Effects of Rumen-Protected Methionine and Rumen-Protected Lysine Supplementation in the Diet on Beef Production Performance and Meat Quality in Holstein Dairy Bulls

Authors: Gao Yan, Wu Jianhao, Qu Yongli, Pan Qiqi, Zhang Shibo, Han Tianlong, Wang Zhibo, Yin Xihan

Date: 2017-10-11T00:00:00+00:00

Abstract

This experiment aimed to investigate the effects of dietary supplementation with rumen-protected methionine (RPMet) and rumen-protected lysine (RPLys) on beef production performance and meat quality of Holstein dairy bulls. A completely randomized design was adopted, selecting 25 healthy Holstein dairy bulls of approximately 12 months of age and similar body weight, which were randomly divided into 5 groups with 5 replicates per group and 1 head per replicate. The control group was fed a basal diet (practical pasture diet); the other 4 experimental groups were supplemented with RPMet 15 g/d (RPM group), RPLys 30 g/d (RPL group), RPLys 30 g/d + RPMet 15 g/d (RPL+M group), and RPLys 30 g/d + RPMet 15 g/d (with the basal dietary crude protein level reduced by 1.71%) [RPL+M(L) group] on the basal diet, respectively. The pre-trial period was 10 d, and the formal trial period was 150 d. The results showed: 1) The final weight and average daily gain of cattle in the RPL+M and RPL+M(L) groups were significantly higher than those in the control group ($P < 0.05$), and the feed-to-gain ratio was significantly lower than that in the control group ($P < 0.05$), but the difference between these two groups was not significant ($P > 0.05$); the RPL+M(L) group had the highest economic benefit at 7.67 yuan/(d · head), which was 0.32 yuan/(d · head) higher than the RPL+M group. 2) Compared with the control group, dietary supplementation with RPMet and RPLys had no significant effect on the net meat percentage of Holstein dairy bulls ($P > 0.05$); the pre-slaughter live weight in the RPM, RPL, RPL+M, and RPL+M(L) groups was significantly increased ($P < 0.05$), with the highest value in the RPL+M group, but there was no significant difference between the RPL+M and RPL+M(L) groups ($P > 0.05$); the dressing percentage in the RPL group was significantly increased ($P < 0.05$); the carcass meat yield percentage and meat-to-bone ratio in all experimental groups were significantly increased ($P < 0.05$), but there was no significant difference among the experimental groups ($P > 0.05$). 3) Dietary supplementation with RPMet and RPLys had no significant effects on loin eye area, shear force, cooking loss, marbling score, pH, and meat color score ($P > 0.05$). 4) Dietary supplementation with RPMet and RPLys also had no significant effect on muscle fatty acid composition ($P > 0.05$). In conclusion, dietary supplementation with RPMet and RPLys could maintain equivalent meat quality and muscle fatty acid content while improving the beef production performance of dairy bulls to a certain extent; moreover, supplementation with RPMet and RPLys could replace some protein feed and increase economic benefit.

Full Text

Effects of Rumen-Protected Methionine and Rumen-Protected Lysine Supplementation in the Diet on Beef Production Performance and Meat Quality in Holstein Dairy Bulls

Gao Yan1, Wu Jianhao2, Qu Yongli1*, Pan Qiqi1, Zhang Shibo1, Han Tianlong1, Wang Zhibo1, Yin Xihan1

(1. College of Animal Science and Technology, Heilongjiang Bayi Agricultural University, Daqing 163319, China; 2. Shanghai Bright Holstein Animal Husbandry Co., Ltd., Shanghai 202177, China)

