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Effects of Supplemental Dietary Biotin on Performance of Holstein Dairy Cows

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Abstract: An experiment was conducted to evaluate the effect of different levels of biotin on productive performance of Holstein dairy cow. In this experiment a change-over design with twelve multiparous cows, three rations and three periods was employed. Ingredients of the basal diet were alfalfa hay (24%) corn silage (16%) and concentrate (60%) on dry matter basis. The experimental diets 1 to 3 contained 0, 10 and 20 mg of biotin per day, respectively. The rations were fed to cows as Total Mixed Rations (TMR), but biotin was top-dressed on the a.m. allotment of ration. The cows were individually ad libitum and milked three times per day. Daily milk yielded was recorded and samples of the milk were taken once per week for determination of milk composition. Blood were taken in end of each period. Dry Matter Intake (DMI) and milk yield of cows were not affected by biotin. Also milk compositions were not affected by biotin. The average of Fat Corrected Milk (FCM) yield for 4% fat for rations contain 0, 10 and 20 mg day^{-1} biotin, respectively 25.45, 26.2 and 25.9 kg day^{-1} were calculated. Blood concentration of were unaffected by different levels of biotin. The differences between averages of the milk cows were not significant.

Key words: Dairy cows, biotin, multiparous cows

INTRODUCTION

Although, a B-vitamin, is synthesized in the rumen, but in the literature B-vitamin supplementation improved lactation performance (Baldwin and Allison, 1983; Midla *et al*., 1998; Zimmerly and Weiss, 2001). Shaver and Bal (2000) and Girard and Matte (1998) showed that supplemental dietary folic acid (1.3 to 2.5 g day^{-1}) and thiamin (150 to 300 mg day^{-1}) increased milk yield in multiparous cows. Milk yield response to vitamin B12 injections (10 mg week) and choline supplemented in a ruminally-protected form were positive (Girard and Matte, 2003; Sharma and Erdman, 1988). Da Costa Gomez *et al*. (1998) showed that in *vitro* synthesis of biotin decreases as the concentrate to forage ratio increases from 17:83 to 50:50. Biotin is involved with gluconeogenesis, propionate metabolism, fatty acid synthesis and amino acid degradation. Pyruvate carboxylase, propionyl-CoA carboxylase, acetyl-CoA carboxylase and beta-methylcrotonyl-CoA carboxylase require biotin as a cofactor to complete a carbon dioxide fixation reaction (Dakshinamurti and Chauhan, 1988). Supplemental dietary biotin (20 mg day^{-1}) improved hoof health and milk yield (Midla *et al*., 1998). Several studies have shown that biotin can increase milk production and cow performance. Milk yield increased linearly with 0, 10 and 20 mg day^{-1} biotin supplemented in diets from 14 day prepartum through 100 day postpartum (Zimmerly and Weiss, 2001). Effects of B vitamins were investigated on periparturient metabolic status and lactation of dairy cows (Minor *et al*., 1998; Rosendo *et al*., 2004). Also effects of B vitamins and biotin in human were exanimated (Said *et al*., 1992; Shriver *et al*., 1993). Dairy cow for keratinization, differentiation of epidermal cells and proper hoof structure need to biotin. The objective of this study was to evaluate the effects of different level of biotin supplementation (10 or 20 mg day^{-1}) on milk production, DMI and plasma metabolites of Holstein dairy cows in Iran.

MATERIALS AND METHODS

Cows and diets: In this experiment, 12 multiparous Holstein dairy cows with an average live weight of 620±15 kg selected from the Tehran University herd in Research Unit of Karaj and were randomly assigned to

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treatments in a replicated 3×3 change-over design with 28 day periods. This experiment conducted from November 2003 to April 2004. All cows were placed in individual pens with concrete floors that were cleaned regularly and fed individually *ad libitum*. Diets were formulated with prevalent ingredient that used for fed animal in Tehran (Iran). Feed intake measurements and Animals were fed one of three diets. Cows averaged Days In Milk (DIM) at trial initiation were 80±10. The three treatments were: 1) control diet © with no supplemental biotin; 2) C plus supplemental biotin at 10 mg day^{-1}; 3) C plus supplemental biotin at 20 mg day^{-1} supply of premixes needed for the trial were prepared prior to the start of the trial by Roche Vitamins. The rations were fed to cows as Total Mixed Rations (TMR), but biotin was top-dressed on the a.m. The diets were fed twice daily (0900 and 1800 h)and feed offered was adjusted daily about 5-10% orts. The TMR was comprised of 24% alfalfa, 16% corn silage and 60% of a concentrate mix to formulate diets to meet NRC (2001) NEL, CP, RUP, macro- and micro-mineral and vitamins. The concentrate consisted of ground barley, SBM, cottonseed meal, corn, wheat, wheat bran, Salt, Limestone, Bicarbonateand a vitamin+mineral premix (240, 150, 183.3, 158.3, 116.7, 116.7, 3.4, 13.3, 11.6 and 6.7 g kg^{-1} DM, respectively). The average chemical composition of diet was shown in Table 1. Cows had free access to water at all times during the experiment.

