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Effects of Moringa oleifera leaf powder inclusion on growth traits and hematological indices in broiler chickens

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أوراق المورينجا أوليفيرا وتأثير إضافة المسحوق على أداء النمو والمعايير الدموية لدجاج التسمين

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الملخص

أُجريت هذه الدراسة في مزرعة خاصة بمدينة بني وليد، ليبيا، خلال شهري أكتوبر ونوفمبر 2024، بهدف تقييم تأثير إضافة مسحوق أوراق المورينجا أوليفيرا إلى علائق دجاج التسمين على الأداء الإنتاجي وبعض المؤشرات الدموية والكيميائية الحيوية، استخدم في التجربة 240 كتكوتًا من سلالة (*Arbor Acres*) بعمر يوم واحد، تم الحصول عليها من مفرخة محلية، وزعت الكتاكيت عشوائيًا إلى خمس معاملات تغذوية وفق تصميم عشوائي كامل، تضمنت معاملة كنترول على العليقة الأساسية وأربع معاملات أضيف إليها مسحوق المورينجا بنسب 2%، 4%، 6%، و8%، أظهرت النتائج أن إضافة المورينجا بنسبة 8% حققت أفضل القيم لمعظم مؤشرات الأداء مثل الزيادة الوزنية، استهلاك العلف، معامل التحويل الغذائي، الوزن النهائي ووزن الذبيحة،وكذلك إلى زيادة أوزان بعض الأعضاء الداخلية كالقلب والكبد والطحال والقوانص. كما سُجل تحسن واضح في الصفات الدموية مثل ارتفاع تركيز الهيموغلوبين وعدد كريات الدم الحمراء والبيضاء وحجم الخلايا المكدسة ومؤشراتها (*MCV, MCH, MCHC*). وفي المقابل، انخفضت مستويات إنزيم *ALT* والكوليسترول الكلي والدهون الثلاثية و*LDL*، بينما ارتفع *HDL* عند المستويات العالية من الإضافة، وعليه يمكن الاستنتاج أن إضافة 8% من مسحوق أوراق المورينجا إلى علائق دجاج التسمين تُحسّن من الكفاءة الإنتاجية والتمثيل الغذائي، وتدعم المؤشرات الدموية، وتساهم في إنتاج لحوم ذات صفات صحية أفضل، دون تأثيرات سلبية على الطيور.

الكلمات المفتاحية: دجاج اللحم، مسحوق أوراق المورينجا اوليفييرا، معدل الأداء، معايير وقياسات الدم .

Abstract

This study was carried out on a private poultry farm in Bani Walid, Libya, during October and November 2024, to investigate the effects of dietary supplementation with *Moringa oleifera* leaf powder (MLP) on growth performance, blood parameters, and biochemical markers of broiler chickens. A total of 240 one-day-old Arbor Acres chicks, obtained from a local hatchery, were allocated randomly into five dietary treatments in a completely

randomized design. The treatments included a control group fed the basal diet and four groups supplemented with 2%, 4%, 6%, and 8% MLP.
Results indicated that the 8% supplementation level significantly improved productive traits such as body weight gain, feed intake, feed conversion ratio, final live weight, and carcass yield. The same group also showed higher relative weights of internal organs, including the heart, liver, spleen, abdominal fat, wings, and gizzard. Hematological assessments revealed increases in hemoglobin concentration, red and white blood cell counts, packed cell volume, and erythrocyte indices (MCV, MCH, MCHC). In addition, supplementation reduced ALT activity, total cholesterol, triglycerides, and LDL, while increasing HDL levels.
In summary, the addition of 8% *Moringa oleifera* leaf powder to broiler diets enhances growth and nutrient utilization, improves hematological and biochemical health indicators, and promotes the production of leaner, healthier meat without harmful effects on the birds.

Keywords: Broiler chickens, Moringa oleifera, growth efficiency, hematology, biochemical traits.

