Effects of Differently Processed Whole-Plant Corn Silage and Corn Stover Silage on Growth Performance and Economic Benefits in Beef Cattle: Postprint

Authors: Chen Yuepeng, Zheng Airong, Sun Xiao, Lin Jinxiang, Xiao Junnan, Liu Boshuai, Wang Wenjing, Wang Chengzhang, Shi Yinghua

Date: 2018-12-24T00:00:00+00:00

Abstract

This study aimed to investigate the differences in silage quality between whole-plant corn and corn straw, with and without silage additives, and their effects on growth performance and economic benefits in beef cattle. One hundred and twenty Simmental crossbred cattle (approximately 18 months of age, with an average body weight of 450 kg) were selected as experimental animals and randomly allocated to 4 groups, with 6 replicates per group and 5 cattle per replicate. Four experimental diets containing different roughage sources were formulated: whole-plant corn silage diet (WS group), whole-plant corn silage with bacterial additive diet (WS-L group), corn straw silage diet (CS group), and corn straw silage with bacterial additive diet (CS-L group). The experiment consisted of 2 phases, including a 10-day pre-experimental period and early and late experimental periods of 40 days each.

The results showed that: 1) The addition of silage additive significantly reduced the neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of whole-plant corn silage ($P < 0.05$), while increasing the dry matter (DM) and crude protein (CP) contents ($P > 0.05$), thereby improving the silage quality of whole-plant corn silage to a certain extent.

2) No significant differences were observed in average daily dry matter intake among all groups ($P > 0.05$). Compared with the CS group, the CS-L group exhibited increased average daily gain and decreased feed-to-gain ratio, but these differences were not significant ($P > 0.05$). In contrast, the WS and WS-L groups showed significantly increased average daily gain ($P < 0.05$) and significantly decreased feed-to-gain ratio ($P < 0.05$) compared with the CS and CS-L groups.

3) The serum total cholesterol (TC) content in the WS-L group was significantly lower than that in the CS-L group ($P < 0.05$), while no significant differences were detected among groups for all other serum biochemical indices ($P > 0.05$).

4) The WS-L group achieved the highest daily profit at 10.98 yuan/(head · d), which represented a slight increase compared with the WS group, and increases of 51.66% and 50.62% compared with the CS and CS-L groups, respectively.

Comprehensive analysis indicated that the addition of silage additive improved the silage quality of whole-plant corn silage but had no significant effect on the silage quality of corn straw silage. Compared with corn straw silage, whole-plant corn silage enhanced the growth performance and increased the economic benefits of Simmental crossbred beef cattle.

Full Text

Effects of Whole Corn Silage and Corn Stalk Silage with Different Treatments on Growth Performance and Economic Benefit of Beef Cattle

CHEN Yuepeng[1], **ZHENG Airong**[2], **SUN Xiao**[1], **LIN Jinxiang**[1], **XIAO Junnan**[1], **LIU Boshuai**[1], **WANG Wenjing**[1], **WANG Chengzhang**[1,3], **SHI Yinghua**[1,3*]

[1]College of Animal and Veterinary Science, Henan Agricultural University, Zhengzhou 450002, China
[2]Forage and Feed Station of Henan Province, Zhengzhou 450008, China
[3]Henan Key Laboratory of Innovation and Utilization of Grassland Resources, Zhengzhou 450002, China

---

Abstract

This experiment aimed to investigate differences in silage quality between whole corn and corn stalk with and without silage additives, and their effects on growth performance and economic benefit in beef cattle. One hundred and twenty Simmental hybrid cattle (approximately 18 months old, average body weight 450 kg) were selected and randomly divided into four groups with six replicates per group and five cattle per replicate. Four experimental diets containing different roughages were formulated: whole corn silage diet (WS group), inoculated whole corn silage diet (WS-L group), corn stalk silage diet (CS group), and inoculated corn stalk silage diet (CS-L group). The trial consisted of two periods: a 10-day preliminary period followed by early and late experimental phases of 40 days each. The results showed that: (1) Adding silage additive significantly reduced neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents

