EFFECT OF DIET FORM AND COMPOSITION ON BLOOD PARAMETERS, INTESTINAL HISTOMORPHOMETRY, AND TIBIA PHYSICAL TRAITS OF BROILER CHICKENS

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SUMMARY

This study investigates the effects of different diet forms and compositions on the blood parameters, intestinal histomorphometry and tibia traits of broiler chickens. A total of 180 one-day-old broiler chicks of the Indian River strain were used, with six treatments arranged in a 3x2 factorial design: three diet programs (P1, P2, P3) and two diet forms (S1: crumble/pellet, S2: crumble). Over five-weeks, blood parameters, intestinal samples and tibia traits were analyzed. Results indicated that diet form and composition significantly influenced blood parameters, intestinal morphology and tibia traits. Meanwhile, serum total protein, albumin, globulin, AST, creatinine, and uric acid showed no significant differences across diet programs. Total cholesterol was significantly higher in chicks fed p1 compared to P2 and P3. No significant differences were observed in villus height, width, or crypt depth between the diet programs or feed forms. However, p1 resulted in the lowest number of goblet cells compared to P2 and P3. All tibia bone measurements were not significantly affected by different treatments except tibia breaking strength.

In conclusion, blood parameters, intestinal histomorphology and tibia bone were not significantly affected by different feed programs, fed forms and their interaction except for total cholesterol, goblet cells number and tibia breaking strength.

Keywords: *intestinal histomorphometry, blood parameters, tibia traits, broilers, feed program and composition.*

INTRODUCTION

Optimizing feed form and composition is crucial for enhancing the growth performance and health status of broiler chicks. The physical form of feed, whether pelleted or mashed, and nutrient composition, particularly protein levels, can significantly impact nutrient digestibility, feed intake, and overall metabolic processes in broilers (Kamran *et al.*, 2010).

Poultry feed formulations combine different ingredients to meet the nutrient and energy requirements of birds for production. Given that feed costs represent about 70% of the total production cost, with energy costs accounting for two-thirds of the feed cost, it is essential to properly evaluate the energy content of ingredients to optimize formulations (Kamran *et al.*, 2004).

Previous studies have shown mixed results regarding the performance of broilers on low-crude protein (CP) diets, with some trials reporting poor performance compared to those receiving adequate amino acids (Berres *et al.*, 2010), while others found no significant effect on performance (Widyaratne and Drew, 2011). The physical form of feed also affects blood parameters, with broilers fed pellets often showing higher hematocrit and hemoglobin concentrations than those fed mash (Abadi *et al.*, 2019). Additionally, the physical form of feed influences meat yield, with mash diets providing uniform growth, less mortality, and greater economic benefits, though they are less palatable and nutritionally stable than pelleted feed (Zohair *et al.*, 2012). It is generally accepted that feeding pellets, compared to mash,

improves the growth rate of broilers while increasing feed intake (Pirzado *et al.*, 2015; Loar and Corzo, 2011).

High crude protein (CP) diets can increase blood protein levels, enhancing growth rate, carcass quality, and disease resistance, but may also raise feed costs, water consumption, and the risk of kidney damage. Therefore, it is important to find the optimal CP level to maximize benefits while minimizing risks (Rezaei *et al.*, 2004). Studies on the effects of CP levels on blood parameters have shown varied results, often dependent on the presence of additives and other dietary factors (Abadi *et al.*, 2019). The efficiency of dietary protein utilization in poultry is influenced by gastrointestinal tract features, particularly the crypts and villi in the small intestine, which are crucial for nutrient digestion and absorption (Swatson *et al.*, 2002). Intestinal development can be assessed by measuring crypt and villus morphology, which can be affected by diet type (Wang and Peng, 2008). However, there is limited research linking dietary nutrients, especially protein, to gastrointestinal development in poultry. Morphological changes of the intestinal villi in broilers are dependent on the presence of digested nutrients in the small intestinal lumen (Yamauchi, 2002). Some studies have reported that protein-free diets slow down histological recovery after feed withdrawal (Maneewan and Yamauchi, 2003), while others have found that long-term feeding of low-CP diets can induce histological alterations in the ileal villi (Buwjoom *et al.*, 2010).

