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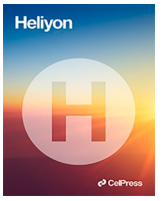

Research article

Effects of genotype and *Phytolacca dodecandra* (Endod) supplementation on growth performance, carcass traits, blood profiles, and breast meat quality of chickens

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ABSTRACT

In this study, we investigated the effects of genotype and Phytolacca dodecandra (Endod) supplementation on the growth, carcass traits, blood profiles, and breast meat quality of chickens. The study lasted for 18 weeks and involved 360 unsexed day-old chicks divided into nine groups with 40 chicks each, replicated four times with 10 chicks per replication. The genotypes studied were Naked-neck * Tetra H, Normal-feathered * Tetra H, crosses and Tetra H * Tetra H, while the diets included a standard commercial ration (C), Phytolacca dodecandra (Endod) at 1 g/kg (C+1), and Phytolacca dodecandra (Endod) at 2 g/kg (C+2). Results showed that both diet and genotype influenced growth performance indicators like final body weight, body weight change, average daily gain, and feed conversion ratio, particularly during the grower and entire phases. When compared to the control diet, the Phytolacca dodecandra (Endod) chicks supplemented at 1 g/kg showed better performances. The genotypes also affected dressing percentage, breast, thigh, keel bone, and gizzard components, with higher values found in the Naked-neck by Tetra H cross. The supplemented chicken group exhibited an improvement in the dressing percentage and breast muscle in comparison to the control. Blood parameters were also significantly influenced ($P < 0.01$) by genotype, diet, and their interaction. Supplementation significantly ($P < 0.01$) increased protein levels while reducing the cholesterol and triglyceride levels in the blood. Incorporating Phytolacca dodecandra (Endod) at a rate of 1 g/kg into the diet of chickens brought a significant improvement in the protein content, and a reduction in the fat content, of their breast muscles. In general, the study indicates that adding up to 2 g/kg of Phytolacca dodecandra (endod) to chicken feed enhances growth performance traits, carcass traits, blood profiles, and breast muscle protein levels, without any negative consequences.

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1. Introduction

In many developing countries, the livestock sector plays a critical role in supporting the national economy by providing essential sources of nutrition, income, and employment opportunities [1]. The growth and transformation of the sector provide huge opportunities for agricultural development, poverty reduction, and food security gains [2]. The global population is expected to reach 8.5 billion in 2030 [3]. Poultry production could be one of the best agricultural options that could sustainability achieve food security and serve smallholder income sources within a short period [4]. The demand for meat and eggs is predicted to increase in line with rising incomes, urbanization, and population growth. This will likely lead to further expansion of the global poultry industry [5]. It was predicted that 153.8 million tons of poultry meat will be produced globally in 2031, an increase of 16 % over 2022 and accounting for roughly 47 % of all meat produced globally [6]. Consumer interest in poultry meat production has developed as a result of several significant and advantageous qualities of poultry meat, such as its accessibility, source of protein, suitability for processing, and lack of religious prohibitions on consumption [7,8]. Poultry is often preferred as a source of protein, especially in underdeveloped nations, due to its affordability, high-quality protein content, and minimal conflicts with religious beliefs [5,9].

The genetics of indigenous chickens can be improved through selection and crossbreeding, leading to increased productivity and income for farmers in developing nations [10,11]. African countries, like Ethiopia, utilize crossbreeding methods to enhance egg and meat production [12]. In the last two decades, the Ethiopian government has imported over numerous exotic chicken breeds to improve the indigenous breeds through crossbreeding, and this has proven advantageous for both small and large-scale farming practices [13]. Breeds such as white leghorns, Rhode Island Reds, Fayomi, Bovans, Sasso, Koekoek, and Tetra H have been introduced [14]. Consequently, the development of selective breeding, such as the Horro chicken breed, and synthetic breed (DZ-White), has resulted in improved performance both on farms and research stations [13].

However, prevalent diseases and the lack of affordable antibiotics have posed a challenge in maintaining the performance of certain chicken breeds [12]. In recent years the use of herbal medicine has increased in livestock production due to the side effects of modern drugs, the high input costs, toxic residues in food, and microbial resistance [15]. Due to these reasons, many countries have banned the use of antibiotics in livestock production [16]. The antibacterial effects of numerous medicinal plants have been demonstrated in many human laboratory experiments [17]. Herbal extracts have beneficial effects as they increase feed intake, improve digestibility, stimulate the immune system, and have anthelmintic properties [18]. *Phytolacca dodecandra* is one of the most commonly used herbal plants in Ethiopian traditional medicine for the treatment of liver and other diseases [19]. The plant has been used as a viable treatment for various diseases, such as malaria, rabies, ascariasis, and skin disorders, in many parts of Africa [20]. In Ethiopia, the local communities use the leaves of the *Phytolacca dodecandra* (Endod) plant to treat poultry diseases like diarrhea [21]. Given these, using locally available plants could benefit rural communities while decreasing reliance on synthetic antibiotics and other chemical additions. *Phytolacca dodecandra* is extensively found in Ethiopia, however, its usage in animal feed is infrequent and its effectiveness in poultry nutrition remains unexplored. Therefore, our study aims to investigate the effect of genotype and *Phytolacca dodecandra* (Endod) supplementation on growth performance, carcass traits, blood profiles, and breast meat quality of chickens.

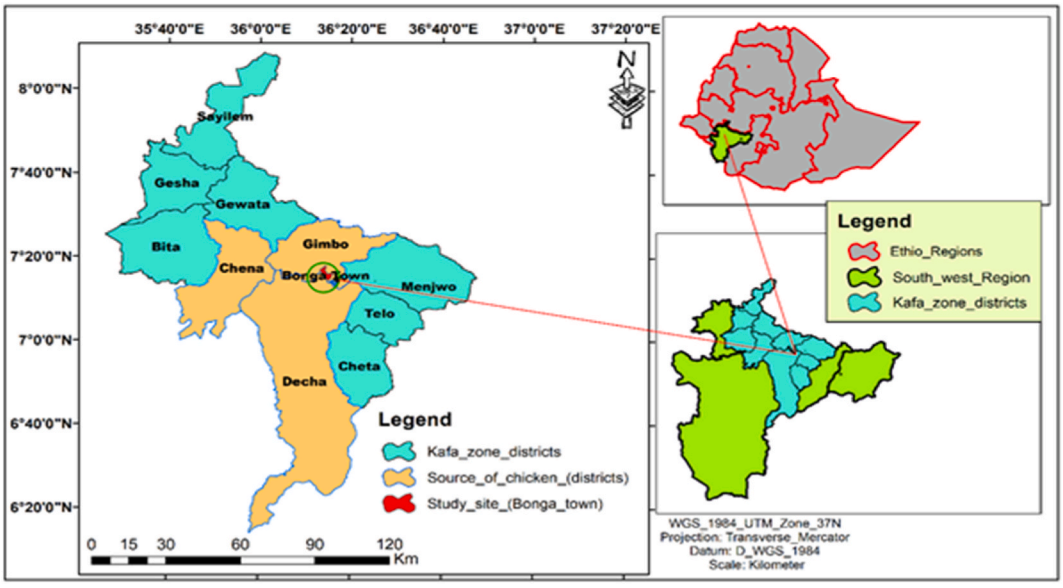

Fig. 1. Map of the study area.

