Effects of Glutamic Acid Residue on Milk Yield and Milk Composition of Dairy Goats: Postprint

Authors: Li Zhongyang, Huaiping Shi, Luo Jun, Liu Chenglong, Li Jie

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

Abstract

This study investigated the effects of glutamic acid residue on milk yield and milk composition in dairy goats to determine the optimal supplementation level of glutamic acid residue in concentrate supplements, aiming to diversify feed ingredient sources and reduce feed costs. A single-factor randomized block design was employed, utilizing 40 healthy second-parity Saanen dairy goats in early lactation [days in milk: (20±5) d] with identical parity, body weight of (59.80±2.15) kg, and similar milk production performance, which were randomly allocated into 4 groups of 10 goats each. The concentrate supplements provided to the four groups were equivalent in nutritional levels, with glutamic acid residue supplementation rates of 0 (control), 2%, 4%, and 6%, respectively. The experimental period comprised 63 days, including a 7-day preliminary period and a 56-day formal experimental period. The results demonstrated no significant differences among groups in daily dry matter intake, milk yield, lactose content, or milk fat content (P>0.05). On day 35, the milk protein content in the 2% and 4% glutamic acid residue groups was significantly higher than that in the control and 6% glutamic acid residue groups (P<0.05); on days 42 and 56, the milk protein content in the 2% glutamic acid residue group, 4% glutamic acid residue group, and control group was significantly higher than that in the 6% glutamic acid residue group (P<0.05). On day 56, compared with the control group, the concentration and absolute yield of -lactoglobulin in milk protein in all treatment groups exhibited an increasing trend; the concentration and absolute yield of -casein in milk protein in the 2% and 4% glutamic acid residue groups exhibited an increasing trend, while those in the 6% glutamic acid residue group exhibited a decreasing trend, though all differences were not significant (P>0.05). No significant differences were observed among groups in the daily absolute yields of milk fat, lactose, or milk protein (P>0.05). It was concluded that glutamic acid residue can be utilized as a feed protein source for dairy goats, with an optimal supplementation level of 4% in concentrate supplements.

Full Text

Effects of Glutamic Acid Residue on Milk Yield and Milk Composition of Dairy Goats

LI Zhongyang[1], SHI Huaiping[1]*, LUO Jun[1], LIU Chenglong[1], LI Jie[2]
(1. College of Animal Science and Technology, Northwest A&F University, Yangling 712100, China;
2. Qianyang County Goat Farm, Qianyang 721100, China)

Abstract

This study investigated the effects of glutamic acid residue on milk yield and milk composition of dairy goats to determine the optimal supplementation level in concentrate supplements, aiming to enrich feedstuff sources and reduce feeding costs. A single-factor randomized block design was adopted. Forty healthy Saanen dairy goats in early lactation [days in milk: (20±5) d], with identical parity, similar body weight [(59.80±2.15) kg] and milk performance, were randomly allocated into 4 groups (n=10). The concentrate supplements for all groups had basically the same nutrient levels, with glutamic acid residue added at 0 (control), 2%, 4%, and 6%, respectively. The experimental period lasted 63 days, including a 7-day pre-trial period and a 56-day formal trial period. The results showed that average daily dry matter intake, milk yield, milk fat percentage, and lactose percentage did not differ significantly among groups ($P>0.05$). On day 35 of the experiment, the milk protein percentage in the 2% and 4% glutamic acid residue groups was significantly higher than that in the control and 6% groups ($P<0.05$). On days 42 and 56, the milk protein percentage in the 2% group, 4% group, and control group was significantly higher than that in the 6% group ($P<0.05$). On day 56, compared with the control group, all experimental groups showed an upward trend in -lactoglobulin concentration and absolute yield in milk protein; the 2% and 4% groups showed an upward trend in -casein concentration and absolute yield, while the 6% group showed a downward trend, though none of these differences were significant ($P>0.05$). The daily absolute yields of milk fat, lactose, and milk protein did not differ significantly among groups ($P>0.05$). It is concluded that glutamic acid residue can be used as a protein feedstuff for dairy goats, with the optimal supplementation level in concentrate supplements being 4%.

