Effect of addıng Moringa leaves powder to the laying hens' diets on the productive performance and egg quality traits.

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Abstract

The practical part of the study was conducted on the campus of the University of Mosul, in the experimental fields of the Animal Production Department, College of Agriculture and Forestry, for a period of ten weeks, preceded by a three-week acclimatization period. The study involved laying hens of the commercial MIZO breed, aged 44 weeks, from August 26 to November 4, 2024. The study aimed to investigate the effect of adding moringa leaf powder to the feed on the productıve performance and egg qualıty of the MIZO laying hens at 44 weeks of age,. A total of 240 MIZO laying hens (192 females and 48 males) were used, randomly divided into three treatment groups. Each treatment group consisted of four replicates (20 birds each), with each replicate comprising 16 females (average weight 1.686 kg) and 4 males (average weight 1.887 kg). The experimental period lasted for 10 weeks. The treatments were as follows: Treatment 1 (control): standard feed (without moringa leaf powder); Treatment 2: standard feed supplemented with 3 g/kg moringa leaf powder; Treatment 3: standard feed supplemented with 6 g/kg moringa leaf powder. Statistical analysis revealed significant improvements in production traits and some egg quality parameters in the supplemented groups compared to the control group.

Introduction

The poultry industry is considered a fundamental pillar for achieving food security for people around the world, as it provides two essential sources of protein: eggs and meat. Chicken eggs are considered a complete food for humans because, by the grace of God, their composition provides all the necessary nutrients (Al-Fayyadh et al., 2011). Pashael et al. (2024) indicated that poultry products are among the most consumed sources of animal protein worldwide. To meet the increasing demand, it has become necessary to improve poultry nutrition to ensure the sustainability of the poultry industry. This industry faces many challenges, including feed availability and the ban on the use of antibiotics. Sorensen (1997) explained that the poultry industry is one of the most important pillars of the economy in many countries, due to its rapid capital turnover and its contribution to meeting human nutritional needs. He also noted that antibiotics were widely used in the poultry industry, both for treating diseases and preventing infections, as well as for promoting growth and production. They were added to feed to improve feed conversion efficiency, which directly impacted animal production efficiency. However, the use of antibiotics led to the emergence of antibiotic-resistant bacterial strains, and these pathogens can be transmitted from poultry to humans, necessitating the adoption of alternative methods to antibiotics to protect both animal and human health. In recent decades, the world has witnessed a growing interest in the use of medicinal plants as a means to promote public health and reduce reliance on synthetic chemical compounds. This trend is attributed to the pursuit of environmental sustainability and food safety. The World Health Organization (WHO) has recommended the use of medicinal plants and herbs as alternatives to antibiotics. Numerous studies have also indicated that the use of medicinal plants as feed additives is based on their easy availability and low cost. Their addition to poultry feed acts as an effective pharmaceutical tool, limiting the proliferation of pathogenic microorganisms in the digestive tract, thus improving growth performance, enhancing digestive efficiency, and boosting immunity. Yusuf et al. (2023) demonstrated that incorporating these plants into laying hen diets contributes to the production of eggs with enhanced nutritional and functional value, by reinforcing and strengthening the naturally occurring components within the egg. This, in turn, benefits the consumer, as the eggs can provide antioxidant properties that promote overall health. The antioxidants provided by these plants are safe and effective. One of the most important of these plants is *Moringa oleifera*, which is widely distributed in tropical and subtropical regions and thrives in arid, hot environments, even in soils with poor water retention. Moringa contains active compounds such as flavonoids, saponins, and plant sterols, which serve as precursors for hormones. It also contains vitamins, minerals, amino acids, and antioxidants, which do not cause problems such as antibiotic resistance or generate harmful residues. These natural products, which have numerous uses for both humans and animals, play a role in improving production and reproductive performance without causing any harm (Scott et al., 2018).

