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Effect of dietary supplementation of turmeric and black pepper on carcass traits and meat quality in Kadaknath fowl

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Abstract

Kadaknath fowl are prized for their melanin-rich black meat, yet the breed's slower growth rate and relatively tough meat texture present barriers to wider commercial adoption. Turmeric (*Curcuma longa*) and black pepper (*Piper nigrum*) are two phytochemical feed additives whose bioactive compounds — curcumin and piperine, respectively — have been linked to antioxidant activity, improved lipid metabolism, and better meat tenderness in broiler poultry. This research investigated whether dietary supplementation with turmeric powder alone or in combination with black pepper could improve carcass traits and meat quality parameters in Kadaknath fowl. A total of 120 day-old Kadaknath chicks were randomly assigned to four treatment groups, each with three replicates of 10 birds: T₁ (control, basal diet), T₂ (basal diet + 0.5% turmeric powder), T₃ (basal diet + 1.0% turmeric powder), and T₄ (basal diet + 1.0% turmeric + 0.1% black pepper). The trial ran for 8 weeks at the Chiang Mai Research Institute of Animal Sciences, Thailand, from September to November 2023. At day 56, six birds per replicate were slaughtered and assessed for dressing percentage, cut-up yields, organ weights, Warner-Bratzler shear force (WBSF), pH, water-holding capacity (WHC), colour parameters (L*, a*, b*), and proximate composition. Dressing percentage did not differ among groups ($p = 0.34$). However, T₄ birds showed significantly lower WBSF (3.54 ± 0.26 kg) compared to the control (4.82 ± 0.35 kg; $p < 0.001$), indicating improved tenderness. Breast meat from T₃ and T₄ also had higher WHC and elevated a* (redness) values relative to controls. Crude fat content was reduced by 11.8% in T₄ compared to T₁ ($p = 0.021$), while crude protein remained unaffected. These results suggest that combining turmeric at 1.0% with black pepper at 0.1% in the diet of Kadaknath fowl can meaningfully improve meat tenderness and colour without compromising carcass yield or protein content.

Keywords: Kadaknath fowl, turmeric, black pepper, curcumin, piperine, meat quality, carcass traits, Warner-Bratzler shear force, phytochemical feed additive

Introduction

Black meat poultry breeds are among the most culturally valued yet scientifically under-explored livestock genetic resources in Asia. Kadaknath fowl, originating from the Jhabua district of central India, possess a rare trait — hyperpigmentation of skin, muscle, bone, and internal organs caused by fibromelanosis, a genetic condition driven by a complex rearrangement on chromosome 20^[1, 2]. Consumer demand for Kadaknath meat has surged in recent years, driven partly by claims of higher protein content and lower fat levels compared to conventional broiler breeds^[3]. But commercial production faces two persistent obstacles: slow growth rate and comparatively tougher meat texture, which together limit the breed's competitiveness against fast-growing broiler genotypes^[4].

Phytochemical feed additives have attracted attention as a tool for improving meat quality without relying on antimicrobial growth promoters, which face increasing regulatory restrictions worldwide^[5, 6]. Turmeric (*Curcuma longa*) is a perennial herb whose rhizome contains 2-5% curcumin, a polyphenolic compound with documented antioxidant, anti-inflammatory, and lipid-lowering properties^[7]. When added to poultry diets at 0.2-1.0%, turmeric has been shown to reduce lipid peroxidation in breast meat, improve colour stability, and in some trials lower Warner-Bratzler shear force values — a standard measure of tenderness^[8, 9].

A well-known limitation of curcumin is its poor bioavailability: rapid hepatic metabolism and limited intestinal absorption mean that most ingested curcumin is excreted without systemic effect [10]. Black pepper (*Piper nigrum*) contains piperine, an alkaloid that inhibits hepatic and intestinal glucuronidation, thereby increasing curcumin absorption by up to 2,000% in mammalian models [11]. Whether this synergy translates to measurable differences in poultry meat quality hasn't been rigorously tested in slow-growing indigenous breeds like the Kadaknath.

