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Meta-analysis of the Effects of Chinese Herbal Additives on the Production Performance, Immune Function and Meat Quality of Sheep

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ABSTRACT

Background: This meta-analysis systematically evaluates the effects of Chinese herbal additives on production performance, immune function and meat quality in sheep to support their application in ruminant nutrition.

Methods: A total of 13 studies, comprising 37 controlled trials, were included in the analysis. The overall effect size was assessed by forest plots and meta-analysis was conducted to identify sources of heterogeneity, perform sensitivity analysis and evaluate publication bias by funnel plots.

Result: Dietary supplementation with Chinese herbal additives significantly increased average daily gain (ADG) and average daily feed intake (ADFI) (P<0.05) and reduced the feed-to-gain ratio (F/G) (P<0.05). Immunological analysis showed that serum IgA and IgM levels were elevated (P<0.05). For meat quality parameters, the additives increased cooking yield and pH (P<0.05) and decreased shear force (P<0.05) with no significant effect on drip loss (P>0.05). Funnel plot analysis revealed minimal publication bias and sensitivity analysis confirmed the robustness and reliability of the results. These findings suggested that Chinese herbal additives contributed to enhanced production performance, immune function and meat quality in sheep. Further research should validate these findings through more controlled feeding trials, while exploring the active ingredients and mechanisms of action of Chinese herbal additives.

Key words: Chinese herbal additives, Immune function, Meat quality, Meta-analysis, Production performance, Sheep.

INTRODUCTION

With the development of scale and industrialization of animal husbandry and the arrival of the era of comprehensive anti-antibiotic ban, seeking green, safe and effective feed additives has become the key to the development of the livestock industry. Chinese herbal medicines, with their natural properties, low toxicity, minimal side effects and multi-functionality, demonstrate significant potential in livestock and poultry breeding (Zhang *et al.,* 2024). Numerous studies indicate that Chinese herbal additives have the advantages of promoting growth, enhancing immune function of the body and improving the quality of animal products (Liu *et al.,* 2024; Wei, 2024; Zhang *et al.,* 2024). Chen *et al.* (2021) reported that a Chinese herbal polysaccharide mixture (CMP), formulated with Lycium barbarum and Astragalus membranaceus at a 2:1 ratio, enhanced ADG and increased the serum concentrations of IgA, IgG and IgM. Additionally, CMP treatment elevated the relative abundance of Fibrobacteria, altered rumen microbial fermentation patterns, improved immune function and ultimately enhanced growth performance. Similarly, Ma *et al.* (2024) added different concentrations of sal*via* sclarea extract to the diet of 2-month-old Chinese Merino lambs and also arrived at the same conclusion. In sheep breeding production, Chinese herbal additives have shown many significant advantages, serving as an effective strategy to improve breeding efficiency. Research suggests that incorporating an appropriate amount of Chinese herbal additives into the diet of sheep can effectively improve the production performance of sheep. On the one hand, herbs can regulate the feed flavor, increase the feed intake, promote the digestion and absorption of nutrients, thus significantly increasing the daily weight gain and shortening the fattening cycle. On the other hand, by regulating the rumen development, it improves the feed digestive utilization and reduces the breeding costs (Du, 2023; Huang, 2023; Karnani *et al.,* 2020). Chinese herbal additives also exhibit unique immunomodulatory effects

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(Li *et al.,* 2020). Many Chinese herbs are rich in polysaccharides, organic acids, alkaloids, volatile oils, anthracenes, *etc.* These substances can regulate the immune function of the animal body and promote the development of immune organs and enhance cellular immune response (He, 2016; Zhang *et al.,* 2016). Herbs can significantly enhance the meat quality by enhancing meat tenderness, flavor and reducing fat content (Wang, 2016; Xia, 2022). At present, there have been many studies on the addition of Chinese herbal additives to sheep diets by domestic and foreign animal husbandry experts, but the quality of the studies varies and the experimental results have not yet been widely recognized due to the differences in feeding methods, raw material composition and processing methods (Zhang, 2023; Zhou *et al.,* 2024).

Meta-analysis significantly enhances the credibility and generalizability of research by systematically integrating multiple independent studies, providing more reliable evidence for scientific decision-making. (Zhang *et al.,* 2023). Meta-analysis was conducted on literature related to the production performance, immune function and meat quality of sheep with Chinese herbal additives from 2005 to 2022, screened from Chinese databases. The aim was to provide a statistical evaluation of these effects, offering a scientific basis for the rational application of Chinese herbal additives in sheep production.

