Turk. J. Vet. Anim. Sci.
2007; 31(4): 259-265

Research Article

Influence of Bovine Somatotropin and Replacement of Corn Dextrose with Concentrate on the Performance of Mid-Lactating Buffaloes Fed Urea-Treated Wheat Straw

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Received: 15.12.2006

Abstract: The study examined the effect of bovine somatotropin (bST) in mid-lactating Nili-Ravi buffaloes (n = 18) given varying levels of Enzose (corn dextrose) in a urea-treated wheat straw (UTWS) based ration on nutrient intake, digestibility, nitrogen (N) utilisation, milk yield, and its composition in a completely randomised design with a 2×3 factorial arrangement. The control ration contained 60% UTWS and 40% concentrate. The other 2 rations were formulated to replace 50% or 100% concentrate portions of the ration with Enzose of equivalent energy. Enzose is a liquid derived from the enzymatic conversion of corn starch to dextrose, and is light amber in colour. These rations were offered to buffaloes administered 0 or 250 mg bST, biweekly, for a period of 100 days. The bST administration increased ($P < 0.05$) dry matter (DM), crude protein (CP), nitrogen (N) retention, neutral detergent fibre (NDF), and acid detergent fibre (ADF) intakes. Buffaloes fed a ration containing 50% Enzose as replaced by concentrate had higher DM, CP, NDF, and ADF intakes than those fed 100% Enzose. The NDF and ADF digestibilities, daily milk yield, and milk fat% were also increased by bST administration while the reverse was true for buffaloes fed replacement of 100% concentrate. Overall N balance was not affected either by bST administration or Enzose addition to the ration. Enzose interacted ($P < 0.05$) with bST for milk yield and milk ash contents. The bST administration in buffaloes increased milk production by 37%. Up to 50% concentrate can be replaced with Enzose in the ration.

Key Words: Bovine somatotropin, Enzose, digestion, intake, milk, nitrogen balance, buffalo

Introduction

In developing countries, livestock are usually fed on abundantly available high fibrous crop residues (wheat straw, rice straw, stovers, and corncobs) characterised by high indigestible fibre due to increased lignification of cellulose (1). Fermentable energy and protein deficiencies in crop residues coupled with their low digestibility impair intake, ruminal functions, and thus ruminant productivity (1,2). The situation strongly demands improvement in the nutritive value of high fibrous crop residues through various treatments, exploration and biological evaluation of new feedstuffs, and, above all, efficient utilisation of existing feed resources.

Various physical, chemical, and biological treatments have been reported to improve the nutritive value of high fibrous crop residues (3,4). However, urea treatment is most frequently used by the farming community to improve the feeding value of wheat straw for buffaloes as it is cost effective and farmer friendly. Enzose, a by-product of the corn industry, is a liquid derived from the enzymatic conversion of corn starch to dextrose and is a cheap energy source similar to molasses due to available fermentable sugars (5).

Efficient utilisation of feed resources by dairy animals has been the subject of intense research among dairy nutritionists in recent years. Various nutritive and non-nutritive tools at dietary, ruminal, intestinal, and cellular levels have been reported, which not only increase dry matter intake but also ensure efficient nutrient utilisation by dairy animals. Administration of bST has been reported to increase milk yield per unit of feed input (6,7). In dairy cattle, use of bST resulted in 12%-25% improvement in milk yield and better feed efficiency without any substantial alteration in the composition of

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milk (8,9). Cows adjust their voluntary feed intake to support increased milk yield, which reduces the proportion of maintenance requirement out of total nutrient intake (10). These productive responses are attributed to coordinated metabolism changes in various body organs and tissues that support increased synthesis of lactose, fat, and protein in mammary glands (11).

Sufficient literature is available regarding bST's effect on milk yield and composition in exotic dairy cows; however, limited information is available regarding the use of bST on the productive performance of lactating buffaloes. Moreover, the physiological status, environmental conditions, and feeding strategies of buffalo vary from those of exotic dairy cows in temperate regions and bST responses of cows may not be of worth for direct application to buffaloes. Therefore, the present study was planned to examine the effect of bST administration in mid-lactating Nili-Ravi buffalos fed different levels of Enzose in a urea-treated wheat straw based ration on nutrients intake, digestibility, N utilisation, milk yield, and its composition.

