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Effect of Adding Moringa Oleifera Seed Powder (MOSP) to Diet on The Productive Performance, Carcass Characteristics and Meat Quality of Broiler Chickens

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ABSTRACT
The experiment was conducted in animal production fields of the Department of Animal Production, College of Agricultural Engineering, University of Salahaddin, in the Grda Rasha area, Erbil, to study the influence of different levels of feed addition of Moringa oleifera seed powder compared to the synthetic antioxidant butylhydroxytoluene (BHT) on growth performance, carcass traits, and meat quality in the broiler. The expirment took place for 35 days (8th of October – 11th November 2024), The average weight of 400 unsexed 1-day-old Ross 308 chicks was 38.85 ± 0.07 g, used and randomly distributed into five experimental treatments with four replicates per treatment (20 birds/replicate). The treatments were as follows: T1: Control (Standard diet=SD). T2: SD + 0.02% BHT. T3: SD + 0.25% Moringa oleifera seed powder (MOSP). T4: SD + 0.50% MOSP. T5: SD + 0.75% MOSP. Statistical analysis results showed significant differences in both treatments T2 and T4 in both live body weight and considerable superiority in the total weight gain rate and feed conversion efficiency rate, while the results of carcass traits (dressing percentage, breast weight, thigh weight) did not show significant differences between treatments. And for meat quality, non-significance different were recorded at pH values, color, and cooking lossing, while significant differences appeared in treatments when investigating water holding capacity (WHC) and shear force in favor of treatment T5. The study concludes that the use of Moringa oleifera seed powder as a feed additive (At a rate of 0.25- 0.50- 0.75%) for broiler chickens contributes to the production of chickens with significant weight gain, feed conversion efficiency, high (WHC), and shear force of broilers' meat.

***Keywords*:** Broiler, Moringa oleifera seeds powder, Butylhydroxytoluene (BHT), growth performance, Carcass traits, meat Quality.

INTRODUCTION

Broiler farming is a key objective in the poultry and animal husbandry industry due fundamental role in food security [1]. In most poultry production, synthetic antioxidants are feed additives to enhance growth performance and improve carcass characteristics [2]. However, synthetic antioxidants have limited efficacy and potential side effects, which hinders the production of healthier broiler chickens that doesn't negatively impact human health upon consumption [3]. Therefore, alternatives to synthetic antioxidants should be proposed and replaced with healthier natural ingredients to help improve growth performance, carcass yield, and meat efficiency in broiler chickens [4]. Medicinal plants are also a safe and natural solution to replace synthetic antioxidants [5]. Moringa oleifera is known for its beneficial antioxidant properties, probiotic effects, and phytochemicals such as chlorogenic and caffeic acids. Moringa is found in many locations worldwide and is a fine source of natural antioxidants including ascorbic acid, flavonoid, phenol, and carotenoid [6]. The Moringa seeds are rich in monounsaturated fatty acids (oleic acid), including 9-octadecenoic acid [7]. They also contain unique bioactive compounds such as 4-(α-L-rhamnosyloxy) benzyl isothiocyanate, niazirin, and niazimycin (associated with antimicrobial and antitumor properties). The seeds contain mainly phenolic acids, such as gallic acid, with flavonoids such as catechin, epicatechin, and kaempferol in bound forms [8]. The seeds also have higher lipid content (>15%) and free amino acids (9.84%) than the leaves [9]. Moringa oleifera seeds contain antioxidants and anti-inflammatory compounds [10], [29]. They also positively affect improving growth performance, body weight, weight gain, and feed conversion ratio [11]. Adding Moringa oleifera seeds to broiler feed improves animal production [12].

Thus, the purpose of this study was to determine how different concentrations of Moringa oleifera Seed Powder (MOSP) additions affected the growth performance, carcass traits, and meat quality of broiler chickens when compared to the synthetic antioxidant BHT.