Keywords: glutamic acid residue; dairy goats; milk yield; milk composition

---

Introduction

Protein is one of the most important material foundations for life activities and occupies a special position in livestock nutrition. As one of the most crucial components of animal bodies, protein is essential for the growth of muscle, skin, hair, and bone, as well as for the synthesis of hormones and enzymes, serving as the primary bearer of life activities. Dietary protein level significantly influences milk yield and quality. For instance, Yu et al. reported that increasing dietary protein level could increase milk yield of Laoshan dairy goats while significantly elevating milk fat, milk protein, and non-fat solid contents. Protein feedstuffs are characterized by high digestibility and absorbability, providing energy required for animal growth, being rich in various essential amino acids lacking in animal bodies, containing high levels of calcium and phosphorus, and having excellent palatability, making them high-quality feed ingredients.

As the world's largest consumer of livestock meat products, China has enormous demand for protein feedstuffs and other raw materials required for livestock production. However, high-quality protein feedstuffs such as fish meal and soybean meal are expensive, with approximately 70% of protein feedstuffs relying on imports. These circumstances necessitate the search for new, inexpensive, and abundant protein feedstuffs to replace traditional ones like fish meal and soybean meal.

The food industry generates large quantities of organic wastewater during the production of monosodium glutamate, yeast, and liquor from grain-based fermentation. This wastewater contains substantial amounts of utilizable components such as microbial cells and nitrogen. Through microbial decomposition and transformation of organic and inorganic nitrogen, various nutrients are synthesized, converting the concentrated liquid via fermentation into high-quality biological protein feedstuffs from food industry by-products. Fermentation of feed ingredients can eliminate anti-nutritional factors, improve palatability, enhance feed utilization efficiency, and consequently improve animal growth performance.

Glutamic acid residue is produced from further processing of condensed molasses fermentation solubles (CMS), a by-product of monosodium glutamate production from molasses fermentation. It retains partial components and flavors of sucrose while adding unique non-protein nitrogen amino acids, vitamins, microbial protein, and other special nutrients from the fermentation process. Combined with its rich inorganic salt composition, glutamic acid residue is suitable as a feed ingredient without affecting animal feed intake. Currently, China has approximately 200 monosodium glutamate factories of various sizes, with an annual production capacity of 1.1 million tons. If all monosodium glutamate factories in the country were to separate and recover waste microbial cells, they could produce approximately 220,000 tons of microbial protein containing about 70% crude protein annually. This would open new protein resources for animal production, alleviating the shortage of protein feed resources in China to some extent, while reducing environmental pollution from waste liquid after microbial cell separation.

Materials and Methods

1.1 Experimental Animals Forty healthy Saanen dairy goats in early lactation [days in milk: (20±5) d] with identical parity (second lactation), similar body weight [(59.80±2.15) kg] and body condition were selected. All experimental goats were in good health without any diseases. A single-factor randomized block design was employed, with the 40 goats randomly divided into 4 groups (n=10). No significant differences were observed among groups in parity, age, days in milk, or milk performance ($P>0.05$).

1.2 Experimental Diets The experimental diets consisted of concentrate supplements, corn silage, and alfalfa hay. The concentrate supplements for all four groups had basically the same nutrient levels, with glutamic acid residue added at 0 (control), 2%, 4%, and 6%, respectively. The composition and nutrient levels of the concentrate supplements are presented in Table 1 .

