Nutrients and Ruminal Digestibility of Baby Corn By-product Silages under Different Harvesting Methods

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Abstract

The objective of this study was to determine nutrients and ruminal digestibility of silages from baby corn by-products. The experiment was assigned in Completely Randomized Design with 5 treatments and 4 replications. The treatments were silages under different harvesting method including baby corn stalks cut at 10, 40 and 70 cm height above ground, baby corn husk with and without silk. After 30 d ensiling, the silage samples were collected and analyzed for nutrients while ruminal digestibility was determined using Batch culture for 24 h incubation. Ruminal gas production was estimated in glass syringe for 24 h. The results showed that increasing in cutting height from 10 to 70 cm improved nutrients of silage by decreasing ($P<0.05$) ADF (39.73 vs. 43.22%DM), NDF (67.50 vs. 70.70%DM) and increasing ($P<0.05$) crude protein (11.60 vs. 10.16%DM), dry matter digestibility (40.13 vs. 37.25%), organic matter digestibility (36.79 vs. 33.16%), NDF digestibility (46.18 and 41.92%). The husk with silk silage had higher ($P<0.05$) crude protein (12.35 vs. 8.75%DM), NDF digestibility (53.87 and 46.52%) and lower ($P<0.05$) ADF (38.78 vs. 40.88%DM), and methane gas production (7.75 vs. 10.75 ml/200mg) than those husk without silk silage but had similar ($P>0.05$) NDF (72.38 and 71.93%DM), dry matter digestibility (44.79 and 45.25%DM), organic matter digestibility (42.26 and 43.36%). The methane gas production was the highest in the husk without silk silage whereas silages from different cutting stalks and silage from husk with silk produced a similar amount of the methane gas (7.25-8.0 ml/200mg; $P>0.05$). In conclusion, increase the stalk cutting height to 70 cm improved the silage quality by increasing nutrients and ruminal digestibility. Silage from baby corn husk with silk had higher nutrients and ruminal digestibility than baby corn stalk silages. Lowering dry matter loss of silage from baby corn husk with silk by reducing moisture prior to ensiling requires further investigation.

Keywords: Baby corn stalk; Baby corn husk; Cutting height; Silage; Nutrient; Ruminal digestibility; Batch culture.

1. Introduction

Baby corn is one of economic plants of Thailand and highly adapted crop which can be grown throughout the country. The crop takes only 55-60 days from seeding to harvest and suitable for growing all the year

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round. Its production over the country was 276,874 ton in 2013 [1]. Hence its by-products including stalk, husk and silk are plenty and can be used as a source of roughage of dairy cows.

Corn silage is wildly used as an important source of roughage for dairy cows and usually accounts for 30 to 40% of the diet [2]. Data reported that increasing in cutting height of corn during harvest to improve the forage quality. Cutting corn higher has shown to increase silage quality because the lower part of the crop is poorly digestible. Wu and Roth (2005) [2] reported cutting corn at 50 cm height improved corn silage quality by increasing contents of protein, net energy and NDF digestibility when compared to cutting corn at 17 cm height. The higher cut corn silage improved milk production when directly substituted in the ration but also decreased milk fat content. When the authors switched from conventional to high cut silage and rebalanced the ration with more forage, they found that there appeared to be a potential advantage of 7 cents per cow per day for the high cut ration. Caetano et al. (2011) [3] studied the nutritional traits and in vitro digestibility of silages from corn harvested at two cutting heights, 5 cm above ground (low) and 5 cm below the intersection of the first ear (high). They found that silages from plants harvested at high cutting height presented average content of dry matter significantly superior to silages from plants harvested at low height. They also found that the raise in the cut height increased in vitro dry matter digestibility and decreased concentrations of fibrous fractions.

However, there was a scanty data of nutrients and digestibility in rumen of silage from baby corn by-products. The objective of this study was to evaluate nutrients and digestibility in rumen of silages from baby corn stalked harvested at different cutting heights and baby corn husk with and without silk. The data from this study will be beneficial for management of silage from baby corn by-products for the highest benefit for dairy cows.