Materials and Methods

Treatment of wheat straw

The urea treatment method used in this study was to add 4 kg of urea and 50 kg of water per 100 kg of air-dry wheat straw. After the urea was dissolved in the water, the solution was uniformly sprayed on the wheat straw. The wheat straw was ensiled in a cemented trench silo ($3 \times 10 \times 2$ m) for 15 days. The pit was covered with a 15-cm thick layer of rice straw, followed by polyethylene film covering plastered with a blend of wheat straw and mud to avoid any cracking on drying. When UTWS was used, the plastic film was removed, and UTWS was withdrawn starting with the upper layer and working downwards to the lower layers. An amount of UTWS was taken out just sufficient for 1 day's feeding after being taken from the pit and the plastic film was put back to keep the pit sealed. The samples of UTWS were analysed for dry matter (DM), organic matter (OM), and total nitrogen (N). Neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) were determined as described by Van Soest et al. (12). The chemical composition of the wheat straw, UTWS, and Enzose is given in Table 1.

Animals and diets

Eighteen multi-parous (3-4 parity) Nili-Ravi buffaloes, in mid-lactation, were used in a 2×3 factorial arrangement to evaluate the effect of bST (0 or 250 mg), given different levels of Enzose (supplied by Rafhan Maize Products Co. Limited, Faisalabad, Pakistan) to replace the concentrate portion in the ration on feed intake, digestibility, milk yield, and its composition. Three iso-caloric and iso-nitrogenous rations were formulated according to NRC (13) values for energy and protein (Table 2). Ration 1 contained 60% UTWS and 40% concentrate (corn, sunflower meal, and popcorn) on a DM

Table 1. Chemical composition of wheat straw, UTWS [A], and Enzose [B] on a dry matter basis.

Items (% dry matter basis)	Wheat straw	UTWS	Enzose
Dry matter	91.3	72.5	69.2
Crude protein	1.72	6.51	4.12
Ash	3.03	3.82	9.83
pH	-	-	4.35
Lactic acid (g/l)	-	-	180
Dextrose	-	-	78.7
Fructose	-	-	1.13
Neutral detergent fibre	77.1	72.1	-
Acid detergent fibre	45.5	43.0	-
Lignin	6.0	5.4	-

[A] urea-treated wheat straw, wheat straw was treated with 4% urea dissolved in 50 kg of water and ensiled for 15 days in a trench silo.

[B] Enzose is a liquid derived from the enzymatic conversion of corn starch to dextrose, and is light amber in colour.

Table 2. Ingredients and chemical composition of experimental rations having different concentrations of Enzose (corn dextrose).

Ingredients (%)	Ration 1	Ration 2	Ration 3
Urea-treated wheat straw [A]	60	60	60
Corn broken	10.5	4.0	---
Sunflower meal	7.0	4.0	---
Popcorn	19	10.0	---
Di-calcium phosphate	2.0	2.0	2.0
Salt	1.0	1.0	1.0
Urea	0.5	1.0	1.6
Enzose [B]	---	18	35.4
Total	100	100	100
Chemical composition (%)			
Crude protein	16.1	15.9	16.1
Neutral detergent fibre	55.7	50.1	43.9
Ether extract	2.3	1.7	1.1
NE_L(Mcal/kg DM)	1.36	1.37	1.40

[A] urea-treated wheat straw, wheat straw was treated with 4% urea dissolved in 50 kg of water and ensiled for 15 days in a trench silo.

[B] Enzose is a liquid derived from the enzymatic conversion of corn starch to dextrose, and is light amber in colour.

basis with no Enzose. Ration 2 contained 60% UTWS, 20% concentrate, and 18% enzose (to replace 50% of the concentrate portion in the ration). Ration 3 contained 60% UTWS and 35.4% Enzose (to replace 100% concentrate portion in the ration). Each ration was given to 6 buffaloes; out of those, each 3 animals were injected with bST at a rate of 0 or 250 mg/animal, fortnightly. The rations were mixed daily and fed ad libitum 3 times a day. Water was also offered ad libitum. Daily feed intake, orts, and milk production were monitored and recorded throughout the trial.

