Effects of Lycium barbarum Polysaccharides on Slaughter Performance, Immune Organ Development, and Meat Quality Traits in Growing Rex Rabbits

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Abstract

This study aimed to investigate the effects of Lycium barbarum polysaccharides on slaughter performance, immune organ development, and meat quality traits of growing rex rabbits. Eighty 40-day-old rex rabbits (half male and half female) were randomly allocated into 4 groups (20 replicates per group, 1 rabbit per replicate). The control group was fed a basal diet, while the experimental groups were fed the basal diet supplemented with 0.1%, 0.2%, and 0.3% Lycium barbarum polysaccharides, respectively. The preliminary period lasted 5 days, and the formal experimental period lasted 30 days. The results showed: 1) Compared with the control group, the semi-eviscerated yield and eviscerated yield of the experimental groups were increased, but the differences were not significant (P>0.05). 2) The spleen index exhibited an upward trend with increasing levels of Lycium barbarum polysaccharide supplementation, peaking in the 0.3% group, while the thymus index was highest in the 0.2% group, but no significant differences were observed among groups (P>0.05). 3) Compared with the control group, the muscle drip loss rate, cooking loss rate, shear force, and lightness (L*) value of the experimental groups were slightly decreased, while the pH at 45 min and 24 h post-mortem were slightly increased, but none of these differences were significant (P>0.05); compared with the control group, the muscle redness (a*) values of the 0.1%, 0.2%, and 0.3% groups increased by 1.85%, 5.86%, and 10.80% (P>0.05), respectively, while the yellowness (b*) values decreased by 10.79%, 7.39%, and 11.93% (P>0.05), respectively. Comprehensive analysis suggested that dietary supplementation with Lycium barbarum polysaccharides had no significant effect on the slaughter performance of growing rex rabbits, but could improve immune organ indices to some extent and enhance meat quality traits, with a recommended supplementation level of 0.3%.

Full Text

Effects of Lycium barbarum Polysaccharides on Slaughter Performance, Immune Organ Development and Meat Quality Traits of Growing Rex Rabbits

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Abstract

This experiment was conducted to investigate the effects of Lycium barbarum polysaccharides (LBP) on slaughter performance, immune organ development, and meat quality traits of growing Rex rabbits. A total of 80 healthy 40-day-old Rex rabbits (half male and half female) with similar body weight were randomly allocated into four groups, each consisting of 20 replicates with one rabbit per replicate. The control group was fed a basal diet, while the experimental groups were fed the basal diet supplemented with 0.1%, 0.2%, and 0.3% LBP, respectively. The experiment included a 5-day pre-feeding period followed by a 30-day formal feeding period.

The results showed that: (1) Compared with the control group, the half-eviscerated yield and completely eviscerated yield in the experimental groups were slightly higher, but the differences were not significant (P>0.05). (2) The spleen index increased with increasing LBP supplementation levels, with the highest value observed in the 0.3% group, while the thymus index peaked in the 0.2% group, though no significant differences were detected among groups (P>0.05). (3) Compared with the control group, the experimental groups exhibited slightly lower drip loss rate, cooking loss rate, shear force, and lightness (L*) value, along with slightly higher pH values at 45 min and 24 h postmortem, but all differences were non-significant (P>0.05). The redness (a*) values in the 0.1%, 0.2%, and 0.3% groups increased by 1.85%, 5.86%, and 10.80%, respectively (P>0.05), while the yellowness (b*) values decreased by 10.79%, 7.39%, and 11.93%, respectively (P>0.05). In summary, dietary LBP supplementation had no significant effect on the slaughter performance of growing Rex rabbits but could enhance immune organ indices and improve meat quality traits to a certain extent, with a recommended supplementation

level of 0.3%.

