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Effects of Dietary Protein and Energy Levels on Productive and Reproductive Performance of Lactating Buffaloes

Research Article

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ABSTRACT

Twenty eight lactating buffaloes were used in a completely randomized design with 2×2 factorial arrangement of four experimental diets including low protein-low energy (LP-LE), low protein-high energy (LP-HE), high protein-low energy (HP-LE) and high protein-high energy (HP-HE). Results showed that the HP-HE diet recorded the highest digestibility coefficients of CP, EE, NFE, nutritive values, TDN and DCP intake, while HP-LE diet had the highest CF digestibility ($P<0.05$). The HP-HE diet had the highest ($P<0.05$) actual milk and 7% FCM yield and the contents of protein, lactose, SNF and TS in milk, HP-LE diet had the highest fat content ($P<0.05$). The HP-HE diet showed the lowest amounts of DM and TDN per kg, 7% FCM, while LP-HE diet had the lowest amount of DCP per kg 7% FCM ($P<0.05$). The LP-HE diet recorded the lowest average daily feed cost, while HP-HE diet showed the lowest feed cost/kg 7% FCM and the highest total revenue and economic efficiency ($P<0.05$). Buffaloes fed HP-HE diet showed short periods from parturition to first estrus and first service, service period, days open, the lowest number of services per conception and the highest conception rate ($P<0.05$).

KEY WORDS economic efficiency, feed conversion, milk yield and composition, reproductive traits.

INTRODUCTION

Complex interrelationships exist among dietary protein and energy and the amount of protein that will be utilized by the dairy cow. These interrelationships have important ramifications on overall nitrogen efficiency of the dairy farm (Rotz *et al*. 1999). Dietary protein supplies metabolizable protein by providing both rumen degradable protein (RDP) that is utilized for microbial protein formation and rumen undegradable protein (RUP) that is digested directly by the cow. High energy diets stimulate microbial protein synthesis, with providing the major source of metabolizable protein (Cadorniga and Satter, 1993). Thus, increasing dietary energy content may increase RDP requirement. It is uneconomical to overfeed protein and energy. Moreover, overfeeding protein results in excessive urinary nitrogen, the most environmentally convertible form of excreted nitrogen (Varel *et al*. 1999). Overfeeding of concentrates will depress ruminal pH and may reduce ruminal fiber digestion and milk fat secretion and also leads to other metabolic problems for the cow (Weimer, 1992; Oliveira *et al*. 1993; Ekinci and Broderick, 1997).

A negative energy balance during early lactation delays the timing of first ovulation and exerts delayed carryover consequences on fertility during the breeding period (Butler, 2003).

Kane *et al.* (2004) suggest that differing levels of CP supplementation in daily diet may alter ptutary and ovarian function, thereby influence reproductive performance.

The objective of this experiment was to quantify the dietary concentrations of protein and energy under standard feeding conditions that would maximize the productive and reproductive performance of lactating buffaloes.

MATERIALS AND METHODS

Experimental animals and rations

Twenty eight lactating buffaloes were used in a completely randomized design with 2×2 factorial arrangement of treatments to evaluate the effect of varying levels of protein and energy on nutrient intake, digestibility, milk yield, feed conversion and economic efficiency. The low and high protein diets were 12 and 16% and low and high energy diets were 60 and 65% TDN were used in four experimental diets including low protein-ow energy (LP-LE), low protein-high energy (LP-HE), high protein–low energy (HP-LE) and high protein–high energy (HP-HE) as shown in Table 1. Dietary CP was varied by stepwise replacement of 15% of concentrate feed mixture (dry matter basis) with an equal amount of soybean meal. Dietary energy was varied by stepwise replacement of 26% of concentrate feed mixture (dry matter basis) with an equal amount of corn grain. Corn silage was harvested at about one-half milk line, chopped to a theoretical length of 1 cm, and ensiled in horizontal silo without additives. Diets were fed after calving immediately for 150 days. The chemical composition of experimental diets is presented in Table 2.