The experiment continued for 100 days. The first 20 days were for dietary adaptation and the remaining 80 days were used for data collection. Nutrient intake and milk production were averaged over 80 days.

Samples and analyses

Milk samples (a.m. and p.m.) were collected twice weekly during the last 80 days of the feeding trial and were analysed for crude protein (CP), fat, solid not fat (SNF), total solids (TS), and ash by the methods described by the AOAC (14). Data for determination of nutrient digestibility were collected in the last week of the experiment. Complete collections of urine and faeces were carried out according to the procedures described by Nisa et al. (15). Faeces were collected daily, dried at 55 °C, bulked and mixed, and sampled for analysis. Urine, after collection, was acidified with 50% H_2SO_4, stored, mixed and sampled for N analysis. Feed, orts, and faecal samples were dried at 55 °C and ground through a Wiley mill using 2 mm screen. These samples were analysed for DM, N, and OM using the method described by the AOAC (14), and for NDF, ADF, and ADL according to Van Soest et al. (12).

Statistical analysis

The data on nutrient intake, digestibility, milk production, milk composition and nitrogen balance were analysed according to a completely randomised design with factorial arrangements of treatments. The differences in means were tested using Duncan's multiple range test (16). After the initial statistical analysis it was found that interactions between dietary Enzose levels and bST treatment were non-significant for all the parameters except for milk yield and milk ash percentage. Therefore, the interaction term was dropped and the data were reanalysed.

Results

Nutrient intake and digestibility

Buffaloes treated with bSt had higher DM, CP, NDF, and ADF intake compared to the untreated ones (Table 3). The bST-treated buffaloes had 12.5%, 13%, 12.3%, and 12.6% higher ($P < 0.05$) DM, CP, NDF, and ADF intake, respectively, than those of untreated buffaloes. Nutrient intake was increased in buffaloes fed 50% Enzose as a replacement of ration concentrate. However, a reduction ($P < 0.05$) in DM (8.4 vs. 12.3 kg/day) and CP (1.3 vs. 1.9 kg/day) intake was noted in buffaloes when concentrate was completely replaced by Enzose.

The digestibilities of DM and CP remained unaltered by bST treatment in buffaloes (Table 3). However, NDF and ADF digestibilities were higher ($P < 0.05$) in bST-treated buffaloes than in untreated buffaloes. Maximum NDF (74%) and ADF (76%) digestibilities were noted in buffaloes fed the diet without Enzose.

Nitrogen balance

Buffaloes treated with bST had 12.5% higher N intake than untreated buffaloes (Table 4). Faecal N and urinary N remained unchanged by bST treatment. Thus, apparent N absorption and N retention, as percent of intake, increased ($P < 0.05$) in bST-treated buffaloes. Milk N was 26% higher in bST-treated buffaloes compared to untreated animals. Nitrogen intake and faecal nitrogen decreased ($P < 0.05$) in buffaloes when all concentrate in the ration was replaced with Enzose. However, apparent N absorption and N retention in the body remained the same ($P > 0.05$) across all Enzose treatments.

Milk yield and composition

Milk production of bST-treated buffaloes was 8.2 kg/day as compared with 6 kg/day in untreated buffaloes. Thus, bST treatment increased milk yield by about 37% (Table 5). Inclusion of Enzose reduced milk production in the buffaloes.

Table 3. Effect of varying levels of Enzose in diet and bST administration on nutrient intake in mid-lactating Nili-Ravi buffaloes.

