36.93	10.00	8.26
Mustard oil cake	92.39	93.99	36.15	7.79	23.19	11.89	21.26
Groundnut cake	91.53	92.69	46.20	1.06	21.88	13.67	28.77
Oats grain	90.59	97.31	11.22	3.27	24.19	12.68	7.02
Prilledfat	99.99	99.9	-	99.80	-	38.78	

The intake of DM (kg/d), TDN (kg/d), MP (g/d) and MEI (Mcal/d) was significantly higher (P<0.05) in animals fed HMEMP than other treatments. CP intake (g/d) was highest in HMEMP (1336.74) and HMP group (1339.57) followed by HME (876.72) and the control group (878.97). Animals fed with control diets or HME had the least intake of DM, OM whereas, CP intake was minimum in animals offered diets having 30% extra energy (HME).

The digestibility of nutrients is given in Table 3. The DM digestibility was significantly (P<0.05) higher in the HMEMP group followed by HMP, HME and the control group. The OM digestibility was statistically similar in HMEMP and HMP group which was significantly higher than HME and control group. The digestibility of CP, NDF and ADF was significantly higher (P<0.05) in HMEMP and HMP followed by HME as compared to the control.

The mean N intake (g/d) was significantly higher in the HMP group as shown in Table 3. N excretion in faeces was also significantly affected by the supplementation of energy and protein in the diet. Overall N balance (g/d) was significantly high in the group fed with 40% extra protein and 30% extra energy (HMEMP)

Table 3. Intake and digestibility of nutrients and nitrogen balance

Parameters	T1	T2	T3	T4	SEM	p-value
DMI (kg/d)	12.21^{c}	12.39^{c}	13.36^{b}	13.98^{a}	0.15	0.02
DMI (kg/100 kg BW)	1.84^{b}	1.84^{b}	1.97^{a}	2.01^{a}	0.02	0.03
TDN (kg/d)	6.06^{d}	7.50^{c}	6.98^{b}	7.79^{a}	0.06	0.01
CPI (g/d)	878.97^{b}	876.72^{b}	1339.57^{a}	1336.74^{a}	9.21	0.04
MPI (g/d)	469.77	503.70^{b}	765.92	768.99^{a}	4.52	0.01
MEI (Mcal/d)	21.20^{d}	27.45^{b}	25.20^{c}	28.41^{a}	0.23	0.01
Digestibility (%) of nutrients						
DM	62.87^{c}	63.21^{c}	66.81^{b}	68.28^{a}	0.40	0.03
OM	64.96^{b}	65.94^{b}	68.61^{a}	69.72^{a}	0.41	0.01
CP	55.11^{c}	59.69^{b}	64.00^{a}	65.14^{a}	0.54	0.04
EE	67.29^{c}	84.23^{a}	68.32^{c}	80.79^{b}	0.30	0.03
NDF	55.00^{b}	50.07^{c}	57.81^{a}	58.57^{a}	0.55	0.01
ADF	35.67^{a}	31.38^{b}	37.81^{a}	36.76^{a}	0.82	0.01
Nitrogen balance						
Total N intake (g/d)	150.33^{c}	143.57^{d}	233.34	226.69^{b}	1.45	0.02
N outgo through faeces (g/d)	67.43^{a}	57.76^{d}	84.16^{a}	79.06^{b}	1.25	0.01
N outgo through urine (g/d)	58.62^{c}	54.33^{d}	116.82	109.50^{b}	1.60	0.04
Nitrogen balance (g/d)	24.28	31.67^{b}	32.36^{b}	38.13^{a}	0.95	0.03
Nitrogen balance % of total N intake	35.67^{a}	35.67^{a}	35.67^{a}	35.67^{a}	0.77	0.02
Nitrogen balance % of total N absorb	29.01^{b}	36.01^{a}	21.73^{d}	25.82^{c}	0.85	0.01

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

The dietary treatments significantly (P<0.05) influenced the live weight changes over the prepartum period. Body weight increased significantly (P<0.05) in the HMEMP group as compared to HME, HMP group and the control as shown in Figure 1. Average Daily Gain (g/d) was significantly higher in the HMEMP group (946.08) followed by HMP (761.67), HME (753.17) and the control (576.08) as depicted in Figure1.

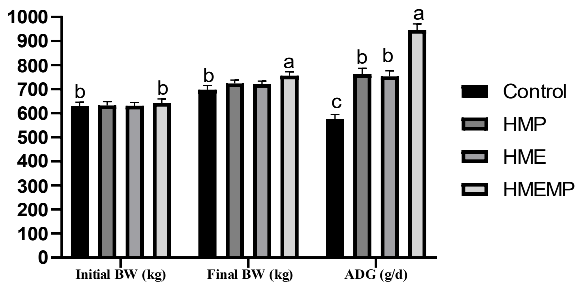

Figure 1. Bodyweight and Average body weight gain in various groups

Figure 2, illustrate the average birth weight (kg) of calves born from dams fed with control, HME, HMP and HMEMP diets and these were 29.36, 31.44, 33.33 and 36.44 kg, respectively.

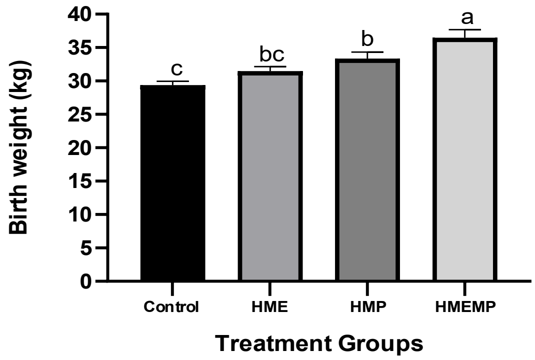

Figure 2. Bodyweight and body weight gain in various groups

Total immunoglobulin concentration (Figure 3) was significantly (P<0.05) higher in HMP and HMEMP groups followed by HME and control group.

