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Comparison of different maize stalk sources in China's dairy production based on the Cornell system*

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ABSTRACT

For optimising the use of maize stalks in China's dairy production system, dry maize stalks (DMS), maize stalk silage (MSS) and high oil maize silage (HOMSS) were compared at 11 concentrate/roughage (C/R) levels from 25/75 to 75/25 with maize stalks used as a sole roughage source in the TMR. The Cornell system V5.0 was used as the base model in computer simulation. Actual chemical analyses of DMS, MSS and HOMSS were used in feed database. Results indicated that the HOMSS, MSS and DMS based TMR supported milk yield up to 28, 25 and 23 kg/d, respectively. At the same C/R level, HOMSS supported the highest milk yield with the highest economic return and the lowest concentrate consumption and the lowest N excretion per kg of milk. DMS supported the lowest milk yield with the lowest economic return, the highest concentrate consumption and the highest N excretion per kg of milk.

KEY WORDS: maize stalk, Cornell system, dairy production system

INTRODUCTION

Due to limited arable land, maize stalks have been the predominant roughage source for dairy and beef cattle in some major crop production areas in China. The traditional way of feeding maize stalks was feeding them in the sun-cured form (dry maize stalks, DMS). Nutrient loss caused by spoilage, leaching and leaf loss during handling is unavoidable. Besides, year-round supply of dry stalks is difficult. Ensilage upon ear-pick-up (maize stalk silage, MSS) will overcome most the above problems. It has been found that the high oil maize stalk contains

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significantly higher amount of available nutrients (LaCount et al., 1995; Dhiman et al., 1996; Zhao, 2003; Yan, 2005; Dong, 2006). In addition, high oil maize keeps the plant green and succulent much longer in the field after ears are harvested, which is favourable for silage making.

The Cornell Net Carbohydrate and Protein System (CNCPS) has a biologically based structure, permitting prediction of nutrient requirements, feed utilization and animal performance over wide ranges in cattle, feed, management and environmental conditions (Fox et al., 1992, 2000; Tylutki and Fox, 1998; Molina et al., 2004; Zhao et al., 2007). Thus, the CNCPS provides a powerful tool in computer simulation.

The objective of the present study was to use the CNCPS version 5.0 as a base model to compare DMS, MSS and HOMSS for optimizing the use of maize stalks in China's dairy feeding system.

MATERIAL AND METHODS

Listed in Table 1 are average values for animal, environment and management factors set as inputs into the CNCPS model for simulations. One of the three maize stalks (treatments: DMS, MSS and HOMSS) was sole roughage sources for individual diets. Eleven simulations were conducted for each treatment with roughage/concentrate ratio (C/R) of 75/25, 70/30, 65/35, 60/40, 55/45, 50/50, 45/55, 40/60, 35/65, 30/70 and 25/75. Feed ingredients for formulation of the concentrate portion were those commonly available in North China area (Table 2).

Table 1. Inputs used for the Cornell Net Carbohydrate and Protein System simulation

Animal description		Management and environment	
Number in group	80	Additive	None
Days to feed	30 days	Added fat	None
Age of animals	40 months	Wind speed	1.6 kph
Body weight	600 kg	Prev. temperature	15.6 deg. C.
Days pregnant	30 days	Prev. relative humidity	40%
Days since calving	94 days	Current temperature	15.6 deg. C.
Lactation number	2	Current relative humidity	40%
Calving interval	12.5 months	Hours in sunlight	0 h
Expected calf birth weight	43 kg	Storm exposure	None
Age at first calving	22 months	Hair depth	0.64 cm
Milk fat	3.5%	Mud depth	0 cm
Milk protein	3.23%	Hair coat	No mud
Condition score	2.6	Cattle panting	None
Breed	Holstein	Minimum night temperature	10 deg. C.
		Activity	Large free-stalls

TMR diets were formulated least costly based on CNCPS prediction as such: 1. the supplied ME, MP, Met Lys, Ca, P, K were balanced for animal total requirements, and 2. rumen nitrogen was maintained at a positive balance. At 75% concentrate level, soyabean hulls inclusion level reached 27% of the TMR to meet the NDF requirement (NDF>23%).

The following predicted results were recorded for each group of animals: 1. milk yield that the diet was able to support, 2. the cost per kg milk, 3. gross income per head animal (milk sale minus feed costs), and 4. total nitrogen excretion per kg milk.

Table 2. Diets used in the Cornell Net Carbohydrate and Protein System simulation

Concentrate/roughage	25/75	30/70	35/65	40/60	45/55	50/50	55/45	60/40	65/30	70/30	75/25
Ingredients, %											
maize grain	0	1	2.5	4.3	6	9	12	15.7	17.5	23	27
soyabean meal	18.5	18.5	17	16	16	13.5	12.5	11	9	10	6.5
cottonseed meal	4	4.5	5	5.2	5	6.5	7	7.8	8.5	8	10
soyabean hulls	0	3.5	8	11.5	15	18	20.5	22	26.5	24.5	27
limestone	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
calcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
premix	1	1	1	1	1	1	1	1	1	1	1
salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
bicarbonate sodium	0	0	0	0.5	0.5	0.5	0.5	1	1	2	2
maize stalks	75	70	65	60	55	50	45	40	35	30	25
Total	100	100	100	100	100	100	100	100	100	100	100

Nutrient compositions of DMS, MSS and HOMSS entered into the CNCPS V 5.0 User-Created Feed Database were primarily based on our lab analyses from samples collected from dairy farms in north China area (Table 3). The price of feed ingredients was based on the average market values. A premium of 40 Yuan /ton was added to MSS as processing costs for ensilage to ensure that DMS was not undervalued. An artificially assumed additional premium of 100 Yuan/ton was added to HOMSS in order to encourage farmers to grow high oil corn (Table 3).