Materials and Methods

Location and management of the experiment:

The study was concluded at the College of Agricultural Engineering Sciences–University of Salahaddin-Erbil at (Gerdarasha farm) from October 8th, 2024, to November 11th, 2024. The Sardam private hatchery in Erbil-Qushtapa provided 400 unsexed one-day-old Ross 308 chicks, with a mean weight of 38.85 ± 0.07 g, which were randomly distributed into five experimental treatments with four replicates per treatment (20 birds/replicate). The chicks were purchased from a local hatchery (Sardam hatchery) and were checked for health and safety.

Experimental treatments:

MOSP was sourced from the local market in Erbil city and dried in standard laboratory conditions, kept away from direct sunlight for 3 to 7 days. A total of 5 kg of Moringa seeds was processed in an industrial mill for 5 minutes per kg. Butylhydroxytoluene (BHT) powder Obtained from the Department of Food Industries, College of Agricultural Engineering Sciences at Salahaddin University-Erbil, and was used at 0.02% of the standard feed, (Its Chemical formula- $C_{15}H_{24}O$). It is a synthetic antioxidant compound, widely used as a feed additive in chicken feed to prevent the oxidation of fats and oils, thus preserving the feed's nutritional value and flavor. BHT It is a single chemical used for this purpose and comes in several forms (Powdered, granulated, and liquid form) [13].

Table (1) Nutrient analysis of dried Moringa oleifera seed powder 100 g

Gradients	%
Moisture	4.03
Crude Protein	28.72
Crude Fat	30.03
Crude Fiber	23.45
Crude Ash	3.13
NFE	10.64

The experimental parameters were as follows

- •T1: Control treatment (Standard diet= SD).
- •T2: SD + 0.02% BHT.
- •T3: SD + 0.25% Moringa oleifera seed powder (MOSP).
- •T4: SD + 0.50% Moringa oleifera seed powder (MOSP).
- •T5: SD + 0.75% Moringa oleifera seed powder (MOSP).

Nutritional needs of broilers

Table (2) Composition and nutritional levels of experimental starter and grower diets (1-35) days.

Ingredients	Starter (%)	Grower (%)
Corn	43.71	51.350
Soya bean meal 44%	38	30.510
Wheat	11	11
Fish meal 56%	2	1.600
Toxin binder	0.150	0.150
Mono Di calcium phosphate 21%	1.200	1.200
Soybean oil	1.500	2.100
DL-Methionine	0.200	0.200
L-Lysine	0.140	0.140
salt	0.300	0.300

Enzyme	0.050	0.050
Calcium Ca %	1.700	1.350
Anticoccidial	0.050	0.050
Total	**100**	**100**
Calculated chemical analyses		
Metabolic energy kcal/ kg	2875	3004
Crud protein %	22.93	20.30
Fat %	3.837	4.591
fiber	4.024	3.687
Avail. P for poultry	0.377	0.359
Calcium Ca %	1.099	0.919
Total phosphorus P%	0.664	0.623
Salt	0.349	0.341
Arginine	1.030	1.263
Lysine	1.200	1.120
Methionine+ Cystine	0.880	0.777
Methionine	0.500	0.496
Threonine	0.750	0.719
Tryptophan	0.220	0.238

Study Parameters

Growth performance

A digital balance (with: ±0.1 g to ±1 g Accuracy) was used to record body weights on days 7,21, and 35. It's done by subtracting the initial weight from the final weight. body weight gain (BWG) was calculated [14]. Following the measurement of feed intake (FI) by replicate, feed conversion ratio (FCR) was measured using the following formula.

Weight gain (g) = BW (at the week ended) – BW (at the week beginning) [14]

FCR = Feed intake during a period / WG at same period duration [14].

Carcass Traits:

Two male birds were selected from each replicate on day 35, fasted for 12 hours, slaughtered, de-feathered, and eviscerated. Internal organs (liver, heart, gizzard, spleen, and bursa of Fabricius) and carcass parts (leg and breast) were weighed separately. Organ weights and cut yields were reported as a percentage of carcass weight:

Cut yield% = [weight of cut/carcass body weight] ×100.

The dressing percentage was shown in the following equations:

Dressing percentage = {Carcass weight-CW (g)/ live body weight-BW (g)} *100 [15].

