Short communication: Performance of lactating dairy cows fed pearl millet grain

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ABSTRACT

Fifteen multiparous Holstein cows were used in a 3 × 3 Latin square experiment to determine the effects of feeding pearl millet grain on feed intake, milk yield, and milk composition of lactating dairy cows. Three isonitrogenous diets with a 57:43 forage:concentrate ratio were formulated. Diets contained 30% corn, 30% pearl millet, or 31% corn and pearl millet mixed 1:1 (wt/wt). Three lactating Holstein cows fitted with ruminal cannulas were used to determine the effects of dietary treatments on ruminal fermentation parameters. Dry matter intake and energy-corrected milk were similar for all dietary treatments and averaged 23.8 and 33.5 kg/d, respectively. Dry matter intake (% of BW) was unaffected by dietary treatments and averaged 3.40%. Milk fat, protein, lactose, and total solids concentrations were not influenced by grain type. Ruminal NH₃-N concentration was unaffected by dietary treatments. However, ruminal pH tended to be lower for cows fed pearl millet than those fed corn and pearl millet mix. It was concluded that pearl millet grain can replace corn in dairy cow diets up to 30% of the diet DM with no adverse effects on milk yield or milk composition.

Key words: milk yield, milk composition, pearl millet grain

Pearl millet [*Pennisetum glaucum* (L.) R.] is a tropical plant processing the C4 photosynthetic pathway (Nelsen, 1995) with tolerance to drought, heat, and low soil pH. Because of its adaptability to harsh conditions, millet can be grown in areas unfavorable to other cereals such as corn (Hanna, 1995). Pearl millet is also grown as a summer grain crop to replace sorghum in areas with low water-holding soils and short growing seasons (Pale et al., 2003). Relative to corn, pearl millet contains greater concentrations of CP but less starch (Nocek and Tamminga, 1991; Hill et al., 1996). Ruminal degradability of pearl millet is greater than that of corn but less than that of barley and oats (Nocek and

Tamminga, 1991). Pearl millet has successfully replaced corn in diets of broilers (Collins et al., 1997), beef cattle (Hill et al., 1996), and lactating goats (Gelaye et al., 1997). However, the nutritive value of pearl millet for lactating cows has not been investigated. Adapted and high-yielding hybrids of pearl millet suitable for growing conditions in eastern Canada have recently been developed by Agriculture and Environmental Renewal Canada (Delhi, Ontario, Canada). The new hybrids produce 3 to 3.5 Mg/ha of grain under nonirrigated and drought conditions and also suppress root-lesion nematodes when used in crop rotation (AERC, 2005; Bélair et al., 2005). Nutrient profile and ruminal nutrient degradabilities of these hybrids have already been determined (Mustafa et al., 2008). However, their feeding value for ruminants has not been evaluated. The objectives of this study were to determine the effects of replacing corn with pearl millet in the diets of lactating dairy cows on subsequent milk yield and composition and on ruminal fermentation.

All experimental procedures were preapproved by the Faculty Animal Care Committee at McGill University (Sainte-Anne-de-Bellevue, Quebec, Canada). Fifteen multiparous cows (DIM = 76 ± 24 d, BW = 704 ± 76.9 kg), including 3 ruminally fistulated cows, were used in a 3 × 3 Latin square experiment with 24-d periods. Three isonitrogenous diets were formulated with a 57:43 forage:concentrate ratio. Corn in the first diet (30% of the diet DM) was replaced by 50 and 100% (wt/wt) of CGPMH 90 pearl millet in diets 2 and 3, respectively (Table 1). Diets were offered ad libitum as TMR twice daily at 0800 and 1600 h. Experimental periods consisted of 14 d of diet adaptation and 14 d of data collection. Feed intake and milk yield were measured on d 15 to 28 of each period. Cows were milked twice daily and milk samples were pooled by proportion according to milk yield at each milking. Diets and grains were sampled daily during each collection period and composited by period.

