

THE USE OF LUPIN IN LAYING HEN NUTRITION: A REVIEW OF ITS EFFECTS ON PERFORMANCE, EGG QUALITY AND HEALTH STATUS

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ABSTRACT

The aim of this review was to evaluate the potential of narrow-leafed (*Lupinus angustifolius*), yellow (*Lupinus luteus*) and white lupin (*Lupinus albus*) as alternative protein sources in laying hen nutrition and to summarize their effects on productive performance, egg quality and health status. Relevant studies published during the last 10–15 years were identified through searches of scientific databases using keywords related to lupin, laying hens, poultry nutrition, and legumes.

Available studies show that lupin can partially replace soybean meal in the nutrition of laying hens without a negative effect on performance, when included at appropriate levels. Narrow-leafed lupin is the most extensively studied species, with recommended inclusion levels of 15–20 %. Yellow lupin shows comparable effects on egg quality, although recommended inclusion levels vary among studies. White lupin has been studied less frequently, with dietary concentrations up to 15–20 % generally considered safe.

Across species, the most consistently reported benefits include improved yolk pigmentation and a more favourable fatty acid profile. Several studies have also described positive effects on gut environment and intestinal fermentation. In contrast, excessive lupin inclusion may impair performance and egg quality, likely due to antinutritional factors and reduced nutrient digestibility.

Overall, lupin represents a promising alternative protein source for laying hens; however, its successful use depends on lupin species, inclusion level, feed formulation, and seed processing methods.

Keywords: alternative protein sources; legumes; soybean meal replacement; poultry feeding; productive performance; fatty acid profile; gastrointestinal health



INTRODUCTION

The search for alternative protein sources has become one of the major priorities of European livestock production. Following the ban on meat and bone meal in animal feeding, soybean products have become the dominant protein source in feed formulations for livestock and poultry. However, the increasing cost of imported soybean commodities, together with concerns regarding genetically modified crops, has intensified interest in locally produced alternative protein sources (Abraham et al., 2019).

Among the most promising alternatives are cultivated lupin species (*Lupinus* spp.), particularly their seeds, which contain crude protein concentrations comparable to those of soybean seeds (David et al., 2024; Struti et al., 2020). In addition, modern lupin cultivars are characterized by relatively low concentrations of antinutritional factors compared with other grain legumes and by a favourable profile of fatty acids (Gresta et al., 2023). The use of lupin seeds in poultry diets depends on appropriate dietary formulation and adequate balancing of limiting amino acids (Lanza et al., 2025).

Although earlier studies reported adverse effects on laying hen performance, mainly due to nutritional imbalances and antinutritional compounds, more recent research indicates that properly formulated lupin-based diets can achieve performance comparable to conventional soybean-based diets (Jeroch et al., 2016).

The aim of this review was to summarize current knowledge regarding the use of different lupin species and cultivars in laying hen diets, with particular emphasis on their effects on productive performance, egg quality, health status and gastrointestinal function. In addition, selected technological processing methods used to improve the nutritional value and digestibility of lupin seeds are discussed.

MATERIAL AND METHODS

This review was based on scientific publications focusing on the use of different lupin species in diets for laying hens. Relevant studies were identified through searches of the Web of Science, ScienceDirect and Scopus databases.

The literature search was conducted using the keywords “lupin”, “*Lupinus albus*”, “laying hens”, “nutrition”, “poultry” and “legumes”, as well as their various combinations. Studies published within the last 10–15 years were considered for inclusion. Publications were selected according to their relevance to the topic, with primary emphasis placed on studies evaluating the effects of dietary lupin inclusion on productive performance, egg quality and health-related parameters in laying hens.

RESULTS AND DISCUSSION

Narrow-leafed lupine

Production performance and egg quality

Most studies evaluating narrow-leafed (blue) lupine in laying hen diets compared different inclusion levels with conventional soybean-based diets, while some also assessed seed processing methods and enzyme supplementation.

Studies evaluating narrow-leafed lupine generally indicate that inclusion levels up to 20% do not adversely affect laying performance or egg quality (Dražbo et al., 2014; Kowalska et al., 2020). Improved yolk pigmentation and a more favourable fatty acid profile were consistently reported. Park et al. (2016) even observed increased egg production in hens fed lupine-containing diets, while lower inclusion levels were associated with a higher proportion of oversized eggs. However, the effects on eggshell quality remain inconsistent. Dražbo et al. (2014) reported improvements in eggshell thickness, weight and strength, whereas Kowalska et al. (2020) and Park et al. (2016) found no significant effects. A slight reduction in egg weight was observed only at the highest inclusion level (25 %) evaluated by Kowalska et al. (2020). Lee et al. (2016) evaluated the use of 15% narrow-leafed lupine as a protein source in laying hen diets, comparing whole and dehulled seeds, with or without enzyme supplementation. Similar to previous studies, no adverse effects on laying performance or hen health were observed. Lupine inclusion resulted in redder and lighter yolks, while a tendency toward reduced eggshell thickness was reported, particularly in enzyme-supplemented diets. No negative effects on gastrointestinal health or bacterial load were detected.

