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Effect of Whole Crop Silages (Triticale or Barley) Versus Corn Silage on Performance of Holstein Lactating Dairy Cows

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Abstract: Whole Crop Corn (WCC), Triticale (WCT) and Barley (WCB) were harvested, chopped and ensiled with urea (15 g kg^{-1} DM) for 45 days. pH of WCT Silage (WCTS) and WCB Silage (WCBS) was similar, but, significantly differed from WCC Silage (WCCS) ($p<0.05$). Crud Protein (CP) (WCCS = 67.2, WCTS = 112.4 and WCBS = 96.4 g kg^{-1}. DM), Non-Protein Nitrogen (NPN), (WCCS = 6/84, WCTS = 16.85 and WCBS = 15.04 mg dL^{-1}) and Neutral Detergent Fiber (NDF), (WCCS = 436, WCTS = 497 and WCBS = 470 g kg^{-1} DM) were significantly different between treatments ($p<0.05$). The results of the incubation of WCCS, WCTS and WCBS using nylon bag technique showed that quickly degradable fraction (a) of Dry Matter (DM) was relatively high for WCTS (0.37±0.01) and intermediate for WCBS (0.32±0.02) and lowest for WCCS (0.24±0.01). Whereas, the slowly fraction (b) for WCTS (0.44±0.02) and WCBS (0.52±0.04) was similar and higher than WCCS (0.54±0.02). The constant fractional rate of degradation (c) of CP for the silages was similar (0.02). In this experiment, the effect of replacing WCCS with WCTS or WCBS on feeding the lactating cows was also investigated. Fifteen Holstein lactating cows (37.1±4.9 kg milk/d) were used in a completely randomized design for 6 weeks. Data were analyzed as repeated measures in time. Cows fed diet containing WCBS had higher feed intake than the cows of the other groups ($p<0.05$). Milk yield and component (protein, lactose, Urea Nitrogen (MUN) and total solid milk) were not affected significantly by the treatments. Blood glucose in mid and end of the experiment in each sampling time (0.0 and 4 h) after feeding was not affected by the treatments, but, this metabolite decreased at the 4 h after feeding. Blood Urea Nitrogen (BUN) in the mid the (4 h) and end of the experiment (before feeding) was significantly affected by treatments ($p<0.05$).

Key words: Silage, whole crop, triticale, lactating cow, degradability

INTRODUCTION

There is an increased range of alternative forages available to Iranian dairy farmers. Improvements in breading, growing, harvesting and storage technology in this area have helped the expansion of alternative to whole crop cereals. Whole crop Cereal silages are the most important fodder crops for feeding dairy cows. Corn silage is a popular forage source for ruminants due to its high yielding properties, energy content, relatively high palatability and incorporating easily into total mixed ration (Cherney *et al.*, 2004; Kononoff *et al.*, 2003; Pierre *et al.*, 1987; Di Marco *et al.*, 2007). However on drought prone sandy soils and in years with insufficient rainfall the yield of corn is very low (7 to 8 tons DM ha^{-1}) (Van Duinkerken *et al.*, 1999). In situations where water is a limiting factor for growing corn, triticale and barley may be an attractive alternative fodder crops (Hill and Leaver, 1999). Triticale grows mainly during the early spring when there is usually a precipitation surplus and so, water is not a limiting factor for growth (Van Duinkerken *et al.*, 1999). When triticale is harvested to perform silage, the Dry Matter (DM) yield ranges between 9 and 11 tons per hectare. Therefore, under water limiting conditions, it may be attractive to replace forage corn by whole crop triticale or Whole Crop Barley Silages (WCBS) (Van Duinkerken *et al.*, 1999). On the other hand, forage accounts important fraction of feed for dairy cows and performance of dairy cows is influenced by Dry Matter Intake (DMI), which, in turn, may be influenced by the content and digestion kinetics of Neutral Detergent Fiber (NDF) in forage (Khorasani *et al.*, 1993). Thus, the quality of forage is an important determinant of performance of the dairy cows. The influence of forage fiber on ruminal fill and intake may be greater when high fiber forages are fed (Heaney *et al.*, 1963). Mertens (1985) reported that dietary

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NDF is correlated highly with digestibility and appears to be correlated with feed intake depression at higher feed intakes. Previous study of Danesh M and Stern (2005) showed that the ruminal and post-ruminal digestion of corn silage CP was not affected by urea treatment (16 vs 24 mg Kg^{-1}DM) in compared with alfalfa. The aim of this study was to determine the chemical composition and *in situ* degradable parameters of DM and CP of WCT, WCB, Whole Crop Corn Silage (WCCS), WCTS and WCBS, the effect of replacing WCCS by WCBS or WCTS on feed intake and milk production of Holstein lactating cows were investigated.