Table 1 Composition and nutrient levels of concentrate supplements (DM basis)

Item	Glutamic acid residue adding amount/%
Ingredients	
Corn	
Wheat bran	
Cottonseed meal	
Soybean meal	
Corn germ cake	
Rapeseed meal	
Corn skin	
DDGS	
Glutamic acid residue	0, 2, 4, 6
Limestone	
CaHPO	
NaCl	
Premix[1]	
Total	
Nutrient levels[2]	
DE/(MJ/kg)	
DM	
CP	

[1]Premix provided the following per kilogram of concentrate supplements: VA 25,000 IU, VD 10,000 IU, VE 50 mg, Fe 45 mg, Cu 30 mg, Zn 90 mg, Mn 40 mg, I 0.8 mg, Se 0.6 mg, Co 0.5 mg.
[2]Nutrient levels were calculated values.

1.3 Animal Management Before the experiment, all goats were vaccinated and dewormed, and pens were cleaned and disinfected. The four groups were then housed in four separate pens. Concentrate supplements and corn silage were fed daily from 07:30–08:00 and 14:30–15:00, while alfalfa hay was fed at 20:00. All goats had free access to water and were allowed free movement. Residual feed was collected before the next day' s feeding, weighed by category, and used to calculate dry matter intake. The experimental period lasted 63 days, including a 7-day pre-trial period and a 56-day formal trial period.

1.4 Sample Collection Goats were milked twice daily during the experimental period. Milk yield was recorded twice weekly during the formal trial period, with each recording representing the sum of morning and afternoon milk yields. Milk samples were collected every 7 days to analyze milk composition parameters including lactose percentage, milk fat percentage, and milk protein percentage. On day 56 of the formal trial period, milk samples were collected and transported to the laboratory for determination of S1-casein, -casein, and -lactoglobulin concentrations in milk protein, and to calculate the absolute yields of these proteins on that day.

1.5 Data Analysis Experimental data were analyzed using one-way ANOVA procedure in SPSS 23.0 software. When significant differences were detected, Duncan' s multiple range test was used for mean comparison.

Results

2.1 Effects of Glutamic Acid Residue on Dry Matter Intake of Dairy Goats As shown in Table 2 , no significant differences in average daily dry matter intake were observed among the control, 2%, 4%, and 6% glutamic acid residue groups during the 8-week formal trial period (P>0.05). However, average daily dry matter intake increased in all groups as the experiment progressed.

Table 2 Effects of glutamic acid residue on average daily dry matter intake of dairy goats (kg/d)

Sampling time	Glutamic acid residue adding amount/%			
	0	2%	4%	6%
Week 1	1.93±0.03	1.97±0.03	1.93±0.04	1.98±0.02
Week 2	1.94±0.01	1.94±0.01	1.94±0.02	1.95±0.01
Week 3	1.97±0.01	1.96±0.10	1.96±0.08	1.97±0.08
Week 4	2.01±0.00	2.00±0.05	2.00±0.04	2.01±0.01
Week 5	2.01±0.00	2.00±0.10	2.00±0.04	2.01±0.02
Week 6	2.01±0.00	2.01±0.00	2.01±0.00	2.01±0.00
Week 7	2.00±0.00	2.00±0.04	2.00±0.05	2.00±0.04
Week 8	2.01±0.00	2.00±0.05	2.00±0.03	2.00±0.05

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

2.2 Effects of Glutamic Acid Residue on Milk Yield of Dairy Goats As shown in Figure 1 [Figure 1: see original paper]-A, milk yield curves of all groups were similar during the formal trial period without obvious fluctuations. At the beginning of the experiment (day 0), milk yield in the 2% and 6% glutamic acid residue groups was significantly higher than that in the control group (P<0.05, Figure 1-B). On days 28 and 56 of the experiment, no significant differences in milk yield were observed among the three experimental groups (2%, 4%, and 6%) and the control group (P>0.05, Figure 1-C and Figure 1-D).

In the same figure, data columns with different small letters mean significant difference (P<0.05), while with the same or no letters mean no significant difference (P>0.05). The same as below.