Keywords: Lycium barbarum polysaccharides; slaughter performance; immune organ index; meat quality traits

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Amid growing concerns over antibiotic misuse and the livestock industry' s push toward antibiotic-free production, developing safe and efficient feed additives has become a research priority. Lycium barbarum polysaccharides (LBP), a water-soluble protein polysaccharide extracted from goji berries, is composed of six monosaccharides: arabinose, glucose, galactose, mannose, xylose, and rhamnose, and represents the primary bioactive component of goji berries. Previous studies have reported that LBP can scavenge free radicals, enhance glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD) activities, and inhibit peroxidation reactions [1]. It can also enhance phagocytic cell function, promote lymphocyte proliferation, and increase complement activity, thereby modulating immune function [2], and exhibits hypoglycemic and hypolipidemic effects [3]. While most LBP research has focused on medical applications [4-7], reports on its use in animal production remain limited. Our previous studies demonstrated that LBP could improve growth performance in Rex rabbits and lactating does, increase kit survival rates, promote kit growth, and reduce maternal weight loss during lactation without adversely affecting serum biochemical parameters [8-9]. However, no studies have investigated the effects of LBP on slaughter performance, immune organ development, or meat quality traits in growing Rex rabbits. This study addresses this knowledge gap to provide a theoretical basis for LBP application in animal production.

1.1 Experimental Materials

The experimental animals consisted of healthy 40-day-old Rex rabbits with uniform body weight. LBP was purchased from Xi' an Kailai Bioengineering Co., Ltd. as a brownish-red powder with 50% purity. The feeding trial and laboratory analyses were conducted at Hebei Agricultural University.

1.2 Experimental Design

A single-factor experimental design was employed. Eighty 40-day-old Rex rabbits (half male and half female) were randomly divided into four groups, each comprising 20 replicates with one rabbit per replicate. The control group received a basal diet, while the experimental groups received the basal diet supplemented with 0.1%, 0.2%, and 0.3% LBP, respectively. All rabbits were managed under identical conditions with free access to feed and water. The experiment consisted of a 5-day pre-feeding period and a 30-day formal feeding period. The composition and nutrient levels of the basal diet are presented in Table 1 .

1.3.1 Slaughter Performance

At 12 h before the end of the experiment, feed was withdrawn. Rabbits were weighed after overnight fasting to obtain live weight before slaughter. After slaughter, bleeding, skinning, and removal of the head, tail, limbs, and all internal organs, the carcass weight was recorded as the completely eviscerated weight. The heart, liver, and kidneys were then added back and weighed to obtain the half-eviscerated weight. The half-eviscerated yield and completely eviscerated yield were calculated as follows:
Half-eviscerated yield (%) = (half-eviscerated weight / live weight before slaughter) × 100
Completely eviscerated yield (%) = (completely eviscerated weight / live weight before slaughter) × 100

1.3.2 Immune Organ Development

Immediately after slaughter, the thymus and spleen were excised and weighed to calculate the thymus index and spleen index:
Thymus index (%) = (thymus weight / live weight before slaughter) × 100
Spleen index (%) = (spleen weight / live weight before slaughter) × 100

1.3.3 Meat Quality Traits

Both sides of the longissimus dorsi muscle were rapidly removed after slaughter for determination of muscle pH, cooking loss rate, drip loss rate, shear force, and meat color [10]. The pH was measured at 45 min and 24 h postmortem using a testo-205 pH meter, with three measurements taken from the upper, middle, and lower regions of each sample and averaged. For cooking loss rate, approximately 30 g of meat sample was accurately weighed (m1), sealed in a plastic bag, heated in an 80°C water bath for 1 h, cooled under running water for 20-30 min, then dried with filter paper and reweighed (m2). Cooking loss rate (%) = [(m1 - m2) / m1] × 100. For drip loss rate, approximately 20 g of meat sample was accurately weighed (m3), placed in a sealed bag inflated with air to prevent contact between the sample and bag wall, suspended in a 4°C refrigerator for 24 h, then dried with filter paper and reweighed (m4). Drip loss rate (%) = [(m3 - m4) / m3] × 100. Shear force was measured by sealing the meat sample in a plastic bag, heating in a 75-80°C water bath for 2 h, cooling under running water for 30 min, then cutting strips 1 cm wide and 0.5 cm thick along the muscle fiber direction. Shear force was measured using a CLM-3B muscle tenderness meter, with three measurements per sample averaged. Meat color was assessed using an i wave WR-18 precision colorimeter to measure lightness (L*), redness (a*)*, and yellowness (b*) values at three locations (upper, middle, lower) on each sample, with results averaged.