Abstract: This experiment was conducted to investigate the effects of adding rumen-protected methionine (RPMet) and rumen-protected lysine (RPLys) to the diet on beef production performance and meat quality in Holstein dairy bulls. A completely randomized experimental design was adopted. Twenty-five healthy Holstein dairy bulls, approximately 12 months of age and with similar body weights, were selected and randomly divided into 5 groups, with 5 replicates per group and 1 animal per replicate. The control group was fed a basal diet (the practical diet used on the farm); the other 4 experimental groups were supplemented in the basal diet with RPMet 15 g/d (RPM group), RPLys 30 g/d (RPL group), RPLys 30 g/d + RPMet 15 g/d (RPL+M group), and RPLys 30 g/d + RPMet 15 g/d with the crude protein level of the basal diet simultaneously reduced by 1.71% [RPL+M(L) group], respectively. The preliminary period was 10 d, and the formal experimental period was 150 d. The results showed that: 1) The final body weight and average daily gain of the RPL+M group and the RPL+M(L) group were significantly higher than those of the control group ($P<0.05$), and the feed-to-gain ratio was significantly lower than that of the control group ($P<0.05$), but the difference between these 2 groups was not significant ($P>0.05$). The breeding benefit of the RPL+M(L) group was the highest, at 7.67 yuan/(d · head), which was 0.32 yuan/(d · head) higher than that of the RPL+M group. 2) Compared with the control group, dietary supplementation with RPMet and RPLys had no significant effect on the dressing percentage of Holstein dairy bulls (P>0.05); the pre-slaughter live weight of the RPM group, RPL group, RPL+M group, and RPL+M(L) group increased significantly (P<0.05), with the RPL+M group being the highest, but there was no significant difference between the RPL+M group and the RPL+M(L) group (P>0.05); the slaughter rate of the RPL group increased significantly (P<0.05); the carcass meat yield and meat-to-bone ratio of all experimental groups increased significantly (P<0.05), but the differences among experimental groups were not significant (P>0.05). 3) Dietary supplementation with RPMet and RPLys had no significant effect on eye muscle area, shear force, cooked meat percentage, marbling grade, pH, or meat color grade (P>0.05). 4) Dietary supplementation with RPMet and RPLys also had no significant effect on the composition of muscle fatty acids (P>0.05). In summary, dietary supplementation with RPMet and RPLys can maintain comparable meat quality and muscle fatty acid content in dairy bulls, and can improve beef production performance to a certain extent; moreover, supplementation with RPMet and RPLys can replace part of the protein feed and increase breeding benefit.

Key words: rumen-protected methionine; rumen-protected lysine; dairy bull; beef production performance; meat quality

Chinese Library Classification No.: S816.7; S823 **Document code:** **Article No.:**

In recent years, with the development of the dairy industry, large numbers of male dairy calves are born each year in China[1]. Because dairy cows themselves do not produce milk, in production—

Received date: 2016-03-11
Funding projects: National Science and Technology Support Program, "Integration and Industrial Demonstration of Scaled Healthy Dairy Cattle Breeding and Production Technologies in Northeast Agricultural Areas" (2012BAD12B05-01); Heilongjiang Provincial Agricultural Reclamation Bureau Project, "Research and Demonstration of Key Technologies for Increasing Production in Scaled Dairy Farms in Heilongjiang Reclamation Areas" (HNK125B-11-02)
Author biography: Gao Yan (1992—), female, from Fushun, Liaoning, master' s student, engaged in research on ruminant animal nutrition. E-mail: 450460312@qq.com
* **Corresponding author:** Qu Yongli, professor, doctoral supervisor, E-mail: Ylqu007@126.com

In terms of meat-producing performance, they also cannot compare with beef cattle or dual-purpose cattle, and therefore, for a long time, they have not received attention from China' s dairy and beef cattle industries[^2]. In many developed countries, dairy bulls are mainly used for beef production. In the British market, 40% of beef comes from fattened dairy bulls[^3]; in the United

States, the number of dairy bulls accounts for 8% of the number of beef cattle fed[^4]; in France, the common practice is to fatten castrated dairy bulls to about 18 months of age before slaughter and marketing[^5]. However, China is currently in a period of transition and is short of beef; the production of dairy bull beef could serve as a new pathway for China’ s cattle industry market, but there is a considerable lack of nutritional regulation technologies for dairy bulls.

At present, lysine and methionine are considered the first and second limiting amino acids, respectively, for ruminants under corn-soybean meal-type diet conditions[^6-^7]. Rumen-protected amino acids are an effective means of improving the utilization rate of dietary protein. Rumen-protected lysine (RPLys) and rumen-protected methionine (RPMet) have been widely used in dairy cow production, and have been shown to achieve good effects on milk yield[^8], milk composition[^9], heat stress[^{10}], and other traits. However, their application effects in dairy bull production have rarely been reported. Therefore, this study aimed to investigate the effects of adding RPMet and RPLys to the diet on beef production performance and meat quality of dairy bulls, to explore the feasibility of replacing part of the protein feed with RPMet and RPLys, and to provide a theoretical basis for the production application of dairy bulls.