2-2: The Importance of Medicinal Plants in Farm Animal Nutrition:

Feed costs account for approximately 80% of the total expenses of livestock production projects. Proper nutrition is the first essential step in improving poultry production performance, as its effects directly impact production rates, thus contributing to enhanced economic efficiency compared to rearing costs (Alagawany et al., 2020). Astati et al. (2025) stated that medicinal plants have gained significant importance in the livestock sector due to their vital role in nutrition, in addition to being an important economic resource for many developing countries, contributing to improved feed quality and increased productivity. Medicinal plants are used because they contain substances with biological properties, such as antimicrobial activity, immune cell stimulation, protection against oxidative stress, and increased antibody production. Medicinal plants are a safe and non-toxic option, used as growth promoters and to increase animal productivity. They also improve the absorption of nutrients in the gut and inhibit intestinal pathogens, representing an effective alternative to antibiotics, which have negative effects on human and animal health. Singh (2020) indicated that medicinal plants are added to animal feed either as powders or extracts, and are administered in specific doses according to a well-designed schedule to ensure maximum benefit. They are characterized by their low cost and environmental friendliness, thus enhancing both their economic and environmental viability.

2-4: Moringa Plant (Plant Description):

Moringa is a fast-growing, perennial tree known for its medicinal and nutritional properties. Its scientific name is Moringa oleifera Lam (Iliysau et al., 2020). The tree is often called the "miracle tree" or "tree of life" due to its importance and wide range of uses, making it one of the most beneficial trees in the world (Quattor Cchieta and Umberto, 2000). Moringa thrives in temperatures ranging from 18 to 40°C and with annual rainfall between 2500 and 760 mm, and in soil with a pH between 5.4 and 8. It is cultivated worldwide. The tree grows rapidly, reaching a height of 10 to 12 meters and a trunk diameter of approximately 45 cm. Its branches are 1 to 1.5 cm long and 2 cm wide (Leone et al., 2015). Moringa has a taproot with tuberous formations that help it tolerate drought and water scarcity (Zhigial, 2014). Its seeds are round, with three angles or three wings (Abu Taher, AbdulBasife, 2017). The tree has small, white, fragrant flowers, and its fruit is a pod (Chaurasia et al., 2017). The leaves have an entire margin, a long central rachis, and pinnate branches with pairs of leaflets, each pair consisting of two opposite leaflets. The leaves are compound and alternate, appearing mainly at the branch tips (Su and Chen et al., 2020).

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5. Nomenclature (Native Habitat of the Plant):

The Indian subcontinent is the native habitat of Moringa. The native Moringa oleifera originates from the western and sub-Himalayan regions of India and Pakistan, and is also found in Asia, Africa, the Philippines, and Cambodia (Mughal et al., 1999). It is also widespread in tropical and subtropical regions (Price, 2007). It is also found in the West Indies, Mexico, Brazil, Central America, and North and South America (Ganatra, 2012). Moringa oleifera is the only species in the genus Moringa within the family Moringaceae, which comprises fourteen species. The tree has many common names due to its diverse uses and numerous benefits, including: miracle tree, horseradish tree, ben oil tree (due to the oil derived from its seeds), drumstick tree, poor man's tree, radish tree (because its root tastes like radish), wild garlic, shelter tree, and tree of life (Alden, 2009). In India, it is called Muringa or Munaga, derived from the Malayalam language of South India (Dwivedi and Sanjay, 2015; Osman, 2012).

Table (1): Plant Classification

Kingdom	Plants
Phylum	Flowering plants
Class	Dicots
Order	Mustard family
Family	Moringa
Genus	Olive tree

(2016a،USDA)

2-6: The Medicinal and Nutritional Importance of Moringa and its Active Compounds.

