Moringa as Natural Feed Supplement

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Application of natural herbs with a view to enhancing production performance and health status has created an important demand in poultry production. With the increasing concerns on this issue, greater attention paid to alternatives to antibiotics for organic meat and egg production has led to a great demand. This study was conducted with view to assessing the possible role of M. oleifera as a natural feed supplement in poultry ration. Various scientific findings and published research articles were considered concerning issues including the study background, objectives, major findings, and conclusions of the review. M oleifera is known as a miracle tree because of its wealthy resource of various nutrients with high biological values. M. oleifera has been used as a growth promoter, immune enhancer, antioxidant, and has a hypo-cholesterol e ect on chickens. It has both nutritional and therapeutic values. However, there is still much confusion in past published articles involving the major roles of M. oleifera in production performance and health status of chickens. Taking this into account, the present study highlights an outline of the experimental uses of M. oleifera on growth performance, egg production performance, egg quality, and health status in broilers and laying hens justified with the past findings to the present. The knowledge gaps from the past studies are considered, and the feasibility of M. oleifera in poultry ration is suggested. The findings have motivated further study on M. oleifera to find out the most active ingredients and their optimal doses in both broiler and laying hen rations. Finally, the present study highlights that supplementation of M. oleifera may play a role in the immunity, sound health, and production performance in poultry.

Moringa oleifera poultry growth performance laying performance health status

1. Introduction

The human population is increasing globally day by day. Meeting the increasing demand of animal protein and providing safe food for human beings that is free from antibiotics by using herbal feed resources is a great challenge for the animal scientists in the future. The issue considering antibiotic resistance has created an augmented force to reduce antibiotic uses in livestock and poultry production [1][2]. Dietary inclusion of herbs and their extracts has growth-promoting roles in poultry [3]. Furthermore, different natural medicinal plants and their extracts as feed supplements have been used as a substitute for antibiotics in poultry production [4][5]. In addition, Mahfuz et al. [6] reported that poultry scientists are now dedicated to applying unconventional natural feed supplement, which may play a role in possible therapies to improve the health as well as production performance of chickens.Thus, poultry researchers are searching for potential natural feed resources that will be both environmentally friendly and safe for human society [7][8].

Until the present day, the application of *M. oleifera* in farm animals to improve the production performance and health status has been limited. Even though it was established that *M. oleifera* has medicinal importance for the health of chickens, unfortunately the inclusion levels of *M. oleifera* in poultry ration and their mode of actions are still under consideration. Taking this into consideration, the present study focuses on uses of *M. oleifera* as a natural feed supplement as well as an alternative to antibiotics that can improve the performance and health status of chickens.

2. Moringa as Natural Feed Supplement

2.1. Biological Role of M. oleifera

The *M. oleifera* tree is globally known for its economic and therapeutic roles (Figure 1). Ithas been honored as the "Botanical of the Year 2007" by the National Institute of Health (USA), [9]. The tree is also known as "never die" or "miracle tree"to the people of Africa [9]. Now the application of *M. oleifera* leaves in preparing foods is receiving great attention. Peoples from Ghana, Nigeria, Ethiopia, East Africa, and Malawi are consuming the moringa tree leaves directly in their diets [10]. Furthermore, *M. oleifera* leaves have been used for making soups, foods, breads, cakes, and yoghurts [11][12][13][14].

Figure 1. *Moringa oleifera* tree, tree leaves, and leaves powder.

2.2. Application of M. oleifera on Performance in Chickens

In most of the feeding experiments in poultry, the fresh, green, and undamaged mature *M. oleifera* leaves were properly air-dried, and then the dried leaves were ground to a fine powder in a hammer mill and considered as moringa leaf powder or leaf meal. Similarly, fresh mature moringa seeds were air-dried and ground and considered as moringa seed meal. In some experiments, the ground particles were then soaked into distilled water for 24 h, and the filtered aqueous solution was considered as moringa extract. Due to the rich nutrient content, especially the high amount of crude protein (CP), vitamins, and minerals, *M. oleifera* leaves can be used as a useful resource of dietary supplementation for livestock as well as poultry [15][16][17]. In addition, Briones et al. [18] stated that moringa leaves can be applied as a dietary supplement in layers and broilers due to high production performance

and improved eggs quality. However, still there are many debates on the chicken's performance with different doses of *M. oleifera* in the previous studies. There are also many variables on doses and part of plant used, such as leaves, extract, sods, or seeds. Finally, many scientists agreed that *M. oleifera* plant might have a positive role in improving the production performance and health status in chickens. Further studies are still needed to detect the actual doses of application for optimum performance in chickens.