2. Materials and Methods

The experiment was conducted with Completely Randomized Design. There were 5 treatments (4 replications) of baby corn by-products, the corn stalk harvested at 10, 40 and 70 cm cutting height above ground, the husk with and without silk. After harvesting baby corns, the stalks and husk with and without silk were cut and chopped to a length of 1 inch average. Ensiling was carried out in double lined polyethylene plastic bags holding 10 kg each. They were kept indoors at room temperature. After 30 d of ensiling, dry matter (DM) losses were measured using DM weights before and after ensiling. The DM was determined in hot air oven at 60^{o}C for 72 h. The dried samples were ground through 1 mm screen and then analyzed for organic matter (OM), crude protein (CP) [4], ADF, NDF [5]. *In vitro* ruminal digestibilities in 24 h of incubation Batch culture were determined following the methods described by [6] and [7]. In brief, rumen fluid was obtained from a dairy cattle previously fitted with rumen fistula. Rumen fluid was strained through 4 layers of cheese cloth, mixed 1:3 with McDougall's buffer and placed in glass culture flasks containing 3 grams of sample. Flasks were purged with CO_2 and then incubated in incubator shaker at 39^{o}C. Samples were collected at 24 h. Samples were used to determine CP, DM and OM [4] and then calculated for the digestibilities. Total gas production was determined following the method described by [8] then methane gas production was measured after infusion of 4 ml of 10M NaOH into the syringe [9]. The result data were analyzed as a Completely Randomized Design using Proc GLM and a comparison of the Least Square means [10].

3. Results and Discussion

Data of nutrients and ruminal digestibility of silages from baby corn by-products are presented in Table 1. One of the most critical factors affecting silage DM losses is the moisture present in the crop at ensiling. Ensiling high moisture forage can increase DM loss [11]. In this study, DM loss was highest for silage from husk with silk followed by those from husk without silk, corn stalk harvested at 70 and 40 cm cutting height, respectively and the lowest for the silage from the stalk harvested at 10 cm cutting height. We found that moisture contents in fresh baby corn by-products were the highest in the husk with silk and the husk without silk followed by the corn stalk harvested at 70 and 40 cm cutting height respectively and lowest for the stalk harvested at 10 cm cutting height (84.00, 84.05, 78.10 75.42, 73.72 %, respectively; data not shown in Table). The data indicated that the increase in DM losses was due to the higher moisture content in the fresh by-products at ensiling.

As shown in Table 1, the increased in stalk cutting height decreased the silage DM contents (25.65, 23.67 and 20.18 %, respectively) and silages from the husk with and without silk contained very low DM (12.60 and 13.94%, respectively). However, the result data had shown that OM contents were not significantly different among silages from stalks cut at different height (92.05-92.11%DM; $P>0.05$) which lower than those of husk with and without silk (94.75 and 96.11%DM, respectively). Seglar (2003) [12] suggested that corn silage should contain DM higher than 28% to avoid the problem of effluent. Mickan and Pitz (2003) [13] suggested that wilting the crops 24 h prior to ensiling increase silage DM. The data indicated that baby corn by-products should be wilted before ensiling.

Cutting baby corn stalk at 70 cm height improved the silage quality by increasing ($P<0.05$) content of crude protein (11.60%DM) comparing to the cutting height at 10 cm (10.16%DM). The results disagreed with [3] who reported no difference in crude protein contents for corn silages from different cutting height. However, a report of [14] which assessed the chemical composition of different morphological fractions of corn stover and found that crude protein content was higher in leaf blade than the stem. Thus the increase in crude protein content in this study might due to the increase of leaf fraction as the cutting height increase. The higher protein content for the corn husk with silk (12.35%DM; $P<0.05$) compared to the without silk (8.75%DM) was due to the high protein content of the silk (18.58%DM) as reported by [15].

ADF contents of silages from the stalk cut at 70 cm height and the husk with silk were not significantly different (39.73 and 38.78%DM; $P>0.05$) and lower ($P<0.05$) than that of the silage from husk without silk (40.88%DM). NDF content of silage from husk with and without silk were not significantly different, 72.38 and 71.93%DM, respectively which higher than the silage from the stalks cut at 40 and 70 cm height (69.81 and 67.50%DM, respectively; $P<0.05$). However, ADF and NDF contents of corn stalk silages decreased as the cutting height increased which were in agree with [3]. Muck (1988) [16] stated that during ensiling, plants produce their own enzymes that continue to hydrolyze starch and hemicellulose to monosaccharides. The hydrolysis provides additional sugars for the lactic acid fermenting microbes and degrades hemicellulose, which lowers the NDF content of the forage. Masoero et al. (2011) [17] reported the upper part of corn stalk had sugar content higher than the basal part. In this study, NDF contents of the fresh corn stalks with different cutting height were not significantly different ranging from 70.73 to 71.88%DM ($P>0.05$; data not shown in Table). Thus, the decreased NDF of the

silage as the cutting height increase might be due to the higher sugar content which enhanced fermentation and hemicellulose degradation during ensiling. The lowered NDF of the silage would lead to the increase of feed intake of dairy cows in particular high producing cows [18].

