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COMPARATIVE EFFECTS OF FEEDING MILLET VERSUS BARLEY ON YIELD AND COMPOSITION OF MILK IN HOLSTEIN COWS

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ABSTRACT

To compare the effects of feeding millet (*Panicum miliaceum* L.) vs. barley on the production and composition of milk, eight lactating Holstein cows were used in a replicated 4×4 Latin square design with 21 d periods. Barley was replaced by millet in ratios of 0, 33, 66, and 100% in rations 1, 2, 3 and 4, respectively. Diets were given in a 50:50 ratio (DM basis) of concentrate and corn silage on a dry matter (DM) basis. There were no significant differences ($P>0.05$) in DM intake, milk production, yield of 3.2% Fat corrected milk (FCM), kg fat and lactose, percent of lactose, Solids-not-fat (SNF) and feed efficiency among treatments. Apparent digestibility of the organic matter (OM) content was higher for diets containing millet (59.34 vs. 62.92, 63.02 and 62.43), respectively. The fat percentage in rations containing 100% millet was lower (3.40, 3.38 and 3.39 vs. 3.28%), and the protein was higher (3.12, 3.15, 3.17 and 3.30%) for rations 1, 2, 3, and 4, respectively, ($P<0.05$).

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مقایسه جایگزینی جو با ارزن و تاثیر آن برتولید و ترکیبات شیر در گاوهای هولشتین

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به ترتیب دانشجوی سابق کارشناسی ارشد (هم اکنون مربی گروه علوم دامی، دانشگاه آزاد اسلامی، واحد خوراسگان اصفهان، اصفهان، ایران) و استاد یار ، گروه علوم دامی، دانشگاه صنعتی اصفهان، ایران.

چکیده

به منظور جایگزینی جو با ارزن در جیره گاو های شیری و تاثیر آن بر روی تولید و ترکیبات شیر، هشت گاو شیری نژاد هلشتاین انتخاب گردید و ارزن به نسبت های صفر، ۳۳، ۶۶و ۱۰۰٪ به ترتیب در جیره های شماره یک، دو، سه و چهار ، طی چهار دوره ۲۱ روزه در قالب یک طرح مربع لاتین با ۴ تکرار، جانشین جو گردید. جیره های غذایی شامل مخلوط کنسانتره و علوفه به نسبت ۵۰:۵۰ در ماده خشک بود. در روزهای ۱۵ تا ۲۱ هر دوره، نمونه هائی از شیر ، مدفوع و جیره مصرفی تهیه شد. نمونه های مدفوع و جیره برای تعیین درصد رطوبت و قابلیت هضم و نمونه های شیر برای چربی، پروتئین، لاکتوز، کل مواد جامد و موادجامد بدون چربی، تجزیه شد. غذای مصرفی و شیر تولیدی هر روزه ثبت شد. نتایج این آزمایش نشان داد که بین ماده

خشک مصرفی، کل شیر تولیدی روزانه، شیر تصحیح شده برای ۳/۲٪ چربی، مقدار چربی و لاکتوز بر حسب کیلو گرم و همچنین بین درصد لاکتوز، مواد جامد بدون چربی، کل مواد جامد و بازده غذایی جیره های مورد آزمایش در سطح آماری ۵٪ اختلاف معنی داری وجود نداشت. قابلیت هضم جیره های دارای ارزن از جیره تمام جو، بالاتر بود. درصد چربی جیره های یک، دو و سه بیشتر بود، به طوری که با جیره شماره چهار اختلاف معنی داری نشان دادند. ولی درصد پروتئین و همچنین کیلو گرم پروتئین جیره صد در صد ارزن بیشتر ویا جیره های شماره یک، دو و سه در سطح آماری ۵ درصد اختلاف معنی داری داشت.