Meat Quality Assessment

pH Measurement

The pH value of the meat samples was determined using the following method [16]. After being homogenized in 90 milliliters of DW (distilled water), a 10 gram piece of beef was put into a beaker. The probe of temperature and the electrode were applied into the sample. The value of pH of meat was determined by taking a measurement on the base of the pH meter.

Water Holding Capacity (WHC)

The water holding capacity of meat samples was determined by the method suggested by [17]. The meat sample (8g) was put in a centrifuge tube, adding a 12 mL NaCl solution (0.6 M). The centrifugal tube (4 0C) was centrifuged for 15 minutes at 10,000 rpm to decant and measure the supernatant. The water holding capacity was assumed from the difference between the NaCl volume used and the supernatant.

WHC (%) = Before weight centrifuging - After weight centrifuging / Before weight centrifuging x 100.

Cooking Loss

Individual weights of Pectoralis major muscle samples from each treatment were recorded as the initial weight (W1). In plastic bags, samples were cooked in a water bath at 80°C for twenty minutes. After 20 minutes of cooling at 25 degrees Celsius, samples were weighed again then recording it as final weight (W2). Cooking loss has determined by the follows:

Cooking loss% = [W1 -W2/W1] ×100 [18].

Where W1 = before cooking weight, and W2 = after cooking weight.

Meat shear force measurement

Cooked muscle samples were cut into uniform blocks measuring 1 × 1 × 2 cm to evaluate the meat's tenderness. Texture analyzer /TA.HD plus®, Stable Micro Systems, United Kingdom, filled by a Volodkevitch bite jaw, has then used to test each block. The shear force was determined by averaging the peak force needed to shear through the sample, which was measured by the device. Good tenderness is indicated by lower shear force values [19].

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Color Measurement

In agreement with the CIE Lab system, which measures lightness (L*), redness (a*), and yellowness (b*), A calibrated Color-Flex spectrophotometer was used to assess the meat's color.

(The Hunter-Lab, USA). To stabilize surface color, samples of the longissimus lumborum (LL) muscle were left to bloom for half an hour at room temperature [20].

Statistical Analysis

A generalized linear model with treatment and major effects was applied. According to the following mathematical model, Duncan's Multiple Range Test was used to assess notable variations among treatment means, with an acceptable level for significance of ($P \leq 0.05$):

$$Yij = \mu + tij + eij$$

Results and discussion

Influence of Moringa oleifera Seed Powder (MOSP) on growth performance in broiler

This study investigated the effects of supplementing MOSP with synthetic antioxidants (BHT) at levels of 0.25%, 0.50%, and 0.75% on broiler chickens' growth-performance. Table 3 displays parameters measured while the experimental period (7–35 days), including BW, BWG, FI, and FCR.

At the 7th day, no significant differences in initial body weight were observed between treatments ($P > 0.05$). In addition, body weight on day 21 did not differ significantly between groups, indicating that dietary treatments did not affect initial growth. On day 35, final body weight in T2 (BHT) and T4 (0.50% MOSP) was significantly higher than in T1 (control) and T5 (0.75% MOSP), with T5 recording the lowest value (2214.25 g) ($P \leq 0.05$). These results demonstrate that BHT and 0.50% MOSP are optimal for growth, whereas high levels of MOSP may reduce growth.

There was no significant difference in BWG during the starter phase (7–21 days) ($P > 0.05$). In the finisher phase (21–35 days), on the other hand, T2 and T4 did significantly better than the other groups ($P \leq 0.05$), with BWG of 1333.25 g and 1323.75 g, respectively. BWG (7–35 days) showed an identical trend, with T2 (2173.75 g) and T4 (2152.00 g) performing greater than T1 (2066.25 g) and T5 (2026.00 g), which suggests that a small MOSP and BHT supplementation results in improved performance.

FI wasn't affected during any of the phases ($P > 0.05$), suggesting that adding MOSP or BHT did not affect the quantity of feed the chickens consumed in their diets. However, during the finisher phase and over the entire period, there were significant improvements in FCR ($P \leq 0.05$). The FCR was best for T2 and T4 (1.50 and 1.50) and the greatest for T5 (1.64). These results show that 0.50% MOSP and BHT can be beneficial for improving the consumption of nutrients and the efficiency of growth.