MATERIALS AND METHODS

Literature search

A literature search was conducted in the China National knowledge infrastructure (CNKI), Wanfang Database, VIP database and Chinese science citation database (CSCD). Keywords included “Chinese herbal additives,” “sheep,” “production performance,” “immune function” and “meat quality.” Production performance indicators included average daily gain (ADG), average daily feed intake (ADFI) and feed-to-gain ratio (F/G); immune indicators included IgA, IgM and IgG levels; meat quality indicators included pH, drip loss, shear force and cooking yield. Studies from 2005 to 2022 were included in the search.

Literature screening

In this study, literature selection was conducted based on the following criteria: 1) Studies must include the effects of Chinese herbal additives on production performance, immune function and meat quality of sheep; 2) The results of the study must include the outcome indicators of production performance, such as ADG, ADFI and F/G, the outcome indicators of immune function, such as serum IgA, IgG and IgM levels and the outcome indicators of meat quality, such as pH, drip loss, shear force and cooking yield; 3) The study must have both a control group and an experimental group; 4) Studies must be published in Chinese. All retrieved literature was independently screened, extracted and reviewed by two researchers. A total of 50 papers were retrieved according to the rules of literature search, among which 37 duplicates, conference papers, conference abstracts and unpublished papers were excluded and 13 papers were finally included.

Data extraction and characteristics

This study selected 13 articles, encompassing 37 controlled trials based on experimental designs. The following data and information were extracted: article title, publication year, sample size, concentration of Chinese herbal additives in experimental diets, the experimental data and the standard deviation. When multiple studies shared the same publication year and author, they were distinguished using superscript numbers (1), (2), (3), (4). A total of 13 papers were included in this meta-analysis, including 16 ADG studies, 16 ADFI studies, 16 F/G studies, 11 IgA studies, 11 IgG studies, 11 IgM studies, 8 pH studies, 5 drip loss studies, 4 shear force studies and 10 cooking yield studies. All included studies were controlled trials involving Chinese herbal additives.

Statistical analysis

Because production performance, immune function and meat quality outcomes were continuous variables, we used the standardized mean difference (SMD) as the effect size metric (Zhang *et al.,* 2023). In this study, the SMD method developed by Hedges *et al.* (1985) and Cohen (1988) was used to evaluate the effect of herbs on the feeding effects (production performance, immune function, meat quality) of sheep. We determined the 95% confidence interval (CI) for all measured parameters and reported their 95% CI values. Detailed procedures are described in the Appendix. Meta-analyses were performed using the Python throughout and effect sizes were pooled using the Cohen or Hedges method in the metacont command. In addition, this analysis was assessed using the I^2 method for between-study heterogeneity. When I^2<50%, inter-study heterogeneity was considered to be low or non-existent, the effect sizes were pooled using fixed-effects model; when I^2>50%, high inter-study heterogeneity was considered to exist. The effect sizes were pooled using the random-effects model. When the 95% confidence interval of the SMD_{++} did not overlap zero, it was considered that the feed additive group had a significant effect on the production performance, immune function and meat quality outcome indicators of sheep relative to the control group. When the SMD_{++} was greater than 0, it was considered that the feed additive group had a positive effect on the variable, while the opposite indicated a negative effect. To ensure the authenticity and accuracy of this analysis, funnel plot was used for bias analysis of published articles. Sensitivity analysis was conducted using Leave-one-out analysis. Sensitivity analysis is usually carried out by excluding each study in turn, assessing the impact of that study on the pooled effect size and heterogeneity, then evaluating the stability of the results.

RESULTS AND DISCUSSION

Meta-analysis of Chinese herbal additives on production performance of sheep

The meta-analysis demonstrated that there was inter-study heterogeneity (P<0.01, I^2>50%) in the quantitative changes in the outcome indicators of production performance represented by ADG, ADFI and F/G after the addition of Chinese herbal additives to the feed, so the random-effects model was applied to pool the effect sizes. The pooled effect sizes of ADG and ADFI were to the right of the null line and the pooled effect size of F/G was to the left of the null line, with none of them intersecting the null line (Fig 1a). The meta-analysis indicated that the addition of Chinese herbal additives to feed significantly increased ADG and ADFI (P<0.05) and significantly decreased F/G (P<0.05). Based on this meta-analysis, these findings suggest that Chinese herbal additives significantly improved the production performance of sheep.

Meta-analysis of Chinese herbal additives on immune function of sheep

The meta-analysis showed that there was inter-study heterogeneity in the quantitative changes in the outcome indicators of immune function represented by serum IgA, IgG and IgM levels after the addition of Chinese herbal additives to the feed (P<0.01, I^2>50%) and therefore the pooled effect sizes were analyzed using a random-effects model. The pooled effect sizes for IgA and IgM were to the right of the null line and the pooled effect size for IgG was to the left of the null line, with none of them overlapping the null line (Fig 1b). Thus, the meta-analysis indicated that the addition of Chinese herbal additives to feed significantly increased serum IgA and IgM levels (P<0.05) and significantly decreased IgG levels (P<0.05). Based on this meta-analysis, these results suggest that Chinese herbal additives can significantly enhance the immune function of sheep.