1 Materials and Methods

1.1 Experimental Design

A completely randomized experimental design was adopted. Twenty-five healthy Holstein dairy bulls, approximately 12 months of age and with an average body weight of ((281.60 ±1.57)) kg, were selected and randomly divided into 5 groups, with 5 replicates per group and 1 animal per replicate. The control group was fed the basal diet (the practical diet used on the farm); the 4 experimental groups were supplemented in the basal diet with RPMet 15 g/d (RPM group), RPLys 30 g/d (RPL group), RPLys 30 g/d + RPMet 15 g/d (RPL+M group), and RPLys 30 g/d + RPMet 15 g/d [with the crude protein (CP) level of the diet simultaneously reduced by 1.71%] [RPL+M(L) group], respectively. The preliminary trial lasted 10 d, and the formal trial lasted 150 d.

1.2 Feeding Management

All experimental cattle were kept in tie-stall housing. The basal diet was formulated with reference to the *Beef Cattle Feeding Standard* (NY/T 815–2004) of the Ministry of Agriculture of China. The composition and nutrient levels of the experimental diets and the supplementation amounts of RPMet and RPLys are shown in Table 1. RPMet and RPLys were supplied by Beijing Yahe Co., Ltd.; their rumen protection rates were 60.25% and 68.81%, respectively. Feed was offered daily at 08:00 and 16:00, with free access to water. Concentrate was fed at 4 kg/d, and roughage was fed as sheepgrass hay at 5 kg/d.

Table 1 Composition and nutrient levels of experimental diets and supplemental levels of RPMet and RPLys (DM basis) %

Items	Control	RPM	RPL	RPL+M	RPL+M(L)
Ingredients					
Corn	55.00	55.00	55.00	55.00	55.00
Soybean meal	24.00	24.00	24.00	24.00	17.00
Wheat bran	15.00	15.00	15.00	15.00	22.00
$NaHCO_3$	1.00	1.00	1.00	1.00	1.00
Premix[1)]	5.00	5.00	5.00	5.00	5.00
Total	100.00	100.00	100.00	100.00	100.00
Nutrient levels[2)]					
NE f/(MJ/kg)	7.21	7.21	7.21	7.21	7.15
CP	16.12	16.12	16.12	16.12	14.41
Lys	0.80	0.80	1.54	1.54	1.41
Met	0.25	0.62	0.25	0.62	0.58
Ca	0.91	0.91	0.91	0.91	0.90
P	1.01	1.01	1.01	1.01	1.03
Extra supplementation					
Rumen-protected lysine RPLys/(g/d)			30.00	30.00	30.00
Rumen-protected methionine RPMet/(g/d)		15.00		15.00	15.00

[1)] One kg of premix contained the following: VA 250 000 IU, VD_3 40 000 IU, VE 1 000 IU, Cu 1 g, Zn 3 g, Fe 5 g, Mn 4 g, I 50 mg, Se 10 mg, Co 10 mg.

[2)] NE f was a calculated value and the others were measured values.

1.3 Sample Collection and Measurement Methods

Growth performance: Body weight was measured with a platform scale at the beginning and end of the experiment, respectively; average daily gain (ADG) was calculated as total weight gain divided by the number of experimental days; the feed-to-gain ratio (F/G) was the amount of feed consumed per kilogram of body-weight gain.

Collection of beef samples: After the feeding trial ended, the experimental cattle were slaughtered at a slaughterhouse in Qiqihar, Heilongjiang Province. Feed was withheld for 24 h before slaughter, and the cattle were weighed. After slaughter, the carcasses were chilled at 0–4 °C for 24 h. Meat samples of the longissimus dorsi between the 12th and 13th ribs were collected and stored frozen at −80 °C.

Slaughter performance: During slaughter, carcass weight, bone weight, and net meat weight were recorded, and the ribeye area was measured.

Meat quality: pH was measured 45 min after slaughter; meat color was evaluated by comparing the color at the cross-section of the longissimus dorsi with a meat-color grade chart, and meat color was divided into 8 grades according to color depth; marbling was classified according to the Japanese beef grading standard; shear force was measured using a C-LM3B digital muscle tenderness meter; the composition and content of fatty acids in beef were analyzed using gas chromatography; cooking yield was determined by placing meat samples in an 80 °C water bath for 30 min, removing them and cooling them to room temperature, blotting surface moisture with absorbent paper, and then weighing. The calculation formula was as follows:

$$\text{Cooking yield}(\%) = 100 \times \left(\frac{\text{meat weight after heating}}{\text{meat weight before heating}}\right).$$

1.4 Statistical Analysis

After the data were organized in Excel, SPSS 19.0 was used to conduct one-way ANOVA, and Duncan' s method was used for multiple comparisons. Experimental data are expressed as "mean ± standard error" ; differences were considered significant at $P < 0.05$.