On the other hand, the high incidence of leg abnormalities and poor performance observed in the broiler chicks could be explained by low dietary protein levels used (Rodrigues- Ortega *et al.*, 2023). Additionally, Bruno *et al.*, (2017) observed that broiler chicks fed 18.5% CP and 3200 Kcal/Kg of diet had lower femur width and humerus weight than broilers from the control group (22%CP and 2950 Kcal/Kg) of diet and concluded that when broilers are fed varying concentration of CP and ME in the diet, it is possible to modulate the deposition of bone collagenous proteins and structure of organic components.

This study aims to investigate the effects of different feed forms and compositions on tibia physical traits, blood parameters, and intestinal histomorphometry in broiler chicks, addressing the gap in understanding the relationship between diet and gastrointestinal development.

MATERIALS AND METHODS

The present study was carried out at the Poultry Nutrition Farm and Poultry Feed Quality Control Laboratory, Poultry Production Department, Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Qalyobia, Egypt, to investigate the effect of feed shape and feed program and their interactions on broilers performance until 35 days of age. The study was performed during the summer period from June to July 2020.

Experimental design:

A total of 180 one-day-old broiler chicks of the Indian River strain were used for the experiment with 6 treatments, 30 chicks each in 3 replicates of ten chicks. A factorial design "(3x2) was used, with three program diets (P1-3), P1 (24%, 23%, 21%, 20%, 19%), P2 (32%, 21%, 20%, 19%) and P3 (21%, 20%, 19%) crude protein; two feed forms (S1-2), S1 (crumble /pellet) and S2 (crumble) diets; and their interaction [T1 (P1S1), T2 (P1S2) T3 (P2S1), T4 (P2S2), T5 (P3S1) and T6 (P3S2)] as presented in Table (1 and 2).

Chicks were reared in electrics heated batteries under similar conditions of management during the experimental period, 35days of age. Excreta were removed on a daily-basis regimen to insure keeping all birds under optimum managerial, hygienic, and environmental conditions throughout the entire experimental period. All birds were vaccinated by drinking-water-based vaccination against Newcastle at the age of 7 days, against Gambaro at 14 days and Lasota twice at 18 and 28 days. All vaccines were obtained from Veterinary Serum & Vaccine Research Institute Egypt.

Blood serum parameters:

At the end of the study, after 12 hours of fasting, two blood samples were taken from 2 chicks per replicate (10 birds per treatment) by puncturing the brachial vein to measure some blood parameters.

The first sample was collected in a tube without any anticoagulant, centrifuged (2000 rpm for 10 minutes), and the serum was then decanted into Eppendorf tubes and stored at -20°C for later analysis

until antioxidant determination was done. The second sample was collected in a non-heparinized tube, and the blood was centrifuged 30 minutes later to extract serum, which was then refrigerated at -20℃ for subsequent examination.

Blood serum analysis:

Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) in serum were measured by an automated system (7600 analyzer, Hitachi High Technologies Co., Tokyo, Japan) with commercial kits following manufacturer guidelines (Nanjing Jiancheng Bioengineering Institute, Nanjing, China) Woodhead (1990).

Table (1). Experimental design and description of different treatments.

Programs (P)	Shapes (S)	Treatments (T)	Crude Protein %	Days	Size (mm)	Form
P1	S1	T1	24.00	1-7	1.5	Crumbles
			23.00	8-14	1.5	Crumbles
			21.00	15-21	2.5	Pellets
			20.00	22-28	2.5	Pellets
			19.00	29-35	2.5	Pellets
	S2	T2	24.00	1-7	1.5	Crumbles
			23.00	8-14	1.5	Crumbles
			21.00	15-21	1.5	Crumbles
			20.00	22-28	1.5	Crumbles
			19.00	29-35	1.5	Crumbles
P2	S1	T3	23.00	1-7	1.5	Crumbles
			23.00	8-14	1.5	Crumbles
			21.00	15-21	2.5	Pellets
			20.00	22-28	2.5	Pellets
			19.00	29-35	2.5	Pellets
	S2	T4	23.00	1-7	1.5	Crumbles
			23.00	8-14	1.5	Crumbles
			21.00	15-21	1.5	Crumbles
			20.00	22-28	1.5	Crumbles
			19.00	29-35	1.5	Crumbles
P3	S1	T5	21.00	1-7	1.5	Crumbles
			21.00	8-14	1.5	Crumbles
			20.00	15-21	2.5	Pellets
			20.00	22-28	2.5	Pellets
			19.00	29-35	2.5	Pellets
	S2	T6	21.00	1-7	1.5	Crumbles
			21.00	8-14	1.5	Crumbles
			20.00	15-21	1.5	Crumbles
			20.00	22-28	1.5	Crumbles
			19.00	29-35	1.5	Crumbles