MATERIALS AND METHODS

Whole crop silages, chemical composition and *in situ* technique: Whole crop corn, triticale or barley (about 25% DM corn and 33% DM triticale and barley), were harvested, chopped and ensiled with urea (15 g kg^{-1} DM) in trench silos, sealed with two layers of plastic sheeting, then allowed to ferment at least for 35 days. Four representative samples of fresh chopped whole crop triticale, barley and fresh silages were collected, oven-dried to a constant weight at 60°C, ground to pass a 2 mm-screen and analyzed for CP according to the Kjeldahl procedure (AOAC, 2004) on the Tecator Auto-analyzer (1030). Determination of NDF was made with method of Van Soest *et al.* (1991). Samples of fresh silage were performed. Approximately 50 g of each sample was mixed with 450 mL distilled water, then the silage extraction was made. The extraction of silage pH was determined using a portable pH meter (Metrohm 691, Swiss). 5 mL of the silage extract was mixed with 5 mL of 0.2 N HCL. NH_3-N of the acidified silage extract was determined using distillation method (Kjeltec 2300 Autoanalyzer, FossTecator AB, Hoganas, Sweden). The ruminal degradable parameter of dry matter and crude protein of the hays and silages were determined using *in situ* procedure (Fathi Nasri *et al.*, 2006). Tow Holstein steers fitted with the rumen fistula were used in the present study. The bags (17×11 cm) were made of polyester nylon cloth with a pore size of 48 μm. Approximately 5 g DM of the samples was placed in each bag and four bags for each treatment were incubated in the rumen for each time (0.0, 2, 4, 8, 16, 24, 48, 72, 96 h). After removal from the rumen, bags were washed in cold running water and dried in air forced oven (60°C, 48 h), then weighted to determine dry matter disappearance. Nitrogen concentration of the incubated samples was determined by the Kjeldahl method (Kjeltec 2300 Autoanalyzer, Foss Tecator AB, Hoganas, Sweden).

Cows, management and experimental design: Fifteen Holstein lactating dairy cows (37.1±4.9 kg milk/d), were used in a complete randomized design for 6 weeks. Cows were kept in individual stalls and had free access to water. Diets and chemical Composition of total mixed rations are presented in Table 1 and 2. Cows were fed enough total mixed ration in two separate feedings at 0800 and 1600 h to allow 5% orts. The a.m. and p.m. daily dry matter intake was recorded. Cows were milked three times daily at 0600, 1300 and 2100 and samples of milk were collected at the end of each week. Milk samples were analysed for lactose and total solids by milko-tester (Foss Electric, Conveyor 4000). Milk Urea Nitrogen (MUN) was determined using enzymatic procedure (Kerscher and Ziegenhorn, 1985).

Blood samples were collected by venepuncture from the jugular vein on days 21 and 45 immediately before (0 h) and 4 h after the morning feed, the samples analyzed for glucose (Reljiæ *et al.*, 1992) and Blood Urea Nitrogen (BUN), (Kerscher and Ziegenhorn, 1985) using spectrophotometer procedure.