2 Results

2.1 Growth Performance and Economic Benefits of Holstein Dairy Bulls

The effects of RPMet and RPLys on the growth performance and economic benefits of Holstein dairy bulls are shown in Table 2. The final body weight and average daily gain of the experimental cattle in the RPL+M group and the RPL+M (L) group were significantly higher than those of the control group ($P < 0.05$), and the feed-to-gain ratio was significantly lower than that of the control group ($P < 0.05$), but this

the difference between the 2 groups was not significant ($P > 0.05$). The combined feed input plus rumen-protected amino acid input costs for the RPL+M group and the RPL+M(L) group were 14.25 and 12.97 yuan/(d · head), respectively, which were 2.70 and 1.42 yuan/(d · head) higher than the control group' s 11.55 yuan/(d · head). However, the average daily gains of the experimental cattle in the RPL+M group and the RPL+M(L) group were 0.62 and 0.55 kg/d higher than that of the control group, respectively. Calculated at the prevailing beef-cattle market price of 16.00 yuan/kg, the weight-gain profits of the RPL+M group and the RPL+M(L) group were 9.76 and 8.80 yuan/(d · head) higher than that of the control group, respectively. Thus, after subtracting costs from weight-gain income, the farming income of the RPL+M group and the RPL+M(L) group was 7.06 and 7.38 yuan/(d · head) higher than that of the control group, respectively, and the RPL+M(L) group was 0.32 yuan/(d · head) higher than the RPL+M group.

Table 2 Effects of rumen-protected methionine and rumen-protected lysine on growth performance and economic benefits of Holstein bulls

Table 2 Effects of RPMet and RPLys on growth performance and economic benefit of Holstein bulls

Items	Control	RPL+M	RPL+M (L)
Initial weight/kg	279.00±25.28	283.02±29.30	281.76±26.54
Final weight/kg	389.31±25.71^{b}	486.90±20.60^{a}	475.77±25.99^{a}
ADG/(kg/d)	0.74±0.02^{b}	1.36±0.09^{a}	1.29±0.04^{a}
F/G	5.45±0.54^{b}	3.00±0.47^{a}	3.09±0.33^{a}
Sale price of beef/(yuan/kg)	16.00	16.00	16.00
Diet input/(yuan/d)	11.55	11.55	10.27
RPAA input/(yuan/d)	0.00	2.70	2.70
Weight gain profit/(yuan/d)	11.84	21.60	20.64
Farming income/(yuan/d)	0.29	7.35	7.67

In the same row, values with no letter or the same letter superscripts mean no significant difference ($P > 0.05$), while values with different small-letter superscripts mean significant difference ($P < 0.05$). The same applies below.

2.2 Meat production performance of Holstein bulls

The effects of RPMet and RPLys on the meat production performance of Holstein bulls are shown in Table 3. Supplementation with RPMet and RPLys had no significant effect on bone weight or dressing percentage ($P > 0.05$). Compared with the control group, the pre-slaughter live weight of the RPM group, RPL group, RPL+M group, and RPL+M(L) group all increased significantly ($P < 0.05$). Among them, the RPL+M group had the highest preslaughter live weight, but it did not differ significantly from the RPL+M(L) group ($P > 0.05$), while it differed significantly from the RPM group and the RPL group ($P < 0.05$). The carcass weight and net meat weight of the RPL group, RPL+M group, and RPL+M(L) group were all significantly higher than those of the control group ($P < 0.05$), whereas the carcass weight and net meat weight of the RPM group did not differ significantly from those of the control group ($P > 0.05$). The slaughter rate of the RPL group was significantly higher than that of the control group ($P < 0.05$), while the other groups did not differ significantly from the control group ($P > 0.05$). The carcass meat yield and meat-to-bone ratio of the RPM group, RPL group, RPL+M group, and RPL+M(L) group were all significantly higher than those of the control group ($P < 0.05$), and differences among the experimental groups were not significant ($P > 0.05$).

