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Effect of Replacing Corn Silage with Whole Crop Rice Silage in Total Mixed Ration on Intake, Milk Yield and Its Composition in Holsteins

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ABSTRACT : This study was conducted to investigate the effects of replacing whole crop corn silage (WCCS) with whole crop rice silage (WCRS) in the total mixed ration (TMR) on nutrient intake, milk yield and its composition in Holstein cows. The *Chucheong* rice variety (*Oryza sativa* L. *Japonica*) and corn (Pioneer 32 P75) were harvested at yellow-ripe stage and were ensiled in round bales and in trench silos, respectively. Two TMR containing either WCCS or WCRS were prepared. These diets were randomly assigned to 16 mid-lactating Holstein cows (8 cows per treatment) and were fed for 120 days. The first 20 days were used for dietary adaptation and for the next 100 days daily feed intake, milk yield and its composition were recorded. The pH, lactic acid, NDF, ADF, CP, Ca and P contents were similar in WCRS and WCCS. The DM, ash and EE contents of WCRS were greater compared with WCCS. Nutrient (DM, NDF, TDN and CP) intakes were similar in cows fed WCCS- and WCRS-based TMR. Daily and 4% fat corrected milk yield were not affected by the treatments. Milk composition (percent milk fat, protein, lactose and total solids) was similar in cows fed either WCCS- or WCRS-based TMR. The concentration of milk urea N was greater in cows fed WCRS-based TMR than those fed WCCS-based TMR. In conclusion, round-baled WCRS can replace WCCS in the diet of mid- to late-lactating Holsteins without any deleterious effects on feed consumption, milk yield and its composition. The present findings raise the possibility that WCRS can be used as an alternative roughage source in the diets of dairy cows in countries with surplus rice production. (**Key Words :** Whole Crop Rice Silage, Intake, MUN, Holsteins)

INTRODUCTION

Ensiling is generally practiced to regularize seasonal fodder availability, to preserve forage at a specific nutritive value and to improve the farm land operation/utilization. The main aim of ensiling is to preserve fodder under anaerobic condition where anaerobic microbes build up organic acids mainly lactic acid by using fermentable carbohydrates (Yahaya et al., 2004). Factors that affect the rate of lactic acid build up, pH decline and final pH of the silage are fermentable carbohydrate in fodder, its buffering capacity (related to the amount of acid needed to change the pH), dry matter (DM) content, the type and amount of bacteria present on fodder (Nisa et al., 2005; Khan et al., 2006). Whole-crop cereal silages, such as wheat, sorghum, oat and maize have extensively been studied (Khan et al., 2006; Ozturk et al., 2006; Zahiroddini et al., 2006; Touqir et al., 2007a,b) and are being used to feed dairy and beef animals in both developed and developing countries. Corn silage is a major component of diets fed to dairy cows because of the high energy yield per unit area, the ease of mechanization and storage, and the uniformly high feeding value (Oshita et al., 2007).

Rice (*Oryza sativa* L. *Japonica*) is the main cash crop in South East Asian countries. Particularly in Korea, rice is a culture and a socio-economic entity. From the centuries the Koreans take advantage of hot and humid summer conditions to cultivate rice. Traditionally after harvesting the rice crop, the straw is used to feed Korean beef cattle (Hanwoo) and grains are consumed as a major staple food. Over the last few decades, introduction of high yielding rice varieties and increased agricultural inputs have greatly enhanced the per acre yield of rice in Korea. In recent years the Korea is producing more rice than its domestic needs. This situation demands either to reduce the land under rice cultivation or to find alternative usage of rice crop. Grains and forages for dairy cattle are imported from other

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Table 1. Mean pH, lactic acid contents, and chemical composition[1] of whole crop corn[2] silage (WCCS) and whole crop rice[3] silage (WCRS)

Parameters (% DM)	WCCS	WCRS
pH	3.98±0.28	4.49±0.21
Lactic acid	3.26±0.19	2.92±0.22
Dry matter	28.7±3.14[a]	34. 80±2.42[b]
Crude protein	7.35±0.81	8.02±0.68
Either extract	1.98±0.16[a]	2.64±0.16[b]
Ash	5.98±0.55[a]	8.48±0.15[b]
NDF	65.77±3.63	67.60±2.98
ADF	38.94±2.92	39.27±3.23
Ca	0.14±0.05	0.22±0.06
P	0.26±0.04	0.30±0.08

[a, b] Means in the row bearing different superscripts are significantly different ($p<0.05$).

[1] Two samples from each silo (n = 5) and bales (n = 5) were used to analyze WCCS and WCRS, respectively.

[2] Corn (Pioneer 32 P75) was harvested at yellow ripe stage for ensiling in trench silos.

[3] *Chucheong* rice variety (*Oryza sativa* L. *Japonica*) harvested at yellow ripe stage and round baled.

countries to Korea. Ensiling surplus rice crop to feed dairy cattle could reduce dependency on the import of feed.