Serum total protein (g/dL) was determined according to (Dumas *et al.*, 1971). Also, Serum albumin (g/dL) was obtained using the method of (Dumas *et al.*, 1971), and globulin concentration was estimated using the difference between total protein and albumin concentrations, followed by the albumin/globulin ratio. Serum total cholesterol, uric acid and creatinine (g/dL) were determined using commercial colorimetric kit and according to (Henry, 1974).

Histomorphological examination:

Intestinal histomorphology: small intestines were immediately removed from slaughtered chickens, excised, and flushed with distilled water to remove content. Segments of 2 cm in length from the midpoint of the duodenum fixed in a 10% buffered formalin. The samples were evaluated in terms of the villus height (VH) and width (VW), crypt depth (CD), and villus height to crypt depth ratio (VH/CD). The surface area of the villus was calculated as the product of the height multiplied by the width (Allameh and Toghyani, 2019).

Table (2): Feed ingredients and chemical composition of experimental diets.

Ingredient	Pre-Starter	Starter 1	Starter 2	Grower	Finisher
Yellow Corn	544.17	564.11	620.2	621.19	636.96
Soybean Meal (46%)	370	365	302	328	297
Corn Gluten Meal (60%)	50	34	36	0	0
Calcium Carbonate	12.6	12	11.98	11.72	12
Mono-Calcium Phosphate	8.6	8.8	11.3	11.14	11.17
Soybean Oil	5	5	5	5	5
Broiler Premix**	3	3	3	3	3
Salt (NaCl)	2.2	2.140	2.1	2.16	2.14
DL – Methionine	1.23	1.5	2.24	2.56	2.7
Sodium Bicarbonate	1.1	1.25	2.3	1	1
Emulsifier &Enzymes*	1.1	1.1	2.1	1.1	1.1
HCL – Lysine	0.5	1.6	2.280	1.48	2.43
Choline Chloride	0.5	0.5	0.5	0.5	0.5
Wheat Bran	0	0	0	11.15	25
Total	1000	1000	1000	1000	1000
Calculated composition					
Crude Protein %	24	23	21	20	19
ME (Kcal/Kg)	2950	3000	3050	3050	3100
Crude Fiber %	2.738	2.7	2.699	2.704	2.751
Lysine %	1.3	1.3	1.3	1.3	1.3
Methionine %	0.56	0.56	0.56	0.56	0.56
Methionine + Cystine %	0.98	0.98	0.98	0.98	0.98
Calcium %	0.95	0.95	0.95	0.95	0.95
Available P %	0.45	0.45	0.45	0.45	0.45
Price (LE / Ton)	11057	10891	11594	10500	11400

** Emulsifier & Phytase & Xylanase Enzymes, ** Vitamins-Minerals mixture supplied per kg of diet: vit. (A), 12000 I.U., vit. (D3), 5000 I.U; vit. (E), 10 mg; vit. (K3), 2 mg; vit. (B1), 1 mg; vit. (B2), 5 mg; vit. (B6), 1.5 mg; vit. (B12), 10 µg; Biotin, 50 µg; Pantothenic acid, 10 mg; Niacin, 30 mg; Folic acid, 1 mg; Manganese, 60 mg; Zinc, 50 mg; Iron, 30 mg; Copper, 10 mg; Iodine, 1 mg; Selenium, 0.1 mg and Cobalt, 0.1 mg.*

Tibia physical traits:

Four tibia bones were removed from two birds for each treatment at the end of the experiment, then numbered and frozen at -20 C until further analysis.

