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Use of dietary feather meal to induce histidine deficiency or imbalance in dairy cows and effects on milk composition

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ABSTRACT

Removing His from a postruminal AA infusion decreases milk protein and increases milk fat content. Feather meal is an inexpensive protein source, high in rumen undegradable protein but low in His. The objective of our study was to investigate dietary feather meal as a method for creating a His deficiency or imbalance to alter milk composition. Four dietary treatments were fed for 4 wk each to 8 multiparous mid-lactation Holstein cows in a replicated 4 × 4 Latin square design. A standard-protein control diet (SP-C) was formulated to provide 3,100 g/d of metabolizable protein (MP). Feather meal was added to the control diet either to replace the MP isonitrogenously (SP-FM) or to increase the MP supply to 3,484 g/d (HP-FM). As an isonitrogenous control for HP-FM, a high-protein diet (HP-C) was formulated with His-adequate protein sources to provide the same MP content as HP-FM. Dry matter intake tended to decrease when feather meal was fed. Predicted flows of digestible His, Met, and Lys, and plasma concentrations of these AA were reduced on both feather meal diets. Predicted flows of total digestible essential AA were not different between HP-FM and SP-C. We concluded that the DMI depression on HP-FM prevented an imbalance of excess AA over His, and created a deficiency of His, Met, and Lys compared with SP-C. Milk production decreased on the 2 feather meal treatments, partly explained by a tendency for DMI to decrease. Milk yield was lowest on SP-FM at 30.3 kg/d and highest on HP-C at 37.9 kg/d. Milk fat yield was not affected by diet but protein and lactose yields were both lower with feather meal. Protein yields were 860 and 998 g/d, whereas lactose yields were 1,384 and 1,561 g/d for SP-FM and HP-FM, respectively. This resulted in a higher fat content and lower protein percentage on FM diets. The ratio of solids-not-fat:fat in milk was lowest on SP-FM at 2.11 compared with 2.56 on SP-C. Adding feather meal to the diet by replacing MP isonitrogenously was more effective at lowering the solids-not-fat:fat ratio than increasing the MP content with an imbalanced protein source.
Key words: feather meal, dairy cow, histidine, milk composition

INTRODUCTION

Several AA infusion studies in lactating cows have shown that essential AA imbalances or deficiencies can increase the fat content of milk. Histidine imbalance and deficiency are particularly noted for increasing milk fat yields, whereas milk protein yields decrease or remain unaffected (Fraser et al., 1991; Kim et al., 1999; Cant et al., 2001; Weekes et al., 2006). When a His deficiency was created by removing His from an abomasal infusion of 1.1 kg of AA/d, milk fat yield increased by 181 g/d and milk protein yield decreased by 186 g/d (Weekes et al., 2006). When a His imbalance was created by infusing 1.1 kg/d of all AA except His, milk fat yield increased by 320 g/d (Weekes et al., 2006).

Feather meal is an ingredient low in His (1.15% of CP) but high in CP (92% of DM) that has poor rumen degradability (35% of CP), with an RUP digestibility of 65% (NRC, 2001). The stimulation of milk protein yield by abomasal His in cows consuming feather meal (Kim et al., 1999, 2000) indicates that feather meal is deficient in His. The objective of the present study was to evaluate whether creating a His imbalance or deficiency using feed ingredients would have similar effects on milk composition to His subtraction from a postruminal AA infusion. Test diets were formulated with a high inclusion of feather meal at 12.6% of DM, or 3.3 kg/d of intake. Replacement of MP with His-deficient feather meal was intended to create a His deficiency, whereas increasing MP with feather meal was intended to create a His imbalance.