Meta-analysis of Chinese herbal additives on meat quality of sheep

The meta-analysis showed that there was inter-study heterogeneity (P<0.01, I^2>50%) in the quantitative changes of meat quality outcome indicators represented by cooking yield, drip loss, shear force and pH after the addition of Chinese herbal additives to the feed, so the random-effects model was applied to pool the effect sizes. The pooled effect sizes of cooking yield and pH were to the right of the null line and the pooled effect size of shear force was to the left of the null line, with none of them intersecting the null line (Fig 1c). Thus, the meta-analysis indicated that the addition of Chinese herbal additives to feed significantly increased cooking yield and pH (P<0.05) and significantly decreased shear force (P<0.05), indicating improved meat tenderness, but had no significant effect on drip loss (P>0.05). Based on this meta-analysis, these results suggest that Chinese herbal additives could significantly improve the meat quality of sheep.

Sensitivity analyses

Chinese herbal additives significantly influenced sheep production performance, immune function and meat quality. This meta-analysis revealed substantial heterogeneity (P<0.01, I^2>50%). These variations may relate to differences in sheep breeds, herbal additive compositions and inclusion rates, basal diets and farm management practices. We conducted sensitivity analyses to evaluate result stability and credibility (Table 1). After sequentially excluding each included study, the pooled effect sizes of the remaining studies were distributed on both sides of the null line without overlapping it, further supporting the accuracy of the findings (Fig 2).

Bias analysis

The studies on production performance, meat quality and immune function outcome indicators were predominantly concentrated in the middle and upper regions of the funnel

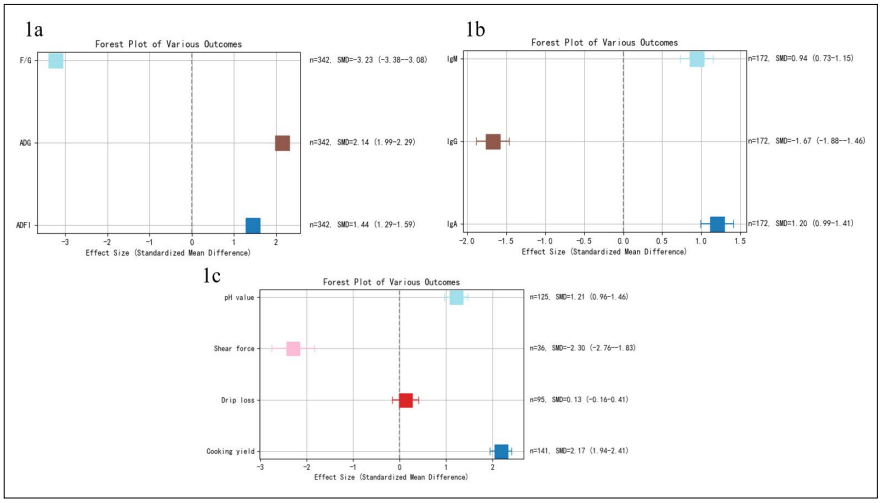


Fig 1: Forest plot showing the effect of Chinese herbal additives on (1a) ADG, ADFI and F/G; (1b) serum IgA, IgG and IgM levels; (1c) cooking yield, pH, drip loss and shear force in sheep.

plot and demonstrated good symmetry (Fig 3). This distribution pattern indicated that the sample size of this meta-analysis was sufficient and representative, the experimental precision was high and the data were reliable. However, several studies were located in the outer regions of the funnel plot, suggesting the presence of some publication bias in this study.

Effect of Chinese herbal additives on the production performance of sheep

Chinese herbal medicine can optimize intestinal development and flora, enhance digestive function and improve production performance (Li *et al.,* 2024; Shao *et al.,* 2025). The meta-analysis results demonstrated that the inclusion of Chinese herbal additives in diets led to significant increases in ADG and ADFI, accompanied by a significant decrease in F/G. These findings are consistent with previous studies by Liang *et al.* (2013). Chinese herbs, containing rich nutrients such as alkaloids, organic acids, trace elements and digestive enzymes, not only provide essential nutrients for growth and development but also promote feed nutrient decomposition, thereby enhancing production performance (Feng *et al.,* 2024). Bao *et al.* (2019) found that astragalus polysaccharide could significantly increase Tibetan sheep's ADG and ADFI and decrease F/G. This effect is probably attributable to its polyphenols' ability to regulate rumen micro-ecological balance, promote the growth of beneficial bacteria and enhance beneficial bacteria activity, ultimately improving the production performance. All of these studies have demonstrated that Chinese herbs can promote animal growth by protecting intestinal tract health and regulating intestinal flora structure. However, some studies have shown that a proportion of Chinese herbal additives that is too high can also affect the production performance of sheep. Shi *et al.* (2024) found that with the increase in the

Table 1: Results of meta-analysis of the effects of Chinese herbal additives on production performance, immunity function and meat quality of sheep.