2. Materials and methods

2.1. Description of the study area

The research was conducted in Kaffa Zone Bonga town, on a poultry shade located between 6°20′ to 8°0′ North latitude and 35°40′ to 37°0' East longitude in Southwest Region, Ethiopia (Fig. 1). Kaffa Zone is divided into twelve districts and four administrative towns and situated within an altitude ranging from 500 to 3000 m.a.s.l. The average annual temperature ranges from 10.1 °C to 27.5 °C. The annual rainfall varies from 1001 to 2200 mm [22].

2.2. Breeding stock and management

The base populations were 41 weeks of 108 Tetra H (*dam line*) and 18 cock (sire line; 6 from each genotype, namely; Tetra H, Naked-neck & Normal-feathered) were kept in the ratio of 1:6 to get better fertility and hatchability. The chickens were given a commercial layer ration with a nutritional composition of 17.3 % crude protein and 2856 kilocalories per kilogram of metabolizable energy [14] and managed under a deep litter system. Egg collection was started after four weeks of eggs laid by the flock to get well-fertilized eggs. Eggs were selected based on uniform size, shape, and cleanliness and stored in a cool room for 10 days. Before being set for hatching, the eggs were fumigated and the incubators were cleaned. The incubation process followed industry standards (Victoria Incubator of Italy) and was conducted at Bonga Poultry Production Center.

2.2.1. Genotypes

In the present study, the chicken genotypes used were the Naked-neck (male) mated with Tetra H (female) (NaT), Normal-feathered (male) mated with Tetra H (female) (NfT), and Tetra H (male) mated with Tetra H (female) (ThT).

2.2.2. Collection and preparation of Phytolacca dodecandra (endod) leave powder

Fresh and disease-free *Phytolacca dodecandra* (Endod) leaves were acquired from a nearby village (Bonga Mesqel adebabay). The leaves were carefully washed with clean drinking water before being laid out to dry on sheets for a week. Upon drying, the stems were removed and the leaves were crushed by hand and kept as stock for later grinding. Subsequently, all the dried leaves were ground into a fine granular powder using a coffee blender mill (Fig. 2).

Fig. 2. Preparation of *Phytolacca dodecandra* (Endod) leaf powder.

2.2.3. Chicks and management

A total of 360-day-old unsexed chicks were used in the study, with 120 chicks per genotype. The average weights of chicks from each genotype were 36.75 ± 0.237 g for ThT, 36.74 ± 0.244 g for NfT, and 36.75 ± 0.264 g for NaT. All the chicks were raised in a floor system with wood-shaving litter under identical management conditions. Initially, flat plastic feeders were used in each pen for feeding for the first two weeks, which were later replaced with bell-shaped feeders. Bell-shaped drinkers were used to supply water to the chicks during the entire study duration. The lighting schedule initially had a ratio of 23 h of light (L) to 1 h of darkness (D) during the first week, and then gradually decreased to a ratio of 16 h L to 8 h D for the remaining duration. During the first week, a light intensity between 40 and 50 lux (4–5 foot candles) was provided at chick level. While from the second week onward, the light intensity was gradually reduced to 20–30 lux (2–3 foot-candles) at chick level [23]. The immunization protocol includes vaccinations against Marek's, Newcastle, and Infectious Bursal (Gumborro) following the National Veterinary Institute (NVI) recommendations [24]. During the trial, birds had free access to water and feed. Feed was provided in crumbled form according to their growth phase (Table 1).

2.3. Experimental design and diets

A total of 360 chicks were divided randomly into nine groups with 40 chicks in each group, and each group was replicated four times with 10 chicks in each replicate. The arrangement was based on a 3 × 3 factorial design, comprising 3 genotypes: NaT, NfT, and ThT, and 3 levels of diets: control (basal diet); (C+1), basal diet plus 1 g/kg *Phytolacca dodecandra* (Endod); and (C+2), basal diet plus 2 g/kg *Phytolacca dodecandra* (Endod) supplementations (Table 1).

2.4. Chemical analysis of Phytolacca dodecandra leaf powder and breast meat

The dry matter (DM), crude protein, crude fat, crude fiber, ash, and the bioactive compounds of *Phytolacca dodecandra* (*Endod*) (Table 2), and breast meat samples were analyzed (Table 7). The bioactive compounds of *Phytolacca dodecandra* (Endod) were also examined at Jimma University College of Veterinary Medicine Nutrition Lab. The ME (Kcal/kg DM) content of the experimental rations was estimated indirectly using the equation, $ME\,Kcal = (9 * fat + 4 * carbohydrate + 4 * Protien)$, as stated by Ref. [25]. The percentage of carbohydrates was calculated using the equation; $\%Carbohydrate = (\%moisture + \%fat + \%protien + \%\,Ash)$, according to Ref. [26].

2.5. Performance variables

The chicks were weighed in a group as soon as they arrived using a sensitive balance (the initial weight), and then they were randomly distributed to the respective pens. The experimental phase was followed by weekly individual weighing for all experimental birds. The following formula was used to calculate the body weight [14].

$$\text{Body weight gain (g)} = \frac{\text{Final body weight (g)} - \text{Initial body weight (g)}}{\text{Experimental days}}$$

The difference between feed offered and feed refused was used to calculate feed intake. Throughout the study period, the measured amount of feed was supplied, and the next morning at 8:00 a.m., feed refusal was collected from each pen. From each pen, the feed that

Table 1
Compositions of nutrients in experimental diets and Phytolacca dodecandra (Endod).