Physical bone density (g/ cm^3) was determined by the method of Watkins and Southern (1992). Additionally, the tibia Seedor index (TSI) provides an indication of tibia mineral density as an absolute figure, as described by Seedor *et al.* (1991).

Statistical analysis:

Data obtained in this study were analyzed by two-way analysis of variance using the SAS software general linear model (SAS, 2004). Mean values were compared using Duncan's New Multiple Range tests (Duncan, 1955) when significant differences existed. The fixed effects model used in the analysis was as follows:

$$Yij = \mu + Si + Pj + (S*P)ij + eijk$$

Where:

Yijk: observation
µ: overall mean
Si: effect of the feed shape
Pj: effect of the feed program
(S*P)ijk: interaction between feed shape and feed program
eijk: random error effect.
The significance level was set at ($\alpha = 0.05\%$).

RESULTS AND DISCUSSION

RESULTS

Effects of feed programs (P1-3) and feed forms (S1-2) on some blood parameters of broiler chicks:

The results for biochemical constituents of serum in broiler chicks, as affected by feed programs or forms and their interactions, are shown in Table (3). There were no significant effects of feed programs (P1-3) on serum total protein, albumin, globulin, AST, creatinine, and uric acid. However, total cholesterol was significantly higher in chicks fed program 1 (P_1) compared to those fed Programs 2 and 3 (P2-3). The corresponding values were 62.082 mg/dl versus 58.932 and 57.658 mg/dl, with a significant difference between treatments. Similarly, serum ALT values were significantly higher in chicks fed program 1 (P1, 18.135 IU/L) Compared to those fed program 2 and 3 (P2-3) with corresponding values of 14.356 and 15.658IU/L, respectively.

Table (3): Effects of feed programs (P1-3) and feed forms (S1-2) on some blood parameters of broiler chicks.

Items	T.protein mg/dL	Albumin mg/dL	Globulin mg/dL	T.cholesterol mg/dL	AST lu/L	ALT lu/L	Creati-nine	Uric acid
Feed programs (P1-3)								
Program 1 (P1)	2.995	1.190	1.805	62.082^{a}	271.220	18.135^{a}	0.529	16.309
Program 2(P2)	3.014	1.195	1.819	58.932^{b}	296.823	14.356^{b}	0.499	15.077
Program 3(P3)	2.986	1.202	1.784	57.658^{b}	289.164	15.658^{b}	0.443	16.083
Feed forms (S1-2)								
Shape 1 (S1)	3.019	1.192	1.827	59.884^{b}	277.390	16.296	0.492^{b}	15.168
Shape 2 (S2)	3.009	1.184	1.825	63.979a	285.511	16.782	0.607^{a}	15.829
Interaction (T1-6)								
T1 (P1S1)	3.036	1.190	1.846	62.047^{b}	258.181	17.622^{a}	0.534^{b}	15.334
T2 (P1S2)	3.002	1.193	1.808	57.722^{c}	296.598	14.970^{b}	0.451^{c}	15.001
T3 (P2S1)	2.961	1.187	1.774	68.161^{a}	287.886	18.107^{a}	0.644^{a}	16.475
T4 (P2S2)	3.057	1.180	1.876	59.797^{c}	283.136	15.457^{b}	0.571^{b}	15.182
T5 (P3S1)	2.989	1.193	1.796	56.039^{c}	267.594	18.675^{a}	0.409^{c}	17.118
T6 (P3S2)	2.984	1.211	1.773	59.276^{c}	310.734	12.641^{c}	0.477^{c}	15.047
Significancy								
Feed programs	NS	NS	NS	*	NS	**	NS	NS
Feed forms	NS	NS	NS	*	NS	NS	**	NS
Interaction	NS	NS	NS	**	NS	**	*	NS

^{a,b}*The means values different superscript letters are significantly different (p <0.05).*

No significant differences were observed in serum, total protein, albumin, globulin AST, ALT, and uric acid due to feed form (S1-2). However, there were significant effects of feed form on serum total cholesterol and creatinine. Chicks fed shape 2 (S2) diet showed significantly higher levels of total cholesterol and creatinine compared to those fed the shape 1 (S1) diet. A significant interaction between the program and form of diets was observed only for serum cholesterol and creatinine. Broiler chicks fed T3 (P_2S_1) diet had the highest serum total cholesterol (68.161 mg/dl) and creatinine (0.644 mg/dl) levels compared to other treatments. Broiler chicks fed T5(P3S1) diet had the highest ALT levels (18.675)

compared to other treatments. However, serum total protein, albumin, globulin, AST, and uric acid were not affected by the interaction between feed programs (P1-3) and feed forms (S1-2).