The miracle tree (Moringa) is known for its medicinal, nutritional, and industrial value (Hegde et al., 2013; Koul & Chase, 2015; Saini et al., 2016). Hao et al. (2020) indicated that moringa contains bioactive compounds that possess antimicrobial, stress-reducing, and immune-enhancing properties, as well as antioxidant and anti-inflammatory effects (Chachar et al., 2024). Daba et al. (2016) stated that moringa contains plant sterols, which are precursors for hormone synthesis and have a structure similar to cholesterol, thus inhibiting its absorption in the intestines and consequently lowering blood cholesterol levels. Moringa provides raw materials for various industries, including cosmetics, ointments, and soap production (Zauro, 2014). Hendrawati et al. (2016) mentioned that the tree is cultivated for ornamental and shade purposes, as well as for honey production, since bees feed on its nectar. The charcoal produced from its wood is of high quality, and its bark is used in leather tanning. Its leaves are used as fodder, and its seeds are used for water purification due to their oil content, which allows them to precipitate suspended particles in water, making it suitable for drinking. Chukwuebuka et al. (2015) stated that moringa leaves contain high levels of protein, amino acids, vitamins, minerals, and antioxidants, which enhance the immune system, lower blood pressure, and reduce blood and body fat. Anwar et al. (2007) confirmed that the active compounds in Moringa leaves play a role in lowering blood pressure and have anti-cancer, antibacterial, and antifungal properties. Ghasi et al. (2000) demonstrated that the leaves lower cholesterol levels. Xiao et al. (2020) indicated that Moringa contributes to regulating the immune system, playing a crucial role in diseases related to immunity and preventing chronic inflammation. Sankhala and Vernekar (2016) pointed out that Moringa leaves contain secondary metabolites with antioxidant and free radical scavenging properties. Hamidi (2015) explained that saponins are secondary metabolites, with steroidal saponins being the most important type, and Alphonse et al. (2017) showed that saponins have the ability to lower blood cholesterol levels. Davide (2016) confirmed that flavonoids are widespread phenolic compounds found in various parts of the plant (roots, leaves, flowers), playing a vital role in reducing the risk of diseases by stimulating the enzymatic system and protecting against many diseases, including cancer and cardiovascular diseases, as well as combating oxidative stress caused by free radicals. Soultan et al. (2015) reported that the Moringa plant contains many vitamins, including vitamins C, B, E, and D. Ahmed et al. (2016) added that vitamin C is found in all parts of the Moringa plant and contributes to calcium and iron absorption, and is important for regulating blood sugar levels. Hofila et al. (2017) demonstrated that vitamin E plays a role in reducing diabetes complications by enhancing antioxidant activity and mitigating oxidative stress. Pawakar and Sasanqan (2017) explained that moringa is a rich source of amino acids, giving it high nutritional value and making it a valuable source of dietary supplements that contribute to a balanced diet, as it contains various bioactive compounds such as saponins, alkaloids, and tannins.

Table (2): Percentage composition of moringa leaf powder (on a dry matter basis).

% Percentages	Ingredients
26.31	Crude protein
2.44	Ether extract
13.07	Total ash
16.08	Crude fiber
42.10	Nitrogen-free extract

Source: (Jassim & Hassein et al., 2019)

Table (3): Chemical composition of Moringa leaves, including essential and non-essential amino acids.

Essential amino acids:	**Quantity (g/100g)**	Non-essential amino acids:	**Quantity (g/100g)**
Arginine	0.4-1.8	Alanine	1.8-3.0
Lysine	0.3-1.4	Aspartate	1.4-2.2
Leucine	0.4-2.2	Cysteine	0.01-0.10
Histidine	0.1-0.7	Glutamate	2.5-2.5
Methionine	0.1-0.5	Glycine	1.51.3
Phenylalanine	0.3-1.6	Proline	1.2-1.4
Threonine	0.1-1.3	Tyrosine	0.01-2.60
Tryptophan	0.1-2.5	Serine	0.01-1.2
Valine	0.4-1.4	Non-essential amino acids:	-

Table (4) shows the percentages of minerals found in Moringa plant leaves:

Minerals	**% Percentages**
Calcium	3.65
Potassium	1.50
Magnesium	0.50
Phosphate	0.30
Sodium	0.164
Sulfur	0.63
Zinc	31.03
Copper	8.25
Iron	490
Manganese	86.8
Selenium	363.00
Boron	49.93

Source (Moyo et al., 2011)

Table (5) Vitamins present in Moringa leaves.