Ingredients	Starter (0–8 weeks)			Grower (9–18 weeks)		
	C	C+1	C+2	C	C+1	C+2
	Compositions (%)					
Maize	40.6	40.6	40.6	45.93	45.93	45.93
Wheat middling	26.83	26.83	26.83	36.22	36.22	36.22
Noug cake	21.47	21.47	21.47	7.25	7.25	7.25
Meat and bone meal	9	9	9	8.5	8.5	8.5
Limestone	1	1	1	1	1	1
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Premix vitamin	0.5	0.5	0.5	0.5	0.5	0.5
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Methionine	0.05	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100	100
Phytolacca dodecandra	0	0.1	0.2	0	0.1	0.2
Calculated Nutrients						
Crude Protein (%)	19.04	19.06	19.08	16.25	16.27	16.29
ME in (Kcal/kg)	2873.2	2875.9	2878.7	2749.8	2749.9	2750.1

C, Control diet; C+1, control diet plus 1 g/kg *Phytolacca dodecandra* (Endod)*; C+2, control diet plus* 2 g/kg *Phytolacca dodecandra* (Endod) *supplementations; ME, Metabolizable energy. The rations were prepared at Bonga Poultry Production Center.*

Table 2
Proximate compositions and bioactive constituents of *Phytolacca dodecandra*.

Proximate	Percent
Dry Matter %	90.2
Crude Protein %	23.5
Crude Fat %	2.43
Crude Fiber %	8.29
Ash %	6.8
ME Kcal/kg	2818.9
Bioactive constituents (Mg/mL)	
Saponin	0.0939
Tannin	0.0837
Alkaloid	0.0837
Flavonoid	0.0838

was offered and refusal was noted. Following that, the feed intake was calculated using the formula provided by Ref. [27].

$$\text{Feed intake (g / b)} = \frac{\text{Feed offered (g)} - \text{Feed refused (g)}}{\text{Experimental days}}$$

The feed conversion ratio (FCR) was calculated by dividing feed intake by body weight gain [28].

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}}$$

2.5.1. Sample collection

At 18 weeks, following a 12-h (h) fasting period, blood samples were collected from the wing vein using 23Gx3/4′-gauge needles and 5 mL syringes from 72 chickens (8 chickens per group; 4 males and 4 females) that were specifically selected based on their weights, closely matching the average weight of the respective group. These chickens were then slaughtered for sample collection.

Chickens were slaughtered by cervical dislocation and bled, and the carcasses were manually de-feathered and eviscerated. After removing the blood and feathers, the dressed carcass weight was measured, and the dressing percentage was calculated by multiplying the proportion of dressed carcass weight to slaughter weight by 100 [29]. Carcasses were weighed, and carcass yield was calculated as % of BW at slaughter following the equations provided by Ref. [14]. Carcass cut-up parts, including breast, thing, drumstick, wings, back, and internal organs, were removed and weighed, and their relative weights were expressed as % of BW at slaughter following [30].

2.6. Blood collection and processing

Blood was collected for hematological studies using 21-gauge sterile disposable needles and 5 mL syringes from the wing vein. The specimens were collected in separate tubes. An anticoagulant, ethylenediaminetetraacetic acid (EDTA), was used during the collection process. Following necessary precautionary measures, the serum was subjected to centrifugation for 10 min at 2000 rpm at room temperature in the laboratory of Bonga Gebretsadik Shawo General Hospital. The separated serum was then dispatched to Jimma University Teaching Hospital for analysis.

2.7. Hematological parameters

The packed cell volume (PCV) was measured by a microhaematocrit capillary tube using a hematocrit reader. Erythrocyte concentration (RBC) and hemoglobin (Hb) were measured using an automated cell counter, while leucocyte concentration (WBC) was manually counted using a WBC counter within 24 h after the collection of blood at Bonga Gebretsadik Shawo General Hospital Laboratory. The mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were calculated (Jain, 1986). The formula used was MCV in femrolitres (fL) = 10 x PCV (%)/RBC counts (millions/μL). MCH in pg/cell = hemoglobin (g/100 mL)/RBC counts (millions/μL). MCHC in g/dL = hemoglobin (g/100 mL) x 100/PCV (%).

2.8. Serum biochemical parameters

The total protein (TP), albumin (Alb), total cholesterol (TC), triglycerides (TG), glucose (Glu), and calcium (Ca) were measured using an automated chemistry analyzer at Jimma University Teaching Hospital using a Blood Chemistry analyzer. The amount of globulin was determined by subtracting the total protein from albumin [31].

2.9. Breast meat proximate measurements

For proximate analysis, a total of 72 breast muscles were skinned and frozen at −20 °C awaiting further analysis, and sent to JU

Table 3
Effect of Genotype and *Phytolacca dodecandra* (Endod) supplementation on growth performance of chickens.