2.2.1. Effects of M. oleifera on Growth Performance in Broilers

The major findings on the role of *Moringa oleifera* on performance in broilers are summarized in Table 1. Alabi et al. [19] applied aqueous *M. oleifera* leaf extracts on the performance in broiler chickens. This study demonstrates that average daily body weight gain and final body weight were higher in 120 mL/L extract-supplemented groups than the control. Feed intake was highest in birds on positive control (having antibiotics) and lowest in birds that consumed 90 mL/liter of leaf extracts. Feed conversion ratio (FCR) was lower in birds on 90 mL/L and 120 mL/L of leaf extracts fed groups. Collectively, the authors suggested that moringa leaf extracts can be added up to 90 mL/L in broiler chickens for optimum performance. The higher body weight and lower FCR in this study might be related to the presence of different bioactive components in moringa leaf extracts that may play a role in improved nutrient utilization in supplemented birds. Similarly, higher body weight was also recorded by Khan et al. [20] who used moringa leaf powder as dietary supplement with 1.2% levels in broilers. Abdulsalam et al. [21] conducted an experiment with moringa leaf meal in broilers and found that supplemented diets could enhance the growth performance at finisher period. The authors finally stated that moringa leaf meal can be applied as a natural source of protein in broiler diets. Similarly, inclusion of *Moringa oleifera* leaves at higher levels (15% and 20%) in broiler diets resulted in a higher growth rate and better health status in broilers [22]. In addition, dietary supplementation of *M. oleifera* leaves at 5% to 20% level showed higher growth performance in broilers [16]. Final live weight, average weight gain, and FCR were higher in 10% moringa leaf meal supplemented diets than the control through a 35-day trial period [23]. Furthermore, feeding with *M. oleifera* leaf powder could improve live weight, body weight gain, dressing percentage, and FCR in broilers [24].

Table 1. Role of *Moringa oleifera* on performance in broilers. †

Types	Study Design	Main Findings	References
Moringa oleifera leaf powder	broilers (Hubbard) from 1–35 days, dose: 6,9,12, and 15 g/kg (supplementation type)	●higher pH of breast muscle ●higher weight and diameter of breast muscle fibers ●higher water holding capacity of breast muscle	[25]

Types	Study Design	Main Findings	References
		●higher weight length index of tibia bone ●higher ash percentage of tibia bone ●no effects on alkaline phosphatase in tibia bone	
Moringa oleifera leaf powder	broilers (Hubbard) from 1–35 days, dose: 0, 0.6%, 0.9%, 0.12%, 0.15% (supplementation type)	●no effects on feed intake, FCR and bursa weight ●higher final body weight ●higher length of small intestine ●higher empty weight of small intestine and ceca ●higher villus height (duodenum, jejunum, ileum) ●higher villus height/crypt depth (ileum) ●higher goblet cell number (total) in duodenum ●higher acidic mucin number in duodenum, jejunum and ileum	[20]
Moringa oleifera leaf extract	broilers (Hubbard)from 1–42 days, dose: 0, 60, 90, 120, 150 mL/L	●higher body weight gain ●lower FCR ●no effects on weight of inner organs	[19]

Types	Study Design	Main Findings	References
		●no effects on dressing percentage	
Moringa oleifera leaf meal	broilers from 0–42 days, dose: 0, 5%, 10% 15%, 20%, (inclusion type)	●higher body weight ●higher hemoglobin percent, and RBC number ●lower TC, LDL	[22]
Moringa oleifera seed powder	broilers from 1–42 days, dose: 0, 0.5%, 0.1%, and 2% (inclusion type)	●no effects on live weight and weight gain ●no effects on FCR ●no effects on dressing percentage, liver weight and heart weight	[26]
Moringa oleifera leaf meal	broilers (ANIK 2000 strain) from 0–49 days, dose: 0, 5%, 7.5%, 10 % (inclusion type)	●higher dressing weight in 7.5% and 10% level ●higher weight of liver, spleen, and gizzard ●no significant effects on body weight gain, feed intake and FCR	[27]
Moringa oleifera leaf meal	broilers (Cobb-500) from 1–35 days, dose: starter (1, 3 and 5 g/kg); grower (3, 9, and 15 g/kg); and finisher (5, 15, and 25 g/kg) (inclusion type)	●higher body weight and weight gain at grower period ●lower FCR ●no effects on feed intake	[28]