RESULTS AND DISCUSSION

The average DMI (dry matter intake) and milk yield of each simulation were shown in Figure 1. DMI and the milk yield of the HOMSS treatment were significantly higher than the others at each C/R ratio. About 4.5-6 kg/day higher milk yield that HOMSS can support than does MSS at the same TMR diet. It also suggests that both DMS and MSS rations support more than 22 kg milk yield if up to 75% concentrate for more than 27% soyabean hulls were included in the TMR.

Table 3. Composition and price of dry maize stalk (DMS), maize stalk silage (MSS) and high oil maize stalk silage (HOMSS)

Item	DMS	MSS	HOMSS
DM, %	60.00	30.38	27.58
NDF, %DM	72.00	66.99	61.18
Lignin, %NDF	10.00	10.00	7.00
CP, %DM	5.14	6.58	7.94
Starch, %NSC	35.00	45.00	59.00
Fat, %DM	1.48	1.48	2.59
Ash, %DM	7.20	9.00	8.80
Physically effective fibre, %NDF	100.00	95.00	85.00
Soluble-protein, %CP	20.00	45.00	50.00
NPN, %Sol-P	95.00	100.00	100.00
NDF, %CP	31.43	16.00	16.40
ADF, %CP	13.57	4.50	7.88
Price, yuan/ton	60.0	100.0	200.0

Regression equations predicting percent of concentrate in the TMR (Yc) from milk production (Xm) for each stalk source are listed below:

DMS: Ycd = 0.037 Xmd - 0.121 (R^2 = 0.998, P<0.0001),
MSS: Ycm = 0.044 Xmc - 0.346 (R^2 = 0.999, P<0.0001),
HOMSS: Ych = 0.064 Xmh - 1.049 (R^2 = 0.994, P<0.0001).

With such high R^2 and P values, the concentrate level in TMR should be well predicted based on the milk yield. At a current typical milk yield level of 20 kg/day, the predicted concentrate levels in TMR are 61.9, 53.4 and 23.1% for DMS (Ycd), MSS (Ycm) and HOMSS (Ych), respectively. At same milk production level, animals fed with MSS based TMR consume less concentrate than with DMS based TMR. HOMSS based TMR consumes less concentrate than does MSS based TMR. This is very important for a farming-land-limiting country such as China.

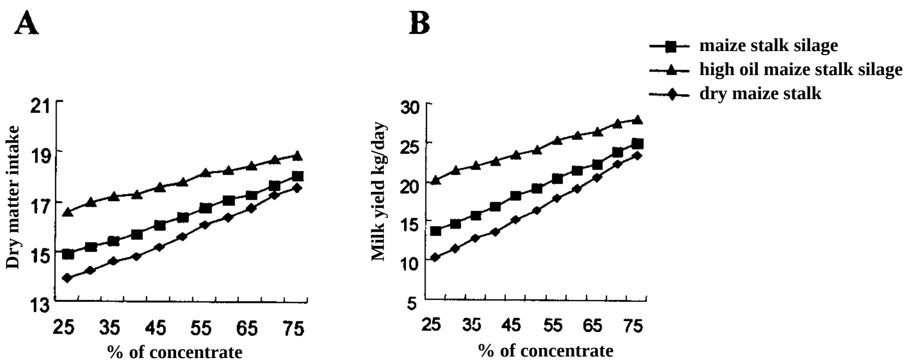

Figure 1. The DMI and milk yield of the cows in three treatments

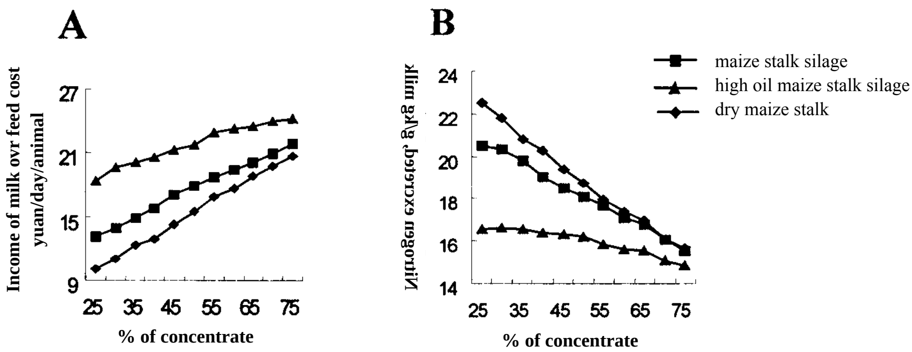

Figure 2. A. Income of milk over feed cost per animal. B. Nitrogen excretion per kg milk

The average results of income for each simulation are showed in Figure 2A. It suggests that although the price of HOMSS was set significantly higher, HOMSS based TMR still brought the highest income. MSS based TMR brought more income than did DMS. As showed in Figure 2B, the nitrogen excretion of HOMSS was much lower than the other two treatments. MSS excreted less nitrogen than did DMS. Making silage is not only a good way to preserve the maize stalks, but also can be more profitable and minimizing the nitrogen excretion.

CONCLUSIONS

Maize stalks can be well used for dairy production especially under conditions where farming land is limited such as in China. Dry maize stalk ration can support about 12-23 kg milk in this research (see Figure 1B). Silage making is a much better way to utilize maize stalks. High oil maize is the best choice for future use in China.

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