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RESEARCH ARTICLE

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Response of lactating cows to supplemental rumen protected methionine and Niacin

Abstract Eight Chinese Holstein cows were used in a 4 × 4 Latin square design to determine the effects of rumen protected methionine (RPMet) and Niacin on milk yield and milk composition of lactating cows with 14 d adaptation and 6-d sampling periods. The cows were fed the control diet or the control diet plus RPMet (25 g·d^{-1}), niacin (6 g·d^{-1}), or RPMet (25 g·d^{-1}) + niacin (6 g·d^{-1}). The results showed that RPMet supplementation in the diet increased 4% fat corrected milk (FCM) yield ($P < 0.05$) and milk fat percentage ($P < 0.05$). However, supplemental RPMet had no effect on the solid non fat (SNF) ($P > 0.05$) and lactose percentage ($P > 0.05$). Dietary niacin supplementation increased milk yield ($P < 0.05$), milk protein percentage ($P < 0.05$) and lactose percentage ($P < 0.05$), but had no effect on milk fat percentage ($P > 0.05$) and SNF ($P > 0.05$). RPMet supplementation in the diet of lactating cows significantly decreased serum urea nitrogen ($P < 0.01$) and glucose contents ($P < 0.05$), but had no effects on nonesterified fatty acids (NEFA), total cholesterol and triglyceride ($P > 0.05$). Niacin supplementation influenced the contents of glucose and NEFA in serum, but had no effects on the urea nitrogen, total cholesterol and triglyceride ($P > 0.05$).

Keywords lactating cows, RPMet, niacin, milk yield, milk composition

1 Introduction

Methionine (Met) has been identified as one of the most limiting AA for the synthesis of milk and milk protein by dairy cows fed diets based on corn. This is particularly the case for cows in early lactation when dry matter intake (DMI) is relatively low and diets often are deficient in Met (Veira et al., 1991). In this stage, an alternate strategy is to feed rumen protected Met (RPMet). Many papers have reported that RPMet can increase the milk protein percentage (Pruekvimolphan and Grummer, 2001), the milk fat percentage (Noftsger and St-pierre, 2002) and the milk yield (Pruekvimolphan and Grummer, 2001) in lactating cows.

Feeding niacin to high producing cows in early lactation might increase the protein synthesis in rumen (Riddell et al., 1981). In addition, the reduction of blood ketones (Dufva et al., 1983) and the improvement of milk protein percentage (Drackley et al., 1998) and milk production (Cervantes et al., 1996) have been reported as a result of feeding niacin.

Met and niacin are also necessary for dairy cow in early lactation. However, no references on supplementing Met and niacin at the same time have been found. The objective of this research is to evaluate the lactation response of dairy cows to supplemental RPMet and niacin in the early lactation.

2 Methods

2.1 Design and treatment

The experiment was carried out on a private farm on February 16 and lasted 84 days. A total of eight cows ((24 ± 7) days postpartum, (3.1 ± 1.4) lactation period, (23.2 ± 4.2) kg milk·d^{-1}) were arranged in a 4 × 4 Latin square with an experimental period of 3 weeks.

Dietary treatments were: (1) the basal diet control (C); (2) the basal diet plus 6 g RPMet·d^{-1}; (3) the basal diet plus 25 g Niacin·d^{-1}; (4) the basal diet plus 6 g RPMet·d^{-1} and 25 g Niacin·d^{-1}. The ingredients and nutritive contents of the basal diet are shown in Table 1. MetaSmart™ (RPMet) used in the diet was supplied by Adisseo Asia Pacific Pte Ltd. Niacin was obtained from Shandong Weifang Xiangweisi Chemical Co., Ltd.

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Table 1 Ingredients and chemical composition of the basal diet (TMR)

	value
ingredient/% DM	
silage	36.7
Brewer's grain	2.6
alfalfa	4.6
corn	29.4
soybean meal (exp.)	1.1
cottonseed meal (exp.)	9.0
cottonseed meal (sol.)	9.0
wheat bran	3.4
premix*	0.6
$NaHCO_3$	0.75
$CaHPO_4$	1.41
NaCl	0.85
$CaCO_3$	0.56
MgO	0.03
chemical composition/%	
NE/MJ·kg^{-1}	6.35
crude protein	14.14
ADF	22.70
NDF	35.62
Ca	0.86
P	0.47

Note: * represents that per kilogram premix provide: VA > 700000 UI, VD3 > 120000 UI, VE > 2100 mg, Fe 1750 mg, Cu 1600 mg, Zn 10000 mg, Mn 3500 mg, Se 42 mg, I 84 mg and Co 42 mg.

