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Economic Implications of Curcuma Longa Supplementation on The Morphometric Development of Organs in Laying Hens: A Review

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Abstract
The search for sustainable alternatives to antibiotic growth promoters has driven interest in phytogenic feed additives such as Curcuma longa (turmeric), known for its antioxidant, anti-inflammatory, and hepatoprotective properties. This review aims to evaluate the effects of dietary Curcuma longa supplementation on the morphometric development of internal organs in laying hens, and to analyze the potential economic implications of these physiological changes. A narrative synthesis was conducted using peer-reviewed in vivo studies published between 2000 and 2024 in English or Spanish. Selected studies reported quantitative data on organ morphometry (e.g., weight, length, or volume), included control and treated groups, and applied statistical analysis. The organs assessed included liver, spleen, intestines, heart, ovaries, and oviduct. Findings show that moderate inclusion levels of turmeric (1–2 g/kg feed) can induce positive morphological changes, such as increased relative weights of liver and spleen, improved intestinal villus height and crypt architecture, and in some cases, enhanced development of the reproductive tract. These effects were associated with elevated antioxidant enzyme activity (e.g., SOD, CAT) and reduced levels of pro-inflammatory cytokines (e.g., TNF-α, IL-6), contributing to better nutrient absorption, immune response, and overall physiological resilience. Economically, improved organ function may translate into enhanced feed conversion efficiency, reduced veterinary interventions, and greater production consistency. However, heterogeneity in experimental design, dosages, and turmeric formulations limits comparability across studies. Further standardized and long-term research is needed to define optimal supplementation strategies and assess cost-effectiveness under commercial conditions.
Overall, Curcuma longa represents a promising phytogenic additive with the potential to support both physiological health and economic sustainability in laying hen production systems.
Keywords: *Curcuma longa, laying hens, organ morphometry, phytogenic additives, intestinal development, poultry production, economic efficiency*

INTRODUCCIÓN

The poultry industry has experienced significant transformation over recent decades, emphasizing not only productivity and feed efficiency but also animal health, welfare, and product quality (Hedman et al., 2020; Sell, 1996). In this evolving context, the incorporation of natural feed additives has emerged as a strategic approach to enhance performance while aligning with consumer preferences and regulatory shifts away from synthetic growth promoters (del Prado et al., 2024; Hristov et al., 2024). Among these additives, Curcuma longa (turmeric) has gained attention due to its multifunctional bioactive compound, curcumin, renowned for its anti-inflammatory, antioxidant, antimicrobial, and hepatoprotective properties (Clavo-Majuan, 2015; Yuebin et al., 2019). In laying hens, dietary inclusion of Curcuma longa has shown potential to improve productive performance indicators—such as feed conversion ratio, egg production, and body weight gain—as well as immunological and gut health markers (Attia et al., 2017; Guamán-Rivera et al., 2024). These physiological improvements may contribute to long-term economic efficiency in poultry operations, especially under conditions that challenge flock health and productivity. However, less attention has been directed toward the morphometric development of internal organs—such as the liver, heart, spleen, intestines, and reproductive tract—as potential indicators of systemic adaptation and functional health. Morphometric parameters are not only relevant from a physiological perspective but may also have economic implications, particularly in terms of nutrient utilization, disease resistance, and productive lifespan (Clavo-Majuan, 2015; Djoumessi-Tobou et al., 2021). For instance, improved intestinal morphology—characterized by increased villus height and optimal crypt architecture—has been associated with enhanced nutrient absorption, which translates into better feed efficiency and lower production costs (Dias-Ferreira et al., 2013). Furthermore, as the poultry sector faces increasing pressures to reduce antibiotic use due to antimicrobial resistance and shifting market demands, the use of phytogenic additives like turmeric represents a cost-effective and sustainable strategy to support organ function and overall flock performance (O'Neill, 2016; Aslam et al., 2024). By influencing organ development and systemic resilience, turmeric supplementation may contribute to economic sustainability through reduced veterinary costs, improved feed conversion, and greater output consistency.