Indicators	No. of studies	Standardized mean difference (95% Confidence interval) (SMD) (95%CI)		Heterogeneity test	
		Effect size	*P*-value	I^2 %	*P*-value
ADG	16	2.14 [1.99, 2.29]	<0.001	94.45%	<0.01
ADFI	16	1.44 [1.29, 1.59]	<0.001	99.28%	<0.01
F/G	16	-3.23 [-3.38, -3.08]	<0.001	99.67%	<0.01
IgA	11	1.20 [0.99, 1.41]	<0.001	95.24%	<0.01
IgG	11	-1.67 [-1.88, -1.46]	<0.001	99.21%	<0.01
IgM	11	0.94 [0.73, 1.15]	<0.001	96.16%	<0.01
pH	8	1.21 [0.96, 1.46]	<0.001	97.49%	<0.01
Drip loss	5	0.13 [-0.16, 0.41]	<0.001	83.17%	<0.01
Shear force	4	-2.30 [-2.76, -1.83]	<0.001	96.78%	<0.01
Cooking yield	10	2.17 [1.94, 2.41]	<0.001	98.60%	<0.01

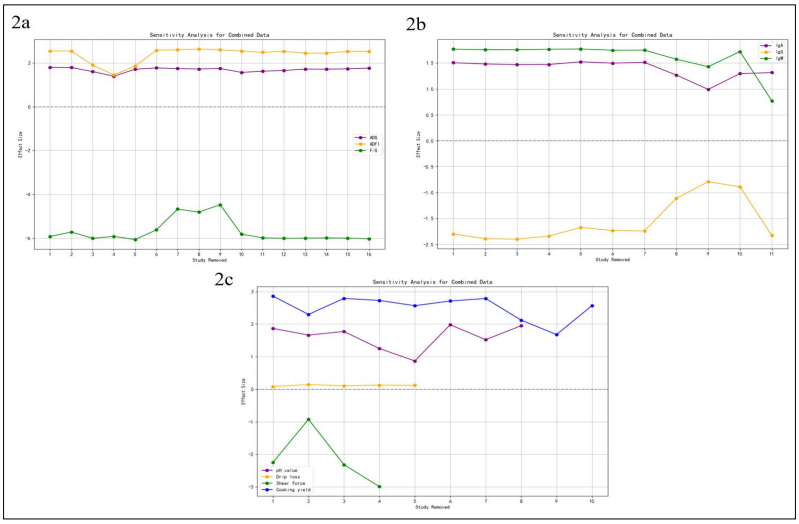


Fig 2: Sensitivity analysis showing the effect of Chinese herbal additives on (2a) ADG, ADFI and F/G; (2b) serum IgA, IgG and IgM levels; (2c) cooking yield, pH, drip loss and shear force in sheep.

level of Eucommia ulmoides leaf extract additive, ADG and ADFI of Hu sheep initially increased and then decreased.

The meta-analysis showed that the addition of Chinese herbal additives to diets could enhance the production performance of sheep to a certain extent, which was aligned with the conclusions reported by Hou *et al.* (2025). Despite the heterogeneity of the outcome indicators such as ADG, ADFI and F/G, the results also confirmed the reliability of the meta-analysis results after corrective analyses and sensitivity analysis.

Effect of Chinese herbal additives on the immune function of sheep

Animal immune function reflects health status and determines growth performance and economic outcomes. The levels of immune cytokines and immunoglobulins in the body can reflect the immune status (Liao *et al.,* 2025). Immunoglobulins mainly include IgA, IgG and IgM, which play crucial roles in host defense against external factors (Hernández-Castellano *et al.,* 2015). Li *et al.* (2025) pointed out that herbal dregs can improve immune function. Qu *et al.* (2024) showed that Chinese herbal additives could significantly increase IgA, IgG and IgM levels in blood and effectively improve the animals' immune capacity. Wu *et al.* (2023) showed that adding 1.5%, 3.0% and 4.5% fermented dregs of Guiqi Yimu Oral Liquid to the basal diet significantly increased the concentrations of IgA, IgG and IgM in Hu sheep serum, possibly because the fermented dregs contain polysaccharides and flavonoid substances. The polysaccharides can enhance anti-tumor immune responses by activating immune cells (Wang *et al.,* 2024) and flavonoids can effectively reduce pro-inflammatory cytokines (Tang *et al.,* 2021). However, some studies showed no significant effects of herbal feed additives on immune function. For example, Zhao *et al.* (2020) added different proportions of Chinese herbal additives to diets of Tan sheep and found no significant differences in IgA, IgG and IgM levels between groups.

