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Antioxidant status, immunoglobulin level, carcass attributes and sensory qualities of Japanese quails (*Coturnix japonica*) fed diets with turmeric (*Curcuma longa*) powder

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Abstract: This study was designed to assess the antioxidant status, immunoglobulin level, carcass attributes, and sensory qualities of Japanese quails offered diets with Turmeric powder using two hundred and fifty-six male Japanese quails randomly designated to four dietary regimens, each consisting of four replicates of sixteen (16) birds. The Turmeric powder (TP) was incorporated into the diet at 0.00%, 0.25%, 0.50%, and 0.75% to create diets TP00, TP0.25, TP0.50, and TP0.75, respectively. The investigation lasted six weeks. The result showed that the total antioxidant capacity (TAC) (1.58 - 4.20 mM Trolox equivalent), superoxide dismutase (SOD) (0.23 - 2.60 U/ML), glutathione peroxidase (GPx) (9.00 - 33.50 U/L), immunoglobulin A (IgA) (0.10 - 0.16 G/L), and bled weight (95.09 - 96.90 %) differ statistically ($p<0.05$). The TAC, SOD, GPx, and IgA increased with increasing TP levels. Except for the bled weight, dressing yield, carcass characteristics, and organoleptic properties showed no statistical differences across the dietary treatments. In conclusion, TP inclusion increased antioxidant status and IgA in Japanese quail. It influences bleed weight and has no adverse effects on carcass characteristics or consumer organoleptic properties. The addition of dietary 0.75% TP supports Japanese quail's health.

Keywords: antioxidants; carcass cuts; dressing yield; immune; turmeric

INTRODUCTION

The use of synthetic additives such as antibiotics has been indicted in the manifestation of resistant pathogenic bacteria and residues in animal products, posing risks to human health (Aydin et al., 2022). This has stimulated research into the use of natural products (Kaplan et al., 2018). Natural alternatives such as herbs, botanicals, and spices are copious in bioactive molecules like organic acids, saponoids, flavonoids, tannins, alkaloids, and glycosides (Kuralkar and Kuralkar, 2021), known to have been used for centuries (Kiczorowska et al., 2017). They possess antioxidant, antibacterial, and immune-supporting effects in livestock (Kostadinović and Lević, 2018).

These compounds can be from leaves, stems, bark, roots, rhizomes, bulbs, fruits, flowers and flowers of plants (Wang et al., 2024). They have been reported to be used singly or as blends of species in diets as supplements available in local markets. They have been used to improve animal health (Upadhaya and Kim, 2017), reduce stress (Gong et al., 2014), and improve antioxidant capacity and meat quality (Tsiplakou et al., 2021).

The preference for organically raised products is on the increase (Samreen et al., 2021).

Japanese quails have valuable, good-quality meat, with low fat and high protein, an appealing food in numerous cultures (Lukanov et al., 2023). The short generation interval, to table size of 5 weeks, small space requirement, and low capital investment make it suitable for urban and peri-urban farming (Ojediran et al., 2022; Ojediran et al., 2023a). Ojediran et al. (2023b) reported a paucity of knowledge on the use of a potential natural additive, Tumeric, on Japanese quails.

Turmeric (*Curcuma longa*), a rhizome belonging to the ginger family, has emerged in recent times as being suitable for birds' feed supplement. The major bioactive compound, curcumin, is well-studied in human nutrition because it has been used as a spice for centuries and in traditional medicine (El-Saadony et al., 2023). The antioxidant, immunological, anti-inflammatory, and antimicrobial characteristics need to be exploited in quails because the applied advantages of turmeric in poultry diet remain underexplored. This study was conducted to evaluate the antioxidant capacity, immunological status, carcass attributes, and sensory features of Japanese quails given a TP diet.

MATERIALS AND METHODS

Quail handling and management

In this investigation, 256 male Japanese quails were adapted to the environment for seven days, brooded on deep litter, and offered a 28% CP diet in a hygienic pen. The quails were randomly allocated to four (4) feeding regimens, of four (4) replicates of sixteen (16) birds in a six-week investigation without diet or water restriction. Each replicate's pen measured 0.75 m^2

Turmeric powder and the diet

The turmeric rhizome in this investigation was obtained from the university farm. They were washed to remove any debris, diced, air-dried, homogenised into powder and incorporated into the diet at 0.00%, 0.25%, 0.50%, and 0.75% to create diets TP00, TP0.25, TP0.50, and TP0.75 (Table 1).