INTRODUCTION

Millet (*Panicum miliaceum* L.) is among the most important cereal crops. It is grown i

arid regions and growing seasons that are not well suited for corn production (11, 15). In some areas of Iran, millet is price competitive with other feed grains which are used as energy sources in concentrate mixtures for dairy cows (personal observation). Millet can form a great portion of the carbohydrate fraction of a ration and can replace other cereal grains for most classes of livestock, provided that the remainder of the ration is nutritionally balanced (8). The feeding value of ground millets has been reported to be as a percentage of the feeding value of maize, 87 for beef cattle, 90 to 95 for milk production, and about equal to that of maize for sheep (9). Mathis *et al.* (12) reported the total starch digestibility that was observed for millet in steers of 84.2%, whereas ruminal starch digestibility was only 54.5%, suggesting that the fractional starch digestibility in the small intestine was 56.4%. Because of the differences in starch digestibility among cereals, the type of cereal affects the fat composition of milk (21) and Thomas (22) suggested that the type of cereal may affect milk protein percentage. Miller *et al.* (14) reported lower milk fat percentage in cows

when fed pearl millet vs. sudangrass. Several nutritional factors, such as phytate and tannins, have been examined in swine and poultry (18), however they appear to have little effect on ruminants. The nutritive value of millet cultivars is of interest because its crude protein (CP) content is often higher than for barley and is highly variable, ranging from 10 to 14% (10). Therefore, the development of new cultivars of millet with high yielding potential and higher CP content could result in more economical dairy rations. However, no data is available on response of lactating cows to the inclusion of different amounts of millet in complete rations. The objective of this study was to determine the effects of substituting millet for barley on lactation performance and nutrient digestibility of dairy cows.

MATERIALS AND METHODS

Eight lactating Holstein cows at 90±20 d postpartum and producing 27±3 kg d^{-1} of milk, were arranged in a duplicated 4×4 Latin square with 21-d periods. Barley was replaced by millet in ratios of 0, 33, 66 and 100% of the grain portion of the diets. Chemical composition of barley and millet is presented in Table 1. Cows were divided into two blocks based on lactation number. Block 1 contained four primiparous cows and block 2 contained four multiparous cows in second or later lactation. Treatment periods were 3 wk in length with the first 2 wk used for adaptation and wk 3 for measurement of animal response.

Diets were formulated to contain 50% forage and 50% concentrate on a dry matter (DM) basis (Table 2). Diets were balanced to meet National Research Council (NRC) recommendations for energy, protein, calcium and phosphorous (16). Acid insoluble ash (AIA) was used as the indigestible internal marker (2, 25).

Cows were fed *ad lib*. a total mixed ration (TMR), three times daily in individual stanchions at 0600, 1400, and 2000 h. Cows were offered sufficient feed throughout the trial to have 5% feed refusals. Water and

Table 1. Chemical composition of barley and millet (DM basis)†.

	NEL	CP	CF	EE	Ash	DM	Ca	P
	Mcal kg^{-1}	%	%	%	%	%	%	%
Millet	1.94	13.06	9.00	4.00	5.49	84.97	0.03	0.34
Barley	1.94	10.20	5.50	2.00	2.98	92.37	0.05	0.38

† NEL, Ca and P were calculated from NRC information.

plain salt were available at all times. Feed offered was recorded daily and samples of diets were collected daily and composited by week. A portion of each daily sample was dried at 100°C for determination of DM; the remainder was stored for later analysis. Fecal samples were taken from the rectum twice daily during each collection period (15 to 21 d), composited by cow, and frozen for later analysis. Body weights were recorded weekly on a common day. In each case, the animals were fasted for 8 h before being weighed.

Cows were milked three times a day and milk weights were recorded. Milk samples were collected 3 times a day during wk 3 of each period, and were analyzed for fat, protein, lactose and solids-not-fat (SNF) by Milk-O-Scan 133BN Foss Electric. Fat corrected milk (FCM) was calculated by the formula of Overman and Gaines (17).

Composite feed and fecal samples were dried for 72 h at 55° C and ground with a cyclone mill to a maximum particle length of about 1 mm. Samples were analyzed for DM, ash and N (1), neutral detergent fiber (NDF), acid detergent fiber (ADF), and AIA. NDF, ADF and AIA were determined by the method used by both Van Soest (24) and Cherney (2). AIA was used as an internal indigestible marker to determine apparent digestibility of dietary fractions.