Table 3 Effects of rumen-protected methionine and rumen-protected lysine on meat production performance of Holstein bulls

Table 3 Effects of RPMet and RPLys on meat performance of Holstein bulls

Items	Control	RPM	RPL	RPL+M	RPL+M(L)
Items	Control	RPM	RPL	RPL+M	RPL+M(L)
SBW/kg	389.31$±25.71 <				

sup > d <
/sup >
|432.60±20.13 <
sup > c <
/sup >
|456.61±25.44 <
sup > b <
/sup >
|486.90±20.60 <
sup > a <
/sup >
|475.77±25.99 <
sup > ab <
/sup >
||Carcassweight/kg|172.75±6.21 <
sup > c <
/sup >
|196.66±8.79 <
sup > bc <
/sup >
|230.21±13.41 <
sup > a <
/sup >
|223.89±12.65 <
sup > ab <
/sup >
|206.99±8.44 <
sup > ab <
/sup >
||Boneweight/kg|35.50±2.21|37.52±3.25|38.15±4.49|39.77±3.21|35.16±5.74||Meatweight/kg|139.5
sup > c <
/sup >
|161.05±7.60 <
sup > bc <
/sup >
|196.66±15.51 <
sup > a <
/sup >
|189.07±18.58 <
sup > a <
/sup >
|172.79±11.16 <
sup > ab <
/sup >
||Dressingpercentage/±3.51 <
sup > b <
/sup >
|45.00±3.29 <
sup > ab <
/sup >
|50.33±2.14 <

2.3 Meat Quality of Holstein Dairy Bulls

The effects of RPMet and RPLys on the meat quality of Holstein dairy bulls are shown in Table 4. Supplementation with RPMet and RPLys had no significant effect on the meat quality of Holstein dairy bulls ($P > 0.05$). The RPL+M group had the largest eye muscle area, at (112.03$±20.13)cm^{2},butthedifferencesamonggroupswerenotsignificant(P>0.05).Comparedwiththecont
The marbling degree was grade 2 in all groups. The meat color degree (45 min) was 6 in all groups.

Table 4 Effects of RPMet and RPLys on meat quality of Holstein bulls

<table>
<tr><th>Items</th><th>Control</th><th>RPM</th><th>RPL</th><th>RPL+M</th><th>RPL+M(L)</th></tr>
<tr><td>Eye muscle area/cm²</td><td colspan="5">96.15$±11.50|105.24±10.68|99.06±15.45|112.03±20.13|108.58±15.55||Shearforce/kg|4.79±0.56|5.2 sup > ∗ < /sup > |7.01±0.24|6.46±0.35|6.96±0.02|7.12±0.76|7.26±$0.81</td></tr>
<tr><td>Meat color degree*</td><td>6</td><td>6</td><td>6</td><td>6</td><td>6</td></tr>
</table>

*: measured at 45 min after slaughter.

2.4 Muscle Fatty Acid Composition of Holstein Dairy Bulls

The effects of RPMet and RPLys on the muscle fatty acid composition of Holstein dairy bulls are shown in Table 5. Supplementation with RPMet and RPLys had no significant effect on the muscle fatty acid composition of Holstein dairy bulls ($P > 0.05$). Among them, the RPM group had the highest unsaturated fatty acid content, at 43.49%, and the differences among groups were not significant ($P > 0.05$).

Table 5 Effects of RPMet and RPLys on muscle fatty acid composition of Holstein bulls (percentage of total fatty acids) %

Items	Groups

	Control	RPM	RPL	RPL+M	RPL+M(L)
Linoleic acid C18:2n6c	2.77±0.23	2.32±0.11	2.91±0.11	2.33±0.12	2.83±0.15
Linolenic acid C18:3n3	0.50±0.05	0.50±0.04	0.45±0.02	0.49±0.05	0.48±0.03
Oleic acid C18:1n9c	37.39±3.18	38.68±0.55	36.39±1.10	38.06±0.54	35.49±2.42
Stearic acid C18:0	19.27±1.56	17.89±1.59	19.01±1.45	20.94±2.10	18.19±1.54
Palmitic acid C16:0	32.35±1.68	32.15±0.65	29.96±0.97	31.42±1.52	29.79±1.04
Palmitoleic acid C16:1	2.51±0.58	2.49±0.19	2.49±0.33	2.56±0.29	2.50±0.05
Polyunsaturated fatty acids PUFA	43.17±3				