($P < 0.05$) while increasing dry matter (DM) and crude protein (CP) contents ($P > 0.05$) in whole corn silage, thereby improving its silage quality to some extent. (2) No significant differences were observed in average daily dry matter intake among groups ($P > 0.05$). Compared with the CS group, the CS-L group showed increased average daily gain and decreased feed-to-gain ratio, but differences were not significant ($P > 0.05$). The WS and WS-L groups exhibited significantly higher average daily gain and significantly lower feed-to-gain ratio compared with the CS and CS-L groups ($P < 0.05$). (3) Serum total cholesterol (TC) content in the WS-L group was significantly lower than in the CS-L group ($P < 0.05$), while other serum biochemical indices showed no significant differences among groups ($P > 0.05$). (4) The WS-L group achieved the highest daily profit at 10.98 yuan per head per day, slightly higher than the WS group and representing increases of 51.66% and 50.62% compared with the CS and CS-L groups, respectively. These findings indicate that silage additive improved the quality of whole corn silage but had no significant effect on corn stalk silage quality. Compared with corn stalk silage, whole corn silage enhanced growth performance and economic benefit in Simmental hybrid beef cattle.

Keywords: whole corn silage; corn stalk silage; silage additive; beef cattle; growth performance

Introduction

Due to the unique nature of the rumen in ruminants, corn stalks have long served as an important roughage source, particularly in beef cattle production where straw-based diets have become conventional. However, mature corn stalks are characterized by high fiber content, severe lignification, low digestibility, and poor nutritional value. To obtain high-quality roughage that meets ruminant production requirements, China implemented the "Grain-to-Forage" program between 2015 and 2017 to promote whole corn silage and enhance ruminant animal production. Whole corn silage offers advantages including high yield, rich nutrition, good palatability, and high digestibility, and has been widely applied in dairy industries worldwide. Studies have demonstrated that whole corn silage can effectively increase milk yield, improve milk quality, reduce feeding costs, and enhance economic benefit in dairy cows, though research on its utilization in beef cattle production remains relatively limited. In practice, silage additives are commonly used to improve silage quality. Addah et al. reported that lactic acid bacteria inoculants during ensiling positively affect feed intake, daily weight gain, milk yield, and feed digestibility, though substantial variation exists among studies with most research focusing on dairy cattle. Therefore, this experiment was conducted to evaluate the effects of silage additives on the quality of whole corn and corn stalk silage, and to compare their impacts on growth performance and economic benefit in Simmental hybrid beef cattle, providing scientific basis for the production and rational application of whole corn silage in beef cattle production.

1.1 Silage Preparation

Two whole corn silage bunkers (approximately 100 t capacity each) were prepared at the experimental farm. Whole corn plants (variety Yuzqingzhu 23) were harvested at the dough stage (September 17, 2016) using a silage harvester, chopped to approximately 1.5 cm lengths, and ensiled. One bunker was sprayed with a commercial silage additive (containing *Lactobacillus plantarum*, *Pediococcus pentosaceus*, *Lactobacillus acidophilus*, cellulase, hemicellulase, and oligosaccharides; viable count 1×10^{11} CFU/g) at a rate of 20 g/t. Two corn stalk silage bunkers (approximately 100 t capacity each) were also prepared using partially green corn stalks (approximately 60% moisture content) remaining after grain harvest from surrounding farmers (September 25, 2016), chopped to 1.5 cm lengths and ensiled. One bunker received the same silage additive. The silos were opened on December 1, 2016, at the start of the feeding trial, and samples were taken to evaluate silage quality before the formal experiment.

