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Full Length Article

Production Performance of Dairy Cows Fed on Steam-Flaked Corn as a Replacement of Crushed Corn

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Abstract

Effect of feeding steam-flaked corn on production performance of lactation dairy cattle was investigated. For this purpose, 112 lactating Chinese Holstein cows having similar milk yields, lactation periods, parities, ages and body scores were randomly separated into two equal (n=56) groups. The experiment continued for 120 days divided into three (1^{st}, 2^{nd} and 3^{rd}) periods, each of 35 days, with an adaptation interval of five days. The crushed corn (CC) based diet was replaced with steam-flaked corn (SFC) gradually from 20−100% replacement plan. During adaptation period, SFC replacement was 20, 55 and 85%; whereas, SFC replacement during experimental periods was 40, 70 and 100% in 1^{st}, 2^{nd} and 3^{rd} periods. Results revealed that the SFC group had better average milk yield than CC group. The mean of these increment milk yields was 1.48 kg (P<0.05). The protein percentage and the sugar in milk of SFC group was higher than CC group; whereas, urine nitrogen and somatic cell count of SFC group was lower than CC group by 0.9% (P>0.05) and 30,800 cells/mL (P<0.05), respectively. The present study confirmed that utilizing SFC diet increased milk yield, improved milk production traits, and enhanced the performance of cows.

Keywords: Steam-flaked corn; Production performance; Chinese Holstein

Introduction

Corn is playing a key role in diet of livestock as a fodder. A majority of feedlots use crushed corn (CC), as opposed to grain corn, in feeding beef, possibly because of enhanced digestion. However, steam-flaked processing has become the most effective and profitable for dairy cattle production. It has wide popularization and application prospects in China. The main composition of yellow corn is starch, which is approximately 72% of the DM (Owens and Zinn, 2005). The processing of corn is an important way to increase starch availability, to improve efficiency of production, and to decrease the possibility of ruminal acidosis and ketosis.

Steam-flaked corn (SFC) processing is the steaming of whole grain at atmospheric pressure between 100−110℃, generally for 30−60 min., followed by the pressing of typical density flake corn via preheated press-roller, and then drying and cooling. These procedures will increase moisture content by 5% to 8%. Due to starch gelatinization, the hydrogen bond sites of intermolecular activity are broken down and the applied force is reduced, and the enzymes easily catalyze the starch. Compared to other methods of processing corn, the steam-flaked method appreciably improves the efficiency of digestion. Moreover, the scores in the evaluation index are all above-average, such as ADG (average daily gain), DMI (dry matter intake), F: G (feed to gain ratio), ME (metabolizable energy) (Huntington, 1997). The same study also mentions that SFC can be explained largely by increased ruminal, post-ruminal and total-tract digestion of starch (Huntington, 1997; Owens and Zinn, 2005). Some researchers are convinced that flaked corn has better performance in rumen intake, in post-rumen entry and total-tract digestion of starch than flaked sorghum. They both proved to cause no potential negative consequences of over processing (Huntington, 1997; Swingle *et al.*, 1999; Theurer *et al.*, 1999; Owens and Zinn, 2005). Zinn noted that flaking improved NE_g values from 15.9 to 25.9% (Zinn *et al.*, 2002). He also pointed out the performance of flaking corn is greater than summarized in NRC Beef (1996), and that NE values for flaked corn have been underestimated. SFC increases digestibility of starch in rumen and the small intestine (Xin *et al.*, 2006). It not only improves the productivity of dairy cattle, but it also maintains the health of cattle due to steam-flaked processing (Leng *et al.*, 2010).

In dairy production, balanced diets and high outputs are the guarantee of high profits. There have been few studies that directly prove SFC of proper proportions in diets. Thus, the objectives of our studies were to compare

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the varying rates at which SFC diets affected production performance in dairy cattle. This would allow ascertaining the best percentage of SFC to be used in the diet composition, and also to provide the foundation for applying SFC in diets of dairy cattle production.

Materials and Methods

Animals

Because the purpose of this study was to find the proper proportion of SFC in the diets in consideration of the limited of cost of inputs through communication with feedlot managers, the SFC was bought from Zhu-Kang Trade Co., LTD of Ningxia. The experimental animals were chosen from the same dairy feedlot (Yinchuan, Ningxia). For this purpose, 112 lactating Chinese Holstein cows having similar milk yields, lactation periods, parities, ages and body scores (Table 1) were randomly separated into two equal (n=56) groups. The groups were housed in similar pens under identical conditions. The experiment continued for 120 days divided into three (1^{st}, 2^{nd} and 3^{rd}) periods, each of 35 days, with an adaptation interval of five days.

