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Influence of Partial Substitution of Alfalfa Hay with Ground Versus Macerated Rice Straw on Dry Matter Intake and Performace of Lactating Holstein Cows

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Abstract: Twelve lactating Holstein cows (578 kg) were used in a replicated 3x3 Latin square design. Treatments consisted of steam-flaked corn-based lactation diets containing (DMB): 1) 50% alfalfa hay; 2) 39% alfalfa hay, 8% ground rice straw; and 3) 39% alfalfa hay, 8% macerated rice straw. Diets were formulated to contain 20% forage NDF (DMB). Rice straw treatments provided 24% of the total forage NDF. Alfalfa hay and rice straw treatments were ground to pass through a 7.6 and 2.6 cm screen, respectively, before incorporation into complete mixed diets. Dry matter intake was lower (5%; $p<0.05$) for alfalfa as the sole forage (ALF) than for the rice straw supplemented diets. Live weight gain was greater (155%, $p<0.05$) for rice straw supplemented diets than for ALF. Live weight gain was greater (14%, $p<0.05$) for macerated rice straw (RSM) than for the ground rice straw supplemented diet (RSG). There were no treatment effects ($p>0.10$) milk yield and milk SNF percentage. However, milk fat and protein percentages were greater (5 and 4%, respectively, $p<0.05$) for the RSM than for ALF and RSG. Milk lactose concentration was greater (5%, $p<0.05$) for RSG than for RSM. Although the expected NE_L content of the basal alfalfa diet (based on tabular values; NRC, 2001) was only slightly (1.6%) greater than that of the rice straw supplemented diets, the observed dietary NE_L was lower (8%, $p<0.05$) and observed vs expected DMI intake was greater (12%, $p<0.05$) for ALF than for RSG and RSM. We conclude that rice straw may replace 24% of the forage NDF provided by alfalfa hay in lactation diets without detrimentally affecting energy intake and fat corrected milk yield. Maceration of rice straw may enhance milk fat and milk protein concentration compared with that of ground rice straw and/or alfalfa hay.

Key words: Partial substitution, alfalfa hay, versus macerated

INTRODUCTION

Due to its comparatively low soluble carbohydrate content (1-2%) and highly lignified sclerenchymatous layer and tissues of the vascular bundles, the digestibility of rice straw is low (38 to 44%)[1,2]. Treatment with either sodium hydroxide or ammonia has increased its digestibility in high-forage diets[3,4] but not with lower forage finishing diets[4-6]. Grinding enhances the feeding value of rice straw in finishing diets. However, fine grinding (1.3 cm screen) provides no additional benefit in feeding value to that of coarser grinding (3.8 cm screen)[7]. Maceration (a process that crushes and stretches forage under high pressure) enhances the feeding value of forages by creating greater surface area and points of entry for fibrolytic bacteria[8]. Torrentera *et al.*[9] demonstrated that maceration of rice straw can elevate its feeding value to a level superior to that of sudangrass hay. Very little information exists in the literature on the use of rice straw as a partial replacement for conventional higher quality forages in diets for lactating dairy cattle. Lee *et al.*[10] observed that partial replacement of a lactation diet with 15% alkali-treated or fermented rice straw did not depress milk yield. However, milk yield was low, averaging 16 kg/d. The objective of this study was to evaluate the influence of partial substitution of ground versus macerated rice straw for alfalfa hay on DMI and milk yield and composition in Holstein cows.

MATERIALS AND METHODS

Twelve lactating Holstein cows (578 kg) were used in a replicated 3x3 Latin square experiment to evaluate the influence of partial substitution of ground versus macerated rice straw for alfalfa hay on DMI and milk yield and composition. Dietary treatments (Table 1) were formulated to contain 20% forage NDF (DMB). Rice straw treatments replaced a portion of the alfalfa hay in the diet, providing 24% of total forage NDF. Complete mixed diets were fed twice daily (0700 and 1900 h), subsequently to milking. Feed refusals were managed using a slick-bunk feeding program. The system is based on consumption scores of 1 through 4, as follows: 1) feed bunk is licked clean (slick bunk; daily feeding allowance is increased by 5%); 2) there remains > 0 and ≤5% of

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Table 1: Composition of diets fed to cows

