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The Effect of Grape Seed Extract on Broiler Production and Physiological Traits: A Comprehensive Review

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Abstract:

This comprehensive review examines the effects of grape seed extract (GSE) on broiler production and physiological traits, highlighting its potential as a natural feed additive in poultry nutrition. Grape seed extract is rich in polyphenols, particularly proanthocyanidins, which possess antioxidant, anti-inflammatory, and antimicrobial properties. These bioactive compounds may enhance growth performance, improve feed efficiency, and promote overall health in broilers. The review synthesizes findings from various studies that investigate the impact of GSE on key performance indicators such as weight gain, feed conversion ratio (FCR), and carcass quality. Additionally, it explores the physiological effects of GSE on parameters such as immune response, gut health, and oxidative stress markers. Evidence suggests that GSE supplementation can lead to improved intestinal morphology, enhanced villus height, and increased beneficial gut microbiota, contributing to better nutrient absorption and overall health. Furthermore, the review discusses the optimal dosage of grape seed extract for maximizing its benefits in broiler production, as well as potential mechanisms underlying its effects. The implications of using GSE as a sustainable alternative to antibiotic growth promoters are also considered, given the growing concerns over antibiotic resistance in livestock.

In conclusion, grape seed extract shows promise as a functional feed additive that can positively influence broiler production and physiological traits. Future research should focus on long-term effects, optimal inclusion rates, and practical applications in commercial poultry farming to fully realize the benefits of this natural supplement.

Key words: Grape seed extract, Broiler Production, performance, Physiological Traits, antioxidant activity, phytogenic feed additives.

1. Introduction

Grape seed extract (GSE), obtained from *Vitis vinifera* L, is rich in bioactive compounds such as proanthocyanidins, epicatechin, gallic acid, and catechin that possess strong antioxidant and anti-inflammatory properties (1). It has attracted increasing attention as a feed additive in poultry production because of its potential to improve growth, immunity, and physiological traits of broiler chickens. GSE modifies the gut microbiota,

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inhibiting pathogenic species and stimulating probiotics, thereby enhancing intestinal homeostasis and nutrient absorption (2). Supplementation of broiler diets with an appropriate dose of GSE can promote the secretion of digestive enzymes and growth hormones. As a result, GSE plays a vital role in lipid metabolism, fatty acid oxidation, immune function, reproductive performance, and overall broiler production (3). However, despite the promising results of GSE inclusion in broiler feed, studies remain limited, particularly in the Southeast Asian region. This systematic review aims to evaluate the impact of grape seed extract on broiler production, immunity, and physiological traits and highlight potential research gaps.

2. Background on Broiler Production

Broiler chickens are selected for growth performance, developing a large percentage of breast muscle and high feed efficiency. The use of antibiotics as growth promoters is banned in some regions due to concerns about antibiotic resistance; attention therefore shifts to alternatives such as grape pomace (GP). The addition of GP to broiler diets positively affects average body weight and feed conversion ratio without compromising digestibility or gut health, and reduces serum cholesterol (4). Although not all production parameters improve, chicken welfare may be enhanced. To limit metabolic and reproductive disturbances during laying, diet adjustments may be necessary to reduce adiposity and improve performance (2). Supplementation with antioxidants such as selenium, vitamins, and polyphenols—found in plant products—is used to enhance health parameters (5). Phenolic compounds have multiple biological effects beyond their antioxidant properties. Grape seed extract (GSE) reduces oxidative stress and improves gut microbiota, beneficial in intensive broiler production systems necessitating efficient gut microbiomes (6). Feeding broiler chickens with grape seed and skin meals enhances α- and γ-tocopherol content and meat oxidative stability. Animal nutrition is evolving toward dietary supplementation with unsaturated fatty acids, which can increase lipid oxidation; inclusion of antioxidants like vitamin E mitigates oxidative damage (7). Grape polyphenols improve meat oxidative stability in poultry, with effects on plasma tocopherol levels being more consistent than those on meat tocopherol accumulation. The effectiveness of grape byproducts depends on total polyphenol content and the specific composition of polyphenolic compounds (8). Grape seeds contain higher amounts of phenolic compounds, mainly flavan-3-ol monomers and B-type procyanidins, with a lower degree of polymerization compared to grape skins, which contain additional compounds such as prodelphinidins with higher polymerization degrees. Differences in polyphenolic structure may affect their biological activity and utilization (9). The impact of adding grape seeds, skins, or their mixture to diets with equivalent grape polyphenol content on growth, digestibility, tocopherol levels, and meat oxidative stability in broilers, therefore, merits investigation.

