Moringa oleifera Leaf Meal: A Sustainable Approach for Poultry Production: A Review

ABSTRACT

Poultry production is one of the fastest ways to ameliorate deficiency of animal protein supply and consumption in many countries. Because of developing bacterial resistance and increased public awareness of health and food safety problems, the use of antibiotics as growth promoters in the chicken industry has been outlawed. This problem has spurred the poultry industry and sector to explore for safe antibiotic alternatives and to focus on developing better long-term feed management solutions in order to improve chicken health and growth. As a result, phytogenics have developed as natural antibiotic alternatives, with a lot of potential in the poultry industry. *Moringa oleifera* has gotten a lot of attention from researchers in the recent past as a natural product with a lot of health advantages for poultry. *Moringa* is known for its antimicrobial, antioxidant, anti-inflammatory, and hypocholesterolemic properties, as well as its capacity to activate digestive enzymes in the stomach, owing to the presence of hundreds of essential ingredients. The potential influence of *Moringa oleifera* as a natural feed supplement on overall growth performance, nutritional digestibility, blood biochemical profile, antioxidant benefits, immunological and egg production response is emphasized in this review.

Keywords: Body weight; egg production; growth performance; immunity; *Moringa oleifera* leaf meal, nutrient utilization;

1. INTRODUCTION

Poultry production is one of the fastest ways to ameliorate deficiency of animal protein supply and consumption in many countries. Energy and protein sources accounts for 95% of total feed cost in poultry production. The plant protein feed stuffs invariably contribute significantly towards the dietary protein supply in most of the practical poultry rations formulated worldwide. Rations based on soybean meal and groundnut meals are

generally favored over other protein sources. With the increasing population and growing demand, there will be acute shortage of major feed ingredients i.e maize and soybean in near future (Thirumalaisamy *et al.,* 2016). *Moringa* leaves are rich in crude protein (24-29%) and can be utilized as feed supplement for poultry (Su and Chen, 2020). It has also wide range of beneficial properties such as growth promoters, antibacterial, antifungal, antioxidant, anti-inflammatory (Mahanta *et al.,* 2017).

Moringa oleifera is a *"Miracle trees"* with all the essential nutritional elements that are essential for livestock and human beings as well (Anjorin *et al.,* 2010). The genus *Moringa oleifera* is having 13 species in the world and having two species in India *viz. Moringa concanensis* Nimmo ex Dalz. and Gibs. and *Moringa oleifera* Lam. *Moringa oleifera* Lam. is referenced in more than 80 countries including India and known in over 200 local languages due to its multifarious uses in the world (Bhargave *et al.,* 2015).

2. LOCAL NAMES OF *MORINGA OLEIFERA*

Hindi names: Sajana, Lingru, Shajna, Saina, Mungaera, Shaijmal, Segra and Sahjan; **Punjabi**: Sanjina, Soanjana, Sejana; **Rajasthan**: Lal Sahinjano, Lingru; **Sindhi**: Swanjera **English**: Horseradish Tree, Ben Tree, Drumstick Tree, Miracle Tree, Mothers Best Friends, Gold of poor; **Bengali**:Sajna/Sajina **Gujarati:** Saragavo **and Pakistan:** Sohangna (**Fahey, 2005).**

3. *MORINGA OLEIFERA* TREE

Moringa oleifera is a fast growing, drought resistant tree and are widely cultivated species of the *Moringaceae* family in tropical and subtropical countries around the world. It is grown in India, Africa, Arabia, Caribbean Islands, South and Central America, Mexico, Hawaii, and throughout Southeast Asia and height that ranges from 1.5-2.0 m (Foidl *et al.,* 2001). *Moringa oleifera* yields a high amount of biomass ranging from 43 to 115 ton/ha annually (Kholif *et al.,* 2016). With regard to leaf production, the leaf fresh weight yield of the plant is 1–5 kg per tree annually. This value is equivalent to 10,000–50,000 kg/ha annually at 1m × 1m spacing (Sánchez *et al.,*2006). *Moringa oleifera* is a plant that posses multiple advantages, because different parts of the tree (leaves, fruits, immature pods and flowers) are edibles and entered in traditional diets in many tropics and sub-tropics countries (Anhwange *et al*., 2004). Three non-governmental organizations in particular-viz. "Trees for Life" (2005), "Church World Service" and "Educational Concerns for Hunger Organization"

(2004) have advocated *Moringa oleifera* as "Natural nutrition for the tropics". Leaves of *Moringa oleifera* have a great value of nutrients thus indicated as the plant serve as a potential source of food supplement, used as a protein complement (Mendieta Araica *et al.,* 2011). Leaves of *Moringa oleifera* are rich in zeatin, a cytokinin in addition to other growth enhancing compounds like ascorbates, phenolic and minerals like Ca, K, and Fe that makes it an excellent crop growth enhancer (Anjorin *et al*., 2010).