Concentrate feed mixture, corn grain and soybean meal were offered two times daily at 8 am and 4 pm, berseem hay once daily at 11 am, corn silage at 12 am and rice straw was given two times at 9 am and 5 pm Buffaloes were allowed to drink water three times a day at 7 am, 1 and 7 pm and were kept under the routine veterinary supervision, throughout the whole feeding trial.

Digestibility trials

Digestibility trial was conducted with 3 animals from each treatment to determine nutrients digestibility coefficients and nutritive values of the experimental rations using acid insoluble ash (AIA) as a natural marker (Van Keulen and Young, 1977). Feces samples were taken from the rectum of each animal twice daily with 12 hours interval during the collection period. Samples of tested feedstuffs were taken at the beginning, middle and end of collection period. The samples of feedstuffs and feces were composted and representative samples were analyzed according to AOAC (1995).

Milk yield and samples

Buffaloes were milked twice daily and individual milk yields were recorded at each milking. Milk samples were collected biweekly at two consecutive evening and morning milkings and analyzed for fat, protein, lactose, SNF and TS using Milko-Scan 133B Foss Electric (Foss Electric, Denmark). Yields of 7% FCM were computed using the formula of 7% FCM=0.265×milk yield (kg)+10.5×fat yield (kg) as stated by Raafat and Saleh (1962).

Feed conversion

Feed conversion was calculated as the amounts of DM, TDN (kg) and DCP (g) required to produce 1 kg 7% FCM.

Economic efficiency

Economic efficiency expressed as the daily feed cost, price of 7% FCM, feed cost per kg 7% FCM and the ratio between daily feed cost and price of 7% FCM. The price of one ton was 1800 LE for concentrate feed mixture, 1600 LE for corn grain, 1900 LE for soybean meal, 800 LE berseem hay, 140 LE corn silage, 80 LE/ton rice straw and 3 LE for kg 7% FCM according to the prices of 2009.

Statistical analysis

The obtained data were statistically analyzed for the effect of dietary protein and energy levels using general liner models procedure adapted by SPSS (2008). The Duncan multiple range test was used to compare difference between means.

RESULTS AND DISCUSSION

Digestibility coefficients and nutritive values

The digestibility coefficients and nutritive values of experimental rations are presented in Table 3. The CP digestibility and DCP value increased ($P<0.05$) in high protein diet. While, the digestibility coefficients of EE and NFE and TDN value increased ($P<0.05$), CF digestibility decreased ($P<0.05$) in high energy diet. The interaction between protein and energy levels showed that HP-HE diet recorded the highest digestibility coefficients of CP, EE and NFE and nutritive values and HP-LE diet had the highest CF digestibility ($P<0.05$). These results agreed with those obtained by Mathis *et al.* (1999) who found that digestion of NDF in poor-quality forages fed to beef cows was elevated with SBM supplementation. Weimer (1992) and Oliveira *et al.* (1993) reported that increased dietary NFC is often observed to depress fiber digestion, partly by depressing ruminal pH. Broderick (2003) found that there was no change in apparent digestibility of DM and OM with increasing dietary CP; however, NDF and ADF digestibility both increased linearly with dietary CP.

Also, as expected it was reported that, there were linear increases in apparent DM and OM digestibility, and linear declines in apparent NDF and ADF digestibility and fecal DM output, with increasing dietary energy. El-Ashry *et al.* (2003) showed that buffaloes fed the highest energy level recorded the highest digestibility of DM, OM, CP, CF, EE and NFE.

Table 1 Formulation of experimental rations (% DM basis)

Feedstuffs	LP-LE	HP-LE	LP-HE	HP-HE
Concentrate feed mixture*	50	35	17	10
Corn grain	-	-	26	20
Soybean meal	-	15	7	20
Berseem hay	15	15	15	15
Corn silage	20	20	20	20
Rice straw	15	15	15	15
Total	100	100	100	100

* Concentrate feed mixture consisted of 35% undecorticated cotton seed cake, 20% wheat bran, 24% yellow corn, 10% rice bran, 5% line seed cake, 3% molasses, 2% limestone and 1% common salt.
LP-LE, low protein-low energy; LP-HE, low protein-high energy; HP-LE, high protein-low energy, and HP-HE, high protein-high energy.