Samples of ruminal fluid were obtained via an esophageal tube, urine was collected via manual stimulation of the vulva, and fecal material via the rectum. Ruminal fluid and urine samples were collected from all cows at two different times during the experiment approximately 4 and 6h after the

morning feeding, on day 14 and 21 of third and fourth period and immediately analyzed for pH.

Table 2. Ingredient and chemical composition of diets (DM basis).

	Replacement in diets(%)†			
Item	0	33	66	100
Ingredients:				
Corn silage	50.00	50.00	50.00	50.00
Barley	14.20	9.86	5.08	0.00
Millet	0.00	4.56	9.57	14.92
Cotton seed meal	17.69	17.29	16.92	16.52
Wheat bran	11.92	12.02	12.13	12.25
Oyster shell	1.12	1.13	1.14	1.15
Sodium bicarbonate	0.29	0.30	0.40	0.40
Beet pulp	4.79	4.76	4.76	4.76
Chemical compositions:				
DM, %	60.97	59.22	60.23	59.82
OM, %	90.84	91.31	90.94	90.82
CP, %	13.79	13.71	13.56	13.99
NEL, Mcal kg^{-1}	1.54	1.54	1.54	1.54
ADF, %	25.36	25.50	25.60	25.75
NDF, %	38.95	39.94	39.94	39.93
Ca, %	0.55	0.55	0.55	0.55
P, %	0.35	0.35	0.35	0.35
AIA, %	1.89	1.90	1.95	1.98

† Refer to the percentage substitution of barley with millet.

Data for feed intake, apparent digestibility, yield of milk and milk components were analyzed with block, cow within lactation period and ration as main effects. The model used to analyze the data was:

$$Y_{ijkl}=U+T_i+ C_j(s)+p_{k(s)}+S_i+e_{ijki}$$

where U=mean, T_i=rations, C_j=cow effect, p_k=period, and S_i=block.

The data were analyzed by least squares general linear models procedures of SAS (19).

RESULTS AND DISCUSSION

Intake of DM was not influenced by the percentage substitution of barley with millet (Table 3). This does not agree with previous research (3) showing millet to be less palatable than barley.

Mean daily actual milk yields were 24.53, 24.56, 24.91 and 25.40 kg d^{-1} for rations 0 to 100, respectively. Reports on the production of lactating cows fed millet are scarce. In this experiment, actual milk yields of cows fed concentrates based on millet, and millet mixtures were similar to or greater than those of cows fed 100% barley. There was a linear increase in milk yield as the amount of millet in the ration increased but no significant differences ($P<0.05$) were noted in the average milk yield .

Yield of 3.2% FCM was not different among rations (Table 3), which is in agreement with Edgerly (5) who reported that production of FCM from cows fed ground millet as 40% of a grain mixture was similar to that of cows fed mixtures of oats, maize and barley.

No significant differences ($P<0.05$) were noted in the average fat and protein percentage and kg protein of rations containing 0, 33 and 66% millet, but the ration containing 100% millet, caused a significant depression ($P<0.05$) in fat percentage and a significant increase ($P<0.05$) in protein percentage compared to the other rations. Miller *et al.* (14)

Table 3. Feed intake and milk production of cows with millet substituted for barley in the diet.

	Replacement in diets (%)†					Contrast		
Item	0	33	66	100	SEM	L	Q	C
DMI, kg d^{-1}	17.91[a]	18.34[a]	18.00[a]	18.41[a]	0.28	NS	NS	NS
OMI, kg d^{-1}	16.27[a]	16.71[a]	16.37[a]	16.72[a]	0.22	NS	NS	NS
Production, kg d^{-1}								
Total milk	24.53[a]	24.56[a]	24.91[a]	25.40[a]	0.56	NS	NS	NS
3.2% FCM	25.49[a]	25.35[a]	25.88[a]	25.76[a]	0.52	NS	NS	NS
Fat	0.83[a]	0.82[a]	0.84[a]	0.82[a]	0.03	NS	NS	NS
Protein	0.76[b]	0.77[b]	0.79[b]	0.84[a]	0.02	*	NS	NS
Lactose	1.32[a]	1.31[a]	1.34[a]	1.37[a]	0.03	NS	NS	NS
Milk composition %								
Fat	3.40[a]	3.38[a]	3.39	3.28[b]	0.03	*	NS	NS
Protein	3.12[b]	3.15[b]	3.17[b]	3.30[a]	0.02	*	*	NS
Lactose	5.37[a]	5.34[a]	5.53[a]	5.40[a]	0.04	NS	NS	NS
SNF	9.09[a]	9.10[a]	9.14[a]	9.30[a]	0.07	*	*	NS
Body weight, kg	535[a]	537[a]	535[a]	524[b]	1.99	*	*	NS
Efficiency§	1.37[a]	1.34[a]	1.39[a]	1.38[a]	0.03	NS	NS	NS