Item	Starter phase (0–8 weeks)						Grower phase (9–18 weeks)					Entire experiment (0–18 weeks)				
	IBW	**FI**	**FBW**	**BWC**	**ADG**	**FCR**	**FI**	**FBW**	**BWC**	**ADG**	**FCR**	**FI**	**FBW**	**BWC**	**ADG**	**FCR**
Genotype																
NaT	36.8	32.1	669.5	632.8	11.3	2.863	71.8	1704.5	1034.9	14.8	4.92	54.3	1704.5	1034.937	13.2	4.12
NfT	36.7	32.1	653.9	617.1	11.0	2.925	71.9	1667.0	1013.1	14.5	4.99	54.3	1667.0	1013.133	12.9	4.20
ThT	36.8	32.2	670.5	633.7	11.3	2.862	71.9	1700.4	1029.9	14.7	4.89	54.2	1700.4	1029.933	13.1	4.11
SEM	**0.025**	**0.019**	**14.7**	**14.7**	**0.262**	**0.068**	**0.321**	**17.4**	**9.15**	**0.131**	**0.041**	**0.009**	**17.4**	**20.8**	**0.138**	**0.042**
Diet																
C	36.8	32.1	659.4	622.7	11.1	2.908	71.9	1642.7^{b}	983.4^{b}	14.0^{b}	5.13^{a}	54.3	1621.9^{b}	983.4^{b}	12.7^{b}	4.27^{a}
C+1	36.7	32.1	683.3	646.5	11.5	2.796	71.9	1767^{a}	1083.7^{a}	15.5^{a}	4.66^{b}	54.2	1729.3^{a}	1083.7^{a}	13.7^{a}	3.96^{b}
C+2	36.7	32.1	651.2	614.4	10.9	2.946	71.8	1662.1^{b}	1010.9^{b}	14.4^{b}	5.01^{a}	54.2	1651.7^{b}	1010.9^{b}	12.9^{b}	4.22^{a}
SEM	**0.025**	**0.019**	**14.7**	**14.7**	**0.262**	**0.068**	**0.321**	**17.4**	**9.15**	**0.131**	**0.041**	**0.009**	**17.4**	**20.8**	**0.138**	**0.042**
Genotype*Diet																
C	36.8	32.3	682.6	645.7	11.5	2.82	71.9	1685.3^{bc}	1002.7^{cd}	14.3^{cd}	5.03^{b}	54.4	1685.3^{bc}	1002.8^{cd}	13.1^{bc}	4.15^{ab}
NaT C+1	36.7	32.3	669.8	633.1	11.3	2.88	71.9	1839.8^{a}	1169.9^{a}	16.7^{a}	4.31^{d}	54.3	1839.8^{a}	1169.9^{a}	14.3^{a}	3.81^{c}
C+2	36.7	32.3	656.3	619.5	11.1	2.93	71.9	1588.4^{c}	932.1^{d}	13.3^{d}	5.40^{a}	54.3	1588.4^{c}	932.1^{d}	12.3^{c}	4.41^{a}
C	36.7	32.1	649.4	612.7	10.9	2.94	71.9	1577.1^{c}	927.6^{d}	13.3^{d}	5.43^{a}	54.3	1577.1^{c}	927.6^{d}	12.2^{c}	4.44^{a}
NfT C+1	36.7	32	662.5	625.7	11.2	2.87	71.9	1686.7^{bc}	1024.2^{bc}	14.6^{bc}	4.91^{bc}	54.2	1686.7^{bc}	1024.2^{bc}	13.1^{bc}	4.14^{abc}
C+2	36.7	32.1	649.7	612.9	10.9	2.97	71.9	1737.3^{ab}	1087.6^{b}	15.5^{b}	4.63^{cd}	54.2	1737.3^{ab}	1087.6^{b}	13.5^{ab}	4.021^{bc}
C	36.7	32.2	646.3	609.5	10.9	2.97	71.9	1665.9^{bc}	1019.7^{bc}	14.6^{bc}	4.95^{bc}	54.3	1665.9^{bc}	1019.7^{bc}	12.9^{bc}	4.20^{ab}
C+1	36.7	32.2	717.5	680.7	12.2	2.66	71.9	1774.6^{ab}	1057.1^{bc}	15.1^{bc}	4.77^{bc}	54.3	1774.6^{ab}	1057.1^{bc}	13.8^{ab}	3.94^{bc}
ThT C+2	36.8	32.2	647.6	610.8	10.9	2.95	71.9	1660.6^{bc}	1013.0^{bc}	14.5^{bc}	4.98^{b}	54.3	1660.6^{bc}	1013.0^{bc}	12.9^{bc}	4.21^{ab}
SEM	**0.044**	**0.033**	**25.4**	**25.4**	**0.454**		**0.556**	**30.1**	**15.8**	**0.226**	**0.071**	**0.015**	**30.1**	**36.1**	**0.239**	**0.072**
P-*Value*																
Genotype	0.936	0.950	0.672	0.672	0.672	0.790	0.999	0.264	0.229	0.229	0.238	0.062	0.114	0.229	0.114	0.177
Diet	0.749	0.995	0.292	0.291	0.291	0.285	0.999	0.001	0.001	0.001	0.001	0.074	0.003	0.001	0.033	0.004
Genotype*Diet	0.439	1.000	0.526	0.527	0.527	0.608	1.000	0.001	0.001	0.001	0.001	0.599	0.001	0.001	0.006	0.001

[a-d] Means with different superscripts within a column differ ($P < 0.05$). Abbreviations: NaT, Naked-neck (male)xTetra H (female); NfT, Normal-feathered (male)x Tetra H (female); ThH; Tetra H (male) xTetra H (female); C = control diet; C+1, C plus Phytolacca dodecandra (Endod) supplementation with 1 g/kg; C+2, C plus Phytolacca dodecandra (Endod) supplementation with 2 g/kg; BWG = Body weight gain; FI = feed intake; FCR = feed conversion ratio; IBW, Initial body weight; FBW, Final body weight; ADG, Average daily gain; SEM = standard error of the mean.

Animal Nutrition Laboratory. Individual samples were thawed for 24 h, and minced through a 5 mm plate meat-grinding machine. Chemical composition analysis of minced meat samples was performed on a wet basis by proximate analysis to determine the DM, ash, crude protein, fat, and fiber contents. The dry matter of fresh samples was analyzed by the oven method set at 105 °C for 12 h. Ash was determined after subjecting the samples to a furnace set at 500°C. Protein was analyzed by the Kjeldahl method and Fat contents were analyzed by the Soxhlet method.

2.10. Statistical analysis

The R General linear model was used to analyze the data and the Tukey STD range test was employed to compare means and a Two-way Analysis of Variance was employed to assess differences between the response variables at ($P < 0.05$) significant level. Before the analysis, data were checked for normality using the Shapiro test.

The data analysis model was as follows:

$$Yijk = \mu + Gi + Dj + (G * D)ij + eijk$$

Where Yijk = represents dependent variables; μ = overall mean; Gi = genotype effect (NaT, NfT & ThT); Dj = effect of diet (C, control/basal diet, C+1, basal diet + 1 g/kg *Phytolacca dodecandra* (Endod), and C+2 basal diet + 2 g/kg *Phytolacca dodecandra* (Endod); (G * D) ij interaction between genotype and diet; and eijk = random error.

3. Results

3.1. Growth performances

The effects of genotype and diet on the chicks' growth performance traits are shown in Table 3. The results indicated that diet and genotype by diet interactions had a significant ($P < 0.05$) effect on the performance traits during the grower and entire growth period, while genotype had no significant ($P > 0.05$) effects. In this study, the diet had a significant effect on the performance measures final body weight (FBW), body weight change (BWC), average daily gain (ADG), and feed conversion ratio (FCR) during the grower and entire phase ($P < 0.05$). The FBW, BWC, ADG, and FCR significantly differ ($P < 0.05$) among the supplemental diets during the grower and entire phase with C+1 having the highest values compared to the others. Supplementing the C+1 diet significantly improved ($P < 0.05$) chicks' performance; during the grower and entire growth phases, FBW, BWC, and ADG significantly ($P < 0.05$) increased while

Table 4
Effect of Genotype and *Phytolacca dodecandra* (Endod) supplementation on carcass traits of chickens.