Introduction

The poultry industry represents a vital component of the global economy through the supply of meat and eggs, which serve as major protein sources for the world's population. Nevertheless, poultry health, welfare, and productivity are strongly influenced by numerous factors, particularly environmental fluctuations, which pose substantial challenges [73]. Since feed expenses account for approximately 60–70% of the overall production costs, the incorporation of nutritional supplements is considered indispensable in poultry production [6]; [60]. To enhance growth efficiency and carcass characteristics in poultry and livestock, organic additives have been employed, although many still contain synthetic growth promoters and antimicrobial agents [8], [9]; [48]; [49]. In recent decades, the poultry sector has become one of the most important agricultural industries, ensuring sufficient animal protein for global food security [53].
Corn and soybean constitute the principal feed ingredients for broiler diets [42]. However, scarcity in both their quantity and quality often results in feeding challenges [29]. To overcome these issues, researchers have proposed alternative feed resources, with emphasis on accessible local ingredients that could partially replace corn and soybean in broiler nutrition [14]; [76]; [30]. Chickens are the most widely consumed poultry species worldwide. Owing to their relatively low fat and cholesterol content, chicken meat is regarded as a healthy protein option [52]. Moreover, chicken remains the least expensive animal protein globally, with its consumption projected to rise by 34% by 2018 [65]. Research indicates that global chicken consumption increased from less than 10 million tonnes in 1960 to more than 120 million tonnes in 2021 [66]. By 2050, this figure is expected to reach 180 million tonnes, reflecting a 1,200% increase since 1960. According to U.S. government statistics, this expansion would result in chicken consumption rates exceeding those of pork by more than threefold and beef by tenfold. By 2030, chicken meat is predicted to represent 41% of global meat consumption, thereby surpassing all other protein sources, particularly animal-based proteins, for the first time. Meanwhile, medicinal plants containing bioactive compounds are increasingly recognized for their health-promoting potential and are widely consumed as supplements, side dishes, or beverages [58].
Synthetic chemicals are frequently used to enhance livestock and poultry growth, but their adverse impact on human health has become evident [26]. Consequently, extensive efforts have been directed toward the development of beneficial feed additives derived from medicinal plants and their by-products, aiming to reduce dependence on synthetic growth promoters [12]; [25]; [27]. The rising global population has intensified the demand for poultry meat that is both safe and of high quality. Although broiler strains with superior growth performance have been developed, they are often exposed to oxidative stress, which adversely affects gut health. Phytobiotics, or plant-based feed additives, have gained attention as natural alternatives to synthetic antibiotics due to their antibacterial, antioxidant, immunomodulatory, and growth-promoting effects [61].
Active phytochemicals are found in extracts of aromatic plants and spices, including fruits, seeds, bark, roots, and leaves. Examples include pepper, mustard, oregano, thyme, black seed, anise, chicory, garlic, *Moringa oleifera*, and rosemary [3]. Their beneficial effects are attributed to compounds such as linalool, cineole, anethole, allicin, allyl isothiocyanates, capsaicin, carvacrol, piperine, and thymol [4]; [5]. However, further investigations are still necessary to fully establish their antimicrobial and antioxidant functions [7]. According to [2], supplementation of broiler feed with *Moringa oleifera* leaf powder (MOLP) enhanced productivity, as the leaves possess high nutritional, antimicrobial, and immunomodulatory properties, making them widely applicable as feed additives [51]. Findings from [54] showed that broilers receiving 2% canola meal and 6% MOLP recorded the highest feed intake among the groups tested. Similarly, [59] indicated that Moringa alkaloids might stimulate feed consumption by regulating glucose homeostasis in birds. These results suggest that MOLP supplementation has the potential to improve feed efficiency and promote growth. Comparable results were reported by [51], who found that broilers

fed varying levels of MOLP had significantly higher final body weights, with the group supplemented at 1.2% MOLP achieving the greatest weight gain.

As a natural growth promoter in poultry diets, *Moringa oleifera* has been recognized for its antibacterial and antioxidant activities. Its health benefits are attributed to bioactive compounds such as flavonoids and phenols [37]; [55]. In addition, Moringa leaves are rich in vitamins, minerals, and essential amino acids that enhance growth and immunity, alongside anti-inflammatory agents like quercetin and kaempferol. Their mineral composition includes calcium, magnesium, potassium, iron, and copper, which reinforce their value as a nutritional supplement [67]. Previous research has demonstrated that inclusion of MOLP at levels below 5% of dry matter improves meat quality, feed conversion efficiency, and growth performance in poultry [37]. Furthermore, nanoparticles have been suggested to improve nutrient utilization due to their large surface area and catalytic properties [15]; [74].

Other studies have confirmed that MOLP contributes to higher meat pH, reduced cooking losses, and decreased triglyceride and cholesterol levels, which are indicators of improved meat quality. Enhanced hemoglobin levels, reduced stress index (H/L ratio), and increased red blood cell counts also highlight its positive hematological effects. Moreover, lower populations of pathogenic *Shigella* and *E. coli* bacteria, coupled with greater growth of beneficial *Lactobacillus*, underline its positive role in maintaining gut health [17]. Thus, MOLP represents a promising natural feed additive for improving growth, meat quality, and health in broilers, while supporting the production of antibiotic-free poultry.

Evidence further shows that inclusion of Moringa leaves in broiler diets can enhance growth, carcass characteristics, blood and biochemical parameters, and gut microbiota balance [56]; [72]. The leaves are particularly rich in fiber, amino acids, vitamins (beta-carotene, B-complex, C, and K), essential minerals, and digestible proteins. They also contain polyphenols, flavonoids such as kaempferol and quercetin, phenolic acids, and compounds with antimicrobial, hepatoprotective, and anti-inflammatory properties [77]. Due to this high nutritional value, Moringa leaves are widely accepted as feed by humans and animals alike, including poultry [71]. Research has validated their role as a nutritional reservoir containing vitamins (A, D, E), minerals (calcium, iron, potassium, phosphorus), amino acids, high-quality proteins, and antioxidants such as vitamin C, beta-carotene, phenols, and flavonoids [44]. Importantly, their low tannin levels and lack of enzyme inhibitors (trypsin, lipase, amylase) facilitate digestion and nutrient absorption [31]. Therefore, Moringa is considered a valuable trace element source and an effective dietary supplement for poultry. Studies confirm that inclusion of MOLP at levels up to 5% improves production traits, hematology, antioxidant status, carcass yield, and immunity against intestinal pathogens, without adverse effects [56]; [71].