3. Nutritional Aspects of Grape Seed Extract

Grape seeds are rich in bioactive phytochemicals with anti-inflammatory and antioxidant properties, potentially benefiting reproductive functions. They contain complex carbohydrates, dietary fiber, fats, proteins, minerals, and phenolic compounds, mainly proanthocyanidins such as epicatechin and gallic acid, which exhibit strong antioxidant activity (1). Grape seed extract (GSE) has been investigated for its effects on various diseases, but limited research focuses on reproductive efficiency in poultry. Some studies indicate GSE may slow ovarian aging by reducing oxidative stress and protect against endocrine disruptors like cadmium (10); however, its impact on egg performance and fertility remains unexplored. The widespread use of antibiotics in animal growth has raised concerns due to residues, resistance, environmental pollution, and health risks,

leading many countries to ban antibiotics for growth promotion in poultry.

Selection for growth performance in poultry has contributed to the deterioration of parental hen health, including poor reproductive efficiency. GSE supplementation was tested in laying hens, with 1% administered from 4 to 40 weeks and 2% during a 2-week period at 38–40 weeks. The 2% GSE diet reduced fat tissue and improved fertility, resulting in heavier and more resistant eggs. Seven phenolic metabolites of GSE were detected in the plasma of treated hens (11). GSE supplementation increased populations of Bifidobacteriaceae, Lactobacilliaceae, and Lachnospiraceae, reflecting modifications in microbiota composition. A short 2-week period of 2% GSE improved metabolic and laying parameters through altered microbiota composition (2).

4. Physiological Traits of Broilers

4.1. Introduction: Physiological Traits of Broilers

Grape seed extract (GSE) is a powerful source of polyphenols, molecules with antioxidant and antimicrobial activity. Such a natural compound is a desirable alternative to synthetic organic acids and antibiotics banned as growth promoters (12).

The poultry industry is seeking promising alternatives not only because of larger consumer demand for wholesome products, but also because of the emergence of resistance to certain antibiotics. The properties of GSE directly support a healthy digestive system, which translates into a more robust immune system. This dual effect is expected to contribute to the improvement of the overall performance of broilers (13).

4.2. Effects of Grape Seed Extract on Broiler Production

GSE is easily incorporated into livestock diets and offers potential health benefits at a rate of 1%; e.g., by reducing bone resorption or cardiovascular risk factors. GSE is known to modify the gut microbiota composition by selectively inhibiting pathogenic bacteria and enhancing probiotic bacteria (2). In broilers, grape product supplementation has resulted in decreased mortality rates and lesion scores after infection, as well as improved meat quality. However, high concentrations of GSE can negatively impact feed conversion and growth (14). The effect of GSE on female parental broiler hens during reproduction is poorly known, although microbiota modification is likely to influence reproductive performance (15). It is therefore relevant to investigate the effect of GSE-supplemented diets on performance and on metabolic parameters linked to fatness in parental female broilers.

4.3. Digestive and Metabolic Effects of Grape Pomace

Grape pomace (GP) — the by-product obtained after grape pressing during wine production — may be used in broiler diets because it contains a high level of polyphenols (e.g., catechin, epicatechin, and procyanidins) with antioxidant, antimicrobial, and anti-inflammatory properties (16). Previous research on the use of grape by-products as feed additives reported a positive effect on immune function and antioxidant status; however, only a few studies have analyzed the effects of GP on growth and meat quality. Accordingly, the effect of dietary GP supplementation on growth performance, apparent total tract digestibility of nutrients, blood profile, and meat quality in broilers has been examined. After 28 days, dietary GP supplementation at 5 or 10 g/kg was not observed to influence body weight gain, feed intake, or feed conversion ratio (5). Similarly, a previous study indicated that a diet including 20 g/kg of grape seed products did not affect body weight gain or feed intake. By contrast, GP exerted a quadratic effect on body weight gain during the initial and overall growth stages (6). Digestibility of ash significantly increased in broilers receiving GP and, despite the lack of change in serum levels of glucose, triglycerides, and total cholesterol, the lowest cholesterol level was

observed for GP dietary_ supplementation. Furthermore, broilers fed the GP-supplemented diet exhibited the highest redness and yellowness among all dietary treatments (17). Grape by-products such as GP contain anthocyanins with antioxidant properties that can protect cells from oxidative damage and promote antioxidant enzyme activity; hence, supplementation of broilers with GP could serve as a natural alternative to synthetic antioxidants (18).