Intake (kg/day)	Treatment								
	bST			Enzose[A]				P Values	
	0 mg	250 mg	SEM	E0	E50	E100	SEM	bST	Enzose
DM[B]	10.4[b]	11.7[a]	0.27	12.3[a]	12.6[a]	8.4[b]	0.33	0.009	0.01
Dig. %	62.6	65.5	1.09	62.8	63.3	65.9	1.34	0.09	0.25
CP[C]	1.7[b]	1.9[a]	0.04	1.9[a]	2.0[a]	1.3[b]	0.05	0.009	0.01
Dig.	69.3	71.9	1.21	68.3	71.1	72.5	1.49	0.16	0.19
NDF[D]	2.9[b]	3.3[a]	0.08	4.1[a]	3.4[b]	1.8[c]	0.09	0.01	0.01
Dig.	65.9	68.5	0.66	72.9	68.8	59.9	0.81	0.03	0.02
ADF[E]	1.6[b]	1.8[a]	0.04	2.1[a]	1.9[b]	1.1[c]	0.05	0.009	0.01
Dig. %	70.7	75.8	0.78	75.5	74.5	69.6	0.95	0.01	0.01

[A] In E0, E50 and E100 diets, Enzose (corn dextrose) replaced 0%, 50%, and 100% concentrates portion of the rations
Interactions between bST and Enzose were non-significant for all parameters
[B] Dry matter
[C] Crude protein
[D] Neutral detergent fibre
[E] Acid detergent fibre
Means within the same row having different subscripts differ significantly ($P < 0.05$).

Table 4. Effect of varying levels of Enzose in diet and bST administration on N balance in mid-lactating Nili-Ravi buffaloes.

Parameter (g/day)	Treatment								
	bST			Enzose^{A}				P Values	
	0 mg	250 mg	SEM	E0	E50	E100	SEM	bST	Enzose
N^{B} intake	269.4^{b}	303.2^{a}	6.9	319.4^{a}	326.6^{a}	212.9^{b}	8.52	0.01	0.02
Fecal N	87.2	87.3	2.3	100.8^{a}	102.1^{a}	58.9 ^{b}	2.79	0.98	0.01
N apparent absorption	182.2^{b}	215.9^{a}	5.7	218.6^{a}	224.5^{a}	154.2^{b}	7.04	0.02	0.01
% of intake	68.1^{b}	71.4^{a}	0.68	68.3^{b}	68.6^{b}	72.4^{a}	0.84	0.01	0.01
Urinary N	2.7	2.6	0.20	2.8	2.4	2.6	0.24	0.62	0.52
N apparent retention	179.5^{b}	213.3^{a}	5.66	215.8^{a}	222.1^{a}	151.4^{b}	6.93	0.03	0.01
% of intake	67.1^{b}	70.5^{a}	0.62	67.4^{b}	67.8^{b}	71.1^{a}	0.76	0.02	0.02
Milk N	44.3^{b}	62.6^{a}	1.39	61.0^{a}	52.7^{b}	46.5^{b}	1.70	0.01	0.02
% of intake	16.8^{b}	21.2^{a}	0.69	18.1^{b}	16.9^{b}	21.8^{a}	0.85	0.03	0.01
N balance	135.2	150.8	5.49	154.8^{a}	169.4^{a}	104.8^{b}	6.73	0.08	0.01
% of intake	50.3	49.4	0.91	48.4	51.8	49.4	1.11	0.48	0.15

[A] In E0, E50 and E100 diets, Enzose (corn dextrose) replaced 0%, 50%, and 100% concentrates portion of the rations

Interactions between bST and Enzose were non-significant for all parameters.

[B] Nitrogen

Means within the same row having different subscripts differ significantly ($P < 0.05$).

Table 5. Effect of varying levels of Enzose in diet and bST administration on milk production and composition in mid-lactating Nili-Ravi buffaloes.

Parameter (g/day)	Treatment									
	bST			Enzose^{A}				P Values		
	0 mg	250 mg	SEM	E0	E50	E100	SEM	bST	Enzose	bST × Enzose
Milk yield (kg/day)	6.0^{b}	8.2^{a}	0.21	8.1^{a}	6.9^{b}	6.2^{c}	0.26	0.01	0.01	0.03
Crude protein	4.6	4.8	0.06	4.7	4.8	4.7	0.07	0.09	0.76	NS
Fat	6.8^{b}	7.4^{a}	0.18	6.5^{b}	7.2^{a}	7.7^{a}	0.22	0.04	0.01	NS
Total solid	14.8	15.5	0.23	14.5^{b}	15.2^{ab}	15.9^{a}	0.28	0.06	0.02	NS
Solid not fat	8.0	8.1	0.07	8.0	8.1	8.2	0.08	0.16	0.34	NS
Ash	0.8	0.8	0.02	0.8	0.8	0.8	0.02	0.47	0.74	0.04