Data collection and analysis

Feed was provided *ad libitum* at 8:00 and 14:00 hr every day.

Antioxidant level and immunological evaluation

Two millilitres of blood were drawn from each of the three birds with a weight as close as possible to the group average that were killed in each replicate on the final day of the feeding trial, and placed in ethylene-diamine-tetraacetic acid (EDTA) for serum analysis. The blood samples were centrifuged for ten minutes at 2000 - 3000 rpm after being left to clot for thirty minutes at room temperature. The supernatants were stored at -20°C in pre-labelled vials. Next, using colorimetric techniques and a spectrophotometer (UV-2600: Shimadzu Corporation, Tokyo, Japan), serum levels of glutathione peroxidase (GPx), superoxide dismutase (SOD), and total antioxidant capacity (TAC) were determined. The experiments were carried out using reagent kits (Jiancheng Bioengineering Institute, Nanjing, China) in accordance with the protocol outlined by Rajput et al. (2013). Kits from Spectrum Company (Cairo) were used to measure the levels of immunological parameters (IgA, IgG, and IgM).

Carcass characteristics

The slaughtered quails were de-feathered, eviscerated, and dissected into carcass primal cuts. The weighing was done using a Kerro sensitive scale.

Organoleptic properties

Each treatment replicate's breast flesh samples were gathered, placed in clearly marked nylon bags, and boiled for fifteen minutes. Ten participants, who often eat meat, were given it to taste after it had cooled. Colour, tenderness, juiciness, flavour, texture, and general attractiveness were all evaluated using a nine-point hedonic scale.

Data analysis

CR design was adopted. One-way ANOVA employing SPSS v25 was used to analyze the

Table 1. Gross composition of experimental diets

Ingredients (%)	TP00	TP0.25	TP0.50	TP0.75
Corn meal	15.00	15.00	15.00	15.00
Corn bran	10.50	10.50	10.50	10.50
Soy bean meal	5.00	5.00	5.00	5.00
Full fat Soya	20.00	20.00	20.00	20.00
Wheat offal	6.00	6.00	6.00	6.00
Limestone	1.00	1.00	1.00	1.00
Palm Kernel Cake	39.00	39.00	39.00	39.00
Bone meal	2.00	2.00	2.00	2.00
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
TP	-	+	++	+++
Total (kg)	100.00	100.00	100.00	100.00
Calculated Nutrients				
Metabolizable Energy (MJ)	11.77	11.77	11.77	11.77
Crude Protein (%)	20.63	20.63	20.63	20.63
Ether Extract (%)	7.20	7.20	7.20	7.20
Crude Fibre (%)	7.79	7.79	7.79	7.79
Calcium (%)	1.01	1.01	1.01	1.01
Phosphorus (%)	0.41	0.41	0.41	0.41
Methionine (%)	0.37	0.37	0.37	0.37
Lysine (%)	1.06	1.06	1.06	1.06

TP00 = Control treatment; TP0.25 = 0.25% TP; TP0.50: 0.50% TP; TP0.75 = 0.75% TP
**Each kg feed contained: Vit. A, 1500IU A, 1500IU; Vit. 2,500IU, Bit. E1101U, Vit B3 40mg; Vit. B6, 20mg; Chlorine chloride, 400mg; Mn 120mg, Fe 70mg; Cu 100m; I l;2.2m Se 0.2mg,; Zn 45m;Co; 0.02m.*
Source: Authors' own elaboration

data, and DMRT at 5% confidence was utilized to resolve the mean significance.

The statistical model used was $Y_{ij} = \mu + DT_i + e_{ij}$

Y_{ij} = Individual observation
μ = population mean
DT_i = effect of i^{th} diet with turmeric
e_{ij} = random error

RESULTS AND DISCUSSION

Result

Antioxidant capacity

The antioxidant capacity of Japanese quails fed diets with TP (Table 2) showed that all antioxidant parameters differ substantially ($p<0.05$). The TAC among diets with TP was reduced compared to quails that received TP00 diet ($p<0.05$). The TAC was reduced across the diets. Observation on SOD shows that it was reduced among diets with turmeric; however, those served diets TP00and TP0.25 were significantly higher ($p<0.05$) than those that received diets TP0.50 and TP0.75, which were lower. Diets with TP0.75 showed the highest ($p<0.05$) GPX (33.50 U/L) than diets that received TP00 to TP0.50 ($p>0.05$) (9.00-16.60 U/L.