Table 1: Composition of experimental diets (% o DM)

	(Diets)†		
Ingredient	WCCS	WCTS	WCBS
Whole crop corn silage	14.35	-	-
Whole crop triticale silage	-	14.35	-
Whole crop barley silage	-	-	14.35
Alfalfa hay, chopped	24.18	24.18	24.18
Barley grain, ground	15.10	15.10	15.10
Corn grain, ground	13.92	13.92	13.92
Soybean meal	9.13	9.13	9.13
Whole cotton seed	9.56	9.56	9.56
Cotton seed meal	2.80	2.80	2.80
Wheat bran	9.13	9.13	9.13
Sodium bicarbonate	0.49	0.49	0.49
Magnesium oxide	0.23	0.23	0.23
Calcium phosphate	0.21	0.21	0.21
Calcium carbonate	0.13	0.13	0.13
Mineral-vitamin premix*	0.77	0.77	0.77

†: WCCS: Whole Crop Corn Silage, WCTS: Whole Crop Triticale Silage and WCBS: Whole Crop Barley Silage *: Premix contained (DM basis): 190000 mg kg^{-1} Ca, 90000 mg kg^{-1} P, 50000 mg kg^{-1} Na, 9000 mg kg^{-1} Mg, 3000 mg kg^{-1} Fe, 3000 mg kg^{-1} Zn, 2000 mg kg^{-1} Mn, 100 mg kg^{-1} Co, 300 mg kg^{-1} Cu, 100 mg kg^{-1} I, 1 mg kg^{-1} Se, 500,000 IU kg^{-1} vitamin A, 100,000 IU kg^{-1} vitamin D3, 100 mg kg^{-1} vitamin E, 3000 mg kg^{-1} antioxidant (B.H.T)

Table 2: Chemical composition of the experimental diets†

Item	WCCS	WCTS	WCBS
Crud Protein (% Dry Matter)	17.1	17.8	17.5
Net energy lactation (Mcal kg^{-1} DM)	1.57	1.56	1.56
Neutral detergent fiber (% Dry Matter)	32.0	34.1	33.6
Acid detergent fiber (% Dry Matter)	20.3	21.9	21.2
Non-structural carbohydrates (% Dry Matter)	41.7	38.2	39.2
metabolizable energy (Mcal kg^{-1} DM)	2.48	2.47	2.48
metabolizable protein (Mcal kg^{-1} DM)	116	112	112
Ca (% Dry Matter)	0.5	0.6	0.6
P (% Dry Matter)	0.5	0.5	0.5
Ether extract (% Dry Matter)	4.4	4.5	4.5
Rumen undegradable protein (g d^{-1})	1393	1415	1400
Rumen degradable protein (g d^{-1})	3083	3230	3186
Microbial crud protein (g d^{-1})	2176	2161	2165
Dry matter intake (kg DM d^{-1})	26.128	26.128	26.128

†: WCCS: Whole Crop Corn Silage, WCTS: Whole Crop Triticale Silage and WCBS: Whole Crop Barley Silage

Statistical analysis: The equation of $P = a+b(1-e^{-ct})$ was used (a = rapidly degradable, b = slowly degradable, c = degradation rate constant). Comparisons between the three silages components (PH, NDF, NH_3-N and CP) were made using complete randomized design. The statistical model was $Y_{ij} = \mu + T_i + \varepsilon_{ij}$, where Y_{ij} = dependent variable, μ = dependent variable mean, T_i = effect of treatment, ε_{ij} = residual error term. Effects of treatments on cow performance were analysed as repeated measures in time using the mixed procedure of SAS (Version 8e, SAS Inst. Inc., Cary, NC). The statistical model was Y = treatment + cow (treatment) + lactation week + treatment by lactation week, Where cow (treatment) was used to test the treatment effect. Statistical significance effects were determined at $p<0.05$. The Duncan procedure was used to test the mean significant difference.