3 Discussion

3.1 Effects of RPMet and RPLys on growth performance and feeding benefits in Holstein dairy bulls

The dietary protein level affects growth gain in beef cattle. In the study by Yang Can[11], the addition of RPMet and RPLys to the diet significantly increased the average daily gain of beef cattle, while the feed-to-gain ratio was significantly reduced. The results of Hussein et al.[12] showed that feeding Holstein steers RPMet and RPLys could increase average daily gain. This is consistent with the results of the present experiment: average daily gain was increased and the feed-to-gain ratio was significantly reduced, thereby improving feed conversion efficiency.

The addition of RPMet and RPLys to the basal diet and to the low-protein diet had no significant effects on the average daily gain or feed-to-gain ratio of the experimental cattle; however, the low-protein diet reduced feeding costs and improved breeding benefits, indicating that RPMet and RPLys can replace part of the protein feed.

3.2 Effects of RPMet and RPLys on meat-production performance in Holstein dairy bulls

Dressing percentage and net meat percentage are important indicators for measuring animal growth performance and carcass performance. The experimental results of Liu Baocang[13] showed that adding RPLys to the concentrate tended to increase pre-slaughter live weight, carcass weight, net meat weight, and carcass meat yield. Similar to the results of the present experiment, in this experiment the pre-slaughter live weight, carcass weight, net meat weight, dressing percentage, carcass meat yield, and meat-to-bone ratio of the cattle supplemented with RPLys in the diet were all higher than those of the control group. Li Xiaomeng et al.[14], in a study on Holstein bulls, showed that the dressing percentage, net meat percentage, and carcass meat yield of the high-energy high-protein group were all higher than those of the medium-energy medium-protein group and the low-energy low-protein group. The results of the present experiment showed that there were no significant differences in any carcass-performance indices between the RPL+M group and the RPL+M(L) group. This may be because the rumen-protected amino acids in the diet supplemented the essential amino acids lacking in the low-protein group, meeting the amino acid levels required for growth of the experimental cattle, indicating that the addition of rumen-protected amino acids to the diet can reduce the amount of protein feed used.

3.3 Effects of RPMet and RPLys on beef quality in Holstein dairy bulls

pH represents the acidity of beef and is an important parameter for evaluating beef quality; it affects the tenderness, palatability, and shelf life of beef, and is also significantly correlated with meat color[15]. In the present experiment, adding RPLys or RPMet alone to the diet decreased beef pH, but the differences were not significant, consistent with the trend in meat color. In the experiment by Xue Feng et al.[16], adding RPLys alone to the diet of Limousin crossbred beef cattle had no significant effect on beef pH or meat-color grade, indicating that differences in the effect of dietary lysine level on meat tenderness were not significant. Bidner et al.[17] obtained similar results in a study of pork quality; the specific reasons remain to be further studied.

Shear force is one of the most commonly used indicators for evaluating meat tenderness. In this experiment, there was no significant difference in beef shear force between the RPL+M group and the RPL+M (L) group; this was consistent with the trend in changes in muscle pH, indicating that replacing part of the protein feed with RPLys and RPMet did not affect beef tenderness.

3.4 Effects of RPMet and RPLys on the Fatty Acid Composition of Holstein Dairy Bulls

Fat intake and related health issues have become one of the issues of widespread concern in today' s society[^{18}]. The three main factors affecting the fatty acid composition of beef fat are animal age, diet composition, and beef-cattle breed[^{19}]. Maddock et al.[^{20}] added 8% flaxseed to the diet and significantly increased the contents of polyunsaturated fatty acids and linolenic acid in muscle. The results of Gillis et al.[^{21}] showed that lipid supplementation during short-term fattening could increase the content of conjugated linoleic acid in adipose tissue, but only by 8.3%–17.5%. Yu Jia et al.[^{22}], in a study of Yanbian yellow cattle, showed that adding flaxseed to the diet could improve the fatty acid composition in blood and increase the content of unsaturated fatty acids in total muscle fatty acids.