This review aims to consolidate and critically assess the current scientific literature on the effects of Curcuma longa supplementation on the morphometric characteristics of internal organs in laying hens. Emphasis is placed on identifying dose-response relationships, physiological relevance, and potential economic outcomes. Ultimately, the goal is to provide a comprehensive understanding of how turmeric can be leveraged not only as a health-promoting additive but also as a component of economically optimized poultry production systems.

MATERIALS AND METHODS

This review followed a structured narrative approach aimed at synthesizing current scientific evidence regarding the effects of Curcuma longa supplementation on the morphometric development of internal organs in laying hens, with a particular focus on the potential economic implications for poultry production systems.

Type of Study

A comprehensive literature search was conducted between January and May 2025 using the following electronic databases: PubMed, Scopus, ScienceDirect, SpringerLink, Google Scholar, SciELO, and Redalyc. The search terms included combinations of the following keywords in English and Spanish: "Curcuma longa", "turmeric", "laying hens", "morphometric parameters", "organ development", "poultry feed additives", "intestinal morphology", "economic impact", and "productive performance in poultry".

Information sources

The following electronic scientific databases were used to search for information:

- PubMed
- Scopus
- ScienceDirect
- SpringerLink
- Google Scholar
- SciELO
- Redalyc

Inclusion criteria

Studies that assessed the use of *Curcuma longa* as a dietary supplement in laying hens (adult or growing) and were published in either Spanish or English were included. A clear methodology and results backed by statistical analysis were required of the chosen studies, which also had to include at least one control group and one or more treated groups, as well as quantitative morphometric evaluations of internal organs like the liver, spleen, intestines, thymus, bursa of Fabricius, heart, ovaries, or oviduct, among others.

Inclusion and Exclusion Criteria

The inclusion criteria for this review encompassed peer-reviewed in vivo studies conducted on laying hens that evaluated the effects of *Curcuma longa* supplementation on the morphometric parameters of internal organs such as the liver, spleen, intestines, and reproductive tract. Only articles published between 2000 and 2024 in English or Spanish were considered. Eligible studies had to report measurable outcomes related to organ size, weight, or structural development, and include potential implications for productive performance or economic relevance. Studies were excluded if they involved broilers or non-avian species, lacked morphometric analysis, or focused exclusively on egg characteristics, meat quality, or hematological data. Additionally, articles without clear methodological design or statistical analysis were omitted. Reviews, editorials, and conference abstracts were also excluded. This selection ensured that the final dataset reflected consistent, relevant, and applicable evidence for laying hen production systems.

Data extraction and analysis

In line with the purpose of evaluating the economic implications of Curcuma longa supplementation on the morphometric development of organs in laying hens, relevant information was systematically extracted from each selected study. This included the authors and year of publication, experimental design, species and number of birds used, as well as the dose, form of administration, and duration of Curcuma longa supplementation. Data on the specific internal organs evaluated and the type of morphometric measurements performed (e.g., weight, length, diameter) were also recorded. Special attention was given to statistically significant results and their interpretation in terms of productive performance, physiological function, and potential economic benefits. The main conclusions of each study were summarized to identify patterns and practical implications for cost-effective poultry production systems.

RESULTS

Several studies reported significant increases in relative liver and spleen weight at moderate turmeric doses (1–2 g/day), suggesting enhanced metabolic and immune activity. These effects, while subtle, could indicate improved detoxification and disease resistance, potentially reducing veterinary costs in production systems. For instance, studies by Ashraf & Sultan (2017) and Djoumessi-Tobou et al. (2021) found that hens supplemented with 2 g/day of C. longa exhibited liver weights 8–12% higher than controls, with no signs of pathological hypertrophy, implying a beneficial physiological adaptation. In the gastrointestinal tract, increased villus height and villus-to-crypt ratio were frequently observed, particularly in the duodenum and jejunum. These changes are associated with enhanced nutrient absorption efficiency, which may translate into improved feed conversion and cost-effectiveness. Dias-Ferreira et al. (2013) and Attia et al. (2017) reported significant improvements ($P < 0.05$) in intestinal morphology in turmeric-supplemented hens, especially at 2 g/kg feed, supporting the hypothesis that organ-level changes contribute to productive gains without increasing feed intake. Regarding the reproductive system, a few studies noted increased oviduct length and ovary weight in turmeric-treated groups, particularly during peak laying periods. These findings may reflect a positive influence on reproductive function, potentially contributing to improved laying persistence or egg mass, although more longitudinal studies are needed to confirm economic outcomes.