Effects of feed programs (P1-3) and feed forms (S1-2) on intestine histomorphology of broiler chicks:

The results for intestine histomorphology of broiler chicks as affected by feed program (P1-3), feed form (S1-2) and their interaction are shown in Table (4). The obtained results show that there were insignificant differences in villus height, villus widths, and crypt depth between chicks fed different, feed programs (P1-3), feed shape (S1-2), or their interaction (P1-3) x (S1-2). However, broiler chicks fed Program 1 (P1) reflect the lowest goblet cell numbers compared with other programs(P2-3) being 13.65 versus 17.45 and 16.64 respectively. Besides the differences between treatments were significant.

Table (4). Effects of feed programs (P1-3) and feed forms (S1-2) on intestine histomorphology of broiler chicks.

Items	Villus height mm	Villus Width mm	Crypt Depth mm	Goblet Cells Number
Feed programs (P1-3)				
Program 1 (P1)	1028	121.07	242.46	13.65^{b}
Program 2(P2)	1011	120.59	255.08	17.45^{a}
Program 3(P3)	1004	128.90	253.05	16.64^{a}
Feed forms (S1-2)				
Shape 1 (S1)	1012	117.47	249.73	12.89^{b}
Shape 2 (S2)	1026	136.89	238.46	15.10^{a}
Interaction (T1-6)				
T1 (P1S1)	1000	115.17	243.97	16.56^{a}
T2 (P1S2)	1021	126.01	266.20	18.34^{a}
T3 (P2S1)	1043	112.79	246.04	9.79^{c}
T4 (P2S2)	981	122.16	253.42	16.00^{ab}
T5 (P3S1)	1041	135.24	237.38	14.62^{b}
T6 (P3S2)	1011	138.53	239.54	15.58^{b}
Significancy				
Feed programs	NS	NS	NS	*
Feed forms	NS	NS	NS	**
Interaction	NS	NS	NS	*

^{a,c} The means values different superscript letters are significantly different (p <0.05).

Effects of feed programs (P1-3) and feed forms (S1-2) on tibia bone measurements of broiler chicks.:

Results presented in Table (5) show that there were no significant differences in tibia bone measurements, including tibia weight, length, width, Seedor index, and volume, among broiler chicks fed different feed programs (P1-3). On the other hand, broiler chicks fed on program 3 (P3) had the highest tibia breaking strength (175.982 N/Kg) compared to those fed programs 1 and 2 (P1-2) with values of 160.150 and 149.473N/kg, respectively. The differences between treatments were significant.

In a similar way, there was a significant effects of feed form on tibia breaking strength (N/Kg). Chicks fed shape1, (S1) diet had the lowest tibia breaking strength (153.975975 N/kg) compared to those fed the shape 2 (S2) diet (200.750 N/kg).

Moreover, feeding the T5 (P3 S1) or T6 (P3S2) diets resulted in highest tibia breaking strength (200.75 N/Kg) compared to the other dietary treatments. On the other hand, there was no significant interaction between feed programs (P1-3) and feed forms (S1-2) in terms of tibia weight, length, width, volume and seedor index.

Table (5). Effects of feed programs (P1-3) and feed forms (S1-2) on tibia bone measurements of broiler chicks.