The present meta-analysis found that Chinese herbal additives significantly increased serum IgA and IgM levels, significantly decreased IgG concentration. IgG, the most abundant immunoglobulin in blood, is crucial for infection immunity in animals. In the literature reviewed in this study, Li *et al.* (2021) found that adding 0.3% Astragalus, 0.3% Isatis root and 0.3% Astragalus-Isatis root mixture to the basal diet significantly reduced IgG levels compared with the control group. This study was also the main contributor to the overall reduction in IgG levels. Wang *et al.* (2021) mixed Astragalus root powder with basal feed and fed it to lambs. After 56 days, they found that the serum concentrations of IgA (P = 0.004), IgG (P = 0.006) and IgM (P = 0.020) were higher than those on day 14. Liu *et al.* (2023) added 0.8% and 1.6% Astragalus powder and 0.8% and 1.6% Isatis root powder to the basal diet. The results showed that the serum IgG levels in the high-dose Astragalus group were significantly higher than those in other groups. While both high- and low-dose Isatis root powder groups initially showed increased immunoglobulin levels compared to controls at 14 days, these levels decreased below control values by 28 days. None of these observed differences reached statistical significance. The variation in experimental outcomes appears directly linked to several key factors, including the inclusion rates of herbal additives, differences in animal species and duration of feeding trials. Previous studies have been affected by issues such as inconsistent effect measures, significant heterogeneity and potential bias, which may lead to an overestimation of immunomodulatory effects. Future research should further investigate how Chinese herbal medicine affects ruminant immune function to better understand the underlying immunophysiological mechanisms.

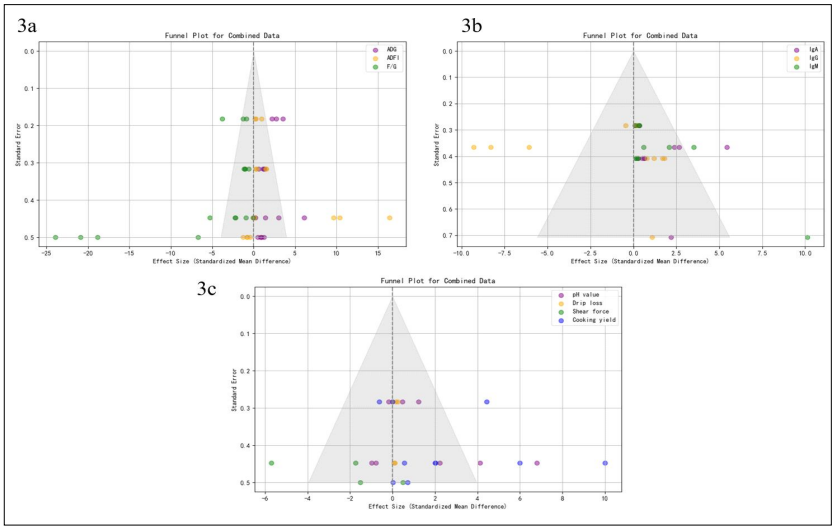


Fig 3: Funnel plot showing publication bias in the effect of Chinese herbal additives on (3a) ADG, ADFI and F/G; (3b) serum IgA, IgG and IgM levels; (3c) cooking yield, pH, drip loss and shear force in sheep.

Effect of Chinese herbal additives on the meat quality of sheep

Cooking yield, drip loss, shear force and pH are important indicators of meat quality (Jin *et al.,* 2022). Xia (2022) demonstrated that Chinese herbal additives had significant promotional effects on sheep farming. Wang *et al.* (2019) showed that adding 4% Chinese herbal additives to the basal feed could significantly reduce shear force of Hu sheep meat and the present meta-analysis results supported this conclusion. Zhang *et al.* (2023) showed that adding 0.1% baicalin in the ration could significantly reduce drip loss and water loss rate in the longissimus dorsi muscle of fattening Hu sheep. The results of Wang *et al.* (2024) demonstrated that the addition of mulberry leaf flavonoids to the feed could significantly reduce the drip loss and improve the quality of mutton. However, this meta-analysis showed that the Chinese herbal additives had no significant effect on the drip loss of mutton. The reasons for the different results of the studies may be attributed to the different levels of nutrition in the diet, herbal ingredients and breeds of sheep. Meat pH is a critical freshness indicator. Pre-slaughter lambs maintain neutral pH. Post-slaughter, glycolytic enzymes convert muscle glycogen to lactic acid, lowering pH (Zhao *et al.,* 2021). The pH of post-slaughter sheep meat was significantly higher in the antioxidant herbal feed group (0.3% Astragalus polysaccharides) and the flavor-improving herbal feed group compared to the high-concentrate control group (Wang, 2023). This indicates that Astragalus polysaccharides and flavor-improving herbal feed additives can delay post-slaughter glycogen-to-lactic acid conversion in mutton. That is conducive to the maintenance of higher water retention of the muscle of the lamb and obtains higher tenderness, which is consistent with the results of Zhang *et al.* (2023). Gao *et al.* (2020) found that the Chinese herbs had no significant effect on the cooking yield of meat, but could significantly improve the brightness of meat and reduce its shear force.