1.2 Feeding Trial

The feeding trial was conducted at Henan Hengdu Xianan Cattle Development Co., Ltd. from December 1, 2016, to March 10, 2017. One hundred and twenty healthy Simmental hybrid cattle with similar body weight (approximately 450 kg) and age (approximately 18 months) were selected and allocated to four groups according to a single-factor completely randomized design, with six replicates per group and five cattle per replicate. The trial consisted of a 10-day preliminary period followed by early and late experimental phases of 40 days each. The four groups were fed whole corn silage diet (WS group), inoculated whole corn silage diet (WS-L group), corn stalk silage diet (CS group), and inoculated corn stalk silage diet (CS-L group). Diets were formulated according to NRC (2000) guidelines, with diet composition and nutrient levels for the early and late periods shown in and , respectively. All diets were fed as total mixed rations (TMR). Before the formal trial, cattle were subjected to disinfection, ear tagging, deworming, and vaccination. All experimental cattle were managed uniformly with separate feeding and water supply. Feed was offered at 08:30 and 14:30 daily, with regular barn spraying disinfection and manure cleaning according to conventional practices.

1.3 Silage Quality Analysis

After fermentation, silos were opened and samples were taken. Partial samples were subjected to sensory evaluation following the method of Wang Chengzhang et al. Additional samples were dried at 65 °C for 48 hours, ground through a

60-mesh sieve, and sealed for nutrient analysis. Dry matter (DM) content was determined by oven-drying method; crude protein (CP) by Kjeldahl method; ether extract (EE) by Soxhlet extraction; crude ash according to national standard GB/T 6438-2007; calcium (Ca) by EDTA complexometric titration per GB/T 6436-2002; total phosphorus (TP) by molybdenum yellow spectrophotometry per GB/T 6437-2002; and neutral detergent fiber (NDF) and acid detergent fiber (ADF) by the Van Soest method. For fermentation analysis, 20 g of silage was homogenized with 180 mL distilled water for 2 minutes, filtered, and analyzed for pH and lactic acid (LA), acetic acid (AA), propionic acid (PA), and butyric acid (BA) contents. pH was measured using a Leici PHSJ-4F pH meter, while organic acids were determined by SHIMADZE-10A high-performance liquid chromatography (column: Shodex Rspak KC-811 S-DVB gel Column, 30 mm × 8 mm; detector: SPD-M10AVP; mobile phase: 3 mmol perchloric acid; flow rate: 1 mL/min; column temperature: 50 °C; detection wavelength: 210 nm; injection volume: 5 L).

1.4.1 Average Daily Dry Matter Intake (ADMI)

Feed offered was recorded at each feeding, and refusals were weighed before morning feeding daily. Diet samples were taken every two weeks to determine moisture content for calculating average daily dry matter intake.

Average daily dry matter intake [kg/(head · d)] = (feed offered - refusals) × diet DM content / feeding days.

1.4.2 Average Daily Gain (ADG)

Cattle were weighed once at the beginning and end of the feeding trial to determine initial and final body weights for calculating average daily gain, measured before morning feeding after overnight fasting.

Average daily gain [kg/(head · d)] = (final weight - initial weight) / feeding days.

1.4.3 Feed-to-Gain Ratio (F/G)

Feed-to-gain ratio was calculated from average daily dry matter intake and average daily gain.

Feed-to-gain ratio = average daily dry matter intake / average daily gain.

1.5 Serum Biochemical Indices

On the final day of the feeding trial, after 12 hours of fasting, one animal from each replicate was selected for blood collection from the tail vein using specialized coagulation tubes. Serum was separated by centrifugation (4 °C, 940 × g, 15 minutes) and stored at -20 °C for analysis. Serum urea nitrogen (UN), glucose (GLU), total protein (TP), total cholesterol (TC), creatinine (Cr), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were measured using a Beckman Coulter automatic biochemical analyzer.

1.6 Economic Analysis

Daily feed costs and daily weight gain income were calculated based on feed ingredient prices and cattle weight gain to compare daily profit per head among groups. Feed unit price was calculated according to ingredient prices and their dietary proportions.