Figure 1 Effects of glutamic acid residue on milk yield of dairy goats

2.3 Effects of Glutamic Acid Residue on Milk Composition of Dairy Goats As shown in Table 3 , no significant differences in milk fat percentage or lactose percentage were observed among groups at any sampling time point during the formal trial period (P>0.05). On day 7, milk protein percentage in the 2% glutamic acid residue group was significantly higher than that in the 6% group (P<0.05). On day 35, milk protein percentage in the 2% and 4% groups was significantly higher than that in the control and 6% groups (P<0.05), with no significant difference between the 2% and 4% groups (P>0.05) or between the control and 6% groups (P>0.05). On days 42 and 56, milk protein percentage in the 2% group, 4% group, and control group was significantly higher than that in the 6% group (P<0.05), though no significant differences were detected among the 2% group, 4% group, and control group (P>0.05). No significant differences in milk protein percentage were observed among groups on days 14, 21, 28, and 49 (P>0.05).

Table 3 Effects of glutamic acid residue on milk composition of dairy goats (%)

Items	Sampling time	Glutamic acid residue adding amount/%			
		0	2%	4%	6%
Milk fat percentage	Day 7	3.97±0.21	4.70±0.4[illegible]	4.3[illegible]±0.[illegible]	4.[illegible]±0.16
	Day 14	4.60±0.34	4.97±0.4[illegible]	4.[illegible]±0.[illegible]	4.[illegible]±0.33

Items	Sampling time	Glutamic acid residue adding amount/%	
	Day 21	4.86±0.51	4.77±0.41±5.25±0.69
	Day 28	4.48±0.12	4.32±0.36±0.27±0.18
	Day 35	4.41±0.21	5.17±0.59±0.30±0.48
	Day 42	4.84±0.30	5.27±5.21±0.93±0.27
	Day 49	5.10±0.16	4.83±0.21±0.97±0.20
	Day 56	4.80±0.30	4.26±0.27±0.21±0.19
Lactose percentage	Day 7	3.42±0.10	3.49±3.24±3.39±0.07
	Day 14	3.32±0.08	3.38±3.17±3.31±0.06
	Day 21	3.44±0.06	3.46±3.34±3.36±0.06
	Day 28	3.12±0.09	3.29±3.17±3.08±0.06
	Day 35	3.38±0.09	3.47±3.49±3.36±0.09
	Day 42	3.33±0.07	3.38±3.51±3.54±0.09
	Day 49	3.23±0.09	3.37±3.48±3.49±0.11
	Day 56	3.55±0.06	3.51±3.56±3.56±0.09
Milk protein percentage	Day 7	2.84±0.05	3.11±2.81±2.67±0.04
	Day 14	2.87±0.03	2.98±2.94±2.80±0.07
	Day 21	2.83±0.04	2.85±2.72±2.74±0.04
	Day 28	2.67±0.04	2.75±2.83±2.65±0.06
	Day 35	2.65±0.03	2.81±2.83±2.63±0.03
	Day 42	2.79±0.03	2.86±2.84±2.63±0.03
	Day 49	2.80±0.06	2.78±2.76±2.66±0.03
	Day 56	2.92±0.04	2.87±2.85±2.62±0.02

2.4 Effects of Glutamic Acid Residue on Concentrations and Absolute Yields of S1-Casein, -Casein, and -Lactoglobulin in Milk Protein As shown in Figure 2 [Figure 2: see original paper], no significant differences in S1-casein concentration or absolute yield were observed among groups on day 56 (P>0.05). Compared with the control group, the 2% and 4% glutamic acid residue groups showed an upward trend in -casein concentration and absolute yield, while the 6% group showed a downward trend, though these differences were not significant (P>0.05). All experimental groups exhibited an upward trend in -lactoglobulin concentration and absolute yield compared with the control group, but the differences were not significant (P>0.05).