Vitamins	Quantity (%)
Vitamin B1	2.64 mg
Vitamin B2	20.5 mg
Vitamin B3	8.2 mg
Vitamin E	113 mg
Vitamin C	17.3 mg
Vitamin D	1324 mg

Source: (Gopalakrishnan et al., 2016)

Materials and Methods

Poultry House

Before introducing the laying hens, the poultry house was prepared. It was a semi-open type, with windows on one side and exhaust fans on the other to ensure proper ventilation. The lighting in the house was set at 16 hours of light and 8 hours of darkness daily, with lights evenly distributed throughout the space. Digital thermometers were placed to monitor the temperature, which was maintained within a range of 21±3°C. An electronic hygrometer was also used to measure the humidity, which was kept between 50-65%. The house was equipped with 10-kg capacity plastic feeders and automatic nipple drinkers. The floor was cleaned and covered with plastic mesh instead of sawdust to prevent dampness and to protect against certain diseases. After completing the preparations, the birds were placed in the pens. Each pen measured 1.5 m x 3 m and housed 16 hens and 4 roosters.

Veterinary Care

Under the direct supervision of the veterinary unit at the poultry farm within the College of Agriculture and Forestry, University of Mosul, a preventive program was implemented, including necessary vaccinations. However, no vaccinations were administered during the experimental period, as the flock was between 44 and 54 weeks old, a period during which vaccinations are not typically given. Feeding Method

The feed was distributed manually at 8:30 AM using 10 kg capacity plastic feeders. 2200 g of feed (110 g/bird) was placed in each feeder, according to the breed recommendations. The feeders were suspended from a rope and adjusted to the height of the birds' backs to facilitate access to the feed. Water was provided ad libitum through automatic drinkers.

Feed Ingredients and Mixing:

The feed ingredients were obtained from local sources. The feed rations for each group were formulated according to the recommendations of the National Research Council (NRC 1994) and mixed in the feed mill located at the Animal Production Department of the College of Agriculture and Forestry, University of Mosul. The feed was then ground in a 500 kg capacity grinder. Moringa leaf powder was added to a small portion of the feed and mixed thoroughly. This mixture was then added to a larger quantity of feed and mixed again, continuing this process until the moringa leaf powder was evenly distributed throughout the feed. The feed composition is shown in the following table.

Table (3) shows the proportions of the feed components and the calculated chemical composition based on (NRC, 1994).

Feed ingredients:	**% Its percentage in the feed**
Yellow corn	47.5
Wheat	15.5
Soybean meal	)44
Sunflower oil	1
Calcium phosphate	1
Limestone	8.25
salt	0.250
Premix (containing 25% protein)	2.5
Calculated chemical analysis	
Protein	17.01
Energy	2800.1
Crude fiber	3.19
Lysine	0.874
Methionine	0.470
Methionine and cysteine	0.535
Calcium	3.325
Available phosphorus	0.373
Linolenic acid	1.381

Egg production rate based on %H.D.P (Hen-Day Production)

%H.D.P = (Number of eggs produced during the period) / (Number of hens at the end of the period * Number of days in the period) x 100

Average egg weight (g)

The weight of the eggs produced by each replicate in each group was measured using a sensitive electronic digital scale (Chinese origin) as described by Naji et al. (1989).

Average egg weight (g/replicate) = (Total weight of eggs produced during the experiment) / (Number of eggs produced during the same period)

Average egg mass

Egg mass was calculated according to the equation described by Naji et al. (1988).

Average egg mass (g/hen/day) = egg weight per replicate *egg production % per replicate /100

Feed consumption

The daily feed ration was provided according to the standard feeding guide for the breed, with each bird receiving 110 g of feed at 8:30 AM at 44 days of age.