The meta-analysis results showed dietary supplementation with Chinese herbal additives could moderately enhance sheep meat quality, which aligns with the conclusions of Zhu *et al.* (2024). Despite the heterogeneity of outcome indicators such as cooking yield, drip loss, shear force and pH, the corrective analyses and sensitivity analyses also confirmed the reliability of the meta-analyses.

Limitations of this study

This study has certain limitations. First, although high-quality Chinese literature was systematically included, the risks of incomplete data and selective reporting could not be entirely eliminated, with funnel plots indicating minor publication bias that might affect the accuracy of the meta-analysis results. Second, substantial heterogeneity among studies was observed due to variations in basal diet composition and experimental duration, which complicated the interpretation of findings. Furthermore, the current analysis only incorporated selected production performance and economic trait indicators, potentially leading to an incomplete assessment of Chinese herbal additives' effects. Finally, the inherent limitations of meta-analysis methodology preclude mechanistic investigations into how these additives function or how their effects may vary across different farming conditions. Future research should incorporate larger sample sizes under standardized protocols to establish a more comprehensive evaluation framework for assessing the practical value of Chinese herbal additives in sheep production systems.

CONCLUSION

Firstly, meta-analysis clearly showed that the addition of Chinese herbal additives to diets had a positive effect on ADG, ADFI and F/G of sheep, which had some significance in production practice. Secondly, meta-analysis results showed that the addition of Chinese herbal additives to diets mainly acted on mucosal immunity and significantly increased the concentration of IgA and IgM in serum. Thirdly, meta-analysis results showed that the addition of Chinese herbal additives to diets positively affected mutton cooking yield, pH and shear force, thus the addition of Chinese herbal additives to diets improved meat quality to some extent.

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Author contributions

Zhina Du designed the experiments and drafted the manuscript. Data processing and visualization were performed by Wu Sun, Xiayang Jin and Yuhong Ma and Shike Ma revised the manuscript.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Data availability statement

The datasets generated during and analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no conflicts of interest.

REFERENCES

Bao, Y.L. and Liu, Y.Y. (2019). Effects of astragalus polysaccharides on growth performance and immune function of confined tibetan sheep. *Chinese Journal of Animal Science*. **55:** 103-106.

Chen, H., Guo, B., Yang, M., Luo, J., Hu, Y., Qu, M., Song, X. (2021). Response of growth performance, blood biochemistry indices and rumen bacterial diversity in lambs to diets containing supplemental probiotics and chinese medicine polysaccharides. *Frontiers in Veterinary Science*. **8:** 2021.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences. Lawrence Erlbaum Associates.

Du, P.G. (2023). Formulation and application suggestions of chinese herbal medicinal fattening feed additives for meat sheep. *Chinese Journal of Traditional Veterinary Science*. **72:** 67-69.

Feng, N., Li, N.N., Liu, X.D., Liu, K.K., Ke, X.Q., Li, Y.X. (2024). Application advantages, existing problems and counter measures of chinese herbal feed additives in sheep breeding and production. *Journal of Animal Science and Veterinary Medicine*. **43:** 105-111.

Gao, Z.G., Di, N., Zhao, Z.X., Zhao, Y.E., Yong, Y.P. (2020). Effects of chinese herbal medicine additives on the meat quality and main umami factors of bamei mutton sheep. *Feed Research*. **43:** 23-26.

He, T. (2016). Functions and research directions of chinese herbal additives in animal husbandry production. Agriculture of Jilin. 88.

Hedges, L. and Olkin, I. (1985). Statistical Methods for Meta-analysis, Academic Press. New York, NY, Google Scholar.

Hernández-Castellano, L.E., Moreno-Indias, I., Morales-delaNuez, A., Sánchez-Macías, D., Torres, A., Capote, J., Argüello, A., Castro, N. (2015). The effect of milk source on body weight and immune status of lambs. *Livestock Science*. **175:** 70-76.

Hou, L.Z., Duan, P.P., Yang, Y.X., Shah, A.M., Li, J.L., Xu, C.B., Guo, T.J. (2025). Effects of residual black wolfberry fruit on growth performance, rumen fermentation parameters, microflora and economic benefits of fattening sheep. *Frontiers in Veterinary Science*. **11:** 1528126.

Huang, X.Y. (2023). Research on the effects of chinese herbal additives on the fattening of lambs. *Chinese Journal of Traditional Veterinary Science*. pp. 10-12.