Feed intake

Average daily feed intake by lactating buffaloes is shown in Table 4. Dietary DCP intake increased (P<0.05) in high protein diet, while the intake of DM and TDN not affected by dietary protein level (P>0.05). Moreover, the intake of DM and TDN increased (P<0.05) in high energy diet, but DCP intake not affected by dietary energy level (P>0.05). Dietary protein and energy interaction revealed that HP-HE diet showed the highest intake of TDN and DCP, but LP-LE diet had the lowest intake (P<0.05). These results are in agreement with those obtained by Broderick (2003) who found that intake of DM increased with increasing dietary protein and energy. El-Ashry *et al.* (2003) showed that buffaloes fed the highest energy level recorded the highest DM, TDN and DCP intake.

Milk yield

Average daily milk and FCM yield are shown in Table 5. The yield of actual milk and 7% FCM increased (P<0.05) in high protein and energy diets. The HP-HE diet recorded the highest actual milk and 7% FCM yield, however LP-LE diet had the lowest yield (P<0.05). Buffaloes fed high protein diet produced 1.57 kg/d more actual milk and 1.53 kg/d more 7% FCM. While, Buffaloes fed high energy diet produced 2.51 kg/d more milk and 1.88 kg/d more 7% FCM. These results revealed that dietary energy level is more effective on the yield of actual milk and 7% FCM than dietary protein level. These results agreed with those obtained by Broderick (2003) who found that increasing dietary protein and energy gave linear increases in milk yield and FCM. Feeding greater amounts of more fermentable NFC would be expected to improve milk yield (Ekinci and Broderick, 1997; Wilkerson *et al.* 1997; Kebreab *et al.* 2000 and Valadares *et al.* 2000). El-Ashry *et al.* (2003) found that buffaloes fed the high energy level showed higher milk yield and 7% FCM.

Milk composition

As shown in Table 5, the contents of protein, SNF and TS in milk increased (P<0.05) in high protein diet. While, the contents of protein, lactose, SNF and ash in milk increased (P<0.05) and that of fat decreased (P<0.05) in high energy diet. Dietary protein and energy interaction and obviously the HP-HE diet revealed the highest milk protein, lactose, SNF and TS contents and HP-LE diet had the highest fat content (P<0.05). These results may be due to the decrease of fiber content with increasing dietary energy (Table 2). These results agreed with those obtained by Broderick (2003) who found that increasing dietary protein and energy increased all milk components except fat which decreased with increasing dietary energy. El-Ashry *et al.* (2003) found that buffaloes fed the high energy level showed higher fat, protein, lactose, SNF, TS and ash percentages.

Feed conversion

Feed conversion expressed as the amounts of DM, TDN and DCP per kg 7% FCM is shown in Table 6. The amount of DM and TDN per kg 7% FCM decreased (P>0.05), but DCP per kg 7% FCM increased (P<0.05) in high protein diet. Moreover, the amounts of DM, TDN and DCP per kg 7% FCM decreased (P<0.05) in high energy diet. Dietary protein and energy interaction revealed that HP-HE diet showed the lowest amounts of DM and TDN per kg 7% FCM, but LP-LE diet had the highest amounts (P<0.05). While, LP-HE diet had the lowest amount of DCP per kg 7% FCM, but HP-LE diet had the highest amount (P<0.05). These results are in accordance with those obtained by Broderick (2003) who found that increasing dietary energy gave linear increases in milk/DM intake. Factors influencing utilization of dietary CP are complex and related to supplying sufficient RDP to meet the needs of ruminal microbes plus sufficient RUP of adequate intestinal digestibility (NRC, 2001). El-Ashry *et al.* (2003) found that buffaloes fed the high energy level showed the best feed efficiency.