Feed conversion ratio for eggs

The feed conversion ratio was calculated according to the equation described by Al-Zubidi (1986):

Feed conversion ratio (g feed/g egg) = (Average feed consumption per bird per day) / (Average egg mass per bird per day)

Egg quality traits

Egg quality was evaluated by measuring the percentage of shell, yolk, and albumen, as well as the egg shape index. For these measurements, two eggs were randomly selected from each replicate in the experimental groups, using the method recommended by Cotterill & Stadelman (1977). Egg length and width (mm)

Eggs were collected from each replicate for measuring egg length and width using a digital caliper (Vernier) (0.001 mm). The egg was placed lengthwise and then crosswise for measurement, and both the length and width were recorded. Two eggs were taken from each replicate of each group at 10:00 AM, and the measurements were taken in the Physiology Laboratory at the College of Agriculture, University of Mosul.

Egg shape index

The egg shape index was calculated according to the equation proposed by Saki et al. (2011) after measuring the egg length and width.

Egg shape index (%) = (Egg width (mm) / Egg length (mm)) × 100

Relative yolk weight (g)

The yolk was weighed using a sensitive electronic scale (Chinese origin) after separating it from the egg white.

Yolk percentage = (Yolk weight (g) / Egg weight (g)) × 100

(Saki et al., 2006)

Yolk index

The yolk index was calculated after measuring the yolk height and diameter according to the equation proposed by Al-Fayyadh et al. (2008).

Yolk index (%) = (Yolk height (mm) / Egg diameter (mm)) × 100

Relative egg white weight (g)

The egg white was weighed using a sensitive scale with an accuracy of 0.01 g after separating it from the yolk.

Relative yolk weight = (Yolk weight (g)) / (Egg weight (g)) × 100

(Al-Fayyadh and Naji, 1989)

Relative shell weight (g)

The eggshell, including its membranes, was weighed after breaking the egg and removing its contents, using a sensitive balance with an accuracy of 0.001 g.

Relative shell weight = (Shell weight (g)) / (Egg weight (g)) × 100

Shell thickness (mm)

The average shell thickness was measured using a Vernier caliper (Chinese origin).

Yolk color

Using a Roche color fan from Roche Diagnostics, the yolk color of the eggs from the study groups was compared to the color fan. The fan, which ranges from 1 to 16 color shades, was placed next to the yolk for comparison.

pH measurement

To determine the pH, one egg from each replicate within the experimental groups was selected. The yolk and egg white were then separated from each sample and placed in separate containers. The pH was measured using an electronic pH meter (made in Singapore). Statistical Analysis

The experimental results were analyzed using a Completely Randomized Design (CRD) and the Statistical Analysis System (SAS) software (2012). Significant differences between means were determined using Duncan's Multiple Range Test (Duncan, 1955) at a significance level of ($\alpha \leq 0.05$) according to the following mathematical model:

$Y_{ij} = M + t_i + E_{ij}$

Where:

Y_{ij} = the value of the experimental unit affected by treatment i

M = the overall mean

Ti = the effect of treatment i

Eij = the experimental error for observation j belonging to treatment i

Results and Discussion

The statistical analysis revealed a significant improvement in egg production rate and egg mass for the third treatment group. Regarding egg weight, all treatment groups were significantly superior to the control group. The feed conversion ratio was also significantly better in the third treatment group compared to the control group. The results of this study were consistent with those of Igugo et al. (2022) and Abdel-Wareth et al. (2021), but differed from those of Shen et al. (2021). The improvement observed when Moringa leaf powder was added to the laying hen feed may be attributed to the presence of antioxidants, which reduced oxidative stress, thus improving overall health and increasing egg production. Alternatively, it may be due to the presence of flavonoids, which improved the efficiency of nutrient digestion and absorption in the intestines, leading to improved production traits.