1.4 Data Processing

Experimental data were initially processed using Excel 2010 software. Analysis of variance (ANOVA) was performed using SPSS 18.0 statistical software. When significant differences were detected, multiple comparisons were conducted using the LSD method. Results are expressed as mean ± standard deviation.

2.1 Effects of LBP on Slaughter Performance of Growing Rex Rabbits

As shown in Table 2 , the control group exhibited the lowest half-eviscerated yield and completely eviscerated yield, while all experimental groups showed slightly higher values, with the 0.3% group achieving the highest values at 1.93% and 1.74% above the control, respectively. However, these differences were not statistically significant (P>0.05), indicating that dietary LBP supplementation had no significant effect on the completely eviscerated yield or half-eviscerated yield of growing Rex rabbits.

Table 2 Effects of LBP on slaughter performance of growing Rex rabbits

Items	Control group	0.1% group	0.2% group	0.3% group
LWBS/g	1,951.60±55.94	1,917.20±19.90	1,941.40±35.08	1,933.40±44.35
Half eviscerated slaughter rate/%	50.77±2.58	51.53±1.84	51.02±1.21	51.75±1.95
All eviscerated slaughter rate/%	47.80±2.73	48.50±1.80	48.30±1.07	48.63±2.17

In the same row, values with no letter or the same letter superscripts mean no significant difference (P>0.05), while with different small letter superscripts mean significant difference (P<0.05), and with different capital letter superscripts mean significant difference (P<0.01). The same as below.

2.2 Effects of LBP on Immune Organ Development of Growing Rex Rabbits

Table 3 shows that the spleen index in experimental groups increased with rising LBP supplementation levels, with the 0.3% group showing an 8.89% increase over the control (P>0.05). The thymus index was highest in the 0.2% group, representing a 5.48% increase compared to the control (P>0.05). These results suggest that dietary LBP supplementation could promote thymus and spleen development in growing Rex rabbits to some extent.

Table 3 Effects of LBP on immune organ development of growing Rex rabbits

Items	Control group	0.1% group	0.2% group	0.3% group
Spleen weight/g	0.88±0.17	0.85±0.15	0.86±0.12	0.95±0.19
Thymus weight/g	2.67±0.19	2.69±0.16	2.73±0.23	2.95±0.17
Spleen index/%	0.45±0.08	0.47±0.06	0.48±0.06	0.49±0.08
Thymus index/%	1.46±0.11	1.52±0.10	1.54±0.09	1.52±0.07

2.3 Effects of LBP on Meat Quality Traits of Growing Rex Rabbits

As presented in Table 4 , the pH values at both 45 min and 24 h postmortem were higher in experimental groups than in the control, indicating that LBP could slow the decline in muscle pH after slaughter. Drip loss rate, cooking loss rate, and shear force were lowest in the 0.3% group, decreasing by 6.06%, 5.09%, and 18.43% compared to the control, respectively, though these differences were not significant (P>0.05). The L* values in experimental groups were slightly lower than the control. The a* values in the 0.1%, 0.2%, and 0.3% groups increased by 1.85%, 5.86%, and 10.80% compared to the control, respectively, while b* values decreased by 10.79%, 7.39%, and 11.93%, respectively (P>0.05).

Table 4 Effects of LBP on meat quality traits of growing Rex rabbits

Items	Control group	0.1% group	0.2% group	0.3% group
pH min	6.74±0.12	6.75±0.23	6.75±0.16	6.81±0.20
pH h	6.15±0.09	6.20±0.19	6.17±0.14	6.28±0.14
Drip loss rate/%	2.31±0.13	2.27±0.18	2.23±0.20	2.17±0.13
Cooking loss rate/%	30.02±0.98	29.42±2.54	29.26±1.02	28.49±2.35
Shear force/kgf	3.31±0.95	3.11±0.77	3.03±0.93	2.70±0.35
Lightness L*	34.47±1.60	34.25±1.83	34.33±1.37	33.69±1.39
Redness a*	3.24±0.31	3.30±0.24	3.43±0.15	3.59±0.37
Yellowness b*	1.76±0.17	1.57±0.11	1.63±0.13	1.55±0.23