Jin, Y.X., Fang, M.Y., Zhang, Q., Chen, Y. (2022). Effects of peanut meal replacing soybean meal and cotton meal on the growth performance, apparent digestibility, slaughter performance, meat quality and ruminal fermentation indexes of fattening sheep. *Journal of Xinjiang Agricultural University*. **45:** 439-446.

Karnani, M., R.K., D., T., S., Manju (2020). Effect of supplementation of herbal products as feed additive on rumen metabolites in marwari goats. *Indian Journal of Animal Research*. **55(2):** 185-188. doi: 10.18805/ijar.B-3932.

Li, C.H., Dong, Y.L., Zhang, R.H., Wang, L., Shi, W.Y., Xu, T., Zhang, H.L. (2020). Effects of chinese herbal medicines on lipid metabolism and immunity function in laying hens. *Indian Journal of Animal Research*. **54(10):** 1291-1295. doi: 10. 18805/ijar.B-1261.

Li, J.K., Jin, X.J., Geng, K., Ren, F.L., Wang, X.H., Geng, C.Y., Jin, Y.H. (2024). Effects of supplementing chinese herbal medicine and active dry yeast preparations on diarrhea rate and rectal microflora diversity in yanbian cattle lactating calves. *China Animal Husbandry and Veterinary Medicine*. pp. 5317-5324.

Li, N., Cheng, H.P., Liu, T.G., Chen, G.S., Sui, X.D., Zhu, C.Y., Han, X.M. (2021). Effects of astragalus membranaceus and radix isatidis on performance and immune indexes of huhan hybrid f1 sheep. *China Feed*. pp. 48-52.

Li, Y.X., Guo, Z.X., Jiang, D., Chen, Y.K., Zhang, D.M., Zhang, W.H. (2025). Research progress of chinese medicine residues in aquaculture. *Feed Industry*. pp. 1-6.

Liang, X., Yamazaki, K., Kamruzzaman, M., Bi, X., Panthee, A., Sano, H. (2013). Effects of chinese herbal medicine on plasma glucose, protein and energy metabolism in sheep. *Journal of Animal Science and Biotechnology*. **4(1):** 51.

Liao, Y.Q., Kang, Y.G., Chang, L.L. (2025). Effects of bacterial enzyme coordinated fermentation of medicinal residue on growth performance, immune indexes and serum biochemical indexes of lambs. *China Feed*. pp. 132-137.

Liu, S.X., Zhang, C.L., Wang, H.J., Zhao, J.Y., Lu, W., He, Z.Q. (2023). Effects of radix astragali and radix isatidis on growth performance, immune and antioxidant functions of goats. *Modern Journal of Animal Husbandry and Veterinary Medicine*. pp. 33-37.

Liu, X.D., Huang, Y., Liu, Y.F., Du, X.T. (2024). The effect of compound herbal additives on improving livestock and poultry production performance. *Feed Industry*. pp. 1-10.

Ma, X., Niu, Y., Nan, S., Zhang, W. (2024). Effect of salvia sclarea l. extract on growth performance, antioxidant capacity and immune function in lambs. *Frontiers in Veterinary Science*. pp. 11-2024.

Qu, Z.H., Han, Z.Q., Bai, Y., Xue, J., Cao, J.L., Ding, Z.X., Zhu, W.B., Zhao, J.H. (2024). Effects of different proportions of compound chinese herbal additives on growth performance, immunity and antioxidant capacity of qianan mutton sheep. *Feed Industry*. pp. 1-11.

Shao, T.C., Huang, Y.E., Cui, X.M., Ji, Q.A., Song, H.H., Bao, G.L., Liu, Y.F. (2025). Effects of compound chinese herbal medicine on growth performance and intestinal health of rabbits. *Chinese Journal of Animal Science*. **61:** 304-310.

Shi, S.M. and Wang, F. (2024). Effects of eucommia ulmoides leaves extract on growth performance, serum biochemical and antioxidant indexes of hu sheep. *China Feed*. pp. 17-20.

Tang, C.L., Wei, J.C., Teng, H.L., Li, F.Z., Huang, M. (2021). Research progress on anti-inflammatory activity of flavonoids and its mechanism. *Chinese Archives of Traditional Chinese Medicine*. **39:** 154-159.

Wang, C.H., Xin, X.Z., Pang, X. (2024). Research progress of traditional chinese medicine and west medicine combination treatment of colorectal cancer. *Traditional Chinese Medicinal Research*. **37:** 84-88.

Wang, X., Liu, J.G., Ma, Y.J., Wang, Y., Chen, L. (2019). Effects of compound chinese herbal medicine additives on slaughter performance, meat quality and rumen histomorphology of hu sheep. *China Herbivore Science*. **39:** 22-25.