Where is the title of the table **Table (2)**

treatment	**Production periods**			
	egg production (%) **)**	**egg weight)**	**egg mass**	**feed conversion ratio**
T1	76.90 ±0.62 ب	60.09 ±0.29	40.38 ±0.31 ج	2.72 ±0.02 أ

		ب		
T2	80.75 ±0.53 ب	60.24 ±0.55 أ	42.67 ±1.47 ب	2.59 ±0.09 ب
T3	86.55 ±0.27 أ	61.68 ±0.60 أ	46.85 ±0.81 أ	2.35 ±0.04 ج

Moringa leaf powder and its effect on the quality traits of MizO chicken eggs:

The results in the table showed no significant differences between the second and third treatment groups compared to the control group in terms of average relative egg white and yolk weight, eggshell thickness, and shape index. These results were consistent with those of previous researchers (Iguo and Kouatchog, 2020; Ashour, 2020), who also found no significant differences between the treatment and control groups. However, a significant improvement ($p \leq 0.05$) was observed in the second and third treatment groups for relative eggshell weight and yolk color. These findings are in agreement with those of Swain and Tesfaye (2017), Ruelase (2023), and Abdel-Wareth (2021). The increased eggshell weight may be due to the fact that moringa leaves contain minerals such as calcium, manganese, and copper, which contribute to improved eggshell quality. Alternatively, the antioxidant properties of moringa leaves may positively affect the animal's health, leading to better calcium absorption and deposition in the eggshell, resulting in a stronger shell. Abou-Elezz et al. (2012) reported that the improved yolk color in the treatment groups is due to the higher concentration of carotenoids in dried moringa leaves (16.3 mg/100 g of dried leaves; NRC, 1985), as well as the presence of biologically active xanthophylls (red and yellow pigments) in moringa leaves. Oxidized carotenoids (hydroxyketones) also contribute to more efficient pigment deposition. Bidura et al. (2020) suggested that this might be due to the fact that the leaves contain 2.7 to 310 mg of carotenoids per 100 g of dry weight. This indicates that the carotenoids present in moringa leaves are well absorbed and utilized for yolk coloration. It is worth noting that yolk color is not directly related to nutritional value, but it is considered a quality indicator that influences consumer perception of egg quality.

Table(3) Effect of adding moringa leaf powder to the feed of laying hens on some quality traits of eggs at 54 weeks of age (means ± standard error)

treatments	egg white (%)	yolk weight	shell weight	Shell thickness ((mm	Egg shape (%) index	Yolk color
T1	60.65 ±1.41 أ	27.85 ±1.00 أ	11.49 ±0.90 ب	0.33 ±0.02 أ	74.54 ±3.06 أ	5.62 ±0.61 ب
T2	60.26 ±1.35 أ	27.52 ±0.98 أ	12.21 ±0.61 أ	0.34 ±0.02 أ	74.47 ±3.38 أ	10.81 ±0.40 أ
T3	60.10 ±1.83 أ	27.68 ±1.24 أ	12.21 ±0.98 أ	0.33 ±0.01 أ	73.83 ±2.73 أ	10.81 ±0.40 أ

Values with different letters in the same column indicate a significant difference at a probability level (α ≤ 0.05).

Effect of Moringa leaf powder on the pH of egg white and yolk in laying hens.

Our study results, shown in Table 21, indicated no significant differences between the treatment groups and the control group in terms of pH values of egg white and yolk. Our findings differed from those of Tesfaye et al. (2018), who observed a significant increase in egg yolk pH compared to the control group. It appears that Moringa leaves may reduce the rapid increase in pH, and a high egg pH is an indicator of an older egg

Table(4) Effect of adding Moringa leaf powder to the feed of laying hens on the pH of egg white and yolk at 54 weeks of age (Mean ± Standard Error).

Treatments	pH function for egg yolks	pH function for egg yolks
T1	8.33 ±0.23 أ	6.42 ±0.17 أ
T2	8.29 ±0.10 أ	6.32 ±0.01 أ
T3	8.45 ±0.38 أ	6.36 ±0.07 أ

Values with different letters vertically indicate a significant difference at a probability level (α ≤ 0.05).

WHERE IS THE CONCLUSION

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