Daily feed cost [yuan/(head·d)] = daily feed consumption [kg/(head·d)] × feed unit price (yuan/kg).
Daily weight gain income [yuan/(head·d)] = average daily gain [kg/(head·d)] × live cattle price (yuan/kg).
Daily profit [yuan/(head·d)] = daily weight gain income - daily feed cost.

1.7 Statistical Analysis

Data were analyzed using SPSS 20.0 software and expressed as "mean ± standard deviation." Duncan' s multiple range test was used for inter-group comparisons, with $P < 0.05$ considered statistically significant.

2.1 Silage Quality Among Groups

Sensory evaluation results for silages are presented in . For color, silages in WS, CS, and CS-L groups appeared yellow-brown, while WS-L group appeared yellow-green. All silages exhibited acidic or vinegar aromas. In texture, CS and CS-L group silages had stems and leaves bonded together that were difficult to separate, whereas WS and WS-L group silages had easily separable stems and leaves. Overall assessment indicated excellent quality for WS-L group silage and moderate quality for WS, CS, and CS-L groups.

Fermentation quality of silages is shown in . No significant differences in pH were observed among groups ($P > 0.05$). Lactic acid content in WS-L group silage was slightly higher than WS group ($P > 0.05$) but significantly higher than CS and CS-L groups ($P < 0.05$), with CS-L group slightly higher than CS

group ($P > 0.05$). Acetic acid content in WS group silage was slightly higher than WS-L group ($P > 0.05$) but significantly higher than CS and CS-L groups ($P < 0.05$), with CS group significantly higher than CS-L group ($P < 0.05$). Propionic acid content in CS group silage was significantly lower than other groups ($P < 0.05$). No butyric acid was detected in any silage.

Nutrient composition of silages is presented in . Dry matter content in WS-L group silage was higher than WS group ($P > 0.05$) but significantly lower than CS and CS-L groups ($P < 0.05$). Crude protein, ether extract, and crude ash contents in WS-L group silage did not differ significantly from WS group ($P > 0.05$) but were significantly higher than CS and CS-L groups ($P < 0.05$). Neutral detergent fiber content in CS group silage was slightly higher than CS-L group ($P > 0.05$) but significantly higher than WS and WS-L groups ($P < 0.05$), with WS group significantly higher than WS-L group ($P < 0.05$). Acid detergent fiber content in CS group silage was higher than CS-L group ($P > 0.05$) but significantly higher than WS and WS-L groups ($P < 0.05$), with WS-L group significantly lower than WS group ($P < 0.05$).

2.2 Effects of Different Silage Treatments on Growth Performance

As shown in , no significant differences were observed in average daily dry matter intake among groups ($P > 0.05$). Average daily gain in WS-L group was slightly higher than WS group ($P > 0.05$) but significantly higher than CS and CS-L groups ($P < 0.05$), with CS-L group slightly higher than CS group ($P > 0.05$). Feed-to-gain ratio in WS and WS-L groups was significantly lower than CS and CS-L groups ($P < 0.05$), with WS-L group lower than WS group ($P > 0.05$) and CS-L group lower than CS group ($P > 0.05$).

2.3 Effects of Different Silage Treatments on Serum Biochemical Indices

As shown in , except for significantly higher serum total cholesterol content in CS-L group compared with WS-L group ($P < 0.05$), no significant differences were observed among groups in ALT and AST activities or TP, UN, Cr, and GLU contents ($P > 0.05$).

2.4 Effects of Different Silage Treatments on Economic Benefit

Prices for inoculated whole corn silage, whole corn silage, inoculated corn stalk silage, and corn stalk silage were 0.41, 0.40, 0.20, and 0.19 yuan/kg, respectively. Prices for concentrate, peanut seedlings, bean dregs, molasses, distiller' s grains, brewer' s grains, and wheat straw during early and late periods were calculated at market rates.