Diets

The crushed corn (CC) based diet was replaced with steam-flaked corn (SFC) gradually from 20-100% replacement plan. During adaptation period, SFC replacement was 20, 55 and 85%; whereas, SFC replacement during experimental periods was 40, 70 and 100% in 1^{st}, 2^{nd} and 3^{rd} periods (Table 2). In CC group, composition of the feedlot diet contained the corn silage, alfalfa, oats hay, cottonseed, brewer's grain and concentrate. For SFC group, ingredients other than the corn silage were used. The dietary composition and nutrient components of the two trial groups were compared, as indicated by the CC and SFC columns in Table 4 and 5.

The diets were mixed and offered as TMR (total mixed ration) three times a day (06:00, 14:00, 19:00). Cows had ready access to feed and water and were milked three times a day (06:00, 13:30, 20:00). Feed intake was measured every 5 days. Milk yield was collected every 10 days and analyses of the nutrient composition of this milk were performed upon collection. In the experiment, cows were housed in open pens, and free to lie and exercise. Also, feed ingestion, water intake, manure and general health were observed and recorded daily; moreover, the two herds had similar management. Specifically, disinfection and injection routines followed the same schedule. No member of either herd demonstrated symptoms of illness for the duration of the study. There were no unexpected variations in the body weights of the cows at any point of either day in the two-day period. All the indices of milk came from DHI of Animal Husbandry Extension Station, Yinchuan, Ningxia.

Statistical Analyses

The analyses were performed by the least squares method as applied in the general linear model (GLM) procedure of SAS software (Version 8.01). The results were presented as means± standard error, p-value.

Table 1: Information of experimental cows

Groups	Average MY (kg)	Average age (year)	Average parities	Average lactation days (days)	Average body scores
CC	37.22	3.43	1.80	58.54±16.68	3.3
SFC	37.24	3.40	1.93	62.25±15.48	3.3

MY= Milk yield, CC= Crushed corn, SFC= Steam flaked corn

Table 2: The percentage (%) of cows fed steam-flaked corn

Process	Adaptation period	First period	Adaptation period	Second period	Adaptation period	Third period
CC	80	60	45	30	15	0
SFC	20	40	55	70	85	100

CC= Crushed corn, SFC= Steam flaked corn

Table 3: Diet compositions

Item	diet
Ingredient: % dry matter	
Corn silage	23.22
Alfalfa	16.5
Oat hay	6.23
Cottonseed	7.86
Brewer's grain	3.85
Concentrate	42.34
Concentrate (%)	
Corn	55
Bean meal	12
Cottonseed meal	10.5
Flax seed	3.2
DDGS	9.4
Premix	2
Dicalcium phosphate	1.5
Calcium	2
Salt	0.8
Sodium bicarbonate	1.7
KCL	1
Feed additives	0.1
Probiotics	0.8

Table 4: Nutrient composition (%)

Item	CC	SFC
CP	15.1	14.82
Ash	8.41	8.44
EE	3.39	3.61
CF	17.25	18.69
Calcium	0.99	0.95
Phosphorus	0.41	0.40

CP: crude protein; EE: crude fat; CF: crude fiber, CC= Crushed corn, SFC= Steam flaked corn

Table 5: The comparison of CC and SFC (%)

Item	CC	SFC
CP	8.16	8.01
Ash	1.24	1.32
EE	3.18	3.08
CF	3.32	3.25
Calcium	0.21	0.15
Phosphorus	0.20	0.21

CC= Crushed corn, SFC= Steam flaked corn

Results

Firstly, we analyzed the DMI (dry matter intake). The data showed that SFC group had not significant difference with CC group (P>0.05) (Table 6). In the 1st and 3rd periods, the milk yield of SFC group was 38.80±6.23 kg/d, 32.80±5.14 kg/d which was significantly higher than CC group (P<0.05); in period 2, the milk yield of SFC group was still better than the milk yield of CC group, but it was not significantly difference (P>0.05) (Table 7). In the whole experiment, SFC group had lower FP, SCC (somatic cell count), UN (urea nitrogen), but higher PP and milk sugar than CC group, which decreased FP, SCC, UN by 0.05%, 30,800 cells/mL,0.22 mg/dl, and increased PP, milk sugar by 0.03% and 0.02%, respectively (Table 8).