Since disease outbreaks remain a major challenge in broiler production, often caused by parasites, bacteria, fungi, viruses, protozoa, and nutritional deficiencies, significant economic losses occur before harvest [45]. In many cases, large doses of antibiotics are administered to improve growth and immune response. However, this has led to pathogen resistance and increased residues in poultry tissues [10].

Therefore, the current study aims to investigate the effects of *Moringa oleifera* leaf powder on the hematological parameters and growth performance of broiler chicks.

methods

This experiment was carried out during October and November 2024 on a private poultry farm in Bani Walid, Libya, to investigate the impact of *Moringa oleifera* leaf powder supplementation on broiler growth performance and selected hematological traits. A total of 240 one-day-old Arbor Acres (AA) chicks were procured from a local hatchery. Upon arrival, the chicks were individually weighed and randomly distributed into five dietary groups under a completely randomized design, each group consisting of four replicates with 12 birds per replicate. The dietary treatments included a control group receiving the basal diet and four experimental groups in which the basal diet was supplemented with *Moringa oleifera* leaf powder at inclusion levels of 2%, 4%, 6%, and 8%. The supplementation rates were determined based on the average active compound content of the leaf powder.

Table (1): Nutrient composition of Moringa oleifera leaf flour.

Constituents	Value/100 g leaf powder (%)
Dry matter (DM)	91.21
Ash content	9.28
Crude protein (CP)	26.5
Crude fiber (CF)	7.95
Ether extract (EE) / Crude fat	4.49
Organic matter (OM)	81.93
Fatty acids	2.05
Nitrogen-free extract (NFE)	42.99
Total phosphorus (mg)	442
Calcium (mg)	71

Recorded Data

1. Growth Performance:

Body weights of broilers were measured at 21, 35, and 42 days of age. Feed intake and weight gain were recorded throughout the experimental periods, and the feed conversion ratio (FCR) was calculated as feed intake divided by weight gain. At 42 days of age, carcasses were weighed, and carcass yield was expressed as a percentage of the live body weight.

2. Blood Sample Collection:

At 42 days of age, six birds from each group were randomly selected between 8:00 and 9:00 a.m. Approximately 3 ml of blood was collected from the wing vein using tubes containing K3-EDTA (1 mg/ml). The non-coagulated blood samples were separated into two portions: one was used immediately for hematological analysis, while the other was centrifuged at 4000 rpm for 15 minutes. The resulting plasma was stored at –20°C until further biochemical analysis. All biochemical parameters were determined colorimetrically using specialized commercial diagnostic kits.

3. Hematological parameters:

The red blood cell (RBC) count ($\times 10^6/ml^3$) was determined according to [38]. Hemoglobin concentration (Hb, g/dL) and packed cell volume (PCV, %) were measured following the procedure outlined by [33]. Calculated indices included mean corpuscular volume (MCV, μm^3) = [hematocrit (%) ÷ RBC] × 10, mean corpuscular hemoglobin (MCH, pg) = [Hb (g/dL) ÷ RBC] × 10, and mean corpuscular hemoglobin concentration (MCHC, %) = [Hb (g/dL) ÷ hematocrit (%)] × 100. Additionally, thin blood smears were prepared by placing a drop of blood on a slide, air-dried, and subsequently stained with Giemsa for microscopic examination.

4. Blood biochemical parameters:

To evaluate protein alterations at 35 days of age, plasma total protein concentration (g/dL) was assessed using specialized kits and a spectrophotometer (Beckman DU-530, Germany), following the manufacturer's instructions [19]. Plasma total cholesterol (mg/dL) was determined according to [24], while alkaline phosphatase (ALP, U/L) was quantified colorimetrically as described by [22].

5. Serum biochemistry evaluation:

At the conclusion of the experiment, 5 ml of blood were collected from two birds per replicate for serum lipid profile analysis, including cholesterol, triglycerides, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL) [20]. Samples were transferred into EDTA-free tubes to avoid interference with serum chemistry.

6. Statistical analysis:

All collected data were analyzed using analysis of variance (ANOVA) suitable for a completely randomized design (CRD). The general linear regression model was applied as described by [70].

A) Growth Performance

Table (2) and Figure (1) summarize the effects of different supplementation levels of Moringa oleifera leaf powder (2, 4, 6, and 8%) compared with the control on broiler growth performance. The control group recorded lower body weight gains of 646, 942, and 1264 g at 21, 35, and 42 days, respectively. In contrast, increasing the supplementation level up to 8% resulted in higher feed intake values (1568, 3442, and 3888 g/day) and weight gains (749, 2124, and 2406 g), followed by the 6% MOLP group (696, 2034, and 2370 g). The control group also showed lower feed intake (1017, 2227, and 2853 g/day) and higher feed conversion ratios (1.57, 2.36, and 2.26 g), whereas the 6% MOLP group recorded higher intake (1252, 3424, and 3879 g/day) during October and November 2024.

