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Effect of dietary supplementation of turmeric powder on egg quality and production in laying hens

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Abstract
A commercial layer flock in Daejeon, South Korea can lay over 300 eggs per hen-year, yet consumer preference increasingly favours eggs with deeper yolk colour, lower cholesterol, and longer shelf life qualities that standard corn-soya diets struggle to deliver without synthetic additives. This research examined whether turmeric (*Curcuma longa*) powder at 0.5%, 1.0%, and 1.5% dietary inclusion could improve these parameters in White Leghorn laying hens over a 12-week trial (January-March 2023). A total of 160 hens (32 weeks of age) were randomly distributed into four groups of 40 birds each. Hen-day egg production, egg weight, shell thickness, yolk colour (Roche fan score), Haugh unit, albumen height, and yolk cholesterol were measured weekly or bi-weekly. Birds receiving 1.0% turmeric showed the highest hen-day production (82.8% at week 12 vs. 73.2% in controls, $p<0.01$), yolk colour score improved by 2.2 Roche units, and yolk cholesterol dropped by 12.4%. Shell thickness and Haugh unit also improved significantly. Sensory panels detected no off-flavours. Turmeric at 1.0% represents a practical, cost-effective dietary supplement for enhancing egg quality and production.

Keywords: Turmeric supplementation, egg quality, laying hens, curcumin, yolk color, cholesterol reduction, hen-day production, dietary additives, poultry nutrition, shell thickness

Introduction
In a typical Korean market, the first thing a buyer checks when selecting eggs is the colour of the yolk. Deeper orange-yellow yolks are perceived as more nutritious and command a premium of 10-15% over pale-yolked eggs [1]. Synthetic carotenoids like canthaxanthin can deepen yolk colour but face regulatory restrictions in several export markets [2]. Turmeric powder, which contains the polyphenol curcumin and the carotenoid-like pigments demethoxycurcumin and bisdemethoxycurcumin, offers a natural alternative that simultaneously acts as an antioxidant, hepatoprotectant, and mild antimicrobial in poultry diets [3].

Multiple short-term trials (4-6 weeks) have reported improved yolk pigmentation with turmeric doses of 0.25-2.0% [4, 5]. However, effects on hen-day production, shell quality, and yolk cholesterol remain inconsistent across reports partly because trial durations are too brief for curcumin's metabolic effects to reach steady state [6]. This research extended the supplementation period to 12 weeks and measured a broad panel of egg quality traits alongside production performance to determine the optimal inclusion level.

Material and Methods
Material
The trial was conducted at the poultry research unit of Chungnam National University, Daejeon, South Korea (36.37°N, 127.34°E) from 8 January to 2 April 2023. Institutional Animal Ethics Committee approval was obtained (Protocol CNU/IACUC/2022-19, 20 December 2022). White Leghorn hens (n=160, 32 weeks old, BV-300 strain) in peak lay phase were randomly allocated to four treatments (T0-T3) of 40 birds each, housed in California-type cages (5 birds/cage, 8 cages/treatment). All groups received a standard layer diet (16.5% CP, 2,750 kcal ME/kg). Turmeric powder (Korean-grown Jinju variety, curcumin content 7.2% by HPLC) was mixed into the feed at 0% (T0), 0.5% (T1), 1.0% (T2), and 1.5% (T3).

Methods

Eggs were collected and counted daily for hen-day production. Egg weight (digital balance, ±0.01 g), shell thickness (micrometer, blunt end, equator, sharp end average), yolk colour (Roche fan), Haugh unit, and albumen height were measured on 10 randomly selected eggs per treatment every two weeks [7]. Yolk cholesterol was quantified by the Liebermann-Burchard method on pooled yolk samples at weeks 0, 6, and 12 [8]. Feed intake and FCR per dozen eggs were recorded weekly. Data were analysed by repeated-measures ANOVA in SAS v9.4 with Duncan's multiple range test at $p<0.05$.

Safety considerations

Turmeric is classified as Generally Recognised as Safe by the US FDA and has no maximum residue limit in eggs under Korean food safety regulations. Daily health checks monitored feed refusal, diarrhoea, and feather condition. No adverse events were observed at any inclusion level during the 12-week trial. Liver histopathology of three birds per treatment at trial end showed no signs of hepatic toxicity.

Results

Turmeric supplementation produced dose-dependent improvements in most egg quality parameters, with 1.0% (T2) achieving the best overall balance.