Total cost of experiment and benefits of SFC group were calculated (Table 9). In Table 9, we just listed the increment. The total of costs and benefits cannot be revealed. Based on our economic analysis of the whole experiment on inputs and outcomes, the cows were fed SFC, which increased efficiency by 400 yuan over the yield value of those cows on the CC diet.

Discussion

Effect on feed intake between the two groups was negligible (P>0.05). Milk yield was increased in each period in SFC group. The milk yield increments were 1.49, 1.29 and 1.66 kg in 1st, 2nd and 3rd periods, respectively. The mean of these increment milk yields was 1.48 kg. Our research showed that feeding cows a diet of 40% SFC had the best impact on the 1st period, because the cows were in 60 days of lactation while under NEB (negative energy balance), and were milked in the promotion and peak periods. Not only SFC diet improved digestion and degradation of the starch in the rumens and small intestines in the 1st period (Chen *et al.*, 2009), but it gave energy which neutralized the NEB. On the other hand, feeding cows SFC maintained the concentration of rumen fluid at a lower lever (Wang *et al.*, 2005), which is beneficial for microorganisms to compound bacterial protein, to utilize energy and protein, simultaneously. The group fed CC just steadily retained. In the 2nd period, the cows were in 100−140 days of lactation, and the lactating curve dipped. Both of groups fell steadily, but the milk yield of SFC group decreased less than the milk yield of CC group. In the 3rd period, where the diet was 100% SFC, there was a distinctive increase in the milk yield. In addition to the lactation curve, a higher rate of digestion was observed in the cows on this diet. The reasons for this include the fact that the SFC diet provides more energy and nutrients to delay the rate of descent of the milk yield. As a matter of course, this explains why the milk yield of CC group decreased at a faster rate. At the end of the trial, we scored the body conditions of the two groups, and the scores of 3.0 and 3.2 were measured, which illustrated that cows can maintain moderate body condition and milk yield after having their CC diets replaced by the SFC diets.

In the whole experiment, milk production traits did not change remarkably and the fat percentage of SFC group dropped slightly. Other research has provided similar results. The fiber zymophyte was restrained as the percentage of SFC was increased in the diet, and the propionic acid fermented completely. Inversely, the protein percentage and the sugar in the milk went up slightly because of the propionic acid and bacterial protein added. Propionic acid is a precursor of the synthesis of glucose.

Table 6: The DMI of two groups (kg/cow day)

Item	CC	SFC
The average of DMI	23.52±1.55	23.23±1.61

DMI: dry matter intake, CC= Crushed corn, SFC= Steam flaked corn

Table 7: The MY of two groups (kg/d)

Experiment period	Testing times	CC	SFC	Differentials
Milk yield before trial		37.22±6.38	37.24±6.89	
First period	1	37.50±6.30	38.30±6.23	0.80±1.35
	2	37.30±6.23	39.50±5.83	2.20±1.35
	3	36.69±5.85*	39.13±6.17*	2.16±1.53
	4	37.50±5.85*	38.28±6.18*	0.78±1.72
	Average	37.32±6.23*	38.80±6.30*	1.49±1.49
Second period	1	36.40±5.65	37.46±6.69	1.06±1.59
	2	34.30±6.35*	36.29±6.10*	1.99±1.60
	3	35.00±6.68	35.99±5.66	0.99±2.20
	4	34.68±6.80	35.80±6.12	1.12±1.88
	Average	35.09±6.37	36.39±6.14	1.29±1.82
Third period	1	33.21±7.73*	35.86±6.24*	2.65±1.60
	2	32.57±6.09*	34.13±4.48*	1.56±2.10
	3	32.54±5.91	33.73±5.94	1.19±1.20
	4	31.55±6.03	32.80±5.14	1.25±0.90
	Average	32.47±6.44*	34.13±5.45*	1.66±1.45
Average		34.96±6.64*	36.44±6.65*	1.48±1.59

*Significant at P<0.05; **Significant at P<0.01; CC= Crushed corn, SFC= Steam flaked corn

Table 8: The results of milk production traits were tested

Item	CC	SFC
FP%	3.88±0.46	3.83±0.44
PP%	3.18±0.15	3.21±0.15
Milk sugar %	4.99±0.086	5.01±0.080
SCC/ten thousand·ml^{-1}	28.07±6.64*	24.99±6.84*
UN/mg·dl^{-1}	12.05±2.22	11.94±1.79