Immunoglobulins

The immunoglobulin level of Japanese quail supplied feed with TP additive (Table 3) revealed

that IGA was significantly impacted ($p<0.05$) while IgG and IgM were not statistically different ($p>0.05$). Quails given Diet TP0.75 had the highest IgA, which was statistically distinct ($p<0.05$) from other diets.

Carcass characteristics

Table 4 displays the dressing yield and carcass characteristics of male Japanese quails fed TP as an additive. Only the bled weight differs substantially ($p<0.05$) by the diet fed. The bled weight of

Table 2. Antioxidant status of Japanese quails fed diets with TP

Parameter	TP00	TP0.25	TP0.50	TP0.75	SEM	P value
TAC (mM Trolox equivalent)	1.58[b]	1.78[b]	2.35[b]	4.20[a]	0.36	0.01
SOD (U/ML)	0.23[b]	0.35[b]	2.55[a]	2.60[a]	0.35	0.00
GPX (U/L)	15.50[b]	9.00[b]	16.60[b]	33.50[a]	3.10	0.01

[ab] Means with varying superscripts are considerably different.
SEM: standard error of mean
TAC: total antioxidant capacity, SOD: superoxide dismutase, GPx: glutathione peroxidase
Source: Authors' own elaboration

Table 3. Immunoglobulin level of Japanese quails fed diets with TP

Parameter	TP00	TP0.25	TP0.50	TP0.75	SEM	P value
IgA (G/L)	0.10[b]	0.11[b]	0.15[a]	0.16[a]	0.01	0.00
IgG (G/L)	2.65	2.40	1.35	2.52	0.25	0.24
IgM (G/L)	0.85	0.80	0.90	0.90	0.03	0.74

[ab] Means with different superscripts are significantly different. SEM: standard error of mean.
IgA: immunoglobulin A, IgG: : immunoglobulin G, IgM: immunoglobulin
Source: Authors' own elaboration

Table 4. Dressing yield and carcass characteristics of Japanese quails fed diets with TP

Parameters (%)	TP00	TP0.25	TP0.50	TP0.75	SEM	P value
Live weight (g)	165.75	161.68	169.35	155.38	4.73	0.79
Bled weight	96.90[a]	95.83[ab]	95.09[b]	96.63[a]	0.26	0.04
Defeathered weight	85.92	85.75	82.86	86.59	1.63	0.88
Carcass weight	66.95	69.55	65.15	70.49	1.70	0.72
Shanks	1.91	1.76	1.74	2.12	0.08	0.37
Thigh	9.02	9.75	9.16	9.26	0.37	0.93
Drum stick	6.58	6.37	6.35	6.93	0.22	0.80
Breast	24.29	27.38	25.57	26.78	0.79	0.57
Wings	6.04	6.17	6.29	6.80	0.21	0.65
Neck	5.79	5.82	4.32	5.32	0.33	0.36
Back	15.09	14.18	13.45	15.70	0.50	0.44

[ab] Means with varying superscripts are considerably different.
Source: Authors' own elaboration

quails offered diets TP00 and TP0.75 were statistically identical but differed ($p<0.05$) from the birds that got TP0.50. However, diet TP0.25 is similar to diet TP00, TP0.50 and TP0.75 in terms of performance.

Organoleptic properties

The result of the organoleptic properties of Male Japanese quail fed TP as an additive is shown in Table 5. All the organoleptic properties considered were not significant ($p>0.05$). The panelists' perception of overall acceptability was the same across the treatments except for Diet 1, the control diet that had a higher value of 6.60.

Discussion

Antioxidant capacity

The antioxidant capacity observed in this study corroborates the observation of Liu et al. (2023) and Nawab et al. (2019), who reported an increase in the antioxidant capacity except malondialdehyde (MDA) of quails fed a diet with dietary curcumin. This is also in line with Wang et al. (2015). Antioxidants are capable of shielding cells against the detrimental impact of lipid peroxidation, which is an indicator of cellular injury brought on by free radicals (Wu et al., 2016). The use of synthetic antioxidants showed liver-carcinogenicity, attributed causing their ban (Rahmani et al., 2017). However, various research showed that phyto-substances in livestock diets provided positive responses, such as antioxidant capabilities, stimulation of immune responses, increased appetite and improved digestive enzyme secretions (Toghyani et al., 2011; Nawab et al., 2019).