Parameters (%BW)											
Item	**DRP**	**BRM**	**THM**	**DSM**	**KBM**	**BKM**	**WNM**	**NKM**	**GZM**	**LVM**	**HTM**
Genotype											
NaT	71.6[a]	14.7[a]	11.7[a]	9.7	7.68[a]	7.3	2.69	3.24	2.463[ab]	1.75	0.477
NfT	70.1[b]	13.8[b]	10.8[b]	9.6	7.29[b]	7.6	2.44	3.22	2.223[b]	1.76	0.496
ThT	72.0[a]	14.8[a]	11.6[a]	9.5	7.55[ab]	7.5	2.46	3.23	2.474[a]	1.80	0.483
SEM	**0.119**	**0.155**	**0.087**	**0.127**	**0.065**	**0.079**	**0.047**	**0.026**	**0.041**	**0.032**	**0.008**
Diet											
C	70.1[b]	13.9[b]	11.6	9.33	7.39	7.48	2.42	3.20	2.54	1.88	0.493
C+1	71.8[a]	14.7[a]	11.7	9.92	7.62	7.55	2.59	3.25	2.32	1.73	0.466
C+2	71.9[a]	14.7[a]	11.8	9.62	7.64	7.32	2.58	3.24	2.40	1.70	0.496
SEM	**0.207**	**0.269**	**0.150**	**0.221**	**0.113**	**0.137**	**0.081**	**0.046**	**0.070**	**0.055**	**0.013**
Genotype * Diet											
C	70.836	12.982	11.3	9.17	7.354	7.26	2.56	3.19	2.43	1.73	0.510
NaT C+1	70.922	13.646	11.6	10.2	7.575	7.62	2.83	3.23	2.46	1.84	0.455
C+2	70.349	14.361	11.9	9.84	7.956	7.15	2.68	3.28	2.66	1.69	0.465
C	69.963	12.246	11.8	9.49	7.402	7.69	2.22	3.25	2.67	2.06	0.509
NfT C+1	69.819	13.805	11.9	9.97	7.482	7.86	2.54	3.23	2.08	1.57	0.463
C+2	69.966	14.198	11.7	9.22	7.304	7.09	2.57	3.19	2.09	1.65	0.516
C	70.875	13.386	11.5	9.34	7.425	7.49	2.47	3.16	2.51	1.86	0.460
ThT C+1	70.916	13.253	11.5	9.58	7.814	7.18	2.42	3.29	2.42	1.79	0.482
C+2	70.561	13.492	11.5	9.81	7.666	7.71	2.49	3.24	2.45	1.77	0.506
SEM	**0.358**	**0.466**	**0.260**	**0.382**	**0.195**	**0.237**	**0.140**	**0.079**	**0.122**	**0.095**	**0.023**
p-*value*											
Genotype	0.0095	0.0173	0.0003	0.0376	0.0475	0.2630	0.0577	0.5238	0.0250	0.3235	0.6614
Diet	0.0071	0.003	0.7798	0.1775	0.3209	0.3098	0.2912	0.6625	0.1095	0.2546	0.3058
Genotype*Diet	0.8771	0.2809	0.6760	0.2711	0.3910	0.0516	0.6447	0.3151	0.0521	0.2547	0.3740

[a] Means with different superscripts within a column differ (P < 0.05). Abbreviations: NaT, Naked-neck (male) * Tetra H (female); NfT, Normal-feathered (male) * Tetra H (female); ThH; Tetra H (male) *Tetra H (female); C = control diet; C+1, C plus Phytolacca dodecandra (Endod) supplementation with 1 g/kg; C+2, C plus Phytolacca dodecandra (Endod) supplementation with 2 g/kg; BW = Body weight; DRP = Dressing percentage; BRM, Breast muscle; THM, Thigh muscle; DSM, Drumstick muscle; KBM, Keel bone muscle; BKM, Back muscle; WNM, Wing muscle; NKM, neck muscle; GZM, Gizzard muscle; LVM, Liver muscle; HTM, Heart muscle; SEM, Standard error of the mean.

FCR was significantly ($P < 0.05$) reduced. On the other hand, genotype by diet interactions were found to have a significant ($P < 0.05$) effect on the performance parameters during the grower and the entire experimental period.

3.2. Carcass traits

Table 4 shows the effect of genotype and diet on carcass characteristics of chickens slaughtered at 18 weeks of age. In the present study, genotype and diet had a significant ($P < 0.05$) effect on the dressing percentage ($P < 0.05$). Genotype had a significant effect on breast yield, thigh, keel bone muscle, and gizzard ($P < 0.05$). The results of dressing percentage were significantly ($P < 0.05$) varied among the genetic group of chickens with lower values recorded in the NfT chicken genotype than the other. The values of thigh muscle in the current study denote lower values observed in the NfT than the other chicken genotypes. The keel bone muscle value in this study showed that the NaT and ThT chicken genotypes had significantly ($P < 0.05$) higher values than the NfT chicken. The values of gizzard in the current study demonstrated that the NfT chicken genotype had a significantly ($P < 0.05$) lower value than the other chicken genotypes. However, diet and genotype by diet interaction had no significant ($P > 0.05$) effects on the carcass components.

3.2.1. Serum biochemical profiles

Table 5 presents the effect of genotype and diet on the chickens' serum biochemical profiles. The study found that genotype had a significant ($P < 0.01$) impact on TP, Alb, Glo, TC, TG, and Glu levels. The NaT genotype had higher TP and Alb levels compared to other genotypes, while the ThT genotype had higher TC and TG levels. The Glu level was higher in NaT and NfT genotypes than in the ThT genotype. Ca levels were lower in the NfT genotype. Dietary treatments also had a significant ($P < 0.01$) impact on serum biochemical profiles. The C+1 and C+2 diets resulted in higher TP, Alb, and Glo levels than the C diet. Furthermore, supplementation of chicken with C+1 and C+2 significantly ($P < 0.01$) reduced TC, TG, and Glu levels, but did not affect Ca levels. The study also found that interactions between genotype and diet had a significant ($P < 0.01$) impact on the chickens' serum biochemical profiles.

3.3. Hematological parameters

Table 6 displays that only RBC, Hb, and PCV were notably impacted ($P < 0.05$) by the addition of *Phytolacca dodecandra* (Endod) in the diet, with higher values observed in C+1 and C+2 than the C. The other hematological parameters remained consistent among the genotypes and diets.