As shown in , WS-L group achieved the highest daily profit per head at 10.98 yuan, representing 3.74 and 3.69 yuan more profit than CS and CS-L groups, respectively. WS group daily profit was 10.92 yuan per head, 3.68 and 3.63 yuan higher than CS and CS-L groups. WS-L group profit was slightly higher than WS group.

3.1 Effects of Silage Additives on Silage Quality

Sensory evaluation can roughly differentiate silages with substantial quality differences, enabling rapid on-site assessment. In this trial, inoculated whole corn silage exhibited yellow-green color, acidic aroma, and easily separable stems and leaves, indicating excellent quality, while other silages were of moderate quality. Bai Yuansheng reported that high-quality silage should have pH between 3.8 and 4.2, with beneficial bacteria such as lactic acid bacteria becoming dominant and inhibiting harmful microorganisms when pH drops below 4.0. In this study, both untreated and inoculated whole corn and corn stalk silages had pH values below 4.0, meeting high-quality silage standards. Inoculation did not significantly affect pH of corn stalk silage but increased lactic acid content and significantly decreased acetic acid content, indicating improved lactic-to-acetic acid ratio, consistent with Nkosi et al. Aksu et al. found that inoculating corn silage with *Lactobacillus plantarum* significantly reduced pH and increased lactic acid content, while Shockey et al. reported that *Pediococcus* and *Lactobacillus* inoculants did not significantly affect lactic acid, acetic acid, or pH reduction. In this trial, the additive reduced pH and increased lactic acid content in whole corn silage, though differences were not significant. The limited effect of additives on whole corn silage may be attributed to naturally high lactic acid bacteria populations on the raw material.

Ensiling involves changes in nutrient composition. Lü Wenlong et al. reported that three different additives increased pH and DM content in earless corn stalk silage at the end of fermentation. Tan Shuyi et al. found that enzyme and lactic acid bacteria additives increased DM and CP contents while decreasing NDF and ADF in corn stalk silage. In this study, while corn stalk silage showed some numerical changes in nutrient content after inoculation, differences were not significant. However, inoculation significantly reduced NDF and ADF contents in whole corn silage. Variations among studies may result from differences in raw materials, fermentation duration, and inoculant types.

3.2 Effects of Different Silage Treatments on Growth Performance

Lower average daily gain in cattle fed corn stalk silage diets compared with whole corn silage diets may be attributed to poor nutritional value, high NDF and ADF contents, and low palatability of corn stalks. Ruminant digestibility of straw is only 20–30%, making it difficult to meet maintenance requirements

when corn stalk silage is the sole roughage source, thereby impairing production performance. Significantly higher average daily gain and lower feed-to-gain ratio in cattle fed whole corn silage diets may result from lower NDF content and higher rumen degradability of NDF in whole corn silage. Additionally, delayed harvest of corn stalks causes substantial nutrient loss before ensiling, reducing protein content, whereas whole corn silage contains grain, providing higher CP and energy levels that enhance weight gain and feed efficiency.

Successful ensiling largely depends on rapid and abundant proliferation of lactic acid bacteria. Currently, silage additives are widely used in corn silage production, with lactic acid bacteria inoculants theoretically promoting fermentation, reducing nutrient loss, and improving quality. Bayatkouhsar et al. reported that microbial inoculation of corn silage did not significantly affect milk composition or yield in dairy cows. Zhou Jie et al. found that feeding lactic acid bacteria-treated corn stalk silage increased daily weight gain by 27.3% in finishing cattle. Nkosi et al. reported increased dry matter intake in lambs fed inoculated whole corn silage. In this trial, inoculated whole corn and corn stalk silages did not significantly improve growth performance in beef cattle. These inconsistent results may be related to differences in inoculant types, silage varieties, animal species, and physiological stages.