*Significant at P<0.05; **Significant at P<0.01; MY: milk yield; FP: fat percentage; PP: protein percentage; SCC: somatic cell count; CC= Crushed corn, SFC= Steam flaked corn

Table 9: Results of feedlot's costs and benefits

Period/ item	Inputs of SFC instead CC	Increment of MY (kg/d· per)	Increment of benefit(yuan/ d per)	Increment of net income (yuan/d·per)	Increment of benefit in the whole experiment
1	0.97	1.49	5.00	4.24	169.66
2	1.77	1.29	4.00	2.00	109.86
3	2.55	1.66	5.81	3.26	130.00
total					410.03

Note: The price of milk is 3.5yuan/kg

The greater the amount of glucose synthesized, the more the glucose is absorbed in the mammary gland, and the greater the increase in lactose. We also found figures for urea and the energy cycle index increased due to the enhancement of the digestibility of starch, while the optimized urea distribution in the internal environment of the organism which leads to the urea nitrogen decreased 0.9%, and the protein percentage of the increased. It can help maintain the health of cows, and decrease the excretion of urea nitrogen.

The SCC had observably improved in SFC group. The ideal indicator of SCC was between 150.000 and 300.000 cells/mL. The cows of SFC group had better body condition than the cows in CC group, and a smaller chance of affecting mastitis, which indicates that SFC can strengthen immunity, and therefore increase resistance to the disease (Dai *et al.*, 2010).

Conclusion

The present study confirmed that utilizing the SFC diet increased milk yield, improved milk production traits, and enhanced the performance of cows. Based on economic analysis, we concluded that adding the appropriate percentage of the SFC diet in the initial lactation period brings better results. In the entire lactation period, feeding SFC is dependent on variables such as the percentage of SFC, different areas and feedlot. It also relates to maize varieties, producing area, harvest time, and amount of precipitation. The same factors which influence corn nutrient also impact the processing of SFC. Moreover, feeding procedures and concentrate-roughage ratio diets affect the processing of SFC, too.

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References

Chen, T., Y.X. Gao, Y.F. Cao, J.G. Li and W.J. Li, 2009. Effects of steam-flaked corn on the production performance and excretion of nitrogen and phosphorus in dairy cows. *Acta Vet. Zootech. Sin.*, 40: 1769–1775

Dai, H., L.P. Ren and Q.X. Meng, 2010. The effects of corn steam-flaking and supplemental live yeast on lactation performance and blood parameters in dairy cows. *J. Chin. Agric. Univ.*, 15: 50–54

Huntington, G.B., 1997. Starch utilization by ruminants: From basics to the bunk. *J. Anim. Sci.*, 75: 852

Leng, J., H. Liu, R.J. Zhu, S.L. Yang, X. Gou and H.M. Mao, 2010. Effects of steam flaked corn, niacin and methionine on milk yield and milk composition of lactating early dairy cows. *Feeding*, 20: 19–22

Owens, F.H. and R.A. Zinn, 2005. Corn grain for cattle: Influence of processing on site and extent of digestion. *Proc. Southwest Nutr. Conf.*, : 86–112

Swingle, R.S., T.P. Eck, C.B. Theurer, M. De la Llata, M.H. Poore and J.A. Moore, 1999. Flake density of steamprocessed sorghum grain alters performance and sites of digestibility by growing-finishing steers. *J. Anim. Sci.*, 77: 1055–1065

Theurer, C.B., O. Lozano, A. Alio, A. Delgado-Elorduy, M. Sadik, J.T. Huber and R.A. Zinn, 1999. Steam-processed corn and sorghum grain flaked at different densities alter ruminal, small intestinal, and total tract digestibility of starch by steers. *J. Anim. Sci.*, 77: 2824–2831

Wang, G.Y., H.M. Mao and J.K. Wen, 2005. Effect of processing of maize on ammonia concentration in rumen fluid. *Feed Indust.*, 26: 51–52

Xin, S.H., Z.Z. Xu, Y.W. Zhang and Q.X. Meng, 2006. Effect of Steam flaked corn technology on Nutritional Value of Maize and Feeding Effect of Dairy Cattle. *C. J. Anim. Hus*., 42: 57–60

Zinn, R.A., F.N. Owens and R.A. Ware, 2002. Flaking corn: Processing mechanics, quality standards, and impacts on energy availability and performance of feedlot cattle. *J. Anim. Sci.*, 80: 1145–1156

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