The improved weight gain in birds fed MOLP diets may be attributed to higher dietary protein levels that were efficiently digested and utilized for growth. This finding aligns with the results of [62] and [21], who reported significantly higher weight gain in broilers fed Moringa oleifera leaf meal (MOLM) at the 1% level compared with controls. However, birds fed 7% MOLM gained less weight than those fed 5% MOLM, likely due to higher crude fiber content, which can impair nutrient absorption and digestion [63]. Moreover, the anti-nutritional factors present in MOLM may contribute to reduced weight gain at higher inclusion levels, despite the higher crude protein content. It has been reported that 1 kg of Moringa leaves may contain 1–23 g of tannins [47], which interfere with protein utilization and, to a lesser extent, carbohydrate and fat metabolism [43]. Similarly, the reduced crude protein levels of the basal diet could explain the poor growth performance observed in the control group. Feeding is a major determinant of broiler production since it represents the highest production cost and has a direct effect on growth performance [11].

The improved nutrient utilization in birds fed MOLM-based diets is consistent with the findings of [34], who demonstrated that broilers fed Moringa-based diets had superior feed conversion ratios and body weight gains compared with the control group. This improvement can be attributed to the rich nutrient profile of MOLM [69]; [16] and its antimicrobial properties [36]. While feed intake generally increased with higher MOLM inclusion levels, a significant decrease was observed at the 7% level, possibly due to reduced diet palatability [47].

These observations support previous findings. For instance, [35] reported increased feed intake in broilers supplemented with MLP up to 5%, with the highest daily intake recorded throughout the experimental period. In contrast, [64] found a reduction in intake following MLP supplementation, a discrepancy that may be explained by the presence of phytochemicals such as moringinine and flavanol glycosides, which, according to [59], may enhance feed intake by stimulating appetite, regulating glucose homeostasis, and promoting digestive enzyme activity.

Further, [54] reported that 2% MOLP supplementation resulted in the greatest weight gain among broilers, while 4% MOLP also improved body weight but not significantly beyond the control. Substitution of MOLP for soybean did not yield notable improvements in weight gain but was associated with decreased feed intake, possibly due to poor palatability of the diets, although such effects were not observed in the current study. Likewise, [63] confirmed that broilers fed graded levels of MOLP exhibited significantly increased body weight, concluding that the improvement was likely driven by the high protein content of MOLP.

Table 2: Effect of feeding different levels of *Moringa oleifera* Leaf powder on weight gain, feed intake and feed conversion of broilers during the month of October and November 2024.

Treatments	Body weight gain (g)			Feed intake (g/day)			Feed conversion efficiency (FCR)		
	21 days	35 days	42 days	21 days	35 days	42 days	21 days	35 days	42 days
Control	646	942	1264	1017	2227	2853	1.57	2.36	2.26
MLP 2%	660	2025	2299	1071	3357	3862	1.62	1.66	1.68

Treatments	Body weight gain (g)			Feed intake (g/day)			Feed conversion efficiency (FCR)		
MLP 4%	690	2026	2335	1121	3391	3870	1.62	1.67	1.66
MLP 6%	696	2034	2370	1252	3424	3879	1.80	1.68	1.64
MLP 8%	749	2124	2406	1568	3442	3888	2.09	1.62	1.62
LSD (0.05)	0.33	0.82	0.83	0.66	0.13	1.01	0.47	0.17	0.16

The data show that supplementation with Moringa oleifera leaf powder (MLP) positively influenced broiler growth performance. Birds fed 8% MLP recorded the highest body weight gain (2406 g at 42 days) and feed intake (3888 g/day), along with an improved feed conversion efficiency (1.62). The 6% group also showed favorable results, though slightly lower than the 8% treatment. In contrast, the control group exhibited the lowest values across all parameters, with reduced weight gain, lower feed intake, and less efficient feed conversion.
Overall, the findings suggest that dietary inclusion of MLP, particularly at the 8% level, enhances feed utilization and supports better growth rates in broiler chickens, while the control diet failed to achieve comparable outcomes.