Types	Study Design	Main Findings	References
		●higher Ca and P content in tibia bone ●no effects on tibia weight, tibia length, and weight-length index of tibia bone ●no effects on ash content in tibia, and bone breaking strength	
Moringa oleifera leaf meal	broilers (Cobb-500) from 1–35 days, dose: starter (1, 3, and 5 g/kg), grower (3, 9, and 15 g/kg) and finisher (5, 15, and 25 g/kg) (inclusion type)	●higher body weight at starter and finisher period ●lower FCR ●no effects on feed intake ●higher dressing percentage, thigh muscle weight and bursa weight ●no effects on CP, CF, DM, EE, ash, NDF, ADF digestibility	[29]
Moringa oleifera leaf meal	broilers (Cobb-500) from 1–35 days, dose: 1%, 3%, and 5% (inclusion type)	●higher body weight and weight gain at starter period ●lower FCR ●no effects on feed intake ●higher thiobarbituric acid reactive values in breast muscle during storage ●higher fatty acid profile (C18:0, C15:0, C20:0, C20:3n6 and C22:6n3) levels	[30]

Types	Study Design	Main Findings	References
		●no effects on thrombogenic index and atherogenic index in breast muscle	
Moringa oleifera leaf meal	broilers (Ross) from 1–49 days, dose: 0, 3%, 5%, and 7% (inclusion type)	●higher final body weight and weight gain ●lower FCR ●higher feed intake ●higher dressing percentage ●higher meat tenderness and juiciness score	[31]
Moringa oleifera leaf meal	broilers from 1–42 days, dose: 0, 7.5%, 15%, and 30% (inclusion type)	●lower final body weight and weight gain ●higher FCR ●lower dry matter digestibility ●no effects on crude protein, crude fiber digestibility ●no effects on lipid metabolic profile (HDL, TC, LDL) ●higher meat color scores	[32]
Moringa oleifera leaf meal	broilers from 1–35 days, dose: 0, 10%, 15% (inclusion type)	●higher body weight gain ●lower FCR ●higher final body weight	[23]

Types	Study Design	Main Findings	References
		●higher RBC number, PCV number, and HB percent	
Moringa oleifera leaf meal	broilers (Habbard) from 0–42 days, dose: 0, 25%, 50%, 75 %, 100% (supplementation type)	●no effects on feed intake ●no effects on weight gain ●lower FCR	[33]
Moringa oleifera leaf powder	broilers from 1–42 days, dose: 0, 0.05%, 0.10% (supplementation type)	●higher body weight gain ●lower FCR ●higher final body weight ●higher dressing percentage	[24]
Moringa oleifera leaf extract	broilers (Cobb)from 1–35 days, dose: 0, 30, 60, 90 mL/L	●higher live weight ●lower FCR ●higher returns to investment ●lower feed intake	[34]
Moringa oleifera leaf meal	broilers (Cobb) from 14–42 days, dose: 0, 5%, 10%, and 15% (inclusion type)	●lower weight gain and final body weight ●higher FCR ●no effects on dressing percentage and carcass weight ●no effects on weight of inner organs	[35]

Types	Study Design	Main Findings	References
		●no effects on CP and EE content in meat ●no effects on total cholesterol, HDL, LDL, total protein, glucose	

† FCR, feed conversion ratio; HDL, high density lipoprotein cholesterol; TC, total cholesterol; LDL, low density lipoprotein cholesterol; RBC, red blood cell; PCV, packed cell volume; HB, hemoglobin; CP, crude protein; CF, crude fiber; DM, dry matter; EE, ether extract; NDF, neutral detergent fiber; ADF, acid detergent fiber.