RESULTS AND DISCUSSION

Chemical composition of the silages: Chemical composition of the silages (corn, triticale or barley) and dry hay (triticale or barley) are presented in Table 3. The pH of WCTS and WCBS extracts was similar. However, with the pH of WCBS and WCTS were higher than WCCS ($p<0.05$). This difference may be resulted from higher crud protein level of WCTS and WCBS than that of WCCS. In addition, the higher concentrations of ammonia–N resulted in higher pH of whole-crop triticale and barley silages. This higher ammonia–N with low soluble carbohydrate can increase buffer capacity and so silage can resistance against decrease of pH. In the other hand, this high pH can prevent from growth of microorganisms (such as lactobacillus) and promote growth of some microorganisms that utilize protein and produce alkaline compound. Crud protein for WCTS and WCBS increased after ensiling which can be resulted from urea treated of these silages. Urea was hydrolyzed by urease produced bacteria. In the present study, the amount of NH_3-N.between silages was significantly different ($p<0.05$). The high level of crud protein of WCT and WCB compared with WCC might cause to increase NH_3-N concentration of these silages. The NDF of WCTS and WCBS increased after ensiling the whole crop forage which can be resulted from degradation of soluble carbohydrate. This reduction caused to increase the percentage of NDF fraction in the silages. In the present study, WCTS had higher, WCBS had mediate and WCCS had a lowest NDF that agreed the result of Khorasani *et al.* (1993) and NRC (2001).

***In situ* degradation:** Dry matter and crud protein degradable coefficients of WCCS, WCTS and WCBS and dry hay (triticale and barley) are presented in Table 4. The results of the incubation of the silages using nylon bag technique showed that quickly degradable fraction (a) of DM was relatively high for WCTS and intermediate for WCBS and lowest for WCCS. A similar results reported by Khorasani *et al.* (1993) who reported that WCBS and WCTS usually contains more soluble DM and CP compared with the other cereal silages. Quickly degradable fraction of DM of dry hey (triticale = 0.31 and barley = 0.32 DM) was higher in compared with corn silage (0.24 DM). This is agreed with Taghizadeh *et al.* (2005) who reported that barley hay contain more DM and CP degradable than corn silage. The constant fractional rate of degradation (c) of CP for silages was similar (0.02). However, in the present study, constant fractional rate of the forage decreased after ensiling which can be resulted from decrease in percentage of quickly and slowly fractional rates of whole crops due to fermentation during ensiling.

Table 3: Chemical composition of whole crop silage (corn, triticale and barley) and dry hay (triticale and barley)

	Silages					Dry hay			
Item	Corn	Triticale	Barley	S.E.M.†	*P*	Triticale	Barley	SEM†	*P*
pH	4.29[b]	5.54[a]	5.58[a]	0.068	<0.01	-	-	-	ns
Crud protein (g kg^{-1} DM)	67.2[c]	112.4[a]	96.4[b]	0.054	<0.01	89.8	69.2	0.23	<0.05
NH_3-N (mL dL^{-1})*	6.48[c]	16.85[a]	15.04[b]	0.310	<0.01	-	-	-	ns
Neutral detergent fiber (g kg^{-1} DM)	498[a]	470[b]	436[c]	5.400	<0.01	470	460	7.07	ns

a,b,c: Means with different superscript letters in the same row differed significantly ($p<0.05$); †: SEM: Standard error of mean, *p*: Probability, ns: Non-significant, *: Silage extract

Table 4: *In situ* dry matter and crud protein degradable parameters of whole crop silage (corn, triticale and barley) and dry hay (triticale and barley)

		Triticale†		Barley†	
Item*	Corn silage†	Dry hay	Silage	Dry hay	Silage
Dry matter					
a	0.24±0.01	0.31±0.01	0.37±0.01	0.32±0.02	0.33±0.01
b	0.54±0.02	0.41±0.02	0.44±0.02	0.45±0.02	0.52±0.04
c	0.03±0.01	0.04±0.01	0.03±0.01	0.05±0.01	0.02±0.05
Crud protein					
a	0.65±0.01	0.64±0.01	0.82±0.01	0.50±0.02	0.80±0.01
b	0.19±0.04	0.20±0.01	0.09±0.01	0.31±0.02	0.11±0.02
c	0.02±0.03	0.06±0.01	0.02±0.01	0.08±0.02	0.02±0.01

*: a: Quickly degradable fraction, b: Slowly degradable fraction, c: Degradation rate constant, †: Parameters±SE

Table 5: Dry matter Intake, milk yield and milk compositions of lactating dairy cows fed diets containing whole crop silage (corn, triticale or barley)