Intensively kept birds are prone to stressors, which causes oxidative stress from diminished antioxidant defence. However, natural products have been reported to mediate immunomodulators which maintained homeostasis (Arif et al., 2022). The use of clove oil and black seed has been reported by Gülçin et al. (2012) and Hussein et al. (2019) to enhance quails' TAC, SOD, and GPx.

Curcumin, the major bioactive component, caused the yellowish pigmentation in turmeric, thus giving it the natural antioxidant potentials with feed additive properties (Wang et al., 2015; Ramos et al., 2017), indicated in its wide range of bio-pharmaco-therapeutic properties, including antioxidant, anti-inflammatory, free-radical scavenging, lipid peroxidation inhibition, antimicrobial, antiviral, antiprotozoal, antitumor activities and boosts the immune response (Zhang et al., 2014; Wang et al., 2015, and Amalraj et al., 2017).

Immunoglobulins

Quails given 0.75% TP had the highest IgA level, though IgG and IgM were not different. The observation on IgG and IgM differs from the report of Reda et al. (2020) when curcumin nanoparticles were used on Japanese quail. However, Emadi and Kermanshahi (2007) showed that dietary turmeric considerably raised broiler's IgA, IgM, and IgG levels. Turmeric curcumin has the ability to modulate immunity, activating neutrophils, macrophages, and B and T cells (Jag-

Table 5. Organoleptic properties of Japanese quails fed diets with TP

Parameters	TP00	TP0.25	TP0.50	TP0.75	SEM	P value
Colour	5.10	4.90	5.00	4.90	0.36	0.95
Flavour	4.00	5.60	4.00	5.60	0.34	0.13
Tenderness	5.30	4.60	5.20	4.60	0.32	0.84
Juiciness	5.90	5.30	5.90	5.30	0.31	0.83
Texture	6.10	4.80	6.10	4.80	0.33	0.27
Overall acceptability	6.60	6.00	6.00	6.00	0.30	0.81

Source: Authors' own elaboration

etia and Aggarwal, 2017). The antioxidant level in this study may have boosted the bird's immunity (Reda et al., 2020). Nouzarian et al. (2011) explained that the level of the turmeric incorporation may not be enough to elicit a response or elevate IgG levels in the NK cells. This shows that turmeric enhances active immune response in quails. With similar IgG and IgM across the diet, it suggests that the birds were not fighting an infection or stress.

Carcass characteristics

The observed result is similar to that of Ojediran et al. (2024) except for carcass weight when *Kigelia africana* was used as an additive in the diet of Japanese quails. Bled weight is the live weight to blood loss relation: blood loss body weight to live weight (in %), related to humane slaughtering process and an important metric for assessing processing efficiency and yield. Except for diet TP0.05, the bleeding weight contrasted favourably with birds given diet TP00.

The observation on dressing yield characteristics confirms the outcome of El-Deck et al. (2003) regarding non-significant dressing weight and percentage of quails supplied 1.0% ginger powder up to six weeks of age. Isabel and Santos (2009) testified to the fact that the addition of organic acid and clove oil did not affect the properties of the carcass. The outcome of the present investigation runs counter to those of Durrani et al. (2006) and Rahmatnejad et al. (2009), who found that quails and broilers offered 0.5g/kg of garlic powder had elevated relative weights for breast and thigh meat.

Organoleptic properties

The perception of the panelists on the organoleptic properties of the quail meat was all the same. This is an indication that the test ingredients did not affect the panel's organoleptic perception. This supports the turmeric extract findings by Sundari et al. (2013). Soeparno (2005) attributed the above attention to the panelists' level of pleasure based on each person's physiological and sensory reaction. Warsito and Rindiani (2015) gave the attributes of good meat to a relative savory taste and pleasant flavor. Ojediran et al. (2019) reported that colour, flavor and acceptability were not influenced by *cassava vinnase*. Meat colour, being the first thing a consumer sees, influences preference. Product deviation from normal appearance results in rejection (Qiao et al., 2002), which could be as a result of pigmentation. Flavour and tenderness are age influenced, while juiciness relies on carcass fat level (Akinwumi et al., 2013).

CONCLUSION

The outcome of the feeding trial showed that TP inclusion in Japanese quail diet increases antioxidant status and IgA. It influences bleed weight, but has no detrimental impact on carcass characteristics and consumer organoleptic properties. The use of 0.75% turmeric powder as an additive supports Japanese quail's health.

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