2.2.2. Effects of M. oleifera on Meat and Bone Quality in Broilers

Dietary manipulation is an important way to improve the meat quality in poultry [2]. The meat derived from broiler chickens is an excellent source of protein, vitamins, minerals, and lower fat and has created a great demand among consumers [36]. Meat pH, tenderness, color (lightness, redness, and yellowness),and water holding capacity are very important meat quality characteristics to the consumers. An experiment on supplementation of *Moringa oleifera* leaf powder on the quality of meat and bone in broilers was conducted by Rehman et al. [25]. This study noticed that supplementation of leaf powder at 12 g/kg level could increase pH, water holding capacity, and muscle fiber diameter in the breast muscle of experimental broilers. In addition, higher weight, ash percentage, and the density of tibia bone in broilers fed with moringa leaf meal were also recorded in their studies [25]. In this study, authors hypothesized that higher muscle pH values in experimental groups were due to the stabilization of the myofibrils by activating antioxidant properties and preventing free radicals. Higher breast muscle weight could be the result of increased protein deposition in moringa-supplemented groups.

2.2.3. Effects of M. oleifera on Health Status in Broilers

Alnidawi et al. [22] has conducted an experiment with a view to examining the effects of *Moringa oleifera* leaf on health status in broilers.This study ensured that total cholesterol content was lower with higher level (at 15% and 20%)of *M. oleifera* fed in broiler diets. Similarly, high-density lipoprotein cholesterol (HDL) content in serum was increased and low-density lipoprotein cholesterol (LDL) was decreased with higher level of supplementation of *M. oleifera* in broilers. It was hypothesized that higher amounts of natural fiber in moringa leaves may have a role in lowering cholesterol level by increasing lipid metabolism in the host body. In addition, the blood parameters, like hemoglobin percent, total red blood cells number, and total packed cell volume, were found to be higher at 20% supplementation levels than the control diet [22].

2.2.4. Effects of M. oleifera on Egg Production, Performance, and Egg Quality in Laying Hens

The egg quality parameters, including egg size, shape, color, shell thickness, and egg yolk cholesterol, directly and indirectly influence egg consumers. In a recent study by Voemesse et al. [37], *M. oleifera* leaf meal was used in layer chickens' diet from 1 day old to 55 weeks of age to investigate the effects of moringa leaf meal on growth performance, egg production performance, and blood parameters. *M. oleifera* leaf meal was used at three different levels (0%, 1%, and 3%). In the growing period from 1 day to 20 weeks of age, this study did not find any significant differences on feed intake, but average daily body weight gain, final body weight, and FCR were improved in *M. oleifera*-supplemented groups. In the laying period, from 21 weeks to 55 weeks, feed intake was lower in moringafed groups, but the laying percent and FCR were higher in supplemented fed groups than the non-supplemented group. The higher body weight gain and egg production may be related to improved digestibility in supplemented groups due to different active components in moringa leaves. The author concluded that feeding moringa leaf meal at 1% level had positive effects on the growth and egg production in laying hens.In addition, *Moring oleifera* at 10% levels showed higher egg production in laying hens [16]. According to Abouz-Elezz et al. [38],

2.2.5. Effects of M. oleifera on Health Status in Laying Hens

Analyzing blood parameters is very important in detecting the health status of birds. According to Voemesse et al. [37], serum albumin level was higher in laying hens fed with 3% level of moringa leaf meal than the control group, but the number of white blood cells (WBCs),red blood cells (RBCs), lymphocytes, and the packed cell volume were lower in moringa-fed groups than the control diets. The authors assumed that lower WBCs and lymphocytes in moringa-fed chickens may be due to the antimicrobial activity of phytochemicals in the moringa leaves. It is well known that a high WBC count is related to an infection caused by bacteria in the host. Lower level of cholesterol content in serum with dietary supplementation of moringa pod meal were observed, which might be influenced by antioxidants (flavonoids and carotenoids) and high fiber presences in the moringa pod meal in the experimental diets [39]. However, this study did not find any significant differences on antibody response against Newcastle disease virus. Lower values for malondialdehyde (MDA) and higher glutathione peroxidase in the plasma of laying hens fed with moringa leaf meal indicated the higher antioxidant activities [40]. Plasma total protein levels were higher by dietary 5% for moringa leaf meal supplementation, which is a good indicator of the liver's synthetic function. Furthermore, lower plasma uric acid in supplemented groups indicated higher protein retention in laying hens [40]. The improved antioxidant enzyme activities and the reduced MDA levels in the plasma and egg yolk indicated the fact that dietary moringa supplementation could improve the antioxidant activities. *Moringa oleifera* is an effective phytobiotic and is known to possess broad-spectrum antibacterial properties and immuno-modulatory functions [20][25][41].

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