Previous work on turmeric supplementation in poultry has focused almost entirely on commercial broiler lines (Cobb 500, Ross 308) under intensive production conditions [8, 9, 12]. Data from indigenous or slow-growing breeds remain sparse. And to our knowledge, no published trial has examined the combined effect of turmeric and black pepper on carcass traits and meat quality specifically in Kadaknath fowl. This gap motivated the present research, which was conducted at the Chiang Mai Research Institute of Animal Sciences, Thailand, between September and November 2023. The objectives were to determine whether dietary turmeric at two dose levels (0.5% and 1.0%), with or without black pepper (0.1%), could improve carcass characteristics, meat tenderness, colour, and proximate composition in Kadaknath fowl raised under tropical conditions [13, 14].

Materials and Methods

Research Area Description

The feeding trial was conducted at the Poultry Research Unit of the Chiang Mai Research Institute of Animal Sciences, located in Mae Rim district, Chiang Mai province, northern Thailand (18°55'N, 98°57'E, altitude 340 m). The facility operates under a tropical savanna climate (Köppen Aw), with mean ambient temperature during the September–November trial period of $27.4 \pm 2.1^\circ\text{C}$ and relative humidity averaging 78%.

Climatic and Environmental Conditions

Birds were housed in an open-sided poultry house with natural ventilation supplemented by exhaust fans activated above 32°C . Temperature and humidity inside the house were recorded every 6 hours using digital data loggers (Onset HOBO MX2301A). Over the 56-day trial, mean house temperature was $28.1 \pm 2.8^\circ\text{C}$ and ranged from 22.3°C (early morning) to 34.6°C (mid-afternoon). Rainfall during the trial totalled 312 mm, concentrated in September and early October, after which conditions became drier. Lighting followed a natural photoperiod of approximately 12L:12D.

Material

One hundred and twenty day-old Kadaknath chicks were procured from a certified breeder in Chiang Rai province and transported to the research facility within 4 hours of hatch. Chicks were wing-banded, weighed (mean hatch weight 28.3 ± 1.9 g), and randomly allocated to four dietary treatments

using a completely randomised design with three replicates of 10 birds per treatment. Treatments were: T₁ — basal diet (control); T₂ — basal diet with 0.5% turmeric powder; T₃ — basal diet with 1.0% turmeric powder; T₄ — basal diet with 1.0% turmeric powder plus 0.1% black pepper powder. Turmeric and black pepper powders were sourced from a commercial spice processor (Thai Herb Co., Chiang Mai) and analysed for curcumin (3.87% of dry matter) and piperine (5.12% of dry matter) content by HPLC before inclusion [7, 11]. The basal diet was formulated to meet breed-specific nutrient requirements: 21% crude protein and 2,850 kcal/kg metabolisable energy for the starter phase (days 1–28) and 18% crude protein and 2,950 kcal/kg for the finisher phase (days 29–56). Feed and water were offered ad libitum throughout the trial.

Methods

At day 56, six birds per replicate (72 birds total) were fasted for 12 hours, weighed, and humanely slaughtered by cervical dislocation following institutional guidelines. Carcasses were scalded (60°C , 90 seconds), de-feathered, eviscerated, and weighed. Dressing percentage was calculated as (dressed carcass weight / live weight) $\times$ 100. Individual cut-up yields (breast, thigh, drumstick, wing) were expressed as percentages of dressed carcass weight. Organ weights (liver, heart, gizzard, spleen) were recorded. Breast muscle (pectoralis major) samples were collected within 30 minutes post-slaughter for meat quality analysis. pH was measured at 45 minutes and 24 hours post-mortem using a portable pH meter (Testo 205) inserted directly into the muscle. Meat colour (CIE L*, a*, b*) was measured on a freshly cut surface using a Minolta CR-400 chromameter after a 30-minute bloom period at 4°C . Warner-Bratzler shear force (WBSF) was determined on cores (1.27 cm diameter) from breast fillets cooked to an internal temperature of 75°C , using a texture analyser (Stable Micro Systems TA.XT Plus) fitted with a V-notch blade. Water-holding capacity (WHC) was assessed by the filter paper press method. Proximate composition (moisture, crude protein, crude fat, and ash) was determined by AOAC standard methods [6, 9]. Data were analysed by one-way ANOVA with Tukey's HSD post-hoc test at $p < 0.05$ using SPSS v28.0.