2.2 Samplings, recordings and analysis

Cows were individually fed twice and refusals were weighed once daily. Dry matter (DM) was determined weekly. Samples of feeds were collected weekly and stored at −20°C for later analyses. All chemical analyses were performed at the Agricultural University of Hebei.

Milk yield was recorded daily during the last 10 days of each experimental period. Cows were milked daily at 05:30 and 15:00. During each period, milk samples were collected during the last 3 days, preserved with potassium dichromate, and stored at 4°C. The milk samples were mixed daily to analyse the protein and fat percentages using MILKYWAY-CP2 (Hangzhou Simpler Technologies Co., Ltd.).

Blood samples were collected by means of jugular vein puncture. After coagulation, the serum was obtained by centrifugation at 3000 r·min^{-1} for 20 min at 4°C. Serum was stored at −20°C. The concentrations of glucose, urea nitrogen, total cholesterol and triglyceride were measured according to the methods from commercial kits (Baoding Great Wall Clinical Reagents CO., Ltd). Serum NEFA concentration was measured by a commercial kit (Nanjing Jiancheng Bioengineering Institute).

2.3 Statistical analysis

The data were analyzed by ANOVA using the general linear model procedure of SAS (SAS Institute, 1999). Differences between treatment means at the 5% level were determined using the least significant difference test.

3 Results

Milk yield and milk composition are presented in Table 2. The milk yield was unaffected by RPMet supplementation ($P > 0.05$), but 4% FCM was increased ($P < 0.05$). The milk fat percentage ($P < 0.05$) and the protein percentage ($P < 0.05$) were higher for cows fed diets containing the supplemental RPMet. In this study, the RPMet supplementation did not affect the lactose percentage and the SNF ($P > 0.05$).

The dietary niacin supplementation increased the milk yield and the 4% fat corrected milk (FCM) yield ($P < 0.05$), and improved the percentages of milk protein ($P < 0.05$) and lactose ($P < 0.05$), but had no effects on the milk fat percentages ($P > 0.05$).

The effects of dietary RPMet or (and) niacin on blood parameters of lactating cows are shown in Table 3. The RPMet supplementation in the diet of lactating cows significantly decreased serum urea nitrogen ($P < 0.01$) and glucose content ($P < 0.05$), but had no effects on the contents of the NEFA, the total cholesterol and the triglyceride in blood ($P > 0.05$). The dietary niacin supplementation influenced the contents of glucose and NEFA in the serum, but had no effects on the contents of the urea nitrogen, the total cholesterol and the triglyceride ($P > 0.05$).

Table 2 Effects of RPMet and Niacin supplementation on milk yield and milk composition

item	treatment				SEM	contrast		
	CK	RPAA	NA[1]	RPAA + NA		RPAA	NA	RPAA × NA
milk yield/kg	23.90	24.71	25.58	25.80	0.256	NS	0.020	NS
4%FCM/kg	21.56	23.36	23.19	24.16	0.012	0.010	0.023	NS
fat/%	3.38	3.64	3.38	3.58	0.033	0.002	NS	NS
protein/%	3.02	3.08	3.05	3.15	0.002	0.018	0.032	NS
lactose/%	4.59	4.59	4.65	4.63	0.009	NS	0.012	NS
SNF/%	8.72	8.78	8.68	8.76	0.034	NS	NS	NS

Note: Control = the control diet; RPAA = the control diet plus RPMet (25 g·d^{-1}); NA = the control diet plus niacin (6 g·d^{-1}); RPAA + NA = the control diet plus RPMet (25 g·d^{-1}) + niacin (6 g·d^{-1}); NS means not significant.

Table 3 Effect of RPMet and Niacin supplementation on blood parameters of lactating cows

item	control	RPAA	NA	RPAA+NA	contrast		
					RPAA	NA	RPAA × NA[3]
urea nitrogen/mg·L^{-1}	128.23 ± 13.79^{Aa}	110.90 ± 3.00^{Bb}	124.53 ± 13.83^{a}	111.50 ± 7.91^{Bb}	0.002	NS	NS
glucose/mg·L^{-1}	645.00 ± 76.37^{ab}	615.00 ± 83.01^{b}	708.89 ± 67.78^{a}	662.22 ± 75.84^{ab}	NS	0.048	NS
NEFA/μmol·L^{-1}	211.79 ± 13.75^{A}	205.25 ± 12.63^{A}	205.09 ± 10.11^{A}	179.66 ± 13.23^{B}	0.001	0.001	0.042
cholesterol/mg·L^{-1}	1206.50 ± 67.17^{a}	1210.32 ± 30.29^{a}	1154.84 ± 36.35^{b}	1157.43 ± 48.23^{b}	NS	NS	NS
triglyceride/mg·L^{-1}	387.85 ± 52.43^{a}	387.22 ± 37.96^{a}	352.13 ± 58.99^{a}	357.77 ± 48.52^{a}	NS	NS	NS