Kairalla *et al*. [21] and Gul *et al*. [22] also found that the bioactive compounds in MOSP improve metabolic processes and intestinal function and enhance growth and feed efficiency. On the other hand, higher inclusion levels, as demonstrated by Obakanurhe & Sanubi [23], may add antioxidants such as tannins and saponins, which reduce palatability and increase the efficiency of the digestive system in absorbing nutrients. Gul et al. [22] and Abed et al. [24] also discussed how MOSP can help improve gut morphology and protein utilization, potentially helping to achieve a higher 0.50% inclusion ratio in both FCR and BWG.

Table (3) Influence of MOSP on growth performance in broiler (at 35 days)

	days	T1	T2	T3	T4	T5	SEM#
Body weight [g]	7	191.00	187.25	186.500	189.00	188.25	0.826
	21	1011.75	1027.75	1016.75	1017.25	1020.75	4.786
	35	2257.25 cd	2361.00 a	2298.00 bc	2341.00 ab	2214.25 d	13.833
Body weight gain [g]	(7-21)	820.75	840.50	830.25	828.25	832.50	2.326
	(21-35)	1245.50 bc	1333.25 a	1281.25 ab	1323.75 a	1193.50 c	11.074
	(7-35)	2066.25 cd	2173.75 a	2111.50 bc	2152.00 ab	2026.00 d	11.176
Feed intake [g]	(7-21)	1168.50	1177.75	1174.50	1168.00	1164.75	2.326
	(21-35)	2008.00	2001.00	1988.75	1989.75	1960.00	11.074
	(7-35)	3176.59	3178.74	3163.03	3157.65	3124.64	11.176
Feed conversion ratio [g]	(7-21)	1.42	1.40	1.41	1.41	1.40	0.007
	(21-35)	1.61 ab	1.50 c	1.55 bc	1.50 c	1.64 a	0.017
	(7-35)	1.53 a	1.46 b	1.49 ab	1.46 b	1.54 a	0.009

a-d mean within the same row for each parameter with different superscripts are significantly different(($P\leq0.05$)). T1: control (standard diet=SD), T2: (SD) + 0.02(BHT), T3 SD + 0.25% additives of MOSP, T4: SD+ 0.50%additives of MOSP, T5: SD + 0.75% additives of MOSP, each value represents the mean of four replicate values, SEM: standard error of the mean.

Influence of MOSP on the Carcass and Organ Indices in broiler

Table 4 shows the effects of dietary BHT and MOSP on carcass traits and organ weights. Chickens fed 0.25% (T3) and 0.50% (T4) MOSP showed significant increases in live body weight and carcass weight ($P\leq0.05$), indicating improved muscle deposition and nutrient absorption. While the total carcass weight increased, the proportion of carcass parts remained unchanged, as evidenced by the absence of any significant effects on dressing percentage, breast yield, or thigh yield ($P > 0.05$). The results of Wahab et al. [12] are consistent with this. Furthermore, the spleen weight of T3 was significantly greater (0.217%) compared to the control group (0.167%), indicating an immunostimulant effect at the 0.25% inclusion ratio, which confirms previous findings by Ochi et al.[25], indicating that the immunomodulatory properties of moringa led to improved lymphoid organ development.

Table (4) Influence of MOSP on the Carcass and Organ Indices in broiler (at 35 days)

Parameter	Treatment					SEM
	T1	T2	T3	T4	T5	
Live body weight (g)	2515.0 b	2526.1 ab	2747.5 a	2740.0 a	2672.5 ab	34.4
Carcass weight (g)	1868.50 c	1894.75 bc	2091.50 a	2068.25 a	2052.13 ab	28.52
Dressing (%)	75.108	75.860	76.123	75.555	76.766	0.329
Breast (%)	41.745	41.766	41.788	42.508	41.978	0.198
Leg (%)	26.058	26.408	26.658	26.606	25.648	0.243
Gizzard (%)	1.398 ab	1.647 a	1.300 b	1.521 ab	1.451 ab	0.043
Heart (%)	0.623	0.608	0.638	0.630	0.607	0.005
Liver (%)	3.223	3.197	3.367	3.235	3.051	0.067
Fabricia (%)	0.197	0.232	0.220	0.206	0.206	0.008
Spleen (%)	0.167 b	0.182 b	0.217 a	0.196 ab	0.177 b	0.005