	Treatment†			Treatment effect*		Time effect*	
Item	WCCS	WCTS	WCBS	SEM	*P*	SEM	*P*
Dry matter intake (kg day^{-1})	19.5[a]	17.7[b]	22.7[a]	1.56	0.01	1.17	0.01
Milk yield (kg day^{-1})	32.2	32.2	28.8	1.65	0.17	1.90	0.01
Milk protein (g kg^{-1})	30.0	29.0	30.0	3.7	0.36	4.0	0.09
MUN (mg day^{-1})	16.32	16.58	16.76	0.20	0.92	0.67	0.11
Milk lactose (g kg^{-1})	47.0	43.0	47.0	0.9	0.17	1.2	0.65
Total solids (g kg^{-1})	116.74	105.24	111.22	1.87	0.07	2.10	0.03

a, b: Means with different superscript letters in the same row differed significantly *p*: Probability †: WCCS: Whole Crop corn Silage, WCTS: Whole Crop Triticale Silage and WCBS: Whole Crop Barley Silage *: When the difference between the treatments was more than 2 times of SEM, it was considered as significant ($p<0.05$)

Table 6: Blood glucose and urea nitrogen concentrations of lactating Holstein dairy cows (mg dL^{-1}) fed diets containing WCCS, WCTS and WCBS

			Treatments[(1)]				
Item	Period	Sampling time	WCCS	WCTS	WCBS	SEM	*P*
Blood glucose							
	1*	0	58.17	58.68	55.61	2.56	0.76
		4	51.07	48.85	53.08	2.40	0.61
	2**	0	60.94	62.42	56.70	2.64	0.45
		4	53.16	56.77	50.91	2.17	0.32
Blood urea nitrogen							
	1*	0	22.06[b]	22.37[b]	25.05[a]	0.58	0.02
		4	20.37	22.32	24.14	1.22	0.24
	2**	0	24.31	24.80	25.78	0.61	0.39
		4	23.57[b]	22.17[b]	28.27[a]	0.01	1.02

[a,b]Means with different superscript letters in the same row differed significantly *p*: Probability [1] WCCS: Whole Crop corn Silage, WCTS: Whole Crop Triticale Silage and WCBS: Whole Crop Barley Silage, *: 21[st] of the experiment, **: 42[nd] of the experiment

Dry matter intake and milk production: Dry matter intake is presented in Table 5. Dry Matter Intake (DMI) was affected by treatment ($p<0.05$) and was the lowest for whole crop triticale silage (17.7 kg d^{-1}), mediate for corn silage (19.5 kg d^{-1}) and highest for whole crop barley silage (22.7 kg d^{-1}), which agreed the results of Khorasani *et al.* (1996); McCartney (1994) and Okine, *et al.* (1994). These authors reported that the low dry matter intake of WCTS was possibly related to high NDF content of this silage compared with barley and corn silages. However, The low DMI when cows fed WCTS, might also due to the other dietary characteristics such as digestibility, time spent chewing during eating and ruminating (Ulyatt *et al.*, 1984; Waldo and Jorgansen, 1981). In addition, the CP contents of the diets influence DMI (Khorasani *et al.*, 1993). Means for milk production and composition are shown in Table 5. Means for milk production in this experiment was not affected by the treatments that agreed the finding of Khorasani *et al.* (1993), Khorasani *et al.* (1997) and Van Duinkerken *et al.* (1999). In the present experiment, milk components (protein, urea, lactose and Total solid) were not affected by the treatments.

Blood glucose and urea nitrogen: Blood glucose and urea nitrogen are presented in Table 6. In this experiment, blood glucose in mid and end of the experiment in each sampling time (0.0 and 4 h) was not affected by the treatments, but, it decreased at the 4 h after feeding. Blood urea nitrogen in the mid (4 h) and in the end of the experiment (before feeding) was significantly affected by treatments ($p<0.05$). Cows fed WCBS had highest blood urea nitrogen compared with the other treatment.

CONCLUSION

Results of this experiment showed that WCTS and WCBS had more soluble DM and CP compared with the WCCS, therefore must be regarded in feeding the dairy cows for optimizing the synchronization and utilization of protein and energy for rumen bacteria. However, there was no significant difference between treatments when the performance (milk production) of cows was considered. This suggests that WCTS and WCBS under special condition such as water limiting may be can used as a substituted forage for WCCS in feeding of lactating cows.

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