Note: Control = the control diet; RPAA = the control diet plus RPMet (25 g·d^{-1}); NA = the control diet plus niacin (6 g·d^{-1}); RPAA + NA = the control diet plus RPMet (25 g·d^{-1}) + niacin (6 g·d^{-1}); A, B and C represent the mean values in the same raw with different superscripts are significantly different ($P < 0.01$); a, b and c represent the mean values in the same raw with different superscripts are significantly different ($P < 0.05$); NS = not significant.

4 Discussion

4.1 Performance

Encapsulated Met products fed to lactating dairy cows had no effect on milk yield and composition (Broderick et al., 1970; Williams et al., 1970; Papas et al., 1984a, b; Yang et al., 1986), or increased the milk protein content (Casper and Schingoethe, 1988), increased both the milk yield and the milk protein content, or increased yield of FCM. The differences in these experiments might have been caused by the differences in the status of Met or other amino acid (AA) of the cows, the amount of Met supplied in the protected products, and the efficacy of the protection scheme in delivering Met to the small intestine.

Pruekvimolphan and Grummer (2001) reported that RPMet increased the 3.5% FCM yield and milk protein. Met is the first limiting amino acid and involved in many processes in the body. The supplemental RPMet could increase the amount of Met in the small intestine in dairy cow, which may provide enough Met for dairy cows to synthesize milk and milk protein. The Met could provide the methyl for the synthesis of choline, which regulates the milk fat metabolism in the mammary gland. In the present experiment, the milk fat percentage was increased when the RPMet was supplemented, which is in agreement with the results of Noftsger and St-pierre (2003).

Jaster and Ward (1990) indicated a slight increase in milk yield when cows were supplied with niacin at different levels. Cervantes et al. (1996) and Drackley et al. (1998) observed that increasing the niacin intake could increase the performance of dairy cattle. This study showed similar results. However, the reasons for improving milk yield were not clear. Niacin might enhance the protein synthesis in the rumen (Riddell et al., 1981) or reduce the blood ketones (Dufva et al., 1983) so as to improve the yield. Horner et al. (1986) observed an increase in milk protein concentration by supplementing 6 g niacin·d^{-1} for the earlier lactating cows, supplying more microbial protein for the cows to synthesize milk.

4.2 Blood parameters

In previous researches, plasma NEFA and glucose were not affected when lactating dairy cows were fed with RPMet + Lys added in the diets (Socha et al., 2005; Chow et al., 1990; Chapoutot et al., 1992; Xu et al., 1998). The lower blood glucose concentrations may be reflective of the fact that the cows supplemented with RPMet may produce more FCM (Socha et al., 2005). In the present study, the cows could produce 1.8 kg·d^{-1} more FCM with dietary RPMet supplementation than those in the control group. RPAA supplementation may reduce the blood urea nitrogen content and improve the crude protein utilization efficiency. Moreover, Niacin could also improve the blood glucose through increasing the propionate concentration in the rumen and produce the substances for the lactose synthesis in the mammary gland. The niacin supplementation may increase the milk protein percentage and the production (Erickson et al., 1992).

Triglyceride (TG) accumulates in the liver when TG synthesis exceeds disappearance via hydrolysis and lipoprotein export. The plasma NEFA, primarily from the mobilization of adipose tissues, acts as the substrate for hepatic TG synthesis and ketogenesis (Emery et al., 1992). Because the hepatic uptake of NEFA is directly related to the plasma concentrations (Bell, 1979), a decrease in plasma NEFA may reduce the amount of substrate for hepatic TG synthesis and ketogenesis. Niacin is antilipolytic (Carlson and Oro, 1962) and when supplemented to the diets of dairy cows, it may decrease the plasma concentrations of NEFA (Minor et al., 1998).

5 Conclusions

Dietary RPMet or niacin supplementation could increase the 4% FCM yield, the milk fat percentage and the milk protein percentage of lactating cows, with no interactive effects between the dietary supplementation of RPMet and the niacin on milk performance.

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