Figure 2 Effect of glutamic acid residue on concentrations and abso-

lute yields of S1-casein, -casein and -lactoglobulin in milk protein of dairy goats

2.5 Effects of Glutamic Acid Residue on Daily Absolute Yield of Milk Components Milk samples collected on days 7, 14, 21, 28, 35, 42, 49, and 56 of the formal trial period were analyzed for absolute yields of milk components at each sampling time point. The average values were then calculated to estimate the daily absolute yields during the formal trial period. As shown in Figure 3 [Figure 3: see original paper], no significant differences were observed in daily absolute yields of milk fat, lactose, or milk protein among the three experimental groups and the control group ($P>0.05$).

Figure 3 Effects of glutamic acid residue on daily absolute yield of milk components for dairy goats

---

Discussion

3.1 Effects of Glutamic Acid Residue on Feed Intake of Dairy Goats Lopez-Campos et al. found that feeding vinasse (one of the raw materials of CMS) to Merino sheep reduced feed intake and growth rate but improved feed conversion efficiency and meat quality. Fernandez et al. reported that feeding CMS to sheep did not affect feed intake, and rumen fistula experiments indicated that diets containing 13% CMS could improve the digestibility of crude protein, neutral detergent fiber, and dry matter in the rumen. In the present experiment, feed intake increased in all groups, with no significant differences in average daily dry matter intake among groups, suggesting that feeding glutamic acid residue does not affect dry matter intake of dairy goats. This result is consistent with the findings of Fernandez et al. These results indicate that fermented CMS raw materials improve feed palatability without affecting feeding behavior, while the increased microbial protein content in fermented feed enhances feed digestibility and conversion.

3.2 Effects of Glutamic Acid Residue on Milk Yield of Dairy Goats Research findings on the effects of glutamic acid residue on milk yield of dairy animals have been inconsistent. Mao reported that adding 1.5% CMS significantly increased milk yield of dairy cows compared with the blank control group, while the 0.75% addition group showed increased milk yield but without significant difference. Mo et al. found that milk yield of dairy buffaloes in both control and experimental groups decreased as the experiment progressed, with the magnitude of decrease increasing as CMS addition level increased. Wu et al. demonstrated that adding 7.6% and 15.2% CMS to diets could significantly increase milk yield of dairy cows, showing a lactation-promoting effect. In this experiment, no significant changes in milk yield were observed in dairy goats after feeding diets with different levels of glutamic acid residue, which differs from the above research results. The discrepancy may be attributed to the fact that milk yield is constrained not only by genetic factors but also by animal parity, dietary nutrient levels, feeding environment, and health status at the time of the experiment.

3.3 Effects of Glutamic Acid Residue on Milk Composition of Dairy Goats Previous studies have shown that CMS contains 30% crude protein, with 40%-50% being microbial protein, making it a high-quality protein feedstuff that can be directly absorbed and utilized by animals and converted into milk protein, thereby indirectly increasing milk protein percentage. Guo et al. reported that adding different levels of CMS to dairy cow diets did not significantly affect milk fat percentage, milk protein percentage, non-fat solid content, or somatic cell count. Su et al. found that adding different levels of CMS to dairy cow diets did not significantly affect milk fat percentage, milk protein percentage, or non-fat solid content. Xiang et al. demonstrated that adding CMS to dairy buffalo diets significantly increased milk protein and milk fat contents but did not significantly affect lactose content.

In this experiment, the milk protein percentage in the 2% and 4% glutamic acid residue groups was significantly higher than that in the control and 6% groups on day 35, while the 6% group showed significantly lower milk protein percentage than the 2% group, 4% group, and control group on days 42 and 56. However, no significant differences were observed in milk fat percentage or lactose percentage among groups, suggesting that dairy goats exhibit dose-dependent responses to glutamic acid residue and that excessive addition is detrimental to milk protein production. Further analysis of milk protein components revealed that although no significant differences were detected in concentrations of S1-casein, -casein, and -lactoglobulin among the four groups, substantial numerical variations were observed in -casein and -lactoglobulin concentrations, with the highest values observed at 4% glutamic acid residue addition. Whether feeding glutamic acid residue diets significantly affects these two milk protein components requires further experimental verification.