Each parameter's a-c mean within the same row, with distinct superscripts, differs considerably (($P\leq0.05$)).
T1:control (standard diet=SD), T2: (SD) + 0.02(BHT), T3 SD + 0.25% additives of MOSP, T4: SD+ 0.50%additives of MOSP, T5: SD + 0.75% additives of MOSP, each value represents the mean of four replicate values, SEM: standard error of the mean.

Influence MOSP on some meat quality in broiler

Table 5 illustrates that MOSP supplementation significantly increased the water-holding capacity (WHC) of moringa and decreased shear force ($P \leq 0.05$). T5 (0.75% MOSP) recorded the lowest shear force (1.335 kg) and the highest WHC value (84.02%), indicating more tender meat. According to Gul et al. [22] and Brenes and Roura [26], these benefits can be linked to the antioxidant properties of moringa, which preserve muscle structure and reduce protein oxidation.

A statistically significant decrease in cooking losses was observed in T4 and T5, suggesting a potential for enhanced moisture retention during cooking. However, cooking losses and pH were not statistically different between treatments. These results confirm the findings of Abed et al. [22], who found that broiler chicken supplemented with MOSP had improved water binding and tenderness. However, anti-nutritional residues at extremely high levels can affect meat quality [22].

Table 5: Influence of MOSP on some meat quality in broiler

Parameter	Treatment					SEM
	T1	T2	T3	T4	T5	
pH	6.275	6.251	6.211	6.218	6.240 a	0.087
Water holding capacity (%)	73.628 c	70.855 c	77.914 b	78.342 b	83.022 a	0.908
Cooking loss (%)	23.608	23.659	23.496	22.939	22.796	1.950
Shear force (Kg)	1.437 ab	1.452 a	1.427 ab	1.401 ab	1.335 b	0.100

Each parameter's a-c mean within the same row, with distinct superscripts, differs considerably (($P \leq 0.05$)). T1: control (standard diet=SD), T2: (SD) + 0.02(BHT), T3 SD + 0.25% additives of MOSP, T4: SD+ 0.50% additives of MOSP, T5: SD + 0.75% additives of MOSP, each value represents the mean of four replicate values, SEM: standard error of the mean.

Influence of MOSP on color characteristics in broiler

Table 6 shows that the color parameters of breast meat—lightness (L*), redness (a*), and yellowness (b*)—were not significantly affected ($P > 0.05$) by MOSP or BHT supplementation. Since the MOSP groups contain natural pigments such as carotenoids and chlorophyll, slight decreases in L* values and increases in a* and b* values were observed. These results are consistent with those of Lungu et al. [27] and Zhang et al. [28], who highlighted the antioxidants in moringa and their protective role in maintaining pigment stability. The safe use of MOSP supplements up to 0.75% without affecting the appearance of the meat supports the absence of any undesirable color changes. In contrast, high inclusion levels (≥ 10%) caused undesirable pigmentation in the reports of [22].

Table 6: Influence of MOSP on color characteristics in broiler

Parameter	Treatment					SEM
	T1	T2	T3	T4	T5	
Lightness	51.720	51.331	49.268	49.483	50.649	0.559
Redness	10.035	11.205	10.899	11.536	11.025	2.163
Yellowness	12.350	12.215	12.053	12.326	12.792	1.375

Each parameter's a mean within the same row, with distinct superscripts, differs considerably (($P \leq 0.05$)). T1: control (standard diet=SD), T2: (SD) + 0.02(BHT), T3 SD + 0.25% additives of MOSP, T4: SD+ 0.50%additives of MOSP, T5: SD + 0.75% additives of MOSP, each value represents the mean of four replicate values, SEM: standard error of the mean.