MATERIALS AND METHODS

All animal procedures were approved by the Animal Care Committee at the University of Guelph (Guelph, ON, Canada). Eight lactating Holstein cows in their sec-

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Table 1. Ingredient and chemical composition of experimental diets

Item	Treatment[1]			
	SP-C	SP-FM	HP-FM	HP-C
Ingredient composition (% of DM)				
Corn silage	15.2	20.4	15.1	15.1
Alfalfa silage	21.5	21.5	21.4	21.4
Alfalfa hay	10.8	10.9	10.8	10.8
Corn, high moisture	25.8	25.9	25.8	25.8
Megalac[2]	1.6	1.6	1.6	1.6
Soybeans, roasted	5.2	0	1.5	0
Soybean meal	9.9	0	3.3	5.5
Corn gluten meal	1.4	0	0.7	6.7
Fish meal	1.5	0	0	0.7
Canola meal	0	0	0	2.6
Blood meal	0	0	0	3.0
Feather meal	0	12.6	12.6	0
Molasses	2.9	2.9	2.9	2.9
Vitamin/mineral premix[3]	4.1	4.1	4.1	4.1
Rumen-protected Met[4]	0.19	0.23	0.24	0
Chemical composition				
DM (%, as fed)	47.4	47.6	48.8	46.9
CP (% of DM)	19.2	16.4	16.1	15.5
Buffer solubility (% of CP)	24.5	24.1	34.7	23.7
NDF insolubility (% of CP)	42.5	37.0	38.8	35.3
ADF insolubility (% of CP)	11.3	7.4	14.1	11.1
NDF (% of DM)	30.3	33.8	30.9	36.9
ADF (% of DM)	20.4	22.8	23.4	25.2
Cellulose (% of DM)	16.3	19.0	19.0	21.0
Lignin (% of DM)	4.1	3.8	4.4	4.1
NFC (% of DM)	45.8	43.3	47.2	41.7
Starch (% of NFC)	51.0	51.8	50.6	48.6
Fat (% of DM)	4.1	3.8	4.4	4.1
Ash (% of DM)	8.7	8.7	8.0	8.1
Calculated NE_{Lp}[5] (Mcal/kg of DM)	1.56	1.52	1.51	1.48
Calculated MP (% of DM)	12.6	12.8	14.1	14.0

[1]SP-C = standard-protein control diet; SP-FM = feather meal was added to the control diet to replace the MP isonitrogenously; HP-FM = feather meal was added to the control diet to increase the MP supply to 3,484 g/d; HP-C = high-protein isonitrogenous control diet, formulated with His-adequate protein sources to provide the same MP supply as HP-FM.

[2]Church & Dwight Co. Inc. (Ewing, NJ).

[3]

[4]Smartamine M (Adisseo Inc., Antony, France).

[5]Net energy of lactation at production levels of intake.

ond or third parity (111 ± 4 DIM and 650 ± 14 kg BW) were assigned to 4 dietary treatments in a replicated 4 × 4 Latin square design. A standard-protein control diet (**SP-C**) was formulated with soybean, corn gluten, and fish meal to provide 3,100 g of MP/d according to NRC (2001; Table 1). Feather meal was added to the control diet either to replace the MP isonitrogenously (**SP-FM**) or to increase the MP supply to 3,484 g/d (**HP-FM**) with a His-deficient protein source. As an isonitrogenous control for HP-FM, a high-protein diet (**HP-C**) was formulated with His-adequate protein sources to provide the same MP supply as HP-FM. The His content of MP was predicted by the NRC (2001) model to be 2.15, 1.76, 1.82, and 2.32% on diets SP-C, SP-FM, HP-FM, and HP-C, respectively. Smartamine M (Adisseo Inc., Antony, France) was included in diets to bring the predicted Lys:Met ratio of MP to 3.1:1 on all treatments. The predicted Met content of MP was 1.96, 1.69, 1.68, and 1.82% for SP-C, SP-FM, HP-FM, and HP-C, respectively.

Each period was 4 wk in duration. Cows were housed in tie-stalls and milked at 0600 and 1500 h daily. Milk was weighed at each milking and sampled during the last 5 d of each period for compositional analysis on a MilkoScan 4000 mid-infrared spectrometer (Foss Electric A/S, Hillerød, Denmark). Body weight was recorded at the end of the second and fourth periods. Cows were offered feed after each milking for ad libitum intake throughout the day. Refusals were removed and weighed before the morning feeding. During the last 5 d of each period, feed and orts were sampled daily for analysis of DM content by oven drying at 65°C for