Conclusion

1. Adding glutamic acid residue to concentrate supplements can significantly alter milk protein percentage in dairy goats but does not significantly affect average daily dry matter intake, milk yield, lactose percentage, milk fat percentage, or daily absolute yields of milk components, indicating that glutamic acid residue can be used as a protein feedstuff for dairy goats.
2. Based on comprehensive analysis, the optimal supplementation level of glutamic acid residue in concentrate supplements for dairy goats is 4%.

References

[1] 蛋白质饲料对畜禽的营养作用 [J]. 甘肃畜牧兽医,2017,47(2):104.
[2] 武文来, 苗春来. 蛋白质对毛皮动物的作用及其影响 [J]. 养殖技术顾问,2011(6):242.
[3] 于子洋, 袁翠林, 王利华, 等. 蛋白质水平对崂山奶山羊泌乳性能的影响 [J]. 中国畜牧杂志,2015,51(7):32-36.
[4] 刘桂荣. 养羊常用蛋白质饲料的种类及特点 [J]. 中国畜禽种业,2016,12(5):67-68.
[5] 张珍誉. 新型蛋白质饲料资源开发技术 [J]. 科技视界,2016(27):353.
[6] 冯东勋. 用味精废水浓缩液发酵生产菌体蛋白饲料 [J]. 中国饲料,1997(23):40-41.
[7] 张岩. 发酵蛋白饲料在动物生产中的应用 [J]. 饲料博览,2015(8):19-23.
[8] 吴铭兴, 吴春峰. 新型液态饲料原料——浓缩糖蜜发酵液 (CMS) 的应用 [J]. 养殖技术顾问,2005(12):16-17.
[9] 赵晓芳. 味精菌体蛋白资源调研及营养价值评定 [D]. 硕士学位论文. 泰安: 山东农业大学,2003.
[10] 孙宇, 时合灵, 付彤, 等. 日粮中添加味精菌体蛋白对奶牛生产性能的影响 [J]. 中国畜牧兽医,2010,37(2):37-39.
[11] LOPEZ-CAMPOS O, BODAS R, PRIETO N. Vinasse added to the concentrate for fattening lambs: intake, animal performance, and carcass and meat characteristics[J]. Journal of Animal Science, 2011, 89(4):1153-1162.
[12] FERNANDEZ B, BODAS R, LOPEZ-CAMPOS O. Vinasse added to dried sugar beet pulp: preference rate, voluntary intake, and digestive utilization in sheep[J]. Journal of Animal Science, 2009, 87(6):2055-2063.
[13] 毛江. 浓缩糖蜜发酵液对奶牛瘤胃发酵和生产性能的影响 [D]. 硕士学位论文. 乌鲁木齐: 新疆农业大学,2015.
[14] 莫乃国, 梁辛, 李翠玲, 等. 白酒糟对奶水牛泌乳性能及乳品质的影响 [J]. 广西畜牧兽医,2014,30(5):260-263.
[15] 吴晋强, 王力生, 刘琦山, 等. 酒糟-单细胞蛋白 (SCP) 及其畜禽饲料效应的研究 . 酒糟-SCP 取代日粮中常规蛋白质饲料对母牛泌乳性能的影响 [J]. 安徽农业大学学报,1999,26(2):170-173.
[16] 郭春华, 魏荣禄, 陈智华, 等. 发酵蛋白饲料对奶牛泌乳性能的影响 [J]. 中国乳业,2008(12):68-70.
[17] 苏锡云, 李振田, 焦喜兰, 等. 味精废液发酵秸秆饲料对奶牛生产性能的影响 [J]. 饲料研究,2008(9):56-58.
[18] 项延润, 杨金勇. 饲喂发酵啤酒糟对尼温一代奶水牛泌乳性能的影响 [J]. 中国牛业科学,2011,37(6):43-45.

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