Economic efficiency

Economic efficiency presented in Table 6, revealed that average daily feed cost and total revenue increased (P<0.05) in high protein diet. While, feed cost per kg 7% FCM and economic efficiency were not affected by dietary protein level (P<0.05). Moreover, feed cost and feed cost per kg 7% FCM decreased (P<0.05), but total revenue and

Table 2 Chemical composition of ingredients and experimental rations

Item	%DM	Composition (%DM)					
		OM	CP	CF	EE	NFE	Ash
Ingredients							
CFM	91.35	91.27	16.43	11.65	3.25	59.94	8.73
CG	91.15	96.85	8.75	2.91	3.41	81.78	3.15
SBM	92.24	92.65	43.78	4.58	1.64	42.65	7.35
BH	90.65	87.82	12.85	28.67	2.76	43.54	12.18
CS	27.80	92.45	8.36	24.38	2.45	57.26	7.55
RS	89.28	83.73	2.36	32.83	1.52	47.02	16.27
Experimental rations							
LP-LE	62.49	89.86	12.17	19.92	2.76	55.01	10.14
HP-LE	62.55	90.07	16.27	18.86	2.52	52.42	9.93
LP-HE	62.49	91.41	12.09	17.16	2.68	59.48	8.59
HP-LE	62.55	91.25	16.10	16.76	2.47	55.92	8.75

CFM, Concentrate feed mixture; CG, Corn grain; SM, Soybean meal; BH, Berseem hay; CS, Corn silage; RS, Rice straw.
LP-LE, low protein–low energy; LP-HE, low protein–high energy; HP-LE, high protein–low energy, and HP-HE, high protein–high energy.

Table 3 Digestibility coefficients and nutritive values of experimental rations by lactating buffaloes*

Item	Protein level				Energy level				Interaction (protein . energy)					
	LP	HP	MSE	P-value	LE	HE	MSE	P-value	LP-LE	HP-LE	LP-HE	HP-HE	MSE	P-value
Digestibility coefficients (%)														
DM	66.55	66.77	±0.38	0.783	66.03	67.29	±0.38	0.100	65.94	66.12	67.15	67.42	±0.38	0.476
OM	67.87	68.03	±0.39	0.842	67.32	68.58	±0.39	0.103	67.28	67.35	68.45	68.71	±0.39	0.488
CP	63.91	66.44	±0.54	0.011	64.65	65.70	±0.54	0.356	63.86[b]	65.43[ab]	63.95[b]	67.45[a]	±0.54	0.031
CF	62.73	64.08	±0.56	0.245	64.78	62.03	±0.56	0.006	64.15[ab]	65.40[a]	61.31[c]	62.75[bc]	±0.56	0.021
EE	69.61	70.14	±0.63	0.694	68.15	71.60	±0.63	0.002	67.85[b]	68.44[b]	71.36[a]	71.83[a]	±0.63	0.017
NFE	68.22	68.33	±0.95	0.957	65.32	71.22	±0.95	0.001	65.28[b]	65.36[b]	71.15[a]	71.29[a]	±0.95	0.002
Nutritive values (%)														
TDN	62.78	63.18	±0.70	0.791	60.90	65.06	±0.70	0.001	60.67[b]	61.12[b]	64.88[a]	65.23[a]	±0.70	0.004
DCP	7.75	10.76	±0.46	0.002	9.21	9.30	±0.46	0.931	7.77[b]	10.65[a]	7.73[b]	10.86[a]	±0.46	0.001

*The means within the same row that have at least one common letter, do not have significant difference (P>0.05).
LP, low protein, and HP, high protein.
LE, low energy, and HE, high energy.

economic efficiency increased (P<0.05) energy with in high diet. Furthermore, LP-HE diet recorded the lowest feed cost, while HP-HE diet showed the lowest feed cost per kg 7% FCM and the highest total revenue and economic efficiency (P<0.05). These results may be attributed to the higgher price of soybean meal (1900 LE/ton) compared to corn grain (1600 LE/ton).