Table 1. Effect of Curcuma longa supplementation on the final weight of hens.

Organ / Parameter	Dose *C. longa*	Morphometric Effect	Statistical Significance	Potential Economic Implications
Liver (relative weight)	1–2 g/kg feed	8–12% increase in relative weight	$P < 0.05$	Improved detoxification and liver health, reduced medication costs
Spleen (relative weight)	1–2 g/kg feed	Moderate increase in size	$P < 0.05$	Enhanced immune response, lower disease incidence
Intestine (villus height)	2 g/kg feed	Significant increase in villus height	$P < 0.05$	Better nutrient absorption, potential feed cost reduction
Reproductive tract (oviduct length)	2 g/kg feed	Slight increase in length	$P < 0.05$	Possible improvements in egg production and quality
Final body weight	1–3 g/day	No significant changes	$P = 0.32$	Maintains production parameters without negative impact

In terms of morphometric characteristics, specific changes in organ dimensions were observed. In particular, the treatment group receiving 1 g/d of C. longa showed a shorter oesophagus length than the control group. This suggests that dietary supplementation with curcumin may influence not only the overall growth of hens, but also the development and size of specific organs, which could reflect changes in nutrient absorption or digestion efficiency.

Table 2. Effect of Curcuma longa supplementation on morphometric characteristics (oesophagus)

Treatment	Dose C. *longa*	Esophagus Length (cm)	Change Compared to Control	Potential Economic Implications
Control	0 g/day	—	—	Baseline for comparison
Treatment 1	1 g/day	↓ (shorter)	Yes	Possible influence on feed passage rate; may affect digestion efficiency and nutrient uptake, impacting feed conversion and production costs
Treatment 2	2 g/day	—	Not reported	Data unavailable
Treatment 3	3 g/day	—	Not reported	Data unavailable

The supplementation of *Curcuma longa* at 1 g/day resulted in a measurable decrease in esophagus length compared to the control group, indicating a statistically significant morphological change. Although the exact numeric reduction in length is not reported, this shortening could potentially alter feed transit dynamics. Given that the esophagus plays a key role in moving feed to the digestive tract, even small reductions in length might influence feed passage rate and nutrient absorption efficiency. Such changes could have downstream effects on feed conversion ratio (FCR), a crucial economic indicator in laying hen production, where improvements or declines of just 2–3% in FCR can translate into significant cost savings or losses. However, since data for 2 and 3 g/day doses were not provided, it remains unclear whether this effect persists or intensifies with higher

supplementation levels. Without precise length measurements and production data, the economic impact remains speculative, but this finding highlights the need for further quantitative studies to clarify whether esophagus morphometry changes induced by Curcuma longa supplementation can meaningfully affect feed efficiency and production costs.

DISCUSSION

The incorporation of turmeric *(Curcuma longa)* into laying hen diets has attracted increasing interest due to its potential to enhance organ morphometric development and improve overall production efficiency, which in turn may yield significant economic benefits (Sureshbabu et al., 2023). Multiple studies on female chickens have demonstrated that moderate levels of turmeric supplementation (1–2 g/day) can induce favorable morphometric changes in key digestive and immune organs without adversely affecting final body weight (Maldonado-Arias et al., 2024).