5. Impact of Antioxidants on Poultry Health

The antioxidant potential of dietary grape polyphenols in chickens is affected by the source of grape polyphenols. The dietary combination of grape seed (GS) and grape skin (GK) led to better results than the separate inclusion of these grape byproducts (19). The combined diet results in higher γ-tocopherol concentrations in plasma and meat, alongside lower meat lipid oxidation, whereas the sole inclusion of GK impairs growth performance and ileal protein digestibility. Differences among dietary treatments can be attributed to the divergent profiles of phenolic compounds between GS and GK (4).

Broiler performance, dietary distiller's dried grains with solubles (DDGS) utilization, and meat oxidative status also respond variably to dietary grape seed extract (GSE) supplementation (1).

Antioxidants delay or inhibit lipid oxidation, thereby enhancing poultry health and production. When strategically introduced into poultry diets, antioxidants tend to improve performance by promoting health and mitigating physiological and environmental stressors (20). The body's antioxidant defense system encompasses phytochemicals such as carotenoids, phenolic compounds, and vitamins E and C; enzymatic constituents including superoxide dismutase, catalase, and glutathione peroxidase (GSHPx); and endogenous molecules like glutathione (GSH) (21). Grape seed extract contributes to this integrated defense by supplying both exogenous antioxidants and upregulating endogenous enzymatic activity, fortifying the bird's ability to counteract oxidative stress and maintain homeostasis (22).

6. Research Methodologies in Feed Additive Studies

The preparation of grape seed extract (GSE) has been documented in previous studies in terms of the starting material and extraction method used, as well as the subsequent concentration and drying steps. In evaluating bone histomorphometry, tibia and femur bones are thawed at room temperature before analysis, with femurs washed with 0.9% saline and dried at 1056C before ashing in a muffle furnace at 6006C to enable measurement of ash, calcium, and phosphorus contents (12). Experimental diets formulated to meet or exceed the minimum nutrient requirements for broiler chickens designate one with no additive as the negative control, and the inclusion of antibiotics and other additives follows a set protocol. Specimens for histological examination are fixed in 10% neutral buffered formalin and decalcified with 10% formic acid. Relative immune organ weights are calculated by dividing the organ weight by the bird's body weight and multiplying by 100 (5).

7. Effects of Grape Seed Extract on Growth Performance

The effect of health-promoting phytochemicals on broiler productivity has received growing attention. Among the most promising nutraceutical additives, grape by-products may be employed as a preventive method to mitigate agrophysical stress and improve broiler productivity (1). Grape extract (GE) and grape seed extract (GSE) are highly concentrated sources of polyphenols with strong antioxidant effects (2). The deployment of AGPs improves growth performances and feed efficiency, from 2.5 to 5%.

8. Influence on Immune Response

The dietary supplementation of grape byproducts rich in polyphenolic compounds modulated the gene expression of PRRs in broiler chicken immune tissues—liver, spleen and bursa of Fabricius. This modulation created an immunostimulant effect, particularly when the Grapeskin (skin) extract was included (23).

8.1. Immune Function Enhancement

A dietary supplement of vinification byproducts rich in polyphenolic compounds decreased the mRNA levels of the predominant pro-inflammatory receptor in the liver of broiler chickens, whereas the stem extract diet induced upregulation of the same receptor in the spleen. Interleukin 8 was upregulated in the bursa of Fabricius and spleen of the stems extract-fed broilers. Although grape byproducts represent a sustainable source of bioactive compounds with antioxidant potential, preliminary knowledge suggests immune stimulation at the transcriptional level (23). The gut microbiota composition modulates the dietary polyphenols–mediated cognitive resilience in mice by affecting the bioavailability of phenolic acids. Absorption and metabolism of polyphenols in the gut influence health status. Flavonoids as anti-inflammatory agents have implications in cancer and cardiovascular disease. Flavonoid intake correlates with reduced mortality from cardiovascular disease and improved bone health (24). The bioavailability of intact proanthocyanidins from grape seed extract in the colon affects their biological activity. The gut microbiota contributes to the bioavailability and physiological functions of dietary polyphenols and to the regulation of immunity. Grape seed proanthocyanidin extract modulates chickens' antioxidant status and increases their resistance to coccidiosis (25). Grape seed and pomegranate seed oils influence the post-slaughter value and physicochemical characteristics of broiler chicken muscles. Dietary grape seed extract affects growth performance, the apparent ileal digestibility of amino acids, plasma lipid levels, and mineral content in broiler chicks. Interactions between diet and gut microbiota are important modulators of immune responses (2).