Seed processing technologies may improve the nutritional value of lupine and its utilization by laying hens. Kponouglo et al. (2024) demonstrated that fermentation improved the nutritional quality of lupine-based diets and resulted in better egg production, egg quality, and maintenance of body weight, whereas germinated grains were associated with reduced laying performance and body weight loss. In addition, all experimental diets reduced egg cholesterol content.

Similarly, Tiruneh et al. (2025) reported positive effects of ground and roasted narrow-leafed lupine seeds on performance and economic efficiency in dual-purpose chickens. The authors suggested that processed lupine could replace a substantial proportion of soybean meal, although direct comparison with laying hen studies is limited due to differences in production type. Tomczak et al. (2024) found that partial replacement of soybean meal with narrow-leafed lupine did not impair laying performance but significantly affected egg protein composition. Higher lupine inclusion was associated with lower protein content in albumen and higher protein content in yolk. According to the authors, a combination of lupine and reduced soybean meal may represent the most practical compromise between nutritional quality and feeding efficiency.

Health, gastrointestinal and metabolic effects

In addition to production performance, the effects of blue lupine on the gastrointestinal tract, gut microbiota, and metabolic processes in laying hens have also been investigated.

Zdunczyk et al. (2014) reported that blue lupine positively modulated the caecal microbiota and increased its fermentative activity, while Lee et al. (2016) found no adverse effects on gastrointestinal health, bacterial load, or overall hen health status.

Wójcik et al. (2024) showed that short-term supplementation with narrow-leafed lupine had no adverse effects on oxidative balance, whereas long-term inclusion of 20–25% may impair liver function and increase oxidative stress. Inclusion levels of 10–15% appeared to be the most favourable, showing only minor adverse effects together with a slight improvement in antioxidant activity. Similarly, Grabowski et al. (2025) observed changes in hepatic protein expression and increased synthesis of acute-phase proteins, particularly at the 25% inclusion level, suggesting activation of metabolic and immune responses under high lupine supplementation.

Yellow lupine

Production performance and egg quality

Several studies have evaluated yellow lupine in combination with other legumes or oilseed meals as an alternative to soybean meal in laying hen diets.

Kowalska et al. (2021) reported that yellow lupine-based diets improved several egg quality traits, including albumen quality, yolk pigmentation, and fatty acid composition. Similar effects on egg quality were observed by Kuźniacka et al. (2020), who additionally reported no adverse effects on laying performance, despite a reduction in albumen height and an increase in albumen weight. Likewise, Krawczyk et al. (2024) found that replacing soybean meal with legumes, including yellow lupine, did not affect laying performance but altered several egg quality characteristics, including yolk colour, Haugh units, shell porosity, and lysozyme activity. In contrast, Rutkowski et al. (2015) reported reduced laying performance, egg weight, and feed efficiency at higher legume inclusion levels, although improvements in albumen quality and yolk pigmentation were also observed. Based on these findings, the authors recommended limiting legume inclusion to approximately 20% of the diet.

In contrast to mixed diets, several studies have evaluated yellow lupine as the main protein source in laying hen diets. Rutkowski et al. (2017) reported that inclusion levels up to 20% had no adverse effects on performance, whereas 25% lupine reduced laying rate, egg weight, feed intake, and feed efficiency. Increasing lupine inclusion improved yolk pigmentation and slightly increased Haugh unit values, but was also associated with poorer eggshell quality. Conversely, Krawczyk et al. (2015) found no negative effects on laying performance, feed

conversion, eggshell quality, or albumen quality at inclusion levels up to 30%. Similar to previous studies, yolk colour intensity increased with lupine supplementation, while favourable changes in yolk fatty acid composition and a slight reduction in cholesterol content were also observed.

Gastrointestinal function and gut microbiota

Studies investigating yellow lupine have evaluated not only production performance but also its effects on intestinal morphology and microbial fermentation. Zdunczyk et al. (2019) reported no adverse effects of yellow lupine (10–30%) on production performance, nutrient digestibility, or blood parameters, except for a reduction in cholesterol concentration. Lupine inclusion induced changes in intestinal morphology that may reflect improved absorptive capacity and was associated with enhanced caecal fermentation, increased short-chain fatty acid production, lower pH, reduced ammonia concentrations, and higher microbial enzymatic activity. However, the authors noted that higher inclusion levels may increase the content of antinutritional factors, particularly non-starch polysaccharides and raffinose family oligosaccharides.