Reproductive performance

Results in Table 7 showed that dietary protein level did not affect postpartum reproductive performance of lactating buffaloes (P>0.05). However, the periods from parturition to first estrus and first service, service period, days open and number of services per conception decreased (P<0.05), but conception rate increased (P<0.05) in high energy diet. Moreover, buffaloes fed HP-HE diet showed short periods from parturition to first estrus and first service, service period, days open, the lowest number of services per conception to first estrus and first service, service period, days open and number of services per conception decreased (P<0.05), but conception rate increased (P<0.05) in high energy diet. Moreover, buffaloes fed HP-HE diet showed short periods from parturition to first estrus and first service, service period, days open, the lowest number of services per conception and the highest conception rate, but buffaloes fed LP-LE diet had the opposite trend (P<0.05).

Table 4 Average daily feed intake (kg/head) by lactating buffaloes fed experimental rations*

Item	Protein level				Energy level				Interaction (protein . energy)					
	LP	HP	MSE	P-value	LE	HE	MSE	P-value	LP-LE	HP-LE	LP-HE	HP-HE	MSE	P-value
DM	15.64	15.87	±0.10	0.262	15.58	15.75	±0.10	0.075	15.46	15.69	15.81	16.05	±0.10	0.220
TDN	9.82	10.03	±0.14	0.495	9.49	10.37	±0.14	0.002	9.38[b]	9.59[b]	10.26[a]	10.47[a]	±0.14	0.002
DCP	1.21	1.71	±0.08	0.002	1.44	1.48	±0.08	0.781	1.20[c]	1.67[b]	1.22[c]	1.74[a]	±0.08	0.002

*The means within the same row that have at least one common letter, do not have significant difference (P>0.05).
LP, low protein, and HP, high protein.
LE, low energy, and HE, high energy.

Table 5 Average daily milk and composition of lactating buffaloes fed experimental rations*

Item	Protein level				Energy level				Interaction (protein . energy)					
	LP	HP	MSE	P-value	LE	HE	MSE	P-value	LP-LE	HP-LE	LP-HE	HP-HE	MSE	P-value
Average milk yield (kg/day)														
Actual	13.41	14.98	±0.45	0.081	12.94	15.45	±0.45	0.001	12.04[d]	13.83[c]	14.77[b]	16.13[a]	±0.45	0.001
7% FCM	11.32	12.85	±0.38	0.037	11.14	13.02	±0.38	0.005	10.27[c]	12.02[b]	12.37[b]	13.68[a]	±0.38	0.001
Milk composition %														
Fat	5.53	5.65	±0.04	0.151	5.67	5.50	±0.04	0.032	5.60[ab]	5.75[a]	5.45[b]	5.55[ab]	±0.04	0.060
Protein	4.16	4.45	±0.06	0.012	4.18	4.44	±0.06	0.030	4.01[c]	4.34[b]	4.31[b]	4.56[a]	±0.06	0.002
Lactose	5.60	5.75	±0.06	0.208	5.53	5.83	±0.06	0.003	5.45[c]	5.60[bc]	5.75[ab]	5.90[a]	±0.06	0.007
SNF	10.47	10.91	±0.12	0.058	10.41	10.97	±0.12	0.011	10.17[c]	10.65[b]	10.76[b]	11.17[a]	±0.12	0.003
TS	15.99	16.56	±0.13	0.021	16.09	16.47	±0.13	0.155	15.77[b]	16.40[ab]	16.21[ab]	16.72[a]	±0.13	0.040
Ash	0.71	0.71	±0.002	1.000	0.71	0.70	±0.002	0.004	0.71[a]	0.71[a]	0.70[b]	0.70[b]	±0.002	0.001

*The means within the same row that have at least one common letter, do not have significant difference (P>0.05).
LP, low protein, and HP, high protein.
LE, low energy, and HE, high energy.