Sample collection: Body weights and Body condition scores (1 to 5 scale) of all animals were measured at the beginning the trial and end of each period and body weight change recorded. One evaluator was assessed all animals for BCS. The cows were individually ad libitum and milked three times per day. Cows were milked three times per day at 0350, 1200 and 2000 h. Milk yield was measured and samples of the milk were taken once per week for determination of milk composition via AOAC (1995). Milk fat, protein, lactose and somatic cell count were averaged for all three milking. DMI were measured daily. Blood samples were obtained from the jugular vein into 10 mL heparinized, evacuated glass tubes at the end of each period (1 to 3). Blood samples were collected in heparinized tubes, stored on crushed ice and immediately transported to the central laboratory of animal science department. Blood samples were centrifuged at 1500x g for 30 min at 4°C and plasma was harvested into polypropylene tubes and stored at -20°C for subsequent analysis.

Plasma samples from all cows were analyzed for glucose and insulin concentrate. Insulin kit provide from

Table 1: Ingredient and chemical composition of basal diet

Item Dietary ingredients, (%) of dietary DM	Basal diet
Alfalfa	24.00
Corn silage	16.00
Barley	14.40
Soybean meal	9.00
Cottonseed meal	11.00
Corn, ground	8.80
Wheat	7.00
Wheat brain	7.00
Salt	0.20
Limestone	0.80
Trace mineral and vitamin premix	0.40
Bicarbonate	0.70
NEL (Mcal kg^{-1})	1.60
CP	17.90
NDF	33.41
ADF	19.50
Ca	0.80
P	0.50

Kavoush laboratory. Feedstuffs were sampled weekly and were dried at 55°C for 48 h and ground through a 1 mm screen. Samples were analyzed for NDF, ADF, N and minerals. The nitrogen and ash in feeds and residues determined according to AOAC (1995) and Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were analyzed, using an automatic fiber analyzer (Fibertec System M, Tecator, USA).

Statistical analyses: Data were analyzed using the general linear models procedure of SAS (1999) with the following statistical model of $Y_{ijk} = \mu + T + P_j + B_k + A_L + R_m + E_{ijklm}$ where Y is the dependent variable, μ the overall mean, T_i effect of treatment, P_j period effect, B_k block effect, Al cow effect, $R_{m\ \text{remain effect of pervious period}}$ E_{ijklm} is the residual error (SASISTAT, 1999).

RESULTS

Average dry matter intake for animals that fed different level of biotin supplementation 0, 10 and 20 mg in day were 22.2, 23.1 and 23.41, respectively that biotin supplementation had no significant effect on DMI.

Although with increase biotin supplementation, DMI increased. Also Biotin supplementation had no significant effect on milk production. Average milk yield for treatment 1 to 3 was 32, 32 and 32.5 kg day^{-1}. Biotin supplementation had no effect on change in body weight or condition score. In this experiment body weight change between treatment were 0.25±0.18, 0.27±0.06 and 0.3±0.14 for 1 to 3 treatment that differences were not significant ($p>0.05$).

Milk productions for 4% fat corrected milk for treatment 1 to 3, respectively were 25.45, 26.2 and

Table 2: Impact of dietary supplementation with biotin on BWC, DMI and milk production and composition

	Supplemental biotin (mg day^{-1})			
Treatments	0	10	20	SE
BWC (kg day^{-1})	0.25	0.27	0.24	0.13
DMI (kg day^{-1})	22.20	23.10	23.41	0.34
BCS	3.25	3.25	3.30	0.10
Milk production (kg day^{-1})	32.10	32.41	32.10	0.80
Fat production (kg day^{-1})	0.81	0.88	0.87	0.05
Protein production (kg day^{-1})	0.79	0.88	0.85	0.02
Lactose production (kg day^{-1})	1.58	1.60	1.54	0.04
FCM (4%)	25.45	26.20	25.93	0.63
Milk composition				
Fat (%)	2.80	2.85	2.85	0.07
Protein (%)	2.77	2.73	2.77	0.03
Lactose (%)	4.99	4.99	4.99	0.03
SCC(1000 mL^{-1})	540.58	471.00	380.00	106.00