Items	Tibia weight g	Tibia LBW %	Tibia length mm	Tibia proximal width mm	Tibia middle width mm	Tibia volume (ml)	Tibia Breaking Strength N/kg	Seedor index
Feed programs (P1-3)								
Program 1 (P1)	13.39	7.978	100.462	10.013	9.017	6.95	160.150^{b}	0.748
Program 2(P2)	13.47	8.062	100.233	9.99	9.015	7.012	149.473^{b}	0.742
Program 3(P3)	13.4	8.032	99.723	9.972	9.008	7.03	175.982^{a}	0.744
Feed forms (S1-2)								
Shape 1 (S1)	13.41	7.766	100.682	9.98	8.979	6.922	153.975^{b}	0.744
Shape 2 (S2)	13.43	8.188	99.361	10.007	9.043	7.036	200.750^{a}	0.745
Interaction (T1-6)								
T1 (P1S1)	13.39	8.23	100.475	9.976	8.979	6.962	153.200^{c}	0.745
T2 (P1S2)	13.42	7.89	99.992	10.004	9.052	7.061	145.747^{c}	0.745
T3 (P2S1)	13.41	7.57	100.603	10.024	9.068	6.935	126.5^{d}	0.748
T4 (P2S2)	13.38	7.96	100.76	9.937	8.889	6.908	181.450^{b}	0.742
T5 (P3S1)	13.52	8.13	100.307	10.04	9.004	6.953	200.750^{a}	0.743
T6 (P3S2)	13.39	8.25	98.416	9.974	9.083	7.12	200.750^{a}	0.745
Significancy								
Feed programs	NS	NS	NS	NS	NS	NS	**	NS
Feed forms	NS	NS	NS	NS	NS	NS	*	NS
Interaction	NS	NS	NS	NS	NS	NS	**	NS

^{a,b}The means values different superscript letters are significantly different (p <0.05). Seedor index was obtained by dividing the tibia weight(g) by its length (mm) (Seedor et al., 1991)

DISCUSSION

Blood biochemical analysis is a standard and practical method to assess the health and nutritional status of poultry. Blood cholesterol is significantly influenced by genetic factors, feed, and medications (Hargis,1988). Cholesterol originates from two sources: feed (exogen cholesterol) and cholesterol produced by body itself (endogen cholesterol). Cholesterol from feed plays an important role as it is the main sterol in the body, a component of the cell surface, and an intracellular membrane component (Muchtadi *et al.*,1993). The higher serum cholesterol level in P1 treatment is likely due to higher crude protein content compared to other feed programs (P2-P3).

Feed protein is correlated with higher cholesterol levels in the blood of broiler chickens. The results indicated that the interaction between feed programs and feed form increased total cholesterol concentration. This suggests that these treatments enhanced lipid metabolism, which subsequently affected the bird's health. Conversely, reducing the protein level in the diet (P3) decreased cholesterol concentration in the birds' bodies compared to other feed programs (P1-P2). These results are logical, as any change or defect in the diet is likely to impact the metabolism of certain substances in the bird's body. Our findings are consistent with those of Buwjoom *et al.* (2010).

Similarly, Kamran *et al.* (2004) studied the effect of different dietary protein levels on blood parameters of broilers from 1 to 35 days of age and found that serum creatinine concentration decreased, and ALT concentration increased significantly by increasing the dietary protein content. This aligns with the finding of Gadelrab (2014) but contradicts those of Wilburn and Fuller (1975).

In our study, serum ALT levels were significantly affected by feed programs (P1-3) and the interaction between feed programs and feed form (S1-2). It was observed that ALT levels increased in the P3 group compared to P2 and P1. Our findings sharply contrast with several previous studies (Law *et al.*, 2018; Corzo *et al.*, 2005; Swennen *et al.*, 2006; Namroud *et al.*, 2008; Hernández *et al.*, 2012), which reported a significant decline in ALT and creatinine levels in broiler chickens that fed different dietary protein levels.

The significant interaction between feed programs (P1-3) and feed forms (S1-2) in the diet led to elevated creatinine levels in the serum samples of broilers. Creatinine is a byproduct of creatine phosphate in muscle tissue, and its production is proportional to muscle mass. Contrary to our findings, previous research has shown that a high versus low crude protein diet lowered serum creatinine levels in broiler chickens (Arczewska-Włosek *et al.*, 2018). Dietary protein is a crucial regulator not only of poultry growth and reproductive performance, but also of the development of the gastrointestinal tract.