3.3 Effects of Different Silage Treatments on Serum Biochemical Indices

Serum biochemical components constitute the material basis for animal life activities, and their variations reflect important biological characteristics. The liver is the primary organ for cholesterol synthesis and storage, with serum total cholesterol content reflecting hepatic health to some extent. In this study, cattle fed inoculated whole corn silage had significantly lower serum total cholesterol than those fed inoculated corn stalk silage, possibly related to liver health status or nutritional differences between silages. Most serum biochemical indices showed no significant differences among groups, and all values indicated normal health status, suggesting that silage additives do not negatively affect cattle health.

3.4 Effects of Different Silage Treatments on Economic Benefit

In practice, diets should improve daily weight gain without compromising economic benefit. Although inoculated whole corn silage diet had higher cost than whole corn silage diet, it also increased average daily gain, resulting in the highest daily profit at 10.98 yuan per head—slightly higher than the WS group and 51.66% and 50.62% higher than CS and CS-L groups, respectively. While inoculated corn stalk silage had higher feed cost than untreated corn stalk silage, it

also increased daily profit. These results demonstrate that although silage additives increased costs for both whole corn and corn stalk silages, they improved average daily gain. Compared with corn stalk silage diets, whole corn silage and inoculated whole corn silage diets significantly improved economic benefit in beef cattle. Overall, cattle fed inoculated whole corn silage diet showed better economic returns than those fed other diets, consistent with previous studies.

4 Conclusion

Silage additive significantly reduced NDF and ADF contents in whole corn silage, decreasing nutrient loss and improving silage quality.

Feeding trials demonstrated that inoculated whole corn and corn stalk silages improved growth performance and economic benefit in beef cattle. Compared with corn stalk silage and inoculated corn stalk silage diets, whole corn silage and inoculated whole corn silage diets significantly increased average daily gain, decreased feed-to-gain ratio, and enhanced economic benefit.

References

[1] FENG Yanglian. Ruminant Nutrition[M]. Beijing: Science Press, 2004: 132-133.

[2] HAMELEERS A. The effects of inclusion of either maize silage, fermented whole crop wheat or urea-treated whole crop wheat in a diet based on a high-quality grass silage on the performance of dairy cows[J]. Grass and Forage Science, 2010, 53(2): 157-163.

[3] PHIPPS R H, SUTTON J D, JONES B A. Forage mixtures for dairy cows: the effect on dry-matter intake and milk production of incorporating either fermented or urea-treated whole-crop wheat, brewers' grains, fodder beet or maize silage into diets based on grass silage[J]. Animal Science, 1995, 61(3): 491-496.

[4] GAO Tengyun, TANG Guifen, LI Honglei, et al. Experiment on feeding growing dairy cows with ear-bearing corn silage and corn stalk silage[J]. China Dairy Cattle, 2000(6): 18-19.

[5] O' MARA F P, FITZGERALALD J J, MURPHY J J, et al. The effect on milk production of replacing grass silage with maize silage in the diet of dairy cows[J]. Livestock Production Science, 1998, 55(1): 79-87.

[6] KIRKLAND R M, PATTERSON D C. The effect of quality of grass and maize silage on the intake and performance of beef cattle[J]. Livestock Science, 2006, 100(2/3): 179-188.

[7] BROENE E M, JUNIPER D T, BRYANT M J, et al. Intake, live-weight gain and carcass characteristics of beef cattle given diets based on forage maize silage harvested at different stages of maturity[J]. Animal Science, 2004, 79(3): 405-413.