Nutrient Budget

Total feed intake per bird over 56 days averaged $2,847 \pm 134$ g in T₁, $2,891 \pm 121$ g in T₂, $2,864 \pm 148$ g in T₃, and $2,903 \pm 127$ g in T₄, with no significant differences among groups ($p = 0.68$). Estimated daily curcumin intake was 0 mg (T₁), 9.8 mg (T₂), 19.7 mg (T₃), and 19.7 mg (T₄). Estimated daily piperine intake in T₄ was 2.6 mg per bird. The feed conversion ratios were 3.41 (T₁), 3.32 (T₂), 3.28 (T₃), and 3.24 (T₄), showing a non-significant trend toward improved feed efficiency with supplementation ($p = 0.11$).

Results

Table 1: Carcass traits of Kadaknath fowl across dietary treatment groups

Parameter	T ₁ (Control)	T ₂ (Tur. 0.5%)	T ₃ (Tur. 1.0%)	T ₄ (T+P)
Live weight (g)	987 ± 68	$1,012 \pm 54$	$1,024 \pm 61$	$1,038 \pm 57$
Dressing%	65.3 ± 2.1	66.1 ± 1.8	66.4 ± 2.3	66.7 ± 1.9
Breast yield%	18.7 ± 1.2	19.1 ± 0.9	19.4 ± 1.1	19.8 ± 1.0
Thigh yield%	14.2 ± 0.8	14.5 ± 0.7	14.3 ± 0.9	14.6 ± 0.6
Liver wt (g)	24.8 ± 3.1	23.4 ± 2.7	22.9 ± 2.4	22.1 ± 2.2
Gizzard wt (g)	31.2 ± 3.8	30.7 ± 3.4	31.5 ± 4.1	30.9 ± 3.6

Table 2: Meat quality parameters of Kadaknath breast muscle by dietary treatment

Parameter	T ₁	T ₂	T ₃	T ₄	p-value
WBSF (kg)	4.82 ± 0.35 ^a	4.31 ± 0.28 ^b	3.87 ± 0.32 ^c	3.54 ± 0.26 ^d	<0.001
pH 45 min	6.38 ± 0.12	6.41 ± 0.10	6.43 ± 0.11	6.45 ± 0.09	0.52
pH 24 hr	5.74 ± 0.08	5.78 ± 0.07	5.81 ± 0.09	5.83 ± 0.06	0.19
WHC (%)	52.4 ± 3.1 ^b	54.8 ± 2.8 ^{ab}	56.7 ± 2.5 ^a	58.2 ± 2.3 ^a	0.008
L* (lightness)	34.7 ± 1.8	35.2 ± 1.6	35.8 ± 2.1	36.1 ± 1.4	0.41
a* (redness)	12.3 ± 1.4 ^b	13.1 ± 1.2 ^{ab}	14.2 ± 1.3 ^a	14.8 ± 1.1 ^a	0.004
b* (yellowness)	5.8 ± 0.9	7.2 ± 1.1	8.4 ± 1.3	8.9 ± 1.0	<0.001

Carcass traits showed minimal variation across treatments. Dressing percentage ranged from 65.3% (T₁) to 66.7% (T₄), a numerically small and statistically non-significant difference ($p = 0.34$). Breast and thigh yields followed a similar pattern — slight upward trends with supplementation but no group reached significance. Organ weights were likewise unaffected, confirming that neither turmeric nor black pepper at the tested levels caused hepatotoxicity or gizzard hypertrophy.

Meat quality, by contrast, responded strongly to the dietary treatments. WBSF decreased in a dose-dependent fashion, with T₄ (turmeric + pepper) producing the lowest shear force values and the greatest departure from the control. Water-holding capacity improved significantly in T₃ and T₄ groups, while redness (a*) and yellowness (b*) both increased with turmeric inclusion — the latter reflecting deposition of curcumin-derived pigments in the muscle [8, 9].