3.1 Effects of LBP on Slaughter Performance of Growing Rex Rabbits

Rex rabbits are primarily valued for their fur, though their meat production potential has gained increasing recognition. Slaughter performance directly reflects pre-slaughter live quality and serves as an important indicator of meat production efficiency, with half-eviscerated yield and completely eviscerated yield being the primary metrics. In this study, all three LBP-supplemented groups showed slightly improved completely eviscerated yield and half-eviscerated yield compared to the control, though differences were not significant. This suggests that dietary LBP supplementation may have a positive trend toward improving slaughter performance in growing Rex rabbits, possibly related to its ability to enhance overall production performance.

3.2 Effects of LBP on Immune Organ Development of Growing Rex Rabbits

The thymus functions as both a lymphoid organ and an endocrine gland, serving as a crucial central immune organ that plays a vital role in the development and maturation of peripheral immune system components. The spleen, rich in T lymphocytes, B lymphocytes, macrophages, and dendritic cells, represents an important peripheral immune organ in rabbits [11]. Immune organ index serves as a key indicator of immune status, with higher values within the healthy range signifying stronger immune function. Wang et al. [12] reported that intraperitoneal injection of 100 mg/kg LBP in mice significantly increased spleen and thymus weights while alleviating antibiotic-induced immune organ damage. In the present study, all LBP-supplemented groups exhibited higher spleen and thymus indices than the control, demonstrating that LBP positively promotes immune organ development and enhances immunity in Rex rabbits. This effect may be attributed to LBP' s bioactive components binding to high-affinity receptors on immune cell surfaces, thereby promoting immune cell proliferation and differentiation and increasing the number of immunocompetent cells such as lymphocytes and macrophages within immune organs. However, the specific mechanisms require further investigation.

3.3 Effects of LBP on Meat Quality Traits of Growing Rex Rabbits

Meat quality traits including pH, water-holding capacity, shear force, and color are crucial for evaluating fresh meat quality. Muscle pH reflects acidity levels and is associated with glycolytic rate and lactate content. In this study, all LBP-supplemented groups showed slower pH decline at both 45 min and 24 h postmortem. This may be explained by the fact that after slaughter, muscle glycogen undergoes glycolysis to produce lactate, which accumulates in muscle tissue [13] and causes pH decline [14]. LBP' s antioxidant properties may reduce glycolysis and decrease lactate production, thereby slowing pH reduction. Water-holding capacity reflects meat's moisture retention ability, affecting flavor and quality, and is typically measured by cooking loss and drip loss rates, while shear force indicates meat tenderness. Research has shown that muscle pH is negatively correlated with drip loss and cooking loss rates, and cooking loss rate is positively correlated with shear force [15]. Rapid pH decline or low 24 h pH postmortem can cause protein denaturation and increased drip loss [16]. In this study, experimental groups showed reduced drip loss, cooking loss, and shear force. This may be because water-holding capacity is related to cell membrane structural integrity, which LBP' s antioxidant effects help maintain by preventing lipid oxidation, thereby preserving membrane integrity and reducing fluid loss from the sarcoplasm [17], consequently decreasing drip loss. Meat color, expressed as L*, a*, and b* values, reflects internal physiological, biochemical, and microbial changes and indicates meat quality and freshness. L* represents lightness, influenced by muscle thickness, color saturation, surface exudate, and light intensity during measurement [18]; a* represents redness, reflecting myoglobin content; and b* represents yellowness. In this study, supplementation with 0.3% LBP slightly decreased L* value while increasing a* value by 10.80% and decreasing b* value by 11.93%, suggesting that LBP may delay oxidation of muscle fat and myoglobin or oxymyoglobin, thereby stabilizing meat color. Sun et al. [19] reported that dietary supplementation with 1,000 mg/kg Astragalus polysaccharide increased breast muscle a* value and decreased b* value, improving meat color—findings consistent with our results.

4 Conclusion

Dietary LBP supplementation had no significant effect on the slaughter performance of Rex rabbits but could enhance immune organ indices and improve meat quality traits to a certain extent, with a recommended supplementation level of 0.3%.

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