The present experiment showed that different dietary treatments did not affect the contents of the various fatty acids in the muscle of Holstein dairy bulls. The RPL group had a higher unsaturated fatty acid content than the other groups, but the difference was not significant. The RPM group had the highest oleic acid content, the RPL group had the highest linoleic acid content, the control group and the RPM group had the highest linolenic acid content, and the RPL+M group had the highest palmitoleic acid content. The mechanism by which RPMet and RPLys affect fatty acids in beef muscle remains unclear and requires further study.

4 Conclusion

Adding RPMet and RPLys to the basal diet of Holstein dairy bulls can, to a certain extent, improve beef production performance, increasing pre-slaughter live weight, carcass weight, net meat weight, dressing percentage, carcass meat yield, and meat-to-bone ratio, while maintaining comparable meat quality and muscle fatty acid content in dairy bulls.

Replacing part of the protein feed with RPMet and RPLys had no adverse effects on beef production performance or meat quality in Holstein dairy bulls, and can reduce feeding costs and improve breeding profitability.

References:

[1] Cao Binghai. Report on the Current Status of Utilization of Dairy Bull Calf Resources in China[J]. Journal of China Agricultural University, 2009, 14(6): 23-30.

[2] Jiao Pinglin, Su Hui, Wu Minglou, et al. Effects of cellulase preparations on the production performance of beef cattle and dairy cows[J]. Chinese Journal of Animal Husbandry, 1997(2): 43-44.

[3] Liu Wen, Lu Jianmin. Modern British Beef Industry[J]. Yellow Cattle Science, 2002, 28(2): 36, 39.

[4] LEHMKUHLER J W, He Liwen. High-quality beef demanded by the production market for Holstein dairy bulls[J]. Chinese Journal of Animal Husbandry, 2015(Suppl. 1): 115-116.

[5] MANDELL I B, GULLETT E A, WILTON J W, et al. Effects of gender and breed on carcass traits, chemical composition, and palatability attributes in Hereford and Simmental bulls and

steers[J]. Livestock Production Science, 1997, 49(3): 235-248.

[6] NRC. Nutrient requirements of dairy cattle[S]. 7th ed. Washington, D.C.: National Academy Press, 2001.

[7] Feng Yanglian. *Ruminant Animal Nutrition*[M]. Beijing: Science Press, 2006.

[8] Sun Hua, Zhang Xiaoming, Wang Xin, et al. Analysis of the effects and economic benefits of rumen-protected methionine on dairy cow production performance[J]. China Dairy Cattle, 2010(11): 7-11.

[9] NOFTSGER S, ST-PIERRE N R. Supplementation of methionine and selection of highly digestible rumen undegradable protein to improve nitrogen

efficiency for milk production[J]. Journal of Dairy Science, 2003, 86(3): 958–969.

[10] Han Zhaoyu, Zhou Guobo, Jin Zhihong, et al. Effects of rumen-protected methionine on production performance, lymphocyte apoptosis, and related genes in dairy cows under heat stress[J]. Chinese Journal of Animal Nutrition, 2009, 21(5): 665–672.

[11] Yang Yao. Study on the application of rumen-protected methionine and rumen-protected lysine in growing-finishing cattle[D]. Master' s thesis. Chongqing: Southwest University, 2014.

[12] HUSSEIN H S, BERGER L L. Feedlot performance and carcass characteristics of Holstein steers as affected by source of dietary protein and level of ruminally protected lysine and methionine[J]. Journal of Animal Science, 1995, 73(12): 3503–3509.

[13] Liu Baocang. Study on the supplementation effect of rumen-protected lysine in concentrate supplements for fattening cattle and sheep[D]. Master' s thesis. Shihezi: Shihezi University, 2014.

[14] Li Xiaomeng, Li Qiufeng, Cao Yufeng, et al. Effects of dietary energy and protein levels on meat quality of Holstein bulls[J]. Chinese Journal of Animal Husbandry, 2015, 51(19): 38–43.

[15] Zhang Jie. Effects of dietary nutritional level, flaxseed, and vitamin E on production performance and meat quality of dairy bulls[D]. Master' s thesis. Baoding: Hebei Agricultural University, 2014.

[16] Xue Feng, Guo Xiaoxu, Guo Wangshan, et al. Effects of dietary supplementation with rumen-protected lysine on carcass traits and meat quality of Limousin crossbred beef cattle[J]. Journal of China Agricultural University, 2010, 15(4): 82–86.