Wang, X.D. (2016). Effects of chinese herbal medicine residue on nutritional quality of mutton. *Journal of Animal Science and Veterinary Medicine*. **35:** 31-35.

Wang, X.J., Ding, L.M., Wei, H.Y., Jiang, C.X., Yan, Q., Hu, C.S., Jia, G.X., Zhou, Y.Q., Henkin, Z., Degen, A.A. (2021). Astragalus membranaceus root supplementation improves average daily gain, rumen fermentation, serum immunity and antioxidant indices of tibetan sheep. *Animal*. **15:** 100061.

Wang, Y. (2023). Study on improving the quality of fattening mutton by chinese herbal medicine. Master.

Wang, Z.H., He, Y.J., Wang, C.L., Zhang, Z.P., Zhong, H.M., Li, A.P., Li, Y.M. (2024). The effect of adding mulberry leaf flavonoids to feed on growth performance, muscle quality and serum biochemical indicators of meat sheep. *China Feed*. pp. 53-56.

Wei, J.L. (2024). The influence of chinese herbal additives on the immunity of muscovy ducks. *Chinese Animal Health*. **26:** 1131-1114.

Wu, P.P. and He, S.J. (2023). Effects of guiqi yimu oral liquid fermented residue on growth properties, slaughter performance, serum biochemical and immune indexes of Hu sheep. *Heilongjiang Animal Science and Veterinary Medicine*. pp. 109-114.

Xia, G.Y. (2022). Application of chinese herbal feed additives in mutton sheep production. *Animals Breeding and Feed*. **21:** 60-62.

Zhang, J., Xun, X.J., Lü, Y., Wang, P.Y., Liu, D.X., Yang, T.T. (2024). Application of chinese herbal feed additives in livestock and poultry production. *Northern Animal Husbandry*. pp. 18.

Zhang, L.C. (2023). Effects of fermented chinese herbal medicine on growth performance, blood biochemical, immune and antioxidant indexes of black goats. *Hunan Journal of Animal Science and Veterinary Medicine*. pp. 41-43.

Zhang, N., Li, H., Jiang, C., Tu, Y., Diao, Q. (2016). Effects of lipopolysaccharide on the growth performance, nitrogen metabolism and immunity in preruminant calves. *Indian Journal of Animal Research*. **51(4):** 717-721. doi: 10.18805/ijar.v0iOF.6831.

Zhang, Q., Zhang, X.Q., Qu, H., Zhang, J.Z., Ma, L.F., Guo, Y., Jia, H., Tana, Wang, J.L. (2023). A meta analysis for the effects of feeding chinese herbal supplements on performance immune function and rumen fermentation in lambs. *Chinese Journal of Grassland*. **45:** 118-129.

Zhang, Y., Sun, W., Ma, S.K., Jin, X.Y., Ma, Y.H., Li, S.S., Wang, S.X. (2023). Meta-analysis of antimicrobial peptides feed additives on growth performance of finishing pigs. *Modern Journal of Animal Husbandry and Veterinary Medicine*. pp. 61-64.

Zhang, Y.D., Zhao, C.Y., Guo, G.L., Wang, B.J. (2023). Effects of compound chinese herbal medicine on growth performance, slaughter performance, meat quality and immune function of mutton sheep. *Journal of Domestic Animal Ecology*. **44:** 25-29.

Zhang, Y.F., Nie, X.Y., Liu, K.X., Meng, C., Ao, C.W. (2024). Effects of probiotic-fermented herbal medicine preparation on growth performance of pigs and quality of pork. *Journal of Domestic Animal Ecology*. **45:** 23-29.

Zhao, J.Y., Yang, B., Luo, R.M., Zhang, H.Y., Su, C.X., Hu, Q.Q., Zhao, X.C. (2021). Metatranscriptomic analysis of microbial metabolic process in chilled tan sheep meat in different chilled storage periods. *Food Science*. **42:** 111-119.

Zhao, Z.W., Zhao, T., Yin, J., Ma, Q., Wang, J. (2020). Effects of chinese herbal medicine additives on growth, immune performance and meat quality of tan sheep. *Chinese Journal of Animal Science*. **56:** 150-153.

Zhou, Y., Wang, H.H., Liu, W.P., Xu, Y.Z. (2024). Effect of compound preparation of chinese herbal aqueous extract on ruminal fermentation and bacterial composition in tan lambs. *China Animal Husbandry and Veterinary Medicine*. pp. 4743-4754.

Zhu, Y.F., Han, Y.S., Zhang, J.S., Li, W., Ding, D.L., Wang, Y.F., Yao, M.L., Li, Q.Y., Lin, X.W., Wang, H., Huang, M., Wang, H.B., Zhong, P. (2024). Research progress on the influence of chinese herbal feed additives on livestock and poultry meat quality. *Heilongjiang Animal Science and Veterinary Medicine*. pp. 17-21.