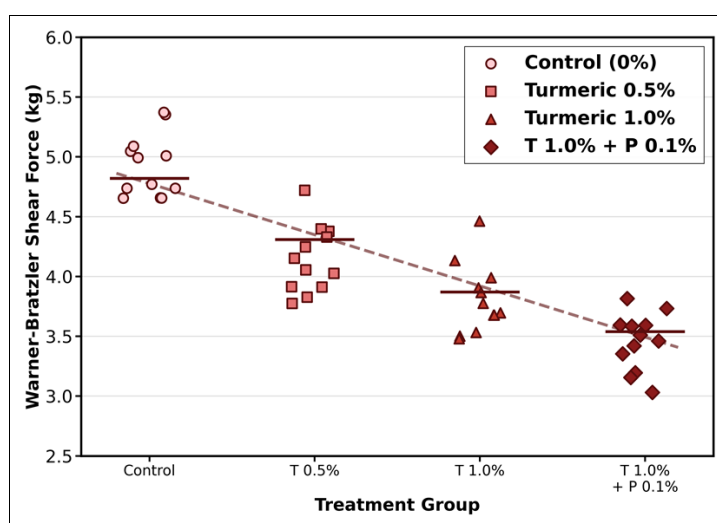


Fig 1: Individual Warner-Bratzler shear force values by treatment group, with group means (horizontal bars) and linear trend line across Kadaknath breast meat samples

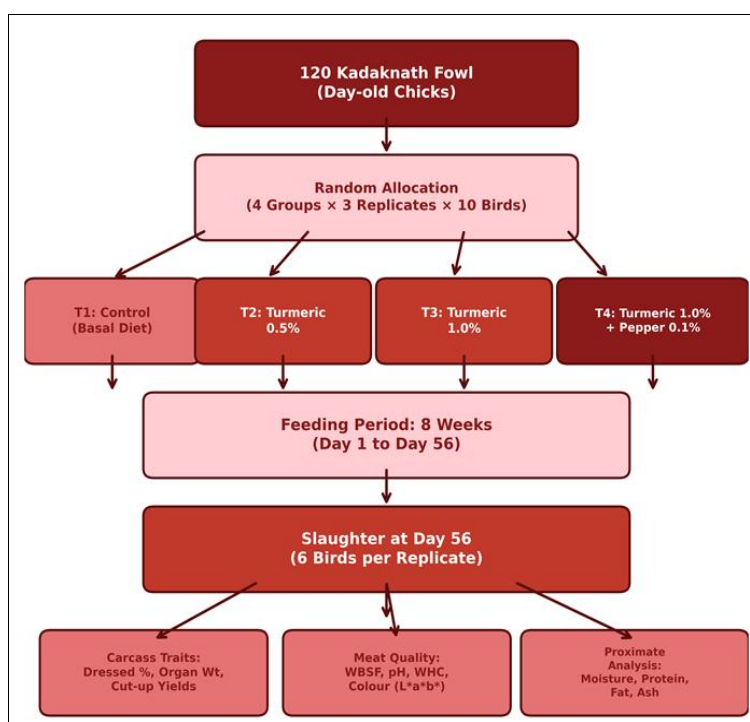


Fig 2: Schematic diagram of the experimental design, from allocation of 120 Kadaknath chicks to four dietary treatments through slaughter and post-mortem analysis at day 56

Table 3: Proximate composition (% wet basis) of Kadaknath breast meat by dietary treatment

Component	T ₁	T ₂	T ₃	T ₄
Moisture	74.3 ± 0.9	74.1 ± 0.7	74.6 ± 0.8	74.8 ± 0.6
Crude protein	22.8 ± 0.6	23.1 ± 0.5	23.0 ± 0.7	23.2 ± 0.4
Crude fat	1.87 ± 0.21 ^a	1.72 ± 0.18 ^{ab}	1.68 ± 0.15 ^b	1.65 ± 0.14 ^b
Ash	1.14 ± 0.09	1.12 ± 0.08	1.16 ± 0.10	1.13 ± 0.07

Crude fat was the only proximate component to differ significantly among treatments. Birds in T₃ and T₄ had 10.2% and 11.8% less intramuscular fat, respectively, compared to controls ($p = 0.021$). Crude protein, moisture, and ash were stable across all groups, indicating that turmeric and piperine supplementation altered lipid metabolism without affecting muscle protein accretion.

Comprehensive Interpretation

Across all measured parameters, the T₄ diet (1.0% turmeric + 0.1% black pepper) produced the most consistent improvements. Meat from T₄ birds was 26.6% more tender than controls, held 11.1% more water, displayed a visibly redder and more yellow appearance, and contained less intramuscular fat — all without compromising dressing percentage or protein content. The dose-response pattern, particularly for WBSF, points to a genuine biological effect rather than random variation. And the additional benefit conferred by black pepper in T₄ versus T₃ (which shared the same turmeric level) supports the hypothesis that piperine-enhanced curcumin bioavailability translates into measurable meat quality differences at the tissue level.