As shown in Table 1, The DM digestibilities of silages from the husk with and without silk were higher than those of the silages from the stalks. The 70 cm cutting height stalk silage had higher DM digestibility than those of the 10 and 40 cm cutting height. Increase in cutting height increased DM digestibility in this study agreed with [3]. Tolera and Sundstol (1999) [14] assessed the chemical composition of different morphological fractions of corn stover and found that dry matter digestibility in rumen was higher in leaf blade than the stem. Thus, increase in cutting height increased DM digestibility in this study might be due to the increase in leaf blade fraction in the silage. Furthermore, we found the pattern result of OM digestibility was similar to that of DM digestibility as shown in Table 1. The obtained data also showed that DM and OM digestibility of silages from baby corn husk with and without silk significantly superior to silages from baby corn stalks.

NDF digestibility of the stalk silage from 70 cm cutting height was higher than those of the 10 and 40 cm cutting height silage but lower than that of silage from the husk with silk (Table 1). Gencoglu et al. (2008) [19] reported mutant corn hybrids having low lignin had higher NDF digestibility leading to increases in feed intake and milk production of dairy cows. The result data in this study indicated that increase in the cutting height to 70 cm not only altered the NDF content but also altered the NDF digestibility which would lead to increase feed intake and milk production of the dairy cows. The data also indicated that the increase in OM digestibility of the 70 cm cutting height silage was due to the increase in NDF digestibility.

We found that the total gas production was highest for the silage from husk with silk comparing to the others. We also found that the total gas production ranked the cutting heights in the same order as the in DM, OM and NDF degradability as shown in Table 1 which indicated that gas production form rumen fermentation reflected the degradability of DM, OM and NDF. The obtained data disagreed with [20] which indicated that *in vitro* gas production might not necessarily reflect the degradability. However, methane gas production was found the highest for the silage from the husk without silk (10.75 ml/200 mg) whereas silages from different cutting stalks and silage from husk with silk produced a similar amount of methane gas (7.25-8.00 ml/200mg). The data indicated similar effect on global warming when feed the cows with silage from baby corn husk with silk and baby corn stalk harvested at different cutting height but feeding the cows with silage from baby corn husk without silk would affect more.

Table 1. Dry matter loss, nutrients, digestibility and gas production in rumen of silages from baby corn by-products**.**

	Baby corn stalk cutting height (cm)			Baby corn husk without silk	Baby corn husk with silk	SEM
	10	**40**	**70**			
Dry matter loss (%)	3. 90^{d}	5.41^{cd}	9.02^{c}	18.80^{b}	30.56^{a}	0.11
Dry matter (%)	25.65^{a}	23.67^{b}	20.18^{c}	13.94^{d}	12.60^{e}	0.29
Nutrients (%DM)						
Organic matter	92.05^{c}	92.11^{c}	92.05^{c}	96.11^{a}	94.75^{b}	0.14
Crude protein	10.16^{c}	10.96^{bc}	11.60^{ab}	8.75^{d}	12.35^{a}	0.29
ADF	43.22^{a}	41.41^{b}	39.73^{c}	40.88^{b}	38.78^{c}	0.32
NDF	70.70^{bc}	69.81^{c}	67.50^{d}	71.93^{ab}	72.38^{a}	0.45
Digestibility (%)						
Dry matter digestibility	37.25^{c}	37.35^{c}	40.13^{b}	45.25^{a}	44.79^{a}	0.62
Organic matter digestibility	33.16^{c}	33.67^{c}	36.79^{b}	43.36^{a}	42.26^{a}	0.71
NDF digestibility	41.92^{c}	38.88^{c}	46.18^{b}	46.52^{b}	53.87^{a}	1.08
Gas production (ml/200 mg)						
Total gas	20.00^{c}	20.50^{c}	22.50^{b}	22.00^{b}	24.00^{a}	0.48
Methane gas	7.50^{b}	7.25^{b}	8.00^{b}	10.75^{a}	7.75^{b}	0.67

^{abcde}Superscript with different letters within row differed ($P<0.05$), SEM: Standard error means.

4. Conclusion

Increase the stalk cutting height to 70 cm improved the silage quality by increasing nutrients and ruminal digestibility. Silage from baby corn husk with silk had higher nutrients and digestibility than baby corn stalk silages. Lowering dry matter loss of silage from baby corn husk with silk by reducing moisture prior to ensiling requires further investigation.