Table 5
Effect of genotype and *Phytolacca dodecandra* (Endod) supplementation on serum biochemical profiles of chickens.

Item	Serum biochemical profiles						
	TP	Alb	Glo	TC	TG	Glu	Ca
Genotype							
NaT	3.420^{a}	0.824^{a}	2.596^{a}	133.0^{b}	52.2^{b}	297.8^{a}	10.3^{a}
NfT	2.962^{b} 0.0236035	0.664^{b}	2.298^{b}	137.3^{ab}	46.2^{b}	301.6^{a}	9.49^{b}
ThT	2.081^{c}	0.628^{c}	1.453^{c}	138.2^{a}	107.3^{a}	205.6^{b}	10.4^{a}
SEM	0.004	0.003	0.004	0.556	1.064	1.102	0.049
Diet							
C	2.633^{c}	0.655^{c}	1.978^{c}	151.5^{a}	81.1^{a}	280.3^{a}	10.2
C+1	2.831^{b}	0.700^{b}	2.131^{b}	130.6^{b}	69.9^{b}	266.7^{b}	9.99
C+2	2.998^{a}	0.761^{a}	2.238^{a}	126.4^{c}	54.7^{c}	258.1^{c}	10.0
SEM	0.073	0.012	0.064	0.964	1.843	5.88	0.076
Genotype * Diet							
C	3.22^{b}	0.720^{c}	2.498^{b}	171.3^{a}	64.0^{b}	307.3^{a}	10.2^{bc}
NaT C+1	3.08^{c}	0.838^{b}	2.243^{cd}	107.5^{f}	58.0^{bc}	268.7^{b}	10.4^{b}
C+2	3.96^{a}	0.915^{a}	3.048^{a}	120.3^{e}	34.5^{de}	317.8^{a}	10.1^{bc}
C	2.85^{e}	0.658^{e}	2.193^{d}	165.5^{cd}	69.3^{b}	318.3^{a}	9.23^{cd}
NfT C+1	3.12^{c}	0.675^{de}	2.440^{b}	135.0^{cd}	48.3^{cd}	303.4^{a}	9.53^{cd}
C+2	2.92^{d}	0.660^{e}	2.260^{c}	147.5^{bc}	21.0^{e}	283.3^{b}	9.73^{bc}
C	1.83^{h}	0.588^{f}	1.245^{g}	141.8^{b}	110.0^{a}	215.5^{c}	11.1^{a}
ThT C+1	2.29^{f}	0.587^{f}	1.710^{e}	133.0^{cd}	103.5^{a}	228.2^{c}	10.0^{b}
C+2	2.11^{g}	0.708^{cd}	1.405^{f}	123.5^{d}	108.5^{a}	173.3^{d}	10.2^{b}
SEM	**0.013**	**0.008**	**0.013**	**1.669**	**3.191**	**3.306**	**0.146**
P-*value*							
Genotype	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Diet	0.001	0.001	0.001	0.001	0.001	0.001	0.221
Genotype*Diet	0.001	0.001	0.001	0.001	0.008	0.001	0. 001

$^{a-h}$ Means with different superscripts within a column differ (P < 0.05). Abbreviations: NaT, Naked-neck (male) * Tetra H (female); NfT, Normal-feathered (male) * Tetra H (female); ThH; Tetra H (male) *Tetra H (female); C = control diet; C+1, C plus Phytolacca dodecandra (Endod) supplementation with 1 g/kg; C+2, C plus Phytolacca dodecandra (Endod) supplementation with 2 g/kg; TP, Total protein; Alb, Albumin; Glo, Globulin; TC, Total cholesterol; TG, Triglycerides'; Glu, Glucose; Ca, Calcium; SEM, Standard error of the mean.

Table 6
Effect of genotype and *Phytolacca dodecandra (Endod)* supplementation on hematology of chickens.

Item	Hematology						
	WBC	Hb	RBC	PCV	MCV	MCH	MCHC
Genotype							
NaT	21.5	10.1	2.992	29.9	100.7	34.9	34.8
NfT	21.7	10.2	2.948	28.6	97.6	36.7	37.9
ThT	22.6	10.4	2.894	30.8	108.2	38.6	35.4
SEM	0.932	0.327	0.088	0.630	3.977	1.830	1.108
Diet							
C	21.2	9.4^{b}	2.77^{b}	28.2^{b}	102.9	37.8	36.8
C+1	23.1	10.5^{ab}	3.163^{a}	31.4^{a}	99.5	34.8	35.1
C+2	21.6	10.8^{a}	2.90^{ab}	29.8^{ab}	104.1	37.6	36.1
SEM	0.932	0.327	0.088	0.630	3.977	1.830	1.108
Genotype * Diet							
C	19.4	9.45	2.760	28.6	104.6	37.1	35.5
NaT C+1	22.2	10.5	3.250	30	92.8	32.4	35.2
C+2	23.0	10.4	2.967	31	104.5	35.2	33.7
C	21.6	9.50	2.825	26.5	94.1	36.9	39.8
NfT C+1	21.4	10.4	3.125	31	99.5	35.7	35.8
C+2	22.1	10.8	2.895	28.5	99.3	37.4	37.9
C	22.4	9.5	2.730	29.4	109.9	39.4	35.2
ThT C+1	25.5	10.7	3.113	33.1	106.1	36.4	34.2
C+2	19.8	11.1	2.840	30.1	108.5	40.1	36.9
SEM	1.614	0.566	0.153	1.091	6.888	3.169	1.918
P-*value*							
Genotype	0.688	0.7509	0.7349	0.065	0.1758	0.359	0.1344
Diet	0.345	0.0142	0.0133	0.005	0.6975	0.451	0.5357
Genotype*Diet	0.175	0.9874	0.9794	0.350	0.7800	0.982	0.6657

[a-h] Means with different superscripts within a column differ ($P < 0.05$). Abbreviations: NaT, Naked-neck (male) * Tetra H (female); NfT, Normal-feathered (male) * Tetra H (female); ThH; Tetra H (male) *Tetra H (female); C = control diet; C+1, C plus Phytolacca dodecandra (Endod) supplementation with 1 g/kg; C+2, C plus Phytolacca dodecandra (Endod) supplementation with 2 g/kg; WBC, White blood cells; Hb, Hemoglobin; RBC, Red blood cells; PCV, Packed cell volume; MCV, Mean corpuscular volume; MCH, Mean corpuscular hemoglobin; MCHC, Mean corpuscular hemoglobin concentration; SEM, Standard error of the mean.