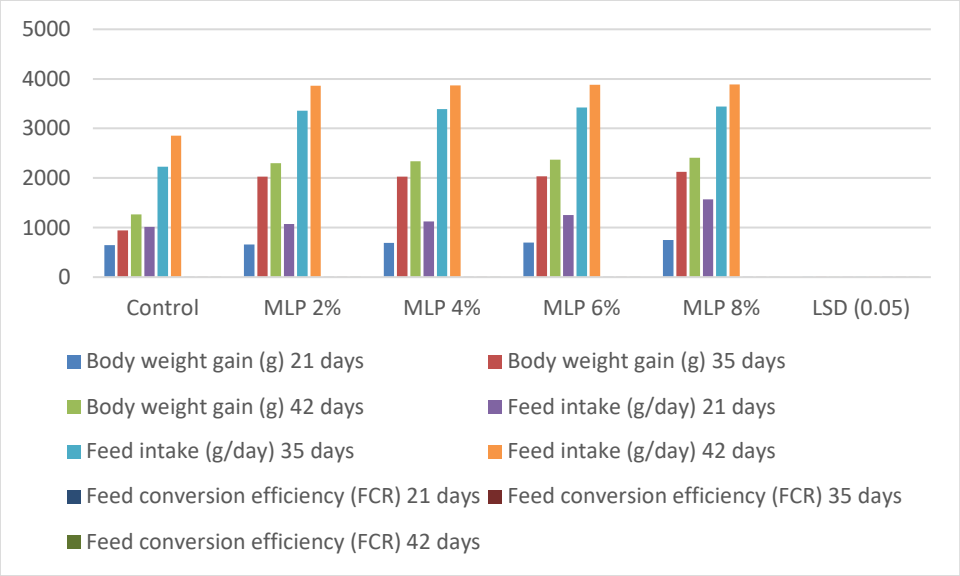


Figure 1: Effect of feeding different levels of *Moringa oleifera* Leaf powder on weight gain, feed intake and feed conversion of broilers during the month of October and November 2024.

B) Carcass Weights

Table (3) and Figure (2) present the effects of different supplementation levels of Moringa oleifera leaf powder (2%, 4%, 6%, 8%, and control) on carcass traits. The data revealed that increasing MOLP inclusion up to 8% yielded the highest values for final body weight, carcass weight, heart, liver, spleen, abdominal fat, wings, and gizzard (2585, 1.98, 15.21, 59.72, 3.76, 49.96, 205.80, and 49.78 g, respectively). The 6% group showed slightly lower but comparable values (2569, 1.92, 14.84, 56.74, 3.64, 40.43, 200.55, and 45.43 g). In contrast, the control group exhibited the lowest measurements across all parameters (2384, 1.74, 13.44, 51.69, 3.01, 35.80, 187.95, and 34.97 g) during the experimental period (October–November 2024).
These findings are in line with [75] and [68], who reported that supplementation of Moringa leaf powder in Japanese quail diets did not lead to significant differences in most carcass traits, although the inclusion of 0.1% Moringa increased gizzard fat content. Similarly, the current results indicate that broilers fed Moringa-supplemented diets had greater final body weight (FBW) and average daily gain (ADG), outcomes that were strongly associated with increased feed intake. Comparable improvements in carcass characteristics and growth performance following Moringa supplementation have also been reported in previous studies [13]; [18].

Table (3): Effect of feeding different levels of Moringa oleifera leaf powder on carcass weights of broiler chickens during October and November 2024.

Treatments	Final body weight (g)	Carcass yield (g)	Heart (g)	Liver (g)	Spleen (g)	Abdominal fat (g)	Wings (g)	Gizzard (g)
Control	2384	1.74	13.44	51.69	3.01	35.80	187.95	34.97
2% MLP	2464	1.83	13.82	55.25	3.20	37.59	194.25	38.40
4% MLP	2519	1.87	14.44	56.70	3.55	39.23	196.35	41.90
6% MLP	2569	1.92	14.84	56.74	3.64	40.43	200.55	45.43
8% MLP	2585	1.98	15.21	59.72	3.76	49.96	205.80	49.78
LSD (0.05)	1.00	0.82	0.46	0.15	0.41	0.03	0.46	0.46

The results indicate that supplementing broiler diets with Moringa oleifera leaf powder improved carcass characteristics and organ weights compared with the control group. Birds receiving 8% MLP achieved the greatest final body weight (2585 g) and carcass yield (1.98 g), alongside higher relative weights of the heart, liver, spleen, abdominal fat, wings, and gizzard. The 6% treatment also showed favorable outcomes, though slightly lower than the 8% group.

By contrast, the control birds recorded the lowest values for all measured traits, reflecting inferior growth and carcass development. These findings suggest that dietary inclusion of MLP, particularly at the 8% level, enhances carcass yield and supports healthier development of vital organs in broiler chickens without negative impacts.

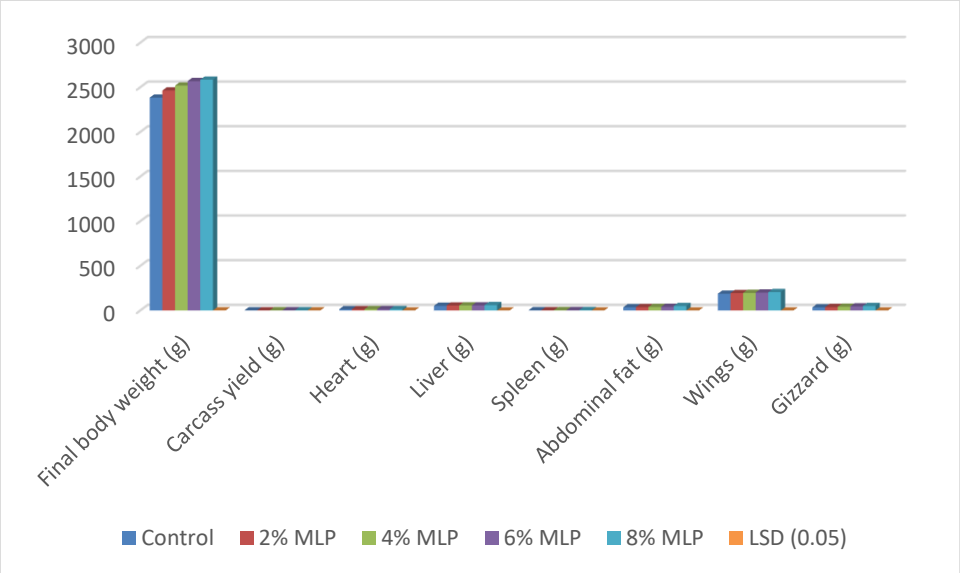


Figure 2 : Effect of feeding different levels of Moringa oleifera leaf powder on carcass weights of broiler chickens during October and November 2024