White lupine

Production performance and egg quality

White lupine has been less extensively studied than narrow-leafed or yellow lupine, but available evidence suggests that it can partially replace soybean meal in laying hen diets without adverse effects on performance or egg quality when included at appropriate levels. Kubis et al. (2018) recommended inclusion levels of 6–12%, whereas Mierlita (2013), Criste et al. (2017), and Laudadio and Tufarelli (2011) reported satisfactory results at approximately 15–20% inclusion. Higher concentrations generally impaired performance, particularly egg production, egg weight, and feed intake (Kubis et al., 2018; Mierlita, 2013; Criste et al., 2017).

In addition to maintaining acceptable performance, white lupine was associated with improvements in egg quality, including enhanced yolk pigmentation and a more favourable fatty acid profile (Criste et al., 2017; Laudadio and Tufarelli, 2011). Similarly, Timová et al. (2020) reported reduced saturated fatty acids and increased mono- and polyunsaturated fatty acids in egg yolks from hens fed white lupine diets, indicating improved nutritional value of eggs.

Blood parameters

Straková et al. (2021) evaluated the effects of replacing soybean meal with dehulled and whole white lupine (cv. Zulika) on blood biochemical parameters in laying hens. Long-term lupine feeding did not adversely affect the health status of hens and had no effect on most blood indicators. However, lupine inclusion was associated with reduced concentrations of total plasma protein, cholesterol, calcium, and triacylglycerols, together with increased alkaline phosphatase activity.

Comparison of lupine species

The interpretation of comparative results is complicated by considerable variability in experimental conditions. Individual studies have used different lupine species and cultivars, varying dietary inclusion levels, and different seed processing methods. Direct comparison of results is therefore limited.

All three lupine species show potential as partial replacements for soybean meal in laying hen diets. Narrow-leafed lupine is the most extensively studied species, with relatively consistent evidence supporting inclusion levels of 15–20%. Yellow lupine produces comparable effects on egg quality, although recommended inclusion levels vary more widely (20–30%) and effects on production performance are less consistent. White lupine has been investigated least frequently, with most studies recommending lower inclusion levels (approximately 5–15%), although successful use at 15–20% has also been reported.

Across species, the most consistent benefits include improved yolk pigmentation and a more favourable fatty acid profile, resulting in enhanced nutritional value of eggs. In contrast, high dietary inclusion levels may reduce laying performance, egg weight, and feed efficiency, likely due to the presence of antinutritional compounds such as non-starch polysaccharides and raffinose family oligosaccharides.

Several studies also suggest beneficial effects of lupine on gut microbial activity and fermentation processes, whereas excessive long-term inclusion may negatively affect hepatic metabolism and oxidative balance. Lupine-containing diets generally do not adversely affect blood biochemical parameters and may contribute to reduced cholesterol concentrations in both blood and eggs.

Overall, when used at recommended inclusion levels, lupine does not adversely affect laying performance, egg quality, or health status and represents a promising alternative protein source for laying hens.

Tab. 1: Comparison of the effects of different lupin species in laying hens

Species	Recommended inclusion (%)	Effects on performance	Effects on egg quality	Health effects
<i>L. angustifolius</i>	15–20	generally no negative effects	Improved yolk and PUFA profile	Positive effects on gut microbiota; adverse liver effects at high levels
<i>L. luteus</i>	20–25	Variable results among studies	Improved yolk colour, variable shell quality	Enhanced gut fermentation and SCFA production
<i>L. albus</i>	6–15	Generally no negative effects	Improved fatty acid profile	Favourable blood biochemical parameters

CONCLUSION

Lupine represents a promising alternative to soybean meal in laying hen nutrition. Available studies indicate that, at appropriate inclusion levels, it does not negatively affect production performance or health status and may improve egg quality, particularly yolk color intensity and fatty acid profile.

Narrow-leafed lupine is the most extensively studied species, with a recommended inclusion levels ranging from 15–20 %. Yellow lupine shows comparable effects; however, greater variability exists among studies regarding optimal inclusion levels. White lupine is the least studied, with suggested inclusion levels typically not exceeding 15 %, or in some cases 20 %.

High dietary inclusion of lupine may impair laying performance, egg weight, and feed conversion, most likely due to antinutritional compounds and reduced nutrient digestibility. Conversely, several studies suggest beneficial effects on gut environment, fermentation processes, and selected metabolic parameters.

Further research is needed to define optimal inclusion levels for individual lupine species and to evaluate processing technologies aimed at improving nutritional value and reducing antinutritional factors.

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