This study was conducted to examine the effects of replacing whole crop corn silage (WCCS) with WCRS in total mixed ration (TMR) on feed intake, milk and its composition in mid to late lactating Holstein cows.

MATERIALS AND METHODS

Whole crop silage

The *Chucheong* rice variety (*Oryza sativa* L. *Japonica*) was cultivated in mid May 2004 in the fields of National Institute of Animal Science, Suwon, Korea and was harvested 30 days after flowering at yellow ripe stage. Crop was harvested using a commercial harvester and wilted for one day. The wilted whole rice crop was then round baled, wrapped using vinyl sheets to provide anaerobic conditions and stored under an open shed for 6 months. After opening the bails, crops were chopped to about 2-3 cm length before feeding in a total mixed ration.

The corn (Pioneer 32 P75) was also cultivated in National Institute of Animal Science, Suwon, Korea in April 2004 and harvested at yellow ripe stage. The forage was chopped (2-3 cm), filled in 5 trench concrete silos (20×3×5) and the silos were pressed to remove air and thereby attain anaerobiasis. Each silo was covered with a 10 cm thick layer of rice straw, followed by a polyethylene film. The polythene film was removed after 7 months to start feeding. After an amount of fermented fodder was taken out from the silo, just sufficient for one day's feeding, the polyethylene film was put back to keep the silo sealed.

The samples of WCCS (each silo) and WCRS (from 5 bales) were taken and analysed for DM, total protein, ash using the methods described by AOAC (1990), NDF, ADF, hemicellulose, cellulose and ADL by the methods of Van Soest et al. (1991). Silage pH was recorded using a pH-mV meter (HM-21P, TOA Corporation, Tokyo, Japan). Lactic acid in samples was determined in aqueous extracts by means of a GLC with a semi-capillary FFAP (nitroterephthalic acid-modified polyethylene glycol) column (Hewlet-Packard, Wardbronn, Germany), over a temperature range of 45 to 230°C. The chemical composition of WCCS and WCRS is presented in Table 1.

Table 2. Ingredient and chemical composition of whole crop corn silage (WCCS) TMR and whole crop rice silage (WCRS) TMR

Item (% DM)	WCCS TMR	WCRS TMR
Concentrate	40.9	45.6
Alfalfa hay	5.5	6.1
Timothy	19.5	21.7
WCCS	34.1	-
WCRS	-	26.6
Chemical composition (% DM)		
DM	68.18	71.19
CP	14.29	14.91
EE	3.21	3.78
NDF	45.05	43.20
ADF	20.17	18.18
Ash	5.29	6.53
Ca	1.00	1.05
P	0.42	0.40
TDN[1]	67.59	68.52

[1] Total digestible nutriments were calculated using equation given in NRC (2001).

Concentrate formula: grounded corn 63.0%, soybean meal 20.0%, wheat barn 9.4%, beet pulp 6.0%, calcium phosphates 0.3%, salt 0.2%, bicarbonate of soda 0.2%, bio Zinc 0.1%, Neo Linkal 0.4%, New Mix DC 0.4%.

Animals, management feeding and sampling

Two TMR diets containing either WCCS or WCRS were formulated daily. These diets were iso-nitrogenous and iso-caloric and were formulated using NRC (2001) standards for energy and protein. Ingredient and chemical composition of TMR diets are presented in Table 2. Sixteen lactating Holstein cows having average body weight (604±56 kg), parity (1.4±0.2), days in milk (110±22) and milk yield (28.2±3.90 kg) were randomly assigned to either WCCS (n = 8) or WCRS (n = 8) based TMR. Animals were housed on a concrete floor in separate pens. Fresh and clean water was made available round the clock in each pen throughout the experimental period. Diets were mixed and fed twice (08:00 and 18:00) daily *ad libitum* (10% feed refusal). The trial lasted for 120 days with the first 20 days for dietary adaptation and 100 days for sample collection. Daily feed intake and milk production were recorded and averaged over 100 days.

Cows were milked twice daily, and individual milk

Table 3. Mean feed intake, milk yield and its composition in Holsteins fed of whole crop corn silage (WCCS) TMR and whole crop rice silage (WCRS) TMR

Parameters (kg/d)	WCCS TMR	WCRS TMR
DM	20.05±1.70	20.84±2.11
CP	2.87±0.22	3.11±0.30
EE	0.64±0.16	0.79±0.19
NDF	9.03±0.88	9.00±1.13
TDN	13.55±1.18	14.27±0.89
Milk yield	30.38±4.32	28.8±3.57
Milk yield (4% FCM[1])	28.69±3.94	27.31±3.19
Milk composition (%)		
Milk fat	3.57±0.56	3.60±0.64
Milk protein	3.14±0.24	3.06±0.18
Lactose	4.76±0.12	4.66±0.16
Total solids	11.72±0.88	11.71±0.75
MUN (mg/ml)	12.64±1.30[a]	15.19±1.50[b]

[a, b] Means in the row bearing different superscripts are significantly different ($p<0.05$).