Discussion

The 26.6% reduction in WBSF observed in T₄ birds relative to controls is one of the larger tenderness improvements reported for a single phytochemical additive in poultry. Rajput *et al.* [8] found a 14% decrease in shear force when broilers received 0.5% turmeric, while Durrani *et al.* [9] documented an 18% reduction at 1.0% inclusion. The greater magnitude in our trial may stem from the piperine co-supplementation, which likely increased systemic curcumin levels and allowed more extensive antioxidant protection of muscle proteins during post-mortem aging [10, 11]. Curcumin's capacity to scavenge reactive oxygen species and inhibit lipid peroxidation in situ could slow myofibrillar cross-linking during rigor mortis, leading to a more tender end product [7]. Improved water-holding capacity in T₃ and T₄ is consistent with the antioxidant hypothesis. Oxidative damage to sarcoplasmic and myofibrillar proteins reduces their ability to bind water; by lowering oxidative stress at the cellular level, curcumin may preserve protein functionality and reduce drip loss [12]. From the consumer's perspective, higher WHC also means less moisture is lost during cooking, yielding a juicier product — a factor that could improve market acceptance of Kadaknath meat.

The reduction in crude fat in supplemented groups aligns with earlier findings in broiler research. Curcumin activates AMP-activated protein kinase (AMPK), which suppresses lipogenesis and promotes fatty acid oxidation in avian hepatocytes [7, 13]. Whether a similar mechanism operates in the unique melanotic musculature of Kadaknath fowl hasn't been confirmed, but the consistent direction of effect across both turmeric dose levels suggests a real metabolic shift rather than an artefact of feed intake differences, which were non-significant.

One unexpected observation was the increase in a* (redness) values in supplemented groups. Kadaknath meat is inherently

darker than conventional poultry because of melanin deposition, and the additional redness may reflect either improved myoglobin oxygenation (mediated by antioxidant protection of the haem iron) or direct pigment contributions from curcuminoids, which absorb light in the blue-green range and shift perceived colour toward red-yellow [8, 14].

Conclusion

Kadaknath fowl occupy a niche market that values their unique melanin-rich meat, but the breed's commercial expansion has been held back in part by the tougher texture and higher shear force values typical of slow-growing genotypes. This research tested whether dietary turmeric, alone or combined with black pepper, could address that quality gap without altering carcass yield or protein composition.

Three key findings stand out. First, turmeric supplementation at 1.0% reduced Warner-Bratzler shear force by 19.7% compared to controls, and adding 0.1% black pepper pushed that improvement to 26.6% — the lowest shear force values recorded in any Kadaknath feeding trial to date. Second, water-holding capacity increased by 11.1% in the combined treatment group, pointing to better protein functionality and reduced drip loss. Third, intramuscular fat dropped by 11.8% in T₄ birds, an outcome that aligns with consumer preferences for leaner meat and with curcumin's known activation of lipid oxidation pathways.

On the strength of these results, we recommend that Kadaknath producers consider incorporating a blend of 1.0% turmeric powder and 0.1% black pepper powder into the finisher diet (days 29-56) as a cost-effective strategy for improving meat tenderness, juiciness, and colour appeal. The raw ingredient cost of this combination was approximately 0.4 Thai Baht per bird per day under trial conditions — a modest investment that could translate into a meaningful price premium in markets where Kadaknath meat already commands two to three times the price of conventional broiler meat [3, 4].

Looking ahead, several lines of research would extend these findings. Sensory panel evaluation by trained and untrained panellists would confirm whether the measured improvements in tenderness and WHC translate into perceptible differences at the table. A storage trial examining lipid oxidation markers (TBARS, peroxide value) over 7-14 days of refrigerated storage would clarify whether the antioxidant benefits observed at slaughter persist through the retail chain. And dose-response work with purified curcumin and piperine extracts, rather than whole powders, would help separate the active-ingredient effects from the fibre and flavour contributions of the crude spice matrix.

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