[8] ADDAH W, BAAH J, OKINE E K, et al. A third-generation esterase inocu-

lant alters fermentation pattern and improves aerobic stability of barley silage and the efficiency of body weight gain of growing feedlot cattle[J]. Journal of Animal Science, 2012, 90(5): 1541-1552.
[9] WEINBERG Z G, MUCK R E, WEIMER P J, et al. Lactic acid bacteria used in inoculants for silage as probiotics for ruminants[J]. Applied Biochemistry & Biotechnology, 2004, 118(1-3): 1-9.
[10] WANG Chengzhang, WANG Tian. Feed Science[M]. Beijing: China Agriculture Press, 2003.
[11] ZHANG Liying. Feed Analysis and Feed Quality Detection Technology[M]. 4th ed. Beijing: China Agricultural University Press, 2016: 71-74.
[12] BAI Yuansheng. Feed Raw Materials Science[M]. Beijing: Beijing Agricultural University Press, 1999: 25-32.
[13] NKOSI B D, MEESKE R, PALIC D, et al. Laboratory evaluation of an inoculant for ensiling whole crop maize in South Africa[J]. Animal Feed Science and Technology, 2009, 150(1/2): 144-150.
[14] AKSU T, BAYTOK E, BOLAT D. Effects of a bacterial silage inoculant on corn silage fermentation and nutrient digestibility[J]. Small Ruminant Research, 2004, 55(1/2/3): 249-252.
[15] SHOCKEY W L, DEHORITY B A, et al. Effects of Microbial Inoculant on Fermentation of Alfalfa and Corn[J]. Journal of Dairy Science, 1985, 68(11): 3076-3080.
[16] WEINBERG Z G, SHATZ O, CHEN Y, et al. Effect of lactic acid bacteria inoculants on in vitro digestibility of wheat and corn silages[J]. Journal of Dairy Science, 2007, 90(10): 47
[17] LÜ Wenlong, DIAO Qiyu, YAN Guilong. Effects of different additives on fermentation quality of earless corn stalk silage[J]. China Animal Husbandry & Veterinary Medicine, 2010, 37(3): 22-26.
[18] TAN Shuyi, WANG Feng, ZHENG Xinli, et al. Effects of compound enzymes and lactic acid bacteria preparation on fermentation quality of corn stalk silage[J]. Cereal & Feed Industry, 2016, 12(8): 54-56.
[19] LIU Jiafang, LI Jie. Development and utilization of straw resources as feed[J]. Feed Review, 1998(2): 20-21.
[20] QI Hongwei, TIAN Ziyu, JIANG Huaizhi, et al. Study on dry matter degradability in rumen of whole corn silage harvested at different times[J]. Journal of Jilin Agricultural University, 2001, 23(4): 97-99, 110.
[21] PENG Xiaopei, XIAO Xishan, LI Jing. Comparison of nutritional value of different silages[J]. Chinese Journal of Animal Science, 2009, 45(19): 47-4
[22] WEINBERG Z G, MUCK R E. New trends and opportunities in the development and use of inoculants for silage[J]. FEMS Microbiology Reviews, 2010, 19(1): 53-68.
[23] BAYATKOUHSAR J, TAHMASEBI A M, NASERIAN A A. The effects of microbial inoculation of corn silage on performance of lactating dairy cows[J]. Livestock Science, 2011, 142(1/2/3): 170-174.
[24] ZHOU Jie, LAN Zhengheng. Feeding and slaughter effects of "Qingbao II" feed additive in beef cattle fattening production[J]. Animals Breeding and Feed, 2009(1): 41-42.

[25] NKOSI B D, MEESKE R, PALIC D, et al. Effects of ensiling whole crop maize with bacterial inoculants on the fermentation, aerobic stability, and growth performance of lambs[J]. Animal Feed Science and Technology, 2009, 154(3/4): 193-203.
[26] WANG Zhanggui. Effects of dietary riboflavin supplementation on immune function and blood biochemical indices of Xin Yangzhou chicks[D]. Master' s thesis. Yangzhou: Yangzhou University, 2005: 28-29.
[27] MA Jianqi. Comparative experiment on fattening effects of corn stalk yellow silage and whole corn silage on Limousin hybrid beef cattle[J]. Journal of Animal Science and Veterinary Medicine, 2008, 27(3): 23-24.
[28] JI Tiancheng. Experiment on feeding effects of whole corn silage on beef cattle[J]. Journal of Animal Science and Veterinary Medicine, 2010, 29(6): 94-95.

Note: Figure translations are in progress. See original paper for figures.