Table 6 Feed conversion and economic efficiency for lactating buffaloes fed experimental rations

Item	Protein level				Energy level				Interaction (protein . energy)					
	LP	HP	MSE	P-value	LE	HE	MSE	P-value	LP-LE	HP-LE	LP-HE	HP-HE	MSE	P-value
Feed conversion per kg 7% FCM														
DM (kg)	1.39	1.24	±0.04	0.028	1.41	1.23	±0.04	0.006	1.51[a]	1.31[b]	1.28[b]	1.17[c]	±0.04	0.001
TDN (kg)	0.87	0.78	±0.02	0.002	0.86	0.80	±0.02	0.082	0.91[a]	0.80[bc]	0.83[b]	0.77[c]	±0.02	0.001
DCP (g)	107.76	133.14	±4.49	0.001	127.94	112.97	±4.49	0.096	116.86[c]	139.01[a]	98.67[d]	127.26[b]	±4.49	0.001
Economic efficiency (LE)														
Feed cost	18.87	20.26	±0.30	0.012	20.10	19.03	±0.30	0.075	19.04[b]	21.15[a]	18.69[b]	19.37[b]	±0.30	0.001
Feed cost/7% FCM	1.68	1.59	±0.05	0.408	1.81	1.46	±0.05	0.001	1.85[a]	1.76[b]	1.51[c]	1.42[d]	±0.05	0.001
Total revenue	33.96	38.54	±1.14	0.037	33.43	39.07	±1.14	0.005	30.82[c]	36.05[b]	37.11[b]	41.03[a]	±1.14	0.001
Economic efficiency	1.80	1.91	±0.06	0.399	1.66	2.05	±0.06	0.001	1.62[d]	1.70[c]	1.98[b]	2.12[a]	±0.06	0.001

*The means within the same row that have at least one common letter, do not have significant difference (P>0.05).
LP, low protein, and HP, high protein.
LE, low energy, and HE, high energy.

Table 7 Reproductive performance of lactating buffaloes fed experimental rations*

Item	Protein level				Energy level				Interaction (protein . energy)					
	LP	HP	MSE	P-value	LE	HE	MSE	P-value	LP-LE	HP-LE	LP-HE	HP-HE	MSE	P-value
First estrus (day)	35.88	34.29	±1.45	0.608	39.78	30.39	±1.45	0.002	40.50^{a}	39.05^{a}	31.25^{b}	29.53^{c}	±1.45	0.001
First service (day)	59.69	58.37	±1.79	0.729	64.84	53.22	±1.79	0.003	65.52^{a}	64.15^{a}	53.86^{b}	52.58^{b}	±1.79	0.002
Service period (day)	44.11	43.03	±0.90	0.575	46.42	40.71	±0.90	0.002	46.85^{a}	45.99^{a}	41.36^{b}	40.06^{b}	±0.90	0.002
Days open (day)	103.80	101.39	±2.68	0.675	111.25	93.93	±2.68	0.004	112.37^{a}	110.13^{a}	95.22^{b}	92.64^{b}	±2.68	0.003
No. service/conception	2.05	1.95	±0.11	0.662	2.35	1.65	±0.11	0.001	2.40^{a}	2.30^{b}	1.70^{c}	1.60^{d}	±0.11	0.001
Conception rate %	64.29	64.29	±2.18	1.000	57.14	71.43	±2.18	0.002	57.14^{b}	57.14^{b}	71.43^{a}	71.43^{a}	±2.18	0.002

*The means with in the same row that have at least one common letter, do not have significant difference (P>0.05).
LP, low protein, and HP, high protein.
LE, low energy, and HE, high energy.

These results are in accordance with those obtained by Chapa *et al.* (2001) who found that the reproduction of postpartum group cows was unaffected by protein supplements. Law *et al.* (2009) reported that there was no effect of dietary protein content on post-partum reproductive performance. Cumulative energy balance was positively associated with conception. El-Ashry *et al.* (2003) showed that buffaloes fed the high energy level recorded the shorter days open.

CONCLUSION

From the present results it can be concluded that productive performance improved by iwhile reproductive performance improved by increasing dietary energy.

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