3.4. Proximate compositions of breast meat

In this study, it was observed that the levels of crude protein and fat in breast meat varied significantly ($P < 0.05$) among different chicken genotypes (Table 7). The exotic ThT genotype displayed comparatively lower values as compared to the other genotypes. Furthermore, administering *Phytolacca dodecandra* to chicken genotypes resulted in increased crude protein and decreased fat contents of breast meat compared to the control group.

4. Discussion

4.1. Growth performances

The use of medicinal plants in animal feeds has gained much attention in recent years due to its potential to enhance growth performances [32]. The active components present in *Phytolacca dodecandra*, also known as *Phytolacca dodecandra* (Endod) or Ethiopian soapberry, have various physiological and biochemical functions in the body [33]. According to the findings presented in Table 2, the plant being studied in the current investigation contains a range of bioactive compounds such as saponins, tannins, flavonoids, and alkaloids, which is in agreement with the results reported by Ref. [33]. Our study indicates that both diet and genotype * diet interactions significantly affect the growth performance of chicks. Consequently, the C+1 diet demonstrated significant improvements in terms of final body weight (FBW), body weight change (BWC), average daily gain (ADG), and feed conversion ratio (FCR) compared to the C+2 and C diets throughout the grower phase and the entire experimental period.

In agreement with this, several authors indicated that supplementation of medicinal plants significantly improved the performance traits of chickens [34–36]. One study found that including herbs such as oregano and thyme in the diet of broiler chickens improved their growth performance, including body weight gain and feed efficiency [37]. These herbs have been shown to have antibacterial and antifungal properties, which can help prevent infections and improve gut health [38]. Similarly, the use of herbal plants Azadirachta indica and Moringa oliefera leaf powder as feed additives has also been shown to improve growth performance in broiler chickens [39]. Likewise, a study [40] reported that peppermint supplementation at the rate of 1.5 % significantly improved the growth performance traits of broiler chickens. The current research discovered that *Phytolacca dodecandra* (Endod) significantly improved the growth performance of chickens and this might be due to the presence of a bioactive component (*i.e.* saponin). In line with this, previous studies have shown that saponins can enhance the secretion of digestive enzymes and promote gut health, thereby improving the absorption of nutrients in poultry [41].

Table 7
Effect of genotype and *Phytolacca dodecandra (Endod)* supplementation on breast meat of quality of chickens.

Item	Nutrient compositions				
	DM	CP	Cf	Fiber	Ash
Genotype					
NaT	27.5	23.6[a]	7.29	6.56	1.557
NfT	27.4	23.1[b]	7.27	6.42	1.560
ThT	27.4	22.9[b]	7.37	6.23	1.520
SEM	0.107	0.069	0.064	0.209	0.021
Diet					
C	27.6	22.8[c]	7.48[a]	6.42	1.541
C+1	27.5	23.2[b]	7.25[b]	6.40	1.545
C+2	27.2	23.7[a]	7.21[b]	6.38	1.552
SEM	0.107	0.070	0.063	0.209	0.021
Genotype * Diet					
C	27.7[ab]	23.3[b]	6.65[d]	6.36	1.623
NaT C+1	27.1[b]	24.2[a]	7.49[bc]	6.33	1.497
C+2	27.5[ab]	23.4[b]	7.74[ab]	6.98	1.553
C	27.5[ab]	22.6[c]	8.16[a]	6.40	1.510
NfT C+1	28.0[a]	22.6[c]	6.99[cd]	6.58	1.555
C+2	26.9[b]	24.2[a]	6.66[d]	6.28	1.615
C	27.5[ab]	22.6[c]	7.65[ab]	6.49	1.490
ThT C+1	27.4[ab]	22.9[bc]	7.25[bc]	6.31	1.583
C+2	27.3[ab]	23.4[b]	7.23[bc]	5.88	1.488
SEM	0.186	0.121	0.109	0.363	0.036
P-*value*					
Genotype	0.939	0.001	0.491	0.548	0.330
Diet	0.099	0.001	0.010	0.993	0.934
Genotype*Diet	0.003	0.001	0.001	0.438	0.170

[a-c] Means with different superscripts within a column differ ($P < 0.05$). Abbreviations: NaT, Naked-neck (male) * Tetra H (female); NfT, Normal-feathered (male) * Tetra H (female); ThH; Tetra H (male) *Tetra H (female); C = control diet; C+1, C plus Phytolacca dodecandra (Endod) supplementation with 1 g/kg; C+2, C plus Phytolacca dodecandra (Endod) supplementation with 2 g/kg; DM, dry matter; CP, Crude protein; CF, crude fiber; ME, Metabolizable energy.

4.2. Carcass traits

In the present study, the dressing percentage, breast, thigh, and keel bone muscle, and gizzard were significantly influenced by genotype among the chicken genetic groups. The NfT genotype displayed lower values when compared to the other groups. Moreover, the diet was found to have a significant effect on the dressing percentage and breast muscle, with higher values observed in the supplemented group compared to the control. The results of this study agree with previous studies on the effect of medicinal plants on carcass yield, as reported by [39,42,43]. These studies found that supplementing the broiler chickens' diets with medicinal plants led to a significant increase in dressing percentages than the non-supplemented. Likewise [44], reported that broiler chickens that were fed diets containing 1 % garlic powder and 0.9g/kg-1 probiotics showed a significant increase in the weights of the carcass, heart, gizzard, spleen, abdominal fat, and liver. However, in contrast to the findings of [45], who observed significant changes in the weights of heart, liver, and gizzard in broiler chickens fed with 2.5, 5, and 7.5 kg/ton garlic powder, the present study did not detect any substantial variations in the organs among the supplementation of *Phytolacca dodecandra*.

4.3. Serum biochemical profiles

Several studies [46–48] have shown that genotype, sex, nutrition, management, and stress are among the factors that can influence the blood biochemical parameters in chickens. Blood metabolites such as total cholesterol, concentrations of triglycerides, glucose, and proteins are important indicators that are directly linked to their health [49]. The normal cholesterol range for chickens is reported to be between 87 and 192 mg/mL according to Ref. [50]. Our study found that the blood cholesterol level in chicken genotypes ranged from 133 to 138.2 mg/dl, with the NaT and NfT genotypes showing lower values than the ThT genotype. Higher cholesterol levels may increase the risk of developing cardiovascular disease [51]. Our study suggests that crossing indigenous normal-feathered and naked-neck chicken genotypes with the exotic Tetra H chicken genotype significantly reduced cholesterol and triglycerides compared to the pure Tetra H chicken genotype.