0 = Control Diet with no supplemental; 10, 20 = Supplemental biotin at 10 and 20 mg day^{-1}, BWC = Body Weight Change, DMI = Dry Matter Intake, FCM = Fat Corrected milk, BCS = Body Condition Score, SCC = Somatic Cell Count

Table 3: Impact of dietary supplementation with biotin on plasma concentration of glucose and insulin

	Supplemental biotin (mg day^{-1})			
Treatments	0	10	20	SE
Glucose in first period (mg dL^{-1})	55.00	56.00	60.30	3.13
Glucose in second period (mg dL^{-1})	55.50	55.00	58.00	2.34
Glucose in third period (mg dL^{-1})	54.00	57.50	59.50	3.10
Insulin in first period (ng mL^{-1})	0.52	0.54	0.50	0.03
Insulin in second period (ng mL^{-1})	0.54	0.54	0.51	0.03
Insulin in third period (ng mL^{-1})	0.54	0.55	0.515	0.04

0 = control diet with no supplemental; 10, 20 = supplemental biotin at 10 and 20 mg day^{-1}

25.93 kg day^{-1}. Milk fat, protein and lactose percentages and fat, protein and lactose yield were not significantly affected by treatments (Table 2). Plasma glucose concentrations in all period were not different across treatments ($p>0.05$), also treatment did not affect, plasma concentrations of insulin (Table 3).

DISCUSSION

Because of analytical and instrument problems we can't measurement biotin, therefore, in this experiment we study effect of supplemental biotin on performance and milk composition and concentration of plasma glucose and insulin. Biotin supplementation had no significant effect on DMI. In beginning of experiment cows days in milk were 80±10 and cows Dry Matter Intake (DMI) increased with increase DIM, but this increase for all animals and treatment were similarly. Zimmerly and Weiss (2001) evaluated 0, 10 and 20 mg day^{-1} supplemental dietary biotin and DMI was not different across treatments during the first 100 DIM. Margerison *et al.* (2002) reported a lack of DMI response to 20 mg day supplemental dietary biotin during the first 120 DIM. Our study support this studies.

Biotin supplementation had no significant effect on milk yield also milk productions for 4% fat corrected milk. Previous results reported that supplementing lactating cows with 10 and 20 mg of biotin/day increased milk production. Midla *et al.* (1998) and Bergsten *et al.* (1999) reported increased mature milk production (1.0 to 2.9 kg day^{-1}, respectively) when cows were fed 20 mg of supplemental biotin/day certainly in our study milk production for 4% corrected fat was increased with supplementation biotin and this increase for 10 mg day^{-1} supplementation of biotin was higher (Table 2), although this increase don't significant. Possible ways that milk production could be increased with biotin supplementation include increased DMI caused by improved hoof health, a shift in nutrient partitioning from body tissue to milk, increased glucose production and increased cellulose digestion. In this study, DMI and glucose was not different across treatments, also nutrient partitioning and cellulose digestion do not measurement.

Milk fat, protein and lactose percentages and fat, protein and lactose yield and somatic cell count were not significantly affected by treatments. Result of Milk fat, protein and lactose percentages and fat, protein and lactose yield in literature was different (Margrison *et al.*, 2002; Midla *et al.*, 1998). Zimmerly and Weiss (2001) reported that yield of milk protein but not fat was increased for biotin-supplemented vs. unsupplemented cows and Milk composition was not different across treatments ($p>0.10$) except for lactose percentage where were higher for treatment with biotin supplement. Biotin is a required co-factor for enzymes involved in propionate utilization and gluconeogenesis (McDowell, 2000). Supplemental biotin may have alleviated a limitation on the activities of these enzymes leading to increased lactose synthesis. Milk fat and protein percentages were unaffected by dietary biotin supplementation in the some studies (Margrison *et al.*, 2002; Zimmerly and Weiss, 2001).

Plasma glucose and insulin concentrations were not different across treatments ($p>0.05$). Similarly, dietary biotin supplementation had no effect on plasma glucose and NEFA concentrations measured at 1, 30, 60 and 100 DIM in the some previous trial (Zimmerly and Weiss, 2001). Although biotin is a cofactor for the gluconeogenic enzyme, pyruvate carboxylase and for the enzyme propionyl-CoA carboxylase, therefore, if activities of those enzymes are limited by biotin supply, glucose production could be increased by biotin supplementation. But in the present study, plasma glucose concentrations elevated were not significant with biotin supplementation.

Hart *et al.* (1978) reported that plasma insulin concentrations are inversely related to milk production

(Hart *et al*., 1978), also biotin infusion (1.0 mM L^{-1}) increased glucose-induced insulin secretions in isolated per fused pancreases of biotin-deficient and sufficient rats (Sone *et al*., 1999). But in this study, plasma insulin concentrations were not affected by biotin supplementation.

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