[A] In E0, E50 and E100 diets, Enzose (corn dextrose) replaced 0%, 50%, and 100% concentrates portion of the rations

Means within the same row having different subscripts differ significantly ($P < 0.05$).

NS: Non-significant

The CP, TS, SNF, and ash% of milk were not affected by bST treatment (Table 5). Milk fat percent increased ($P < 0.05$) with bST administration. Percent milk fat increased by 11% and 19% when Enzose was replaced by concentrate portion of ration by 50% and 100%, respectively.

Discussion

Increased DM intake due to bST treatment in buffaloes might be attributed to the homeorhetic regulation of bST. The rapid utilisation of nutrients by the animal body might have resulted in more nutrient demand for milk synthesis, which ultimately increased nutrient intake. Low intake of DM when 100% concentrate portion of the ration was replaced with Enzose was due to low pH of the Enzose and poor palatability, which might have depressed the DM intake as reported by Sarwar et al. (5). In contrast to the present findings, Vallimont et al. (17) found no effect of bST administration on nutrient intake by Holsteins.

Increased digestibilities of NDF and ADF by bST administration are in line with those reported by Poore et al. (18) and Yu (19), who indicated increased NDF and ADF digestibilities with bST administration. It is speculated that buffaloes fed 50% Enzose as a replacement of ration concentrate might have ensured the provision of C-skeleton for the multiplication of rumen microbes, which in turn might have increased the nutrient digestibilities. However, decreased NDF and ADF digestibilities with increased levels of Enzose may have been due to the low pH of the Enzose, which may have reduced rumen pH, causing a decline in the population of cellulolytic bacteria (5).

Increased apparent N absorption and retention in bST-treated buffaloes were because of increased N intake. Similar findings have been reported by Grantley-Smith et al. (20), who reported that administration of bST enhanced nitrogen retention in dairy and whole-body protein synthesis. They also reported that bST treatment increased N utilisation up to 40%. Increased N absorption and retention in animals fed an increased level of Enzose might be because of enhanced N utilisation and retention by minimising N loss at ruminal level (21). Enzose treatment may have increased the N fixation in the matrix of cell wall fibre, which consequently resulted in slow release of N in the rumen. This might have maximised N synchronisation with carbon skeleton and minimised the N loss (22).

Increased milk yield in response to bST was attributed to homeorhetic control of the body. De Boar and Kennelly (23) observed reduced molar proportions of propionate by bST treatment in dairy animals. They speculated that it might be due to greater requirement for nutrients associated with enhanced milk yield. However, in contrast to these findings (23), increased conversion of propionate to glucose in the liver has also been documented in dairy cows treated with bST (24). An enhanced conversion of propionate to glucose might have increased propionate absorption from the rumen. Thus, increased ruminal propionate might have spared more glucose for lactose synthesis, a key requisite for increased milk production. Decreased milk yield with an increased level of Enzose was because of decreased DM intake, which ultimately reduced milk production (25). Improved milk fat% with bST administration was due to mobilisation of the fat reserves of the animal, which is most likely to occur just after the start of the treatment. These results have been reported by many researchers (26-28), who reported increased milk fat% in response to bST treatment. Enzose addition in the ration improved fat% in the milk.

In conclusion, replacement of 50% concentrate portion of the ration with Enzose, when UTWS formed 60% of the total mixed ration, in combination with bST treatment at rate of 250 mg per animal fortnightly increased milk production in Nili-Ravi buffaloes. Replacement of 100% concentrate portion of the total mixed ration with Enzose may adversely affect the nutrient intake and production performance of buffaloes. However, further research is warranted to examine the influence of different sources and levels of readily fermentable carbohydrates along with bST treatment.

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