Notable morphological modifications include reductions in esophagus and gizzard lengths, alongside increases in heart size and alterations in liver, gallbladder, and cecum dimensions (Maldonado-Arias et al., 2024). Such changes suggest that turmeric's bioactive components, particularly curcumin, may stimulate enzymatic activity and improve the efficiency of nutrient absorption. Enhanced organ development can lead to better feed conversion ratios, ensuring that nutrients are more effectively utilized for growth and egg production. This improved nutrient assimilation not only supports bird health but also contributes to improved production metrics, which are economically favourable for smallholder and backyard operations (Maldonado-Arias et al., 2024). From an economic perspective, improved organ morphometrics may directly correlate with higher production efficiency and reduced operational costs. Enhanced digestive tract functionality minimizes feed wastage and maximizes nutrient uptake, reducing the cost per unit of production. Moreover, the morphological improvements are likely associated with enhanced immune responses and robust health status, diminishing the need for expensive antibiotic treatments and lowering veterinary intervention costs (Jasim et al., 2024). The transition away from antibiotics is particularly relevant given global regulatory trends aimed at mitigating antimicrobial resistance, thereby positioning turmeric as an attractive natural alternative for sustainable poultry production (Jasim et al., 2024).

However, evidence also indicates that the benefits of turmeric supplementation are dose-dependent. Studies comparing different supplementation levels have shown that while low to moderate doses (1–2 g/day) are beneficial, higher doses (e.g., 3 g/day) may have detrimental effects, such as reduced body weight and potentially impaired overall growth (Maldonado-Arias et al., 2024). This observation underscores the need for careful dose optimization to ensure that the beneficial impacts on organ morphometrics are not counterbalanced by adverse effects on production performance. Maintaining an optimal dosage regimen is thus critical to fully harnessing the economic benefits from improved organ development.

Additional support for the economic potential of turmeric supplementation is derived from studies in broiler chickens, which have shown improved intestinal morphology manifested by increased villus height and width; these changes are indicative of enhanced nutrient absorption and overall gastrointestinal efficiency (Bondar et al., 2023). Although these studies were conducted in broilers, the underlying physiological mechanisms are comparable in laying hens, suggesting that similar improvements in intestinal and organ morphology may be achieved. Enhanced gut health contributes to reduced mortality and better production performance, thereby bolstering profitability through a reduction in feed costs and losses associated with poor health.

Research has shown that incorporating curcumin into the diets of laying hens exposed to heat stress leads to a significant increase in serum levels of superoxide dismutase (SOD), a key antioxidant enzyme, compared to unsupplemented control groups (Pallasco, 2021). Notably, hens receiving curcumin at doses of 150 and 200 mg/kg exhibited marked enhancements in SOD activity by the third and ninth weeks of supplementation. In addition to SOD, other antioxidant markers such as catalase (CAT) activity and total antioxidant capacity (T-AOC) were also positively affected, indicating curcumin's effectiveness in counteracting oxidative stress in poultry (Nadia et al., 2008). Curcumin, the principal bioactive constituent of turmeric, also plays a critical role in regulating inflammatory responses (Yuebin et al., 2019). Experimental evidence demonstrates that turmeric supplementation can significantly lower the concentrations of pro-inflammatory cytokines, particularly interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), which are central to intestinal inflammatory processes (Aderemi & Alabi, 2023; Bondar et al., 2023)). Elevated TNF-α levels are commonly linked to increased intestinal permeability and disruption of immune homeostasis (Bondar et al., 2023). By suppressing TNF-α

expression, curcumin may help preserve intestinal barrier function, thereby enhancing gut health and reducing inflammation-related complications (Iweala et al., 2023).

CONCLUSIONS

Dietary supplementation with Curcuma longa in laying hens has demonstrated potentially beneficial effects on the morphometric development of internal organs, including increases in the relative weight and length of key structures such as the liver, intestines, ovaries, and oviduct. These physiological improvements are likely associated with turmeric's recognized antioxidant, anti-inflammatory, and hepatoprotective properties. From an economic perspective, enhanced organ function and development may translate into improved nutrient absorption, reproductive efficiency, and overall health—factors that can contribute to increased productivity and reduced veterinary costs. Nevertheless, inconsistencies in dosing strategies, formulation types, and study designs limit the ability to define optimal supplementation protocols. Therefore, standardized and longitudinal studies are necessary to elucidate the underlying biological mechanisms and to quantify the cost-benefit ratio of Curcuma longa use in commercial poultry systems.

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