The composited feed samples were oven-dried at 60°C for 48 h, ground through a 1-mm screen, and stored for later analysis. Orts were measured daily to determine daily feed intake for each cow. Ground feed and grain samples were analyzed for DM, ash, and ether extract

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Table 1. Ingredients and chemical composition of dietary treatments (DM basis)

Item	Dietary treatment		
	Corn	Corn plus pearl millet	Pearl millet
Ingredient, %			
Alfalfa silage	30.0	29.7	31.0
Corn silage	17.3	17.3	17.3
Grass hay	6.9	6.9	6.9
Ground corn	30.2	15.8	
Ground millet		15.4	30.2
Soybean meal	8.8	8.0	7.4
AminoPlus ¹	3.5	3.5	3.5
Megalac ²	1.5	1.5	1.5
Sodium bicarbonate	0.9	0.9	0.9
Blue salt ³	0.4	0.4	0.4
Mineral mix ⁴	0.6	0.6	0.6
Chemical composition, %			
DM	50.4	49.8	50.0
Ash	6.2	6.4	6.3
Ether extract	3.3	3.7	4.0
CP	17.0	17.5	17.7
NDF	36.3	38.9	40.0
ADF	24.0	24.2	23.3
Ca	0.73	0.71	0.82
P	0.39	0.39	0.40

¹Contained 50.5% CP, 20% NDF, 8% ADF, 1.4% ether extract, 0.42% Ca, and 0.7% P. Ag Processing Inc. (Omaha, NE).

²Church and Dwight (Princeton, NJ).

³Contained 99% NaCl, 400 mg/kg of Co, and 70 mg/kg of I.

⁴Contained per kg: 4.5% Ca, 2.5% P, 6.6% Na, 1.5% Mg, 1.2% K, 0.11% S, 1,372 mg of Fe, 1,032 mg of Mn, 1,500 mg of Zn, 247 mg of Cu, 16 mg of I, 16 mg of Co, 10 mg of Se, 185,000 IU of vitamin A, 32,500 IU of vitamin D₃, and 900 IU of vitamin E.

using standard procedures (AOAC, 1990). Neutral detergent fiber (Van Soest et al., 1991) and ADF (AOAC, 1990) were determined using an Ankom fiber analyzer (Ankom Inc., Fairport, NY). The NDF analysis was conducted using α -amylase and without the use of sodium sulfite. Crude protein was measured with a Leco nitrogen analyzer (FP-428 Nitrogen Determinator, Leco Corporation, St. Joseph, MI). Grains were also analyzed for starch content according to McCleary et al. (1997). Milk samples were analyzed for fat, protein, lactose, and MUN by using an infrared analyzer (MilkoScan model Foss 4000, Foss Food Technology, Hillerød, Denmark). Milk TS were determined according to AOAC (1990).

Three multiparous, lactating Holstein cows fitted with rumen cannulas were used to determine the effects of the dietary treatments on ruminal fermentation parameters. Periods consisted of 14 d of diet adaptation and 7 d of data collection. Dietary treatments were the same as in the production study. Samples of ruminal fluid were collected from various part of the rumen at 0, 2, 4, 6, 8, 10, and 12 h post morning feeding as described by Vargas-Bello-Pérez et al. (2008). Ruminal pH was measured immediately using an Accumet pH meter (AB15 Plus, Fisher, Pittsburgh, PA). Ten milliliters of ruminal fluid was preserved by adding 1 mL

of 0.1 *N* HCl and was later analyzed for NH₃-N colorimetrically with a multichannel Lachat Autoanalyzer (Lachat Instruments, Milwaukee, WI).

Data for the production study were analyzed as a 3 × 3 replicated Latin square design using PROC MIXED of SAS (SAS Institute, 1989) with fixed effects of treatment and period, and cow within period as the random effect. Data for ruminal parameters were analyzed as repeated measurements across time by using PROC MIXED of SAS. The model included effects of treatment, period, time, and treatment by time interaction. Significant differences were declared at $P < 0.05$.

Pearl millet used in this study contained (mean ± SD) 2.0 ± 0.09% ash, 6.7 ± 0.14% ether extract, 13.9 ± 0.70% CP, 63.4 ± 1.82% starch, 18.3 ± 0.68% NDF, and 4.4 ± 0.57% ADF. Respective values for corn were 1.3 ± 0.3, 3.9 ± 0.53, 9.1 ± 0.26, 72.2 ± 1.46, 15.3 ± 1.34, and 8.2 ± 0.76%. The chemical profile of pearl millet in this study was within the range previously reported for 5 different hybrids grown in southwestern Quebec (Mustafa et al., 2008).

Intakes of DM ($P = 0.786$) and CP ($P = 0.216$) were not affected by dietary treatments; however, cows fed pearl millet consumed more ($P = 0.010$) NDF than those fed corn (Table 2). This was likely because of the higher NDF content of pearl millet relative to corn.