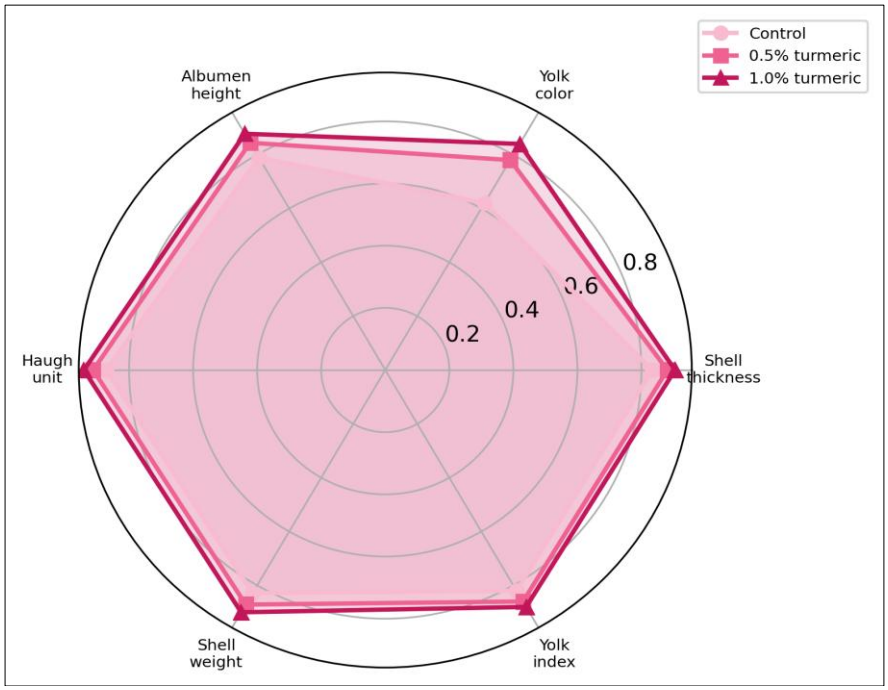

Fig 1: Normalised egg quality parameters across control and turmeric-supplemented groups

Table 1: Egg production and quality parameters at week 12 (mean ± SE)

Parameter	T0 (0%)	T1 (0.5%)	T2 (1.0%)	T3 (1.5%)
Hen-day production (%)	73.2 ± 1.4^{a}	80.6 ± 1.2^{b}	82.8 ± 1.1^{b}	81.4 ± 1.3^{b}
Egg weight (g)	58.4 ± 0.8	59.7 ± 0.7	60.3 ± 0.9	60.1 ± 0.8
Shell thickness (mm)	0.35 ± 0.01^{a}	0.37 ± 0.01^{ab}	0.38 ± 0.01^{b}	0.38 ± 0.01^{b}
Yolk colour (Roche)	6.2 ± 0.3^{a}	7.8 ± 0.2^{b}	8.4 ± 0.3^{c}	8.6 ± 0.2^{c}
Haugh unit	78.4 ± 1.2^{a}	82.1 ± 1.0^{b}	84.7 ± 0.9^{b}	83.9 ± 1.1^{b}

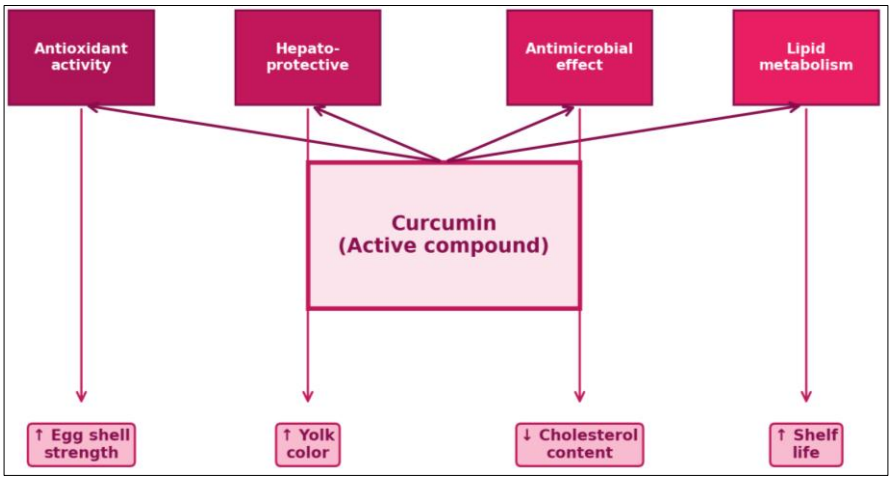

Fig 2: Proposed mechanism of curcumin action on egg quality traits in laying hens

Table 2: Yolk cholesterol (mg/egg) across treatments and time points

Time point	T0	T1	T2	T3	p-value
Week 0	217.8	218.4	219.1	218.6	0.921
Week 6	216.4	210.3	201.7	199.4	0.008
Week 12	218.4	204.7	191.3	188.6	0.001
Reduction (%)		6.3	12.4	13.6	