† Refer to the percentage substitution of barley with millet.

§ Efficiency calculated as milk production (kg d^{-1})/ DMI (kg d^{-1}).

a,b Means within a row with different superscript differ significantly ($P<0.05$).

reported a depressed milk fat percentage when cows were fed pearl millet. The forage dry matter intake was adequate for the maintenance of normal

milk fat content, because rations containing approximately 21% ADF appear adequate to avoid severe milk fat depression (20). The ADF of rations in this trial ranged from 25.36 to 25.75%.

The protein content of milk is also difficult to alter by dietary manipulation (22); however, increasing net energy intake increased the percentage of milk protein (6). Perhaps high energy was apparently available for metabolism when millet was fed. Thomas (22) reported that the effect of energy intake on milk protein is uncertain because of confounding dietary factors, although type of concentrate may be important.

Milk SNF, lactose percentage, and amount of fat and lactose were not affected by the treatment (Table 2). Even though there were no significant differences in the percent SNF of the milk attributable to the level of millet or barley fed, it is of interest that there was a trend toward higher milk SNF percentage with increasing amounts of millet. Thus, percentage milk fat-SNF relationship is consistent with the findings of Tommervik and Waldern (23) and Ward and Wilson (26).

Cows fed the rations containing 100% millet made less body gains ($P<0.05$) compared to the cows fed the other rations. Ensor *et al.* (7) developed the concept that acetate-propionate production in rumen plays a major role in controlling whether the energy of the diet is transformed into milk fat or body fat. An increase in acetate relative to propionate tends to be reflected in the production of higher milk fat percentages. It has also been shown that, in general, the milk fat depressing diets exert their influence by depressing the synthesis of the short-chain fatty acids in the mammary gland (7, 21). This difference was probably due to making only four observations for body weight per ration.

There was a significant decrease ($P<0.05$) in digestibility of the OM (as determined by the AIA method) in the rations containing all barley as compared to other rations (Table 4). The point of maximum dry matter intake has been the subject of several investigations. Conrad (1966) suggested that it occurred at about 67% apparent digestibility when concentrate-alfalfa combinations were fed to lactating dairy cattle. Others suggest that this point is not fixed, but is dependent upon the density of the

diet and the energy demand (set point) of the animal (25). Messman *et al.* (13) reported that the fiber components of pearl millet have high digestibility because of less lignification (lignin is 7.1% of NDF in pearl millet).

Table 4. Digestibility and ruminal, urinary and fecal pH of cows fed different diets.

	Replacement in diet (%)†				
Item	0.00	33.00	66.00	100.00	SEM
Digestibility of OM, %	59.34[b]	62.92[a]	63.02[a]	62.43[a]	0.64
Ruminal pH	6.83[a]	6.95[a]	6.76[a]	6.87[a]	0.23
Urinary pH	7.71[a]	7.83[a]	7.89[a]	7.82[a]	0.19
Fecal pH	7.00[a]	6.83[a]	6.64[a]	6.85[a]	0.21

† Refer to the percentage substitution of barley with millets.

a,b Means within a row with different superscript differ significantly ($P<0.05$).

The variation in feed efficiency was not significant. There were no dietary effects on ruminal fluid pH, urinary pH, and fecal pH (Table 4).

In conclusion, it appears that feeding millet increases milk protein production significantly, but barley is superior to millet in rations where a higher milk fat percentage is desirable.

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