[17] BIDNER B S, ELLIS M, WITTE D P, et al. Influence of dietary lysine level, pre-slaughter fasting, and rendement napole genotype on fresh pork quality[J]. Meat Science, 2004, 68(1): 53–60.

[18] BRAY G A. Epidemiology, risks and pathogenesis of obesity[J]. Meat Science, 2005, 71(1): 2–7.

[19] Xu Long. Effects of dietary factors on fatty acid digestion and metabolism, growth efficiency, carcass quality, and fatty acid composition in beef[D]. Doctoral dissertation. Hohhot: Inner Mongolia Agricultural University, 2013.

[20] MADDOCK T D, BAUER M L, KOCH K B, et al. Effect of processing flax in beef feedlot diets on performance, carcass characteristics, and trained sensory panel ratings[J]. Journal of Animal Science, 2006, 84(6): 1544–1551.

[21] GILLIS M H, DUCKETT S K, SACKMANN J R. Effects of supplemental rumen-protected conjugated linoleic acid or corn oil on fatty acid composition of

adipose tissues in beef cattle[J]. Journal of Animal Science, 2004, 82(5): 1419-1427.

[22] Yu Jia, Chen Na, Gao Qingshan, et al. Effects of flaxseed on fatty acids in the blood and muscle of Yanbian yellow cattle and on the expression of related genes[J]. Chinese Journal of Animal Science, 2015, 51(Suppl.): 87-91.

Effects of Rumen-Protected Methionine and Rumen-Protected Lysine Supplementations in Diets on Meat Production Performance and Meat Quality of Holstein Bulls

GAO Yan1 WU Jianhao2 QU Yongli1* PAN Qiqi1 ZHANG Shibo1 HAN Tianlong1 WANG Zhibo1 YIN Xihan1

(1. *College of Animal Science and Technology, Heilongjiang Bayi Agricultural University, Daqing 163319, China;*
2. *Shanghai Bright Holstan Co. Ltd., Shanghai 202177, China*)

Abstract: This experiment was conducted to investigate the effects of rumen-protected methionine (RPMet) and rumen-protected lysine (RPLys) supplementations in diet on meat production performance and meat quality of Holstein bulls. Twenty five Holstein bulls aged about 12 months with similar body weight were selected and divided into 5 groups by random experiment design, and each group included 5 replicates with 1 bull per replicate. The control group was fed a basal diet (ranch practical diet), and the other 4 groups were fed the basal diet added with RPMet 15 g/d (RPM group), RPLys 30 g/d (RPL group), RPLys 30 g/d+RPMet 15 g/d (RPL+M group) and RPLys 30g/d+RPMet 15g/d (meanwhile dietary crude protein level was lowered 1.71%) [RPL+M(L) group], respectively. Adaptation and experimental periods lasted for 10 and 150 d, respectively. The results showed as follows: 1) RPL+M and RPL+M(L) groups had significantly higher final weight, average daily gain than control group (P<0.05), and had significantly lower ratio of feed to gain than control group (P<0.05), but there were no differences between the above two groups (P>0.05); the highest economic benefit of farming was RPL+M (L) group [7.67 RMB/(d · bull)], which was 0.32 RMB/(d · bull) higher than that of RPL+M group. 2) Compared with control group, meat percentage

Corresponding author, professor, E-mail: ylqu007@126.com

(Responsible editor: Wang Zhihang)

was not affected by RPMet and RPLys supplementation ($P > 0.05$); the RPM, RPL, RPL+M, and RPL+M(L) groups had significantly higher body weight before slaughter ($P < 0.05$), with the highest value in the RPL+M group, although it did not differ significantly from that in the RPL+M(L) group ($P > 0.05$); the RPL group had a significantly higher dressing percentage ($P < 0.05$); all experimental groups had significantly higher carcass meat percentage and meat-to-bone ratio ($P < 0.05$), with no significant differences among experimental groups ($P > 0.05$). 3) Dietary supplementation with RPMet and RPLys had no significant effects on eye muscle area, shear force, cooked meat percentage, marbling score, pH, or meat color ($P > 0.05$). 4) There were no significant differences in muscle fatty acid composition ($P > 0.05$). It is concluded that dietary supplementation with RPMet and RPLys can maintain similar meat quality and muscle fatty acid composition in Holstein bulls, improve meat production performance, replace part of the protein feed, and increase the economic benefits of farming.

Key words: RPMet; RPLys; bulls; meat production performance; meat quality

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