C) Blood Constituents

Table (4) and Figure (3) illustrate the effects of different supplementation levels of Moringa oleifera leaf powder (2, 4, 6, and 8%) compared with the control group on blood constituents. The results indicated that inclusion of MOLP up to 8% significantly reduced ALT, total cholesterol (TC), triglycerides (TG), and low-density lipoprotein (LDL) levels (35, 174.25, 111.41, and 3.41 mg/dl, respectively), whereas the control group showed significantly higher values (58.37, 273.29, 142.41, and 9.41 mg/dl). Conversely, birds receiving 8% MOLP exhibited significantly higher values of total protein (7.57 g/dl) and high-density lipoprotein (HDL, 78.31 mg/dl), compared to the control group which recorded 6.64 g/dl for total protein and 56.34 mg/dl for HDL.

These findings are consistent with [62], who reported that Moringa oleifera leaves improved immune responses and intestinal health in broilers. Similarly, [39] suggested that Moringa enhances immune function, though this effect may be attributed to lectins present in the pods, which modulate physiological responses [46]. On the other hand, [57] observed that dietary inclusion of 0.2%, 0.4%, and 0.6% MOLM had no significant impact on serum protein, albumin, globulin, or AST, though ALT activity decreased significantly in birds receiving 0.4% supplementation. This suggests that the bioavailability of polyphenols and their metabolites in M. oleifera leaves may be tissue-specific and limited [28].

In agreement with the present results, [28] found that feeding 20% MOL reduced plasma cholesterol and LDL levels compared with controls. Likewise, [32] reported that 0.25–0.40% MOLM supplementation lowered total cholesterol, triglycerides, and LDL cholesterol, while also reducing AST and ALT at all tested levels. Since ALT and AST are liver enzymes released into circulation during tissue damage [50], the significantly lower ALT levels observed in this study suggest improved liver function in birds receiving MOL diets. A similar hepatoprotective effect was reported by [32], who confirmed that MOLM supplementation significantly reduced plasma ALT activity.

Furthermore, the hypocholesterolemic effect of Moringa may be attributed to phytosterols such as sitosterol, which inhibit intestinal cholesterol absorption and promote fecal excretion in steroidal form [23]. Additionally, M. oleifera may enhance lecithin-cholesterol acyltransferase activity in HDL, facilitating cholesterol scavenging and removal, while also activating lipoprotein lipase to accelerate cholesterol clearance from blood vessels [41].

Table (4): Effect of feeding different levels of *Moringa oleifera* Leaf powder on blood constituents of broilers during the month of October and November 2024.

Treatments	Total serum protein (g/dl)	ALT (U/L)	Total cholesterol (mg/dl)	Triglycerides (mg/dl)	HDL (mg/dl)	LDL (mg/dl)
Control	6.64	58.37	273.29	142.41	56.34	9.41
2% MLP	6.96	51.37	216.44	135.50	59.25	7.52
4% MLP	7.25	45.20	191.17	128.66	65.45	5.45
6% MLP	7.38	39.78	183.95	123.14	70.63	4.59
8% MLP	7.57	35.00	174.25	111.41	78.31	3.41
LSD (0.05)	0.12	0.24	11.10	0.04	1.21	1.13

The biochemical analysis revealed that supplementing broiler diets with Moringa oleifera leaf powder improved serum protein levels and positively influenced lipid profiles compared to the control group. Birds fed 8% MLP recorded the highest total serum protein (7.57 g/dl) and HDL cholesterol (78.31 mg/dl), while simultaneously showing marked reductions in ALT activity (35.00 U/L), total cholesterol (174.25 mg/dl), triglycerides (111.41 mg/dl), and LDL cholesterol (3.41 mg/dl), The 6% treatment produced comparable improvements, although the 8% level achieved the most favorable results.

In contrast, the control group exhibited lower serum protein alongside elevated ALT, total cholesterol, triglycerides, and LDL values, indicating poorer liver function and lipid metabolism. These findings suggest that Moringa oleifera supplementation—especially at 8%—enhances protein metabolism, supports liver health, and promotes healthier lipid profiles in broiler chickens.