In the present study, the ThT chicken genotype had significantly higher values of TC and TG compared to the other genotypes. Consistent with this study, the results reported by Ref. [52] explained that the exotic Kuroiler chicken genotype had higher values of TC and TG compared to the indigenous normal feathered, naked neck and their crossbreds. Our results showed that total protein concentration varied among the genotypes with lower values observed in the exotic ThT than in the other chicken genotypes. Consistent with this [30], observed that the R genotype displayed the highest Alb value in comparison to other genotypes. Based on [53] findings, an increase in the overall amount of proteins in the plasma indicates the essential role of globulin in enhancing the immune system.

The serum protein levels of birds are considered important indicators for the determination of their health status [54]. The current

results showed that the inclusion of *Phytolacca dodecandra* significantly increased the levels of TP, albumin, and globulin compared to the control group. In addition, TP, albumin, and globulin showed linear increases with increasing supplementation of *Phytolacca dodecandra*. The present study results are in the same scenario as the results of [55], who noted higher serum TP, Alb, and Glo levels were observed with broilers fed *Persicaria odorata* Leaf Meal. The incorporation of varying levels of *Phytolacca dodecandra* into the chicken feed resulted in a considerable enhancement in the plasma levels of total protein, albumin, and globulin as compared to the control group. In line with this, a study conducted by Ref. [56] found that the inclusion of garlic supplements in the diet of chicken resulted in a significant improvement in TP, Alb, and lipid profile. Similarly [55], observed that supplementation of *Persicaria odorata* Leaf Meal linearly increased the serum levels of TP, Alb, and globulin. According to the findings of the current study, the reduction of blood cholesterol and triglyceride levels resulted from the addition of *Phytolacca dodecandra* in the diet of chicken genotypes, which is in line with the results reported by Ref. [57] who observed similar effects upon the inclusion of ginger powder in the diet of broiler chicken. Similarly, in agreement with our current study, the trends of serum total protein and globulin were reported by Ref. [58] for broilers fed with anise and thyme essential oils. Moreover, the inclusion of dietary fermented garlic powder led to a significant increase in serum levels of total protein and albumin, while cholesterol and triglyceride concentrations were significantly reduced [59]. Similarly [60], reported a significant reduction in cholesterol and triglyceride levels when garlic powder was added to the diet of broiler chicken.

4.4. Hematology parameters

Blood tests can be used to evaluate physiological and pathological conditions in organisms [61]. In this particular study, hematological blood indicators fell within the normal range [62], indicating that chickens supplemented with *Phytolacca dodecandra* had sufficient nutrients and improved immune status. However, variations in hemoglobin (Hb), red blood cell (RBC), and packed cell volume (PCV) values were observed among dietary treatments, with higher values in chickens supplemented with *Phytolacca dodecandra* compared to the control group. These findings align with previous studies [46]; reported that the inclusion of black seed resulted in a significant increase in Hb, RBC, and PCV counts, while [63] found that chickens supplemented with up to 2.5 g/kg of dried leaf meal from *Azadirachta indica* led to higher PCV, RBC, and Hb levels. According to Ref. [64], chickens fed a diet containing 200 mg/kg of rosemary exhibited improved PCV levels, and supplementing the chicken with both rosemary and garlic increased Hb concentrations compared to the control diet.

4.5. Proximate compositions of breast meat

In the present study, variations were observed in the level of crude protein and dry matter in breast meat of chicken genotypes, with exotic ThT genotypes showing lower values compared to other genotypes. These findings agree with a prior study by Ref. [65] which found higher levels of crude protein in indigenous chicken compared to the other genotypes. Similarly [66], reported that the crude protein content in high breast yield (HBY) and standard breast yield (SBY) hybrid chicken were 22.82 and 23.48, respectively, which were consistent with the present study. In our study, it was observed that the supplementation of *Phytolacca dodecandra* at C+2 and C+1 groups exhibited protein contents of 23.7 % and 23.2 %, respectively, which were higher than the control group's protein content of 22.8 %. In line with this study [67], reported that the inclusion of Ajwain seed powder in the diet of broiler chicken led to a significant increase in crude protein in the breast meat compared to the control group. According to the research conducted by Ref. [68], the inclusion of medicinal plants, such as black pepper, as a supplementary diet for broiler chickens had a remarkable effect on improving the protein levels in their breast meat. The study revealed that the addition of black pepper (24 g/100 g) to the diet of broilers increased protein content. The impact of supplementing fermented *Salicornia herbacea* L. (FSH2), a medicinal plant, on meat quality of chickens was examined by Ref. [69]. According to the findings, FSH2 significantly improved the protein content (increased from 21.98 % to 22.98 %) and resulted in a reduction in fat content (decreased from 4.08 % to 3.38 %) of the breast meat of broiler chicken. Consistent to these findings, addition of garlic powder, black pepper powder, red pepper powder, and a combination of all three powders led to a significant rise in the crude protein levels in breast meat, while simultaneously decreasing the fat levels compared to control [70]. Likewise, in a study by Ref. [67], chickens that were given dietary supplements comprising of the garlic bulb and husk exhibited a significant increase in protein content of thigh muscles while simultaneously showing a decline in fat content compared to chickens that were not given any supplements.

5. Conclusion

In general, the study showed that supplementing chicken feed with *Phytolacca dodecandra* (Endod) at 1 g/kg can improve growth performance, carcass traits, and blood profiles of chickens. The study also found that genotype by diet interactions significantly affected performance parameters, with the NaT genotype showing better results. Furthermore, blood parameters were significantly influenced by genotype, diet, and their interaction, with supplementation increasing protein levels and reducing cholesterol and triglyceride levels in the blood. Overall, the results suggest that *Phytolacca dodecandra* (Endod) supplementation can have a significantly positive impact on chicken health and performance.

Ethical statement

All procedures were approved by the College of Veterinary Medicine and Agriculture, Addis Ababa University Ethical Review

Committee with certificate Ref. No: VM/ERC/02/01/14/2022.

Data availability

Data will be made available on request.

CRediT authorship contribution statement

Abiyu Tadele: Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Gebreyohannes Berhane:** Writing – review & editing, Visualization, Validation, Supervision. **Wondmeneh Esatu:** Writing – review & editing, Visualization, Validation, Supervision. **Fikerte Kebede:** Writing – review & editing, Visualization, Validation, Supervision. **Teketay Wassie:** Writing – review & editing, Visualization, Validation, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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