Table 2. Effects of feeding pearl millet grain on performance of dairy cows

Item	Dietary treatment			SEM ¹	P-value ²
	Corn	Corn plus millet	Pearl millet		
Intake, kg/d					
DM	23.7	24.1	23.5	0.51	0.786
CP	4.0	4.2	4.2	0.09	0.216
NDF	8.6 ^b	9.4 ^{ab}	9.5 ^a	0.20	0.032
Intake, % of BW	3.33	3.45	3.41	0.114	0.730
Milk, kg/d					
Yield	39.6	40.0	39.9	2.18	0.990
ECM ³	33.8	33.7	33.1	1.78	0.978
Fat	1.60	1.57	1.52	0.098	0.860
Protein	1.23	1.22	1.21	0.053	0.988
Lactose	1.81	1.81	1.79	0.106	0.491
TS	4.66	4.69	4.66	0.242	0.966
SNF	3.07	3.12	3.14	0.175	0.944
Composition, %					
Fat	4.07	4.00	3.83	0.142	0.524
Protein	3.13	3.09	3.07	0.063	0.794
Lactose	4.56	4.52	4.48	0.047	0.491
TS	11.85	11.77	11.76	0.183	0.921
SNF	7.78	7.84	7.92	0.190	0.866
MUN, mg/dL	13.6	14.6	13.9	0.60	0.209
Ruminal pH	6.33	6.37	6.27	0.056	0.165
Ruminal NH ₃ -N, mg/dL	16.9	16.0	15.7	3.26	0.923

^{a,b}Means in the same row with different superscripts differ ($P < 0.05$).

¹Pooled standard error of the mean.

²P-values for treatment effects.

³Calculated according to Tyrrell and Reid (1965).

Grain type had no effect on milk yield ($P = 0.990$) and ECM ($P = 0.978$), which averaged 39.8 and 33.5 kg/d, respectively. Yields of milk fat ($P = 0.860$), protein ($P = 0.988$), and lactose ($P = 0.491$) were also unaffected by grain type. No data on lactational performance of dairy cows fed pearl millet are available. However, replacing corn with pearl millet in diets of lactating goats (up to 40% of diet DM) had no effect on feed intake or milk yield (Gelaye et al., 1997). Inclusion of pearl millet in beef cattle diets resulted in performance similar to that obtained with corn and sorghum (Hill and Hanna, 1990; Hill et al., 1996). It has been reported that in ruminant diets with similar CP concentrations, pearl millet can supply between 85 and 92% of the energy found in corn (Hill et al., 1996; Gelaye et al., 1997). However, ME intake was similar when the grains were fed at 40% of the dietary DM (Terrill et al., 1998). Milk fat ($P = 0.524$), protein ($P = 0.794$), lactose ($P = 0.491$), total solids ($P = 0.921$), SNF ($P = 0.866$), and MUN ($P = 0.209$) concentrations were also unaffected by grain type. Similar findings have also been observed when pearl millet replaced corn in the diets of dairy goats (Gelaye et al., 1997).

No time by treatment interactions were noted for ruminal fermentation parameters and therefore only main effects were reported in Table 2. Grain type had no effect on ruminal pH ($P = 0.165$) or NH₃-N concen-

tration ($P = 0.923$). However, a tendency ($P = 0.074$) for a higher ruminal pH was observed for cows fed the corn-millet mix relative to those fed the pearl millet. Replacing corn with pearl millet in diets of beef cattle increased ruminal pH in one study (Hill et al., 1996) and decreased it in another (Hill and Hanna, 1990). In growing goats, substituting pearl millet for corn had no influence on ruminal pH but depressed NH₃-N concentration. Reasons for discrepancies in ruminal fermentation parameters between studies may include grain inclusion level, forage:concentrate ratio, and differences among animal species.

In conclusion, pearl millet can be used to replace corn up to 30% of the diet DM in the diets of lactating dairy cows with no adverse effects on milk yield or milk composition. Feeding pearl millet to lactating dairy cows may reduce supplemental protein traditionally added to corn-based diets. Further studies are needed to determine the effects of long-term feeding of pearl millet grain on performance of dairy cows. The feeding of pearl millet grain with different forage:concentrate ratios warrants further investigation.

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