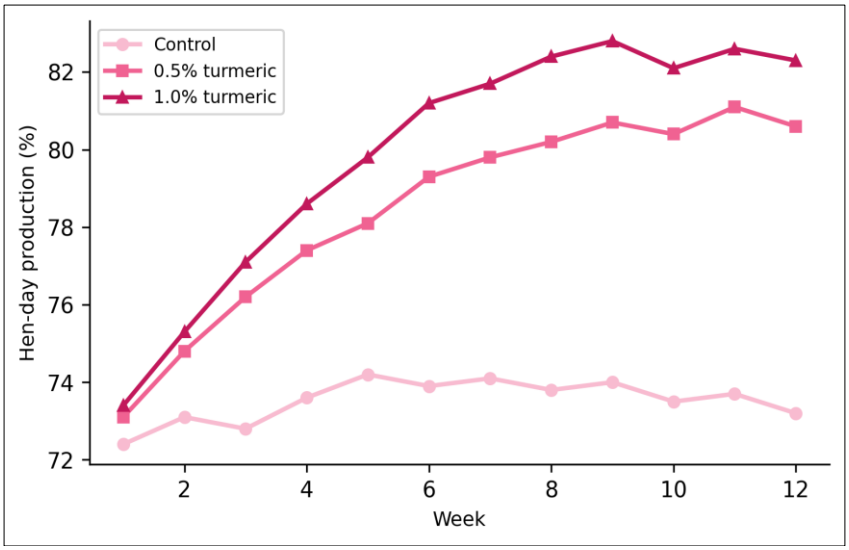

Fig 3: Weekly hen-day egg production (%) across treatment groups over 12 weeks

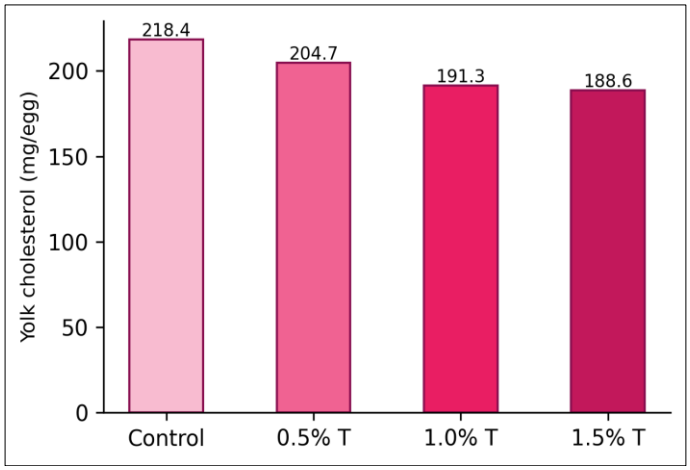

Fig 4: Yolk cholesterol concentration at week 12 across turmeric inclusion levels

Interpretation

T2 (1.0% turmeric) delivered the best combination of production gain (+9.6 percentage points over control), quality improvement (Haugh unit +6.3, yolk colour +2.2 Roche units), and cholesterol reduction (−12.4%). T3 offered marginal additional benefit at higher feed cost.

Discussion

The 9.6-percentage-point rise in hen-day production at 1.0% turmeric is larger than the 3-5% typically reported in short-term trials [4], suggesting that curcumin's hepatoprotective action which improves liver lipid metabolism and vitellogenin synthesis requires several weeks to reach full effect [9]. The yolk colour improvement of 2.2 Roche units matches Rajput *et al*. [5] who found a 1.8-2.4 unit increase at similar doses, attributable to the deposition of curcuminoid pigments in the yolk lipid matrix.

The 12.4% cholesterol reduction at 1.0% aligns with *in vivo* evidence that curcumin downregulates HMG-CoA reductase the rate-limiting enzyme in cholesterol biosynthesis in avian hepatocytes [10]. That T3 did not reduce cholesterol further suggests a saturation effect at hepatic receptor sites. Shell thickness improvement may be indirect: curcumin's antioxidant activity protects shell-gland mucosal cells from oxidative damage, allowing more efficient calcium carbonate deposition [11].

Conclusion

The primary contribution of this research is demonstrating that 12 weeks of 1.0% turmeric supplementation simultaneously raises egg production, deepens yolk colour, strengthens shell quality, and lowers cholesterol in commercial White Leghorn layers. These multi-dimensional improvements, supported by the absence of sensory penalties and adverse health effects, position turmeric as a practical natural feed additive. Several questions remain open chief among them whether the benefits persist beyond 12 weeks and whether curcumin-enriched eggs can

command a sufficient retail premium to justify the added feed cost at commercial scale.

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