Conclusion

Similar to the effects of synthetic antioxidant BHT, this study shows that adding 0.50% of Moringa oleifera seed powder (MOSP) to the diet may significantly enhance broiler performance, carcass yield, and meat quality. Without adversely influencing feed intake or meat color, MOSP at this level increased weight gain, carcass weight, feed efficiency, and meat tenderness. However, higher inclusion (0.75%) lowered performance, probably because of anti-nutritional factors. Additionally, increased spleen weight suggests that average levels (0.25–0.50%) may support immune function. However, these results support MOSP as a natural substitute for artificial antioxidants to improve grill diets regarding health and production. Its mechanisms and economic feasibility in commercial settings need more investigation.

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تأثير إضافة مسحوق بذور المورينجا أوليفيرا الى العلف على أداء الاداء الانتاجي وخصائص الذبيحة وجودة اللحم في دجاج التسمين

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الخلاصة

أجريت هذه التجربة في حقول الانتاج الحيواني التابعة لقسم الإنتاج الحيواني، كلية الهندسة الزراعية، جامعة صلاح الدين، في منطقة كرده رش ، أربيل، لدراسة تأثير مستويات مختلفة من مسحوق بذور المورينجا أوليفيرا ***Moringa oleifera*** كإضافة علفية مقارنة بمضاد الأكسدة الاصطناعي ***BHT*** على أداء النمو، و خصائص الذبيحة، وجودة اللحوم في الدجاج اللاحم. تمت التجربة لمدة 35 يوماً (من 8 إكتوبر 2024 الى 11 نوفمبر 2024) ، تم استخدام 400 فرخ نوع ***Ross 308***، عمر يوم واحد، غير مُجَنَّن، بمتوسط وزن 38.85 ± 0.07 غرام، ووُزِّعت عشوائيًا على خمس معاملات تجريبية، بواقع أربع مكررات لكل معاملة (20 طائرًا/مكرر). وكانت المعاملات كما يلي: ***T1***: مجموعة ضابطة (تلقت عليقة (علف) قياسية). ***T2***: عليقة قياسية + 0.02 % بوتيل هيدروكسي تولوين ***T3 .(BHT)***: عليقة قياسية + 0.25% مسحوق بذور المورينجا أوليفيرا ***T4 .((MOSP***: عليقة قياسية + 0.50% مسحوق بذور المورينجا أوليفيرا. ***T5***: عليقة قياسية + 0.75% مسحوق بذور المورينجا أوليفيرا. أظهرت نتائج التحليل الإحصائي فروقًا معنوية في كلتا المعاملتين ***T2*** و***T4*** في كلٍّ من وزن الجسم الحي، وتفوقًا ملحوظًا في معدل الزيادة الوزنية الكلية وكفاءة التحويل الغذائي، بينما لم تُظهر نتائج خصائص الذبيحة (نسبة التصافي، وزن الصدر، وزن الفخذ) فروقًا معنوية بين المعاملات. أما بالنسبة لجودة اللحوم، فلم تُسجَّل فروق معنوية في قيم الأس الهيدروجيني (***pH***) واللون وفقد الطهي، بينما ظهرت فروق معنوية في المعاملات عند دراسة سعة الاحتفاظ بالماء (***WHC***) وقوة القص لصالح المعاملة ***T5***. وخلصت الدراسة إلى أن استخدام مسحوق بذور المورينجا أوليفيرا كإضافة علفية (بمعدل 0.25- 0.50- 0.75%) على الدجاج اللاحم يُسهم في إنتاج دجاج ذي زيادة وزنية ملحوظة، وكفاءة تحويل غذائي عالية، وسعة الاحتفاظ بالماء (***WHC***) عالية، وقوة قص عالية للحوم الدواجن.

الكلمات المفتاحية: الدجاج اللاحم ، مضاد الاكسدة الصناعي (***BHT***)، مسحوق بذور المورينجا أوليفيرا، أداء النمو، خصائص الذبيحة، جودة اللحم.