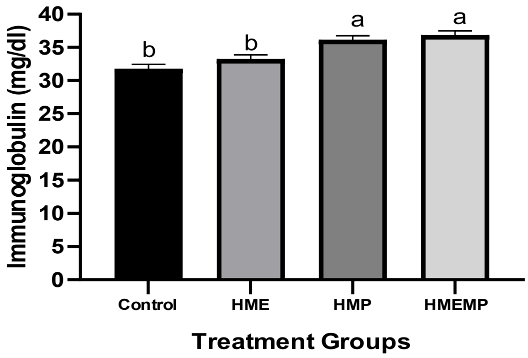

Figure 3. Immunoglobulin concentration in various groups

The present study demonstrated that dry matter intake (DMI) increased progressively with the advancement of pregnancy across all groups, with a significant (P<0.05) improvement observed in the HMEMP group. This aligns with the findings of Singh et al. (2016) and Proto (1993), who reported that DMI in pregnant buffaloes increases during mid-gestation and begins to drop closer to parturition. The higher DMI in HMEMP group might be attributed to the increased nutrient density, better palatability, and a physiological drive to meet the elevated nutrient demands of fetal growth. Contrary to this, Panigrahi et al. (2005) noted no significant effect of different concentrate amounts on DMI in crossbred cows prepartum. Similarly, Shelke (2010) and Silvestre et al. (2011) observed that protected fat and protein feeding in Murrah buffaloes did not adversely affect DMI, although they improved intake of CP and ME. In contrast, Schroeder et al. (2022) and Weiss et al. (2011) reported a reduction in DMI with protected fat supplementation in dairy cows. These discrepancies may be due to differences in dietary composition, physiological status, and breed. Significantly higher intake of CP, MP, ME, and TDN in HMEMP and HMP groups corroborates the enhanced dietary nutrient supply. The observed differences are expected, as animals were intentionally fed 40% more protein and/or 30% more energy in these groups. Similar findings were reported by Mustafa et al. (2017), where transition buffaloes offered high ME and MP diets showed increased nutrient intake. The lowest CP intake in HME animals compared to HMP and HMEMP reflects that energy supplementation alone without corresponding protein enhancement may not stimulate CP intake.

Digestibility coefficients of DM, OM, CP, NDF, and ADF were significantly higher in HMEMP and HMP groups. These results agree with El-Ashry et al. (2003), who observed improved digestibility in buffaloes fed higher energy diets. Moreover, Jawid (2016) reported improved CP digestibility in buffaloes fed with higher metabolizable protein diets, though digestibility of other nutrients remained unaffected. The improved fiber digestibility (NDF and ADF) in high-protein groups is supported by Lee et al. (2011), who noted low fiber digestibility in animals receiving low-CP diets. Conversely, Christensen et al. (1993) found no improvement in OM, NDF, and ADF digestibility despite increasing dietary CP, suggesting that beyond a certain threshold, digestibility may plateau or depend on factors beyond CP level alone, such as forage quality and rumen microbial efficiency.

Significantly higher nitrogen (N) intake and retention in the HMEMP and HMP groups suggest superior nitrogen utilization efficiency when adequate protein is supplied. These results are consistent with Colmenero and Broderick (2006) and Castillo et al. (2001), who documented a linear relationship between N intake and N excretion, and found that 72% of consumed N is typically excreted via faeces and urine. Additionally, Lee et al. (2011, 2012) and Giallongo et al. (2014) observed that lower MP diets result in higher urinary N loss, implying suboptimal nitrogen retention. The significantly improved nitrogen balance in the HMEMP group indicates that synchronized supply of both energy and protein optimizes ruminal microbial activity and nitrogen retention, leading to better utilization and reduced wastage. Buffaloes fed the HMEMP diet exhibited the highest body weight gain and average daily gain (ADG), followed by HMP and HME groups. These findings are supported by Schoonmaker et al. (2003), Radunz et al. (2010) and Gamit et al. (2024), who observed improved body weight and growth performance in cattle fed higher energy or protein diets during late gestation. However, Vaswani et al. (2025) reported no change in DMI and body weight change after supplementing by pass fat. The enhanced ADG in the HMEMP group suggests that simultaneous supplementation of energy and protein supports both maternal tissue accretion and fetal growth more effectively than individual nutrient supplementation.

The significantly higher birth weights in calves born to buffaloes fed HMEMP and HMP diets are indicative of improved intrauterine growth. These observations are supported by Gunn et al. (2013) and Bolze et al. (1985) who reported higher birth weights in calves from dams fed high-protein diets. Similarly, Radunz et al. (2010) and Pandey et al. (2024) found that feeding high-energy diets and nano minerals, respectively, during late pregnancy enhances calf birth weight. The combined energy-protein supplementation appears to create a more favorable intrauterine environment, thereby promoting better fetal development.

Significant increase in plasma total immunoglobulin levels in the HMP and HMEMP groups suggests improved maternal immunity status and possibly better passive immunity transfer potential to the offspring. This is consistent with the findings of Chatterjee et al. (2003), Aggarwal et al. (2016), and Deka et al. (2014), who noted that improved nutritional status during late pregnancy is associated with enhanced immune response in buffaloes. The elevated Ig levels in protein-supplemented groups reinforce the role of dietary protein in supporting immue function during late gestation.

CONCLUSION

Feeding additional metabolizable energy (30%) and metabolizable protein (40%) above ICAR, 2013 requirements during last four months of pregnancy in buffaloes resulted in higher body weight gain and better nutrient digestibility compared to groups fed individual diets having high levels of energy (HME) or protein (HMP).

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