8.2. Disease Resistance

Disease-resistance is vitally important to genetic development, for which dietary grape seed extract (GSE) has been explored as a potential supplement. GSE is a rich source of bioactive phytochemicals and diverse compounds such as complex carbohydrates, dietary fiber, fats, proteins, minerals, and phenolic compounds. The phenolics—proanthocyanidins containing components like epicatechin and gallic acid—exhibit strong antioxidant capability, which may be at the root of their protection against oxidative stress in many organisms (26). Broilers receiving dietary GSE show improved resistance against common pathogens such as Escherichia and Enterococcus species, accompanied by positive changes in microbiota and enhanced intestinal homeostasis. Furthermore, GSE appears to affect intestinal structure and function, indicated by processed waste and intestinal villus characteristics (1,2).

9. Antioxidant Activity of Grape Seed Extract

Grape seed extract (GSE) contains a high concentration of polyphenolic compounds that act as powerful antioxidants by scavenging free radicals (4). Feeding broiler chickens with GSE enhances α- and γ-tocopherol content of meat, and improves its oxidative stability (1). The antioxidative properties of flavonoids from grape pomace, grape seed extract, and grape seeds counteract lipid oxidation in chicken patties, thereby improving product freshness and shelf life.

10. Effects on Digestive Health

Grape seed extracts (GSE) are increasingly incorporated into animal diets and have been associated with several beneficial health effects, including reduced bone resorption and attenuation of

cardiovascular risk factors. A key factor in the bioavailability of grape-derived products is the gut microbiota, which also mediates or enhances their physiological impacts. While monomeric constituents such as catechins are absorbed in the small intestine, oligomeric procyanidins persist in the colon, where gut bacteria metabolize them into various phenolic acids (27). Several studies have assessed the influence of grape proanthocyanidin supplementation on broiler performance. Dietary polyphenols reduced mortality and lesion scores following Eimeria vaccination, and polyphenol-rich extracts from grape byproducts increased body weight and decreased ether extract content in broilers (28). Procyanidin supplementation improved feed efficiency without modifying growth parameters. Grape pomace inclusion enhanced meat oxidation resistance and increased the α-tocopherol content of chicken fat, further improving product acceptability. However, supplementation with GSE at concentrations of 0.01 to 1% elevated duodenal inflammation and upregulated pro-inflammatory cytokines, compromising feed conversion and growth, indicating sensitivity to dosage (29). GSE intake also modulates microbial communities by inhibiting pathogenic bacteria—including Escherichia, Salmonella, Helicobacter, and Proteus species—while promoting probiotic growth and associated microbes involved in lipid metabolism. Such microbiota alterations can reduce adiposity and inflammation, as well as increase glucose tolerance, insulin sensitivity, and energy expenditure (30). Effects on growth performance and body composition, however, remain underexplored. Modified microbial profiles in hens correlate with improved reproductive parameters. A controlled study was designed to evaluate the impact of dietary GSE supplementation on the production performance and metabolic markers of parental female broilers (2).

10.1. Gut Microbiota

Gut microbiota composition plays a pivotal role in optimizing feed efficiency in modern broiler production, prioritizing enhanced feed conversion and elevated growth rates on calorie-rich diets. Due to intensive selection, reproductive performance remains low in modern broiler lines, while the bone and cardiac health of both parents and progeny are considerably affected (31). Nutritional solutions that enhance animal performance while maintaining robust physiological status are urgently required. Grape seed extract (GSE) is easily incorporated into broiler diets and offers established health benefits, including reduced bone resorption and decreased cardiovascular risk factors. The metabolic fate of grape polyphenols partly relies on their interaction with intestinal microbiota, and gut bacteria likely mediate or amplify these beneficial effects (2). Monomeric compounds such as catechins are absorbed in the small intestine, whereas oligomers and polymers reach the colon to undergo extensive microbiota-mediated metabolism into phenolic acids and other bioactive metabolites. Accordingly, GSE significantly modifies microbiota composition by selectively suppressing pathogenic bacteria and promoting probiotic populations; GSE-induced microbiota alterations have been associated with improved metabolic parameters such as decreased adiposity and inflammation (32). Although microbiota-driven regulation of body composition and metabolic outcomes is well documented in obese mice and human subjects, little is known about its impact on growth performance in broilers or reproductive efficiency in hens (33). Microbiota engineering could enable synergistic association of performance and robust physiology in modern broilers; for instance, coherent use of probiotics has previously enhanced egg production and quality in laying hens. The present study examines the effects of a GSE-supplemented diet on performance and fat-related metabolic parameters in parental female broilers (34).