	Treatments[a]		
Item	ALF	RSG	RSM
Ingredient Composition (DMB %)			
Steam-flaked Corn	35.75	37.55	37.55
Alfalfa hay	50.00	39.00	39.00
Ground rice straw	0.00	8.00	0.00
Macerated rice straw	0.00	0.00	8.00
Canola Meal	3.50	3.50	3.50
Fishmeal	0.50	0.50	0.50
Dicalcium Phosphate	0.50	0.55	0.55
Magnesium Oxide	0.30	0.30	0.30
Salt	0.40	0.40	0.40
Limestone	0.05	0.55	0.55
Urea	0.00	0.65	0.65
Yellow grease	3.00	3.00	3.00
Cane molasses	6.00	6.00	6.00
Nutrient composition, DM basis			
NE_L, M(cal kg^{-1})	1.72	1.68	1.68
Crude protein, (%)	16.50	16.50	16.50
UIP, CP (%)	31.10	33.20	33.20
NDF, (%)	25.70	25.90	25.90
ADF, (%)	17.10	20.40	20.40
NFC, (%)	42.30	44.10	44.10
Ether extract, (%)	5.90	5.90	5.90
Calcium,(%)	1.03	1.01	1.01
Phosphorus,(%)	0.37	0.37	0.37
Potassium, (%)	1.20	1.20	1.20
Magnesium, (%)	0.38	0.38	0.38
Sulfur, (%)	0.27	0.24	0.24

[a]ALF=Alfalfa, RSG=Ground Rice Straw, RSM=Macerated Rice Straw

Table 2: Composition of forages fed to lactating cows

	Treatments[a]		
	Alfalfa	RSG	RSM
Composition,(%)			
CP	25.0	4.1	4.8
ADF	31.0	34.0	35.7
NDF	39.3	57.5	59.9
ASH	9.2	12.8	12.6
Ether extract	2.9	1.9	2.3
NE_L, M(cal kg^{-1})	1.28[b]	0.66[c]	

[a]RSG=Ground Rice Straw; RSM=Macerated Rice Straw,
[b] NRC (2001), [c]NRC (1984)

previous days feeding (no change in feeding allowance); 3) there remains >5 and ≤10% of previous days feeding (daily feeding allowance is reduced by 5%); and 4) there remains greater than 10% of previous days feeding allowance (drinker, cow health, etc., are reviewed; daily feeding allowance is adjusted according to circumstances). All cows received Treatment 1 (Table 1) for 7 d before initiation of the trial. The trial consisted of three 26-d experimental periods. At the beginning of each period, cows were weighed and body condition score measured. Treatment effects on DMI were measured during the final 14 d of each period. Cows were housed in individual pens (3x16 m) with automatic waterers, individual feed bunks and shade (9 m^2). Cows were milked twice daily at 0630 and 1830. Following the pm milking at the beginning and end of each experimental period, cows were weighed and body condition score (CS) was recorded (5-point scale)[11]. Treatment effects on milk yield and composition were determined for the eight consecutive milkings during the final 4 d of each period. Milk samples from each cow and within each collection period were composited and analyzed for fat, protein, lactose and casein (Milko scan FT-120, Foss technology, Eden Prairie,MN). Dietary energy values were determined based on observed DMI (kg/d), average BW (kg), ADG (kg/d), milk yield (MY, L/d), milk protein (MP,%) and milk fat (MF,%; NRC, 2001): NE_L, Mcal $kg^{-1}=(0.086*((BW_{initial} + BW_{final})/2)^{0.75})+(MY*((0.927*MF)+(0.0588*MP)+0.192))+(ADG*(1.32+(1.25*CS)))$. The trial was analyzed as a replicated 3x3 Latin square experiment[12]. Comparisons among treatment means were tested using LSD[13].

RESULTS AND DISCUSSION

Treatment effects on lactational performance are shown in Table 3. Dry matter intake was lower (5%, respectively; $p < 0.05$) for alfalfa as the sole forage (ALF) than for the rice straw supplemented diets. Likewise, live weight gain was greater (155%, $p < 0.05$) for rice straw supplemented diets than for ALF. Live weight gain was greater (14%, $p < 0.05$) for macerated rice straw (RSM) than for the ground rice straw supplemented diet (RSG). Consistent with changes in weight gain, final body condition score also tended ($p=0.12$) to be greater for rice straw supplemented diets than for ALF. There were no treatment effects ($p > 0.10$) milk yield and milk SNF percentage. However, milk fat and protein percentages were greater (5 and 4%, respectively, $p < 0.05$) for the RSM than for ALF and RSG. Milk lactose concentration was greater (5%, $p < 0.05$) for RSG than for RSM. Differences in milk lactose reflect compensating changes in milk protein and fat. Thus, RSM tended to increase (5%, $p=0.15$) FCM yield over that of ground rice straw.