[1] Fat corrected milk 4% = milk (kg/d)×(44.01×milk fat %+163.56)/339.60 (Tyrrell and Reid, 1965).

yields were recorded. Milk samples were collected at two consecutive milking (pm and am) weekly with a 12 h interval and analyzed with a Lactoscope (MK2; Delta Instruments, Drachten, the Netherlands) to determine total solids, lactose, fat protein, milk urea nitrogen (MUN) and somatic cell score. Fat corrected milk (FCM; 4% fat) was calculated as described by Tyrrell and Reid (1965) using the equation:

$$4\%\ FCM = milk\ (kg/d)\times(44.01\times milk\ fat\ \%+163.56)/339.60$$

Statistical analysis

The data on chemical composition, nutrients intake, milk and its composition were analyzed by t-test using SAS (1988).

RESULTS AND DISCUSSION

Chemical composition, lactic acid contents and pH of WCRS and WCCS are presented in Table 1. Lactic acid contents and pH were similar ($p<0.05$) in WCRS and WCCS. Similar lactic acid contents and pH were previously reported by others for WCCS (Thomas et al., 2001) and for WCRS (Islam et al., 2004c; Maruyama et al., 2005). The DM, ash and EE contents of WCRS were greater ($p<0.05$) compared with WCCS. The NDF, ADF, CP, Ca and P contents were similar ($p<0.05$) in WCRS and WCCS. The concentrations of DM, NDF, ADF, CP, EE, Ca and P of WCCS were similar to those reported in (NRC, 2001). The rice crop was harvested at yellow ripen stage because unpublished data from our laboratory indicated greater per acre DM, organic matter yield and better nutritive value of Chucheong at this sage. The rice crop at ensiling contained 38.90, 7.8, 63.8, and 35.4% DM, CP, NDF and ADF, respectively. Increased concentrations of NDF and ADF and reduced CP in silage compared with whole rice crop indicated the loss of CP during ensiling. Similar results were reported by others (Khan et al., 2006; Touqir et al., 2007a,b) when they ensiled oat, sorghum, jambo or mott grass. However, in present study, DM and ash contents were lower and EE and CP contents were higher in WCRS than those reported by Islam et al. (2004a). This discrepancy may be attributed to the differences in harvest stage, wilting method and rice variety used. In present study, Chucheong, a food rice variety was ensiled instead of Hamasari, a forage variety of rice reported by Islam et al. (2004a,b). Hamasari characterized by a longer stem, higher leaf and lower grain than Chucheong (RDA, 2006). Because Hamasari rice variety is taller than grain type Chucheong, thus it may have lower proportion of head and consequently lower yield and nutritive value (particularly CP).

Dry matter, CP, EE, NDF and TDN intakes were similar ($p<0.05$) in Holstein cows fed either WCRS or WCCS based TMR. The DMI of silage in dairy animals is negatively correlated with silage pH, concentration of acids (Khan et al., 2006; Nisa et al., 2006) and moisture content (NRC, 2001). In the present study both TMR diets contained similar DM and pH of WCRS and WCCS was also similar and in safe range. Consistent with present findings Takahashi et al. (2007) reported similar nutrients intake and milk yield in Holstein cows when they replaced Sudangrass hay with WCRS in the diets. They also reported similar ruminal metabolite concentrations (total VFA, pH), bacterial and protozoal population in cows fed either Sudangrass hay or WCRS. Islam et al. (2004a) fed the WCRS (Hamasari variety) harvested at yellow mature with low (40% DM) and high concentrate (60% DM) levels to early, mid and late lactating Holsteins. They reported DM intake increased with increasing the dietary concentrate level in early and mid lactation. However, concentrate level did not affect the DM intake in late lactating cows. In present study, the Holstein cows were in mid to late lactating stage and were fed a 40-45% concentrate with silage. The DM intake of Holsteins in present study was similar to those reported by Islam et al. (2004a) in mid to late lactating Holsteins on WCRS based diets.

Daily (kg/d) and 4% fat corrected milk yield were similar ($p<0.05$) in cows fed WCCS and WCRS based TMR. Similar milk yield in cows fed WCCS or WCRS can be attributed to similar nutrients intake and their utilization to support mid to late lactation needs. Percent milk fat, protein, lactose and total solids were also similar ($p<0.05$) in Holsteins fed either WCRS or WCCS based TMR. Milk urea N (mg/dl) was greater ($p<0.05$) in cows fed WCRS based TMR compared with those fed WCCS based TMR.

Takahashi et al. (2007) reported that ruminal ammonia concentration was greater at 2 and 5 hour post-parandial in cows receiving WCRS compared with those fed Sudangrass hay. Greater milk urea N in cows fed WCRS can possibly be attributed to higher ruminal ammonia levels because, in the present study, contribution of protein to total dietary protein from forage source was higher in WCRS based TMR.

CONCLUSION

It can be concluded from the present results that WCCS can be replaced with WCRS in the diets of mid to late lactating Holsteins without any deleterious effects on feed consumption, milk yield and its composition.

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