10.2. Nutrient Absorption

Most of the absorption of feed polyphenols takes place in the small intestine. Monomeric flavonoids such as catechins can be absorbed in the proximal part of the gastrointestinal tract because of their reduced size and increased polarity. However, a majority of grape seed polyphenols are present in polymeric and oligomeric forms that are unlikely to be absorbed before the colon. Their microbial fermentation delivers monomeric phenolic acids, which are subsequently absorbed in the large intestine (2). Grape seed extract (GSE) supplementation had a positive impact on egg production, egg weight, nutrient digestibility, and decreased lipid peroxidation in laying hens during the first stage of production (1).

11. Economic Implications of Feed Additives

Feed additives are critical to both the profitability and sustainability of livestock production. Feed cost accounts for an estimated 70% of total broiler production expenses, while net profit remains the ultimate indicator of successful farmer activity. A variety of feed additives, including phytogenic compounds, vitamins, amino acids, minerals, and the relatively newer class of acidifiers, can alter feed econometrics and exert both direct and indirect influences. The use of antibiotics as growth promoters, while highly effective in improving growth performance, is now officially banned, even in low-income countries, due to resistance concerns, leading to alternative feed additives (1).

12. Comparison with Other Feed Additives

With the ban on antibiotic growth promoters (AGPs) in Europe, the poultry industry has explored various alternatives to sustain poultry health and performance. These alternatives include prebiotics, probiotics, organic acids, plant extracts, enzymes, and substances with antioxidative and immunomodulatory properties (2). Grape seed extract (GSE) has gained traction as a polyphenol-rich feed additive in food-producing animals, including poultry (35).

Studies have reported that GSE supplementation leverages antioxidant and anti-inflammatory properties to reduce mortality rates and improve meat quality. Nevertheless, GSE's benefits can be offset when incorporated at too high levels, resulting in decreased feed conversion efficiency and stunted growth (1).

The physiological functions of grape polyphenols depend on their composition and chemical form, which can be influenced by the grape cultivar, origin, and processing techniques (4). Marketing of grape-derived products touting beneficial health effects, along with a growing array of products seeking to improve animal growth and health, has further stimulated interest in potential applications of GSE in broiler production.

13. Limitations of Current Studies

Despite the considerable attention devoted to the application of grape seed extract (GSE) in poultry production, current studies are not without limitations. Within the literature, the effects of GSE on reproductive efficiency—a critical economic parameter—remain largely unknown. Existing studies document the influence of GSE on the egg production of golden laying hens during the early stages of production, but do not confirm these observations nor confirm the associated impact on fertility (1). Therefore, the effect of GSE on short-term production and associated physiological traits, in particular fertility, requires further investigation.

14. Conclusion

In poultry production, supplemental agents such as microelements and phytobiotics have gained favor over traditional antibiotics due to the latter's association with increased microbial resistance, environmental contamination, and residues in animal products. Grape seed extract (GSE) offers a promising natural alternative through its antimicrobial, anti-inflammatory, and antioxidant

properties derived primarily from polyphenols and flavonoid compounds.

Administering GSE at concentrations of 200, 250, and 300 mg/kg to broiler diets induces dose-dependent enhancements in hematologic and biochemical parameters. For instance, blood counts of erythrocytes, hemoglobin, and packed cell volume increase, and levels of cholesterol, triglycerides, and liver enzymes such as SGOT and SGPT decline. Optimal improvements emerge with 300 mg/kg of GSE, which also promotes growth performance and blood constituent data that reflect a beneficial physiological state aligning with GSE's known bioactive effects (2).

The importance of intestinal health is underscored by the capacity of certain intervention strategies to modulate gut microbiota composition, thereby optimizing nutrient absorption while minimizing intestinal damage. Collectively, these findings highlight that natural feed additives represent efficacious, eco-friendly, and sustainable tools for boosting poultry production and welfare when critical physiological processes are targeted.

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