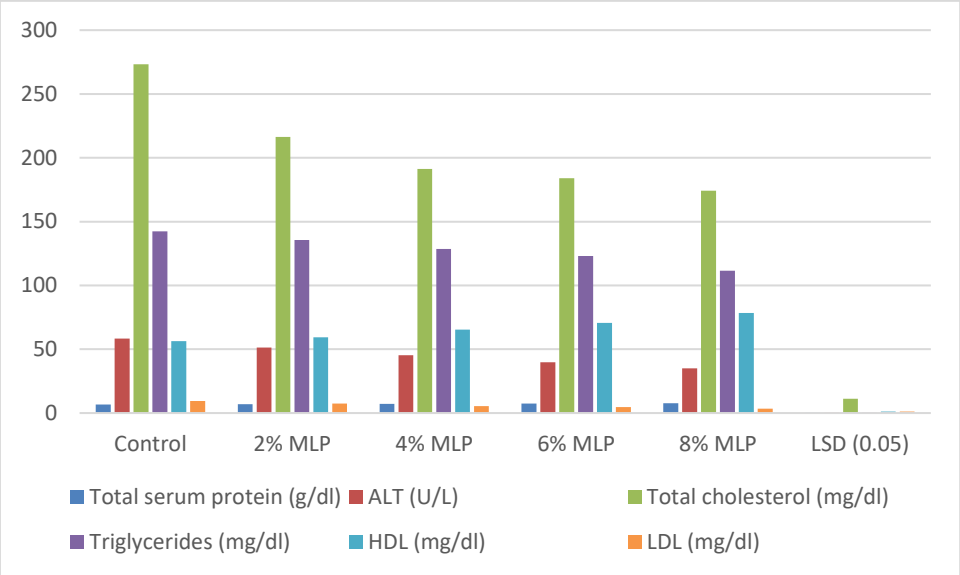


Figure 2 : Effect of feeding different levels of *Moringa oleifera* Leaf powder on blood constituents of broilers during the month of October and November 2024.

Haematological Constituents of Blood

Table (1) and Figure (1) illustrate the effects of different supplementation levels of Moringa oleifera leaf powder (2, 4, 6, 8%) compared with the control on hematological traits. The results demonstrated that increasing MOLP supplementation up to 8% significantly elevated RBC (3.09 mil/mm³), WBC (80.25 thous/mm³), Hb (13.83 g/dL), PCV (44.77%), MCH (69.55 pg), MCV (215.41 µm³), and MCHC (40.37%). Birds receiving 6% MOLP recorded slightly lower values, with RBC (2.56 mil/mm³), WBC (76.80 thous/mm³), Hb (11.00 g/dL), PCV (41.10%), MCH (63.79 pg), MCV (206.13 µm³), and MCHC (35.26%). In contrast, the control group showed the lowest hematological values: RBC (1.59 mil/mm³), WBC (50.32 thous/mm³), Hb (8.31 g/dL), PCV (26.26%), MCH (46.88 pg), MCV (139.16 µm³), and MCHC (23.83%).

These findings are consistent with [1], who reported similar increases in RBC count and Hb levels in broilers supplemented with 0.75% and 1% MOLM. Such consistency indicates that MOLP supplementation exerts a positive effect on broiler health. The hematopoietic properties of M. oleifera may be attributed to its high-quality protein content and diverse profile of essential amino acids, which serve as building blocks for hemoglobin synthesis in red blood cells [40].

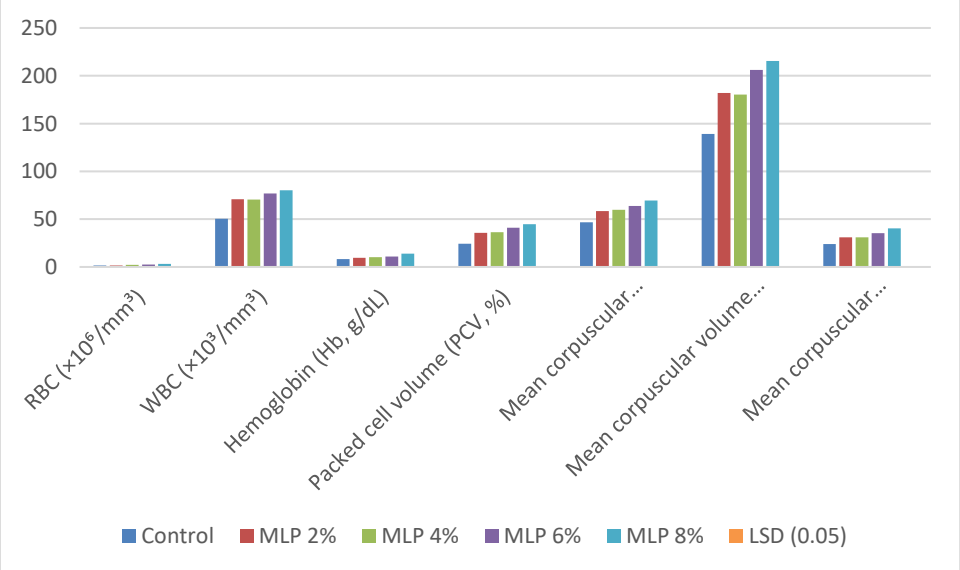
Although serum biochemical parameters may not always exhibit significant changes with MOLP supplementation, the hematological profile in the present study showed notable improvements. This agrees partly with the findings of [57], who reported that while RBC, PCV, and Hb values did not differ significantly between treatment groups, numerical increases were observed in broilers fed diets supplemented with MOLP.