5. References

[1] http://www.oae.go.th (retrieved on March 5, 2014).

[2] Wu, Z., Roth, G., Considerations in Managing Cutting Height of Corn Silage. Extension Publication DAS., College Park, Pennsylvania State University, pp. 3-72., 2005.

[3] Caetano, H., Oliveira, M.D.S., Junior, J.E.F., Rego, A.C., Carvalho, M.V., Renno, F.P., Nutritional Characteristics and *In Vitro* Digestibility of Silages from Different Corn Cultivars Harvested at Two Cutting Heights, Revista Brasileira de Zootecnia, Vol. 40, pp. 708-714, 2011.

[4] AOAC., Official Methods of Analysis, 16th edn., Association of Official Agricultural Chemists, Washington, DC., 1995.

[5] Goering, H.K., Van Soest, P.J., Forage Fiber Analysis (Apparatus, Reagents, Procedures and Some Applications), Agricultural Handbook No. 379. ARS-USDA, Washington, DC., 1970.

[6] Srichana, D., Kondo, S., Effect of Rice Bran Extracts on Fermentation, Protein, Dry Matter and Organic Matter Digestibility in Rumen *In Vitro*, J. Dairy Sci., Vol. 93 No. Suppl. 1, pp. 143, 2011.

[7] Srichana, D., Kondo, S. Jiwajinda, S., Suthitham, W., Effect of *Costus speciosus* Extracts on Rumen Fermentation in Batch Culture, Thai Science and Technology Journal, Vol. 20, No. 3, pp. 187-194, 2012.

[8] Manke, N.H., Rabb, L., Salewski, A., Steingass, H. Fritz, D., Schneider, W., The Estimation of the Digestibility and Metabolisable Energy Content of Ruminant Feeding Stuffs from the Gas Production When They are Incubated with Rumen Liquor In Vitro, J. Agric. Sci., Vol. 93, pp. 217-222, 1979.

[9] Fievez V., Babayemi O. J., Demeyer D., Estimation of Direct and Indirect Gas Production in Syringes: A Tool to Estimate Short Chain Fatty Acid Production that Requires Minimal Laboratory Facilities, Animal Feed Science and Technology, Vol. 123–124, pp 197–210, 2005

[10] SAS, SAS/STAT User's Guide:Version 9.1th ed. SAS Inst Inc, Cary, NC., 2004.

[11] Muller, J.P., Green, J.T., Kjelgaard, W.L., Corn Silage Harvest Techniques, National Corn Handbook. Iowa State Univ, Iowa, 1987.

[12] Seglar, B., Fermentation Analysis and Silage Quality Testing, In: Proceedings of the Minesota Dairy Health Conference, College of Veterinary Medicine, University of Minesota, pp 119-136, 2003.

[13] Mickan, F.J., Piltz, J.W., Mowing and Wilting Pastures Cops. In: Successful Silage (TopFodder Silage Manual), Ed. Kaiser, A., Piltz, J.W., Burns, H. and Griffiths, N., Dairy Australia and New South Wales Department of Primary Industry, pp.143-170, 2003.

[14] Tolera, A., Sundstol, F., Morphological Fractions of Maize Stover Harvested at Different Stages of Grain Maturity and Nutritive Value of Different Fractions of the Stover. Anim. Feed Sci Technol., Vol. 81, pp. 1-16, 1999.

[15] Chunjula, P., Study on an Integration of Beef Cattle Raising and Baby Corn

Production, Master's Thesis. Kasetsart University, Thailand, 1991.

[16] Muck, R. E., Factors Influencing Silage Quality and Their Implications for Management, J. Dairy Sci., Vol. 71, pp. 2992-3002, 1988.

[17] Masoero, F., Gallo, A., Zanfi, C., Giuberti, G., Spanghero, M., Effect of Nitrogen Fertilization on Chemical Composition and Rumen Fermentation of Different Parts of Plants of Three Corn Hybrids, J. Anim Feed Sci and Tech. 164: 207-216, 2011.

[18] National Research council, Nutrient Requirements of Dairy Cattle, 7threv. ed. National Academy of Sciences, Washington, DC., 2001.

[19] Gencoglu, H., Shaver, R., Lauer, J., Brown Midrib Corn Silage for Lactating Dairy Cows. http://www.uwex.edu/ces/crops/uwforage/silage.htm.pdf., 2008.

[20] Cone, J.W., van Gelder, A.H., Influence of Protein Fermentation on Gas Production Profiles, Anim. Feed Sci. Technol., Vol. 76, pp. 251-264, 1999.