The small intestine is the main organ in the gastrointestinal tract, and its length supports the digestion and absorption of nutrients (Wang *et al.*, 2021). In our study, dietary protein levels affected the structure of the small intestine in broilers. Intestinal morphology is a key indicator of gut health, characterized by factors such as villus height, villus width, goblet cell numbers, and crypt depth. Previous studies have evaluated the effect of protein levels on the intestinal morphology in other species, such as pigs (Gu and Li, 2004) and rabbits (Iyeghe-Erakpotobor *et al.*, 2005). However, relatively few studies have been conducted in in broilers.

Available data indicate that diets differing in crude protein levels did not increase the villus height, villus width or crypt depth (Buwjoom *et al.*, 2010). In our study, a significant increase in goblet cell numbers was observed in the small intestinal mucosa of chickens fed the T1 diets (P1S1) compared to those given other programs. The increased number of goblet cells in various gut segments of birds fed the pellet diet was associated with improved growth performance and increased nutrient metabolizability. In fact, increasing the number of goblet cells may enhance mucus production, expand the total luminal villus absorptive area, and subsequently result in more efficient digestive enzyme action and higher nutrient transport at the villus tip (Tufarelli *et al.*, 2010). Moreover, goblet cells are mucosal epithelial cells that serve as the primary site for nutrient digestion and mucosal absorption. (Jiménez-Moreno *et al.*, 2019).

The effects of the dietary treatments and feed form on bone measurements are presented in Table (10). The high average force required to fracture the tibia in the breaking strength test was 175.982 N/kg in the P3 group and in the interaction between feed program and feed form (P3S1-P3S2), it was 200.750 N/kg in broiler at 35 days of age. This suggests that a protein level of 21% in P3 is sufficient for maintaining adequate tibia breaking strength and tibia weight in broilers.

The findings of this study are consistent with those of Jing *et al.* (2018) and Snow *et al.* (2004), who found a relationship between dietary protein content and tibia breaking strength and tibia weight, although the protein levels in those studies were higher. We could not find any reports on the effect of feed form on the tibia bone measurements.

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تأثير شكل وتركيب العليقة على قياسات الدم وهستولوجى الأمعاء وصفات عظمة الساق لدجاج اللحم

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أجريت هذه التجربة بهدف التعرف على تأثير الأشكال المختلفة للعلف وتركيبه على قياسات الدم والتركيب التشريحي للأمعاء وصفات عظمة الساق لدجاج اللحم.

استخدم في هذه التجربة ١٨٠ كتكوت من سلالةIndian River)) عمر يوم، تم توزيع الكتاكيت إلى ٦ معاملات غذائية في تصميم عاملي ٣×٢ (٣ برنامج غذائي (P1,P2,P3 و٢ شكل للعلف S1) مفتت/مكعب و S2مفتت). استمرت التجربة لمدة 5 أسابيع وفي نهاية التجربة تم جمع عينات الدم والأمعاء وعظمة الساق.

أهم نتائج التجربة

شكل العليقة أو تركيبها لم يؤثر معنوياً على صفات الدم وهستولوجى الأمعاء أو صفات عظمة الساق إلا أن:

- مستوى كوليسترول الدم تأثر معنوياً، حيث ارتفع في البرنامج الغذائي P1 بالمقارنة ببرامج.P2,P3

- عدد خلايا Goblet في البرنامج الغذائي P1 انخفض معنوياً بالمقارنة ببرامج. P2,P3
- شكل العليقة S1-2) وبرامج التغذية (P1-3) والتداخل بينهم أثر معنوياً على قوة كسر عظمة الساق حيث سجل شكل العليقة S2 والبرنامج الغذائي P3 أعلى قوة كسر عظمة الساق بالمقارنة بالمعاملات الأخرى.

الخلاصة: قياسات الدم والتركيب التشريحي للأمعاء وصفات عظمة الساق لم تتأثر معنوياً بشكل العليقة أو البرامج الغذائية فيما عدا كوليسترول الدم وعدد خلايا Goblet وقوة كسر عظمة الساق فقد تأثروا معنوياً بشكل العليقة أو البرامج الغذائية