Table(5): Effect of feeding different levels of *Moringa, oleifera* Leaf powder on blood ,blood haematological of broilers during the month of October and November 2024.

Treatments	RBC ($\times 10^6$/mm^3)	WBC ($\times 10^3$/mm^3)	Hemoglobin (Hb, g/dL)	Packed cell volume (PCV, %)	Mean corpuscular hemoglobin (MCH, pg)	Mean corpuscular volume (MCV, µm^3)	Mean corpuscular hemoglobin concentration (MCHC, g/dL)
Control	1.59	50.32	8.31	24.26	46.88	139.16	23.83
MLP 2%	1.64	70.82	9.62	35.84	58.40	182.05	30.92
MLP 4%	2.31	70.49	10.25	36.38	59.76	180.18	31.03
MLP 6%	2.56	76.80	11.00	41.10	63.79	206.13	35.26
MLP 8%	3.09	80.25	13.83	44.77	69.55	215.41	40.37
LSD (0.05)	0.04	0.89	0.04	0.18	0.77	0.98	0.74

The hematological evaluation showed that supplementation with Moringa oleifera leaf powder had a positive influence on blood parameters of broiler chickens. Birds receiving 8% MLP exhibited the highest values across all indices, including RBC count (3.09 $\times 10^6$/mm^3), WBC count (80.25 $\times 10^3$/mm^3), hemoglobin concentration (13.83 g/dL), packed cell volume (44.77%), mean corpuscular hemoglobin (69.55 pg), mean corpuscular volume (215.41 µm^3), and mean corpuscular hemoglobin concentration (40.37 g/dL). The 6% group also demonstrated improved hematological traits, though slightly lower than those obtained at 8%.

Conversely, the control treatment recorded the lowest RBC, WBC, Hb, PCV, and erythrocyte indices, reflecting weaker hematological status and reduced oxygen-carrying capacity of the blood. These results suggest that dietary supplementation with Moringa oleifera leaf powder, particularly at 8%, enhances hematopoiesis, improves blood quality, and supports better physiological performance in broiler chickens.



Conclusion

The results of this study clearly demonstrate that supplementing broiler diets with Moringa oleifera leaf powder (MLP) at an inclusion level of 8% significantly improved growth and health performance. The higher final body

weight (FBW) and lower feed conversion ratio (FCR) observed indicate more efficient utilization of feed nutrients and enhanced digestive physiology. Hematological analyses further revealed increases in red blood cell (RBC) count and hemoglobin (Hb) concentration, which reflect improved oxygen-carrying capacity of the blood and overall physiological health. In addition, reductions in triglycerides (TG), cholesterol, and abdominal fat suggest that MLP supplementation promotes the production of leaner and healthier meat. Importantly, no adverse effects were detected in the MLP-fed birds, confirming the safety of this supplement.

Discussion

The findings of this research are in agreement with earlier reports indicating that dietary inclusion of medicinal plants enhances poultry growth and health status. Studies such as [62] and [21] showed that supplementation with Moringa oleifera leaf meal significantly improved weight gain and feed efficiency, a result attributed to the plant's high protein content, essential amino acids, and bioactive compounds including flavonoids and phenolics with antioxidant and antimicrobial properties.

The observed improvements in RBC and Hb levels are consistent with [1], who reported similar increases in broilers supplemented with MOLM. These hematological improvements can be linked to the high-quality protein and essential amino acids in M. oleifera, which are vital for hemoglobin synthesis [40].

The reductions in cholesterol, triglycerides, and abdominal fat highlight the potential of MLP to improve meat quality by lowering harmful lipid fractions while promoting higher HDL levels. This effect may be explained by the presence of phytosterols such as sitosterol, which reduce intestinal cholesterol absorption and enhance its excretion in steroidal form [23]. Furthermore, Moringa may increase lecithin-cholesterol acyltransferase activity in HDL, facilitating cholesterol removal, and activate lipoprotein lipase to promote lipid clearance from blood vessels [41].

Overall, these results reinforce the growing evidence that Moringa oleifera supplementation not only improves growth efficiency but also enhances hematological and biochemical health parameters, thereby producing healthier broiler meat free from antibiotic residues.

Recommendations

Optimal Inclusion Level: Based on the present findings, inclusion of Moringa oleifera leaf powder up to 8% in broiler diets is recommended to maximize growth performance and carcass quality.

Safe Use: The results confirm that MLP is a safe and effective natural feed additive with no adverse health effects on broilers.

Future Research: Further studies should investigate long-term effects of MLP at different inclusion levels, as well as its impact on other poultry species and production environments.

Commercial Application: Poultry producers are encouraged to integrate MLP into feeding programs, not only to enhance productivity but also to reduce reliance on synthetic growth promoters and costly treatments.

Consumer Health: Adoption of MLP contributes to the production of leaner, healthier, and antibiotic-free meat, meeting the increasing consumer demand for safe and functional animal products.

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