Very little information exists in the literature regarding the feeding value of rice straw as a partial replacement for forage in diets for lactating dairy cattle. However, increased milk fat percentage has been a consistent response to partial substitution of alfalfa hay with grass hay[14,15]. Replacing as much as 33% of alfalfa hay in lactation diets with wheat straw has sustained high milk yield (40 kg/d) and energy intake[16-19]. In as much as the fiber content of forage is the primary component of its functionality[20], it is expected that differences in performance due to forage source diminish when forages are compared at equivalent levels of forage-NDF supplementation.

Table 3: Treatment effects on milk production of lactating cows

Item	Treatments[a] Alfalfa	RSG	RSM	SD
Cow replicates	4	4	4	
weight (kg)				
IW	579.0	580.0	575.0	13.0
FW	582.0	588.0	585.0	11.0
Body weight change (kg)	3.6[b]	8.6[c]	9.8[d]	0.6
Body condition score				
Initial	3.21	3.21	3.25	0.14
Final	3.23	3.31	3.31	0.15
Condition score change	0.02	0.10	0.06	0.20
DMI (kg d^{-1})	20.5[b]	21.3[c]	21.9[c]	1.2
Estimated DMI (kg d^{-1})	19.1[b]	21.8[c]	23.0[d]	0.9
Observed NE_L Intake, M(cal/d[e])	30.4	31.2	32.1	4.1
Expected NE_L Intake, M(cal/d)	28.2	28.9	30.1	3.9
Observed vs Expected NE_L Intake	1.08[b]	0.98[c]	0.96[c]	0.08
Observed dietary NE_L M(cal kg^{-1})	1.58[b]	1.70[c]	1.72[c]	0.14
Milk Yield, L/d	29.3	28.4	29.3	1.9
4.0 % FCM Yield (kg d^{-1})	26.1	25.5	26.7	2.0
Milk Composition (%)				
Fat[fg]	3.26[b]	3.28[b]	3.43[c]	0.18
Protein	2.76[b]	2.75[b]	2.87[c]	0.06
Lactose	4.68[b]	4.87[c]	4.62[b]	0.13
SNF	8.49	8.48	8.48	0.11
Total Solids	11.75	11.76	11.92	0.20

[a]Treatments are as follows: Alfalfa, Ground Rice Straw (RSG), Macerated Rice Straw (RSM), [bcd] Means in a row with different superscripts differ ($p<0.05$), [e] NE_L Intake = DMI x tabular NE_L of the diet

The basis for the increase in milk fat and protein percentages due to maceration of rice straw is not certain, but may be related to greater intestinal protein and starch uptake. Lopez-Soto *et al.*[21] observed that in cows fed a steam-flaked corn-based diet containing 40% forage as ground versus macerated rice straw, maceration increased ruminal NDF turnover rate by 52%. The increased rate of ruminal turnover was associated with a 7% decrease in ruminal OM digestion and a 14% increase intestinal OM digestion. Maceration increased net protein supply to the small intestine by 10%.

Although the expected (based on tabular values)[20] NE_L content of the basal alfalfa diet was only slightly 1.6%; (Table 1) greater than that of the rice straw supplemented diets, observed dietary NE_L was lower (8%, $p<0.05$) and the observed vs expected DMI intake was correspondingly greater (12%, $p<0.01$) for alfalfa as the sole forage than for rice straw supplemented diets. A limitation of the NE estimates in the present study is that body weight change and condition scores were measured across the entire 26 d test periods, while DMI was measured during the last 14 d and milk yield and composition were measured during the final 4 d of each period. Notwithstanding, estimates of treatment effects on dietary NE_L are supportive of the contention that when diets are formulated based on an equivalent forage NDF basis, partial substitution of alfalfa hay with rice straw may enhance dietary energy density without affecting milk yield.

Implications: Rice straw may replace 24% of the forage NDF provided by alfalfa hay in lactation diets without detrimentally affecting energy intake and fat corrected milk yield. Maceration of rice straw may enhance milk fat and milk protein concentration compared with that of ground rice straw and/or alfalfa hay.

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