4. *MORINGA OLEIFERA* AS A TRADITIONAL MEDICINE

According to Ayurveda, a traditional medicine system *Moringa* can prevent more than 300 diseases in human (Ganguly *et al.*,2013). *Moringa* oil has tremendous cosmetic value and is used in body and hair care as a moisturizer and skin conditioner. *Moringa* oil has been used in skin preparations and ointments since Egyptian times (Fugile, 2001).

5. *MORINGA OLEIFERA* LEAF AS A THERAPEUTIC USES

Phytochemicals like sterols, tannins, trepenoids, saponins, alkaloids, phenolics and flavonoids like isoquercitin, isothiocyanates, quercitin, kaemfericitin, also glycoside compounds are present in *Moringa oleifera* leaves **(**Jung, 2014). The extracts of *Moringa oleifera* both mature and tender leaves have potent antioxidant activity against free radicals, prevent oxidative damage to major biomolecules and provides significant protection against oxidative damage (Patel, 2011).The leaves of *Moringa oleifera* have shown sympatholytic activity and antiviral activity against herpes simplex virus type-1 along with hypercholesterolemia effects, antibacterial activity (Talreja, 2010). Antifungal activities (Nickon *et al.*, 2003), hepato protective (Pari and Kumar, 2002), growth promotion and antimicrobial effect (Mbikay, 2012).

6. NUTRITIONAL ROLE OF *MORINGA OLEIFERA* LEAF

The most amazing fact about *Moringa oleifera* leaf is that it is a store house of nutrients such as vitamins (β-carotene of vitamin A, vitamin D, vitamin E, vitamin B-complex and vitamin C); minerals (Calcium, Chromium, Copper, Magnesium, Manganese, Phosphorus, Selenium and Zinc) and amino acids (Nkukwana *et al.*,2015) and medicinal chemicals. The nutritional content in the leaves of *Moringa* varies with location (Anjorin *et*

al., 2010). The dry leaves of *Moringa oleifera* contains 7 times more vitamin C than orange, 10 times vitamin A than carrot, 17 times calcium than milk, 15 times potassium than bananas, 25 times iron than spinach and 9 times proteins than yogurt (Fuglie, 1999 and Dhakar *et al.* 2011). The *Moringa oleifera* leaves contain a high protein content of 20–33% on a dry matter basis, with all of the necessary amino acids. Amaglo *et al.*(2010) found that dry *Moringa* leaf contained 34.80% ether extract, 31.65% protein, 7.54% fiber, 8.9% moisture and 6.53% ash contents on dry matter basis. While Kakengi *et al. (*2005) observed that, *Moringa oleifera* leaf meal contains 29.7l% CP, 22.5% CF, 4.38% EE, 27.9% calcium, 0.26% phosphorus and negligible amount of tannin (1.23g/kg).

7. INCORPORATION OF *MORINGA OLEIFERA* LEAF MEAL IN POULTRY FOR SUSTAINABLE PRODUCTION

A) EFFECT ON GROWTH AND PRODUCTION PERFORMANCE

According to Ashong and Brown (2011) found that chicks fed with 10% *Moringa* leaf meal, incorporation may reduce feed intake and weight gain. While Olugbemi *et al.*(2010) reported that the 5% addition of *Moringa oleifera* leaf meal with cassava based diet (20% and 30%) of broilers did not show any significant effect (P>0.05) on FCR, body weight gain, feed consumption, economics of broiler production as compared to a diet without cassava and *Moringa oleifera* leaf meal. This observation could be generally traced to increasing fibre content of the diet which may have impaired nutrient digestibility and absorption. Likewise Ayssiwede *et al*. (2011) observed that *Moringa oleifera* leaf meal (MOLM) inclusion @ 0, 8.0, 16.0 and 24.0% in the diets of growing indigenous Senegal chickens had not caused any adverse impact on live body weight, average daily body weight, FCR, and mortality up to 24% MOLM but significantly decreased of feed intake obtained in birds of 16.0% and 24.0% MOLM and also significantly better growth performances, feed costs and economic margins were recorded in birds fed 8.0% and 16.0% MOLM in diets. Furthermore Hassan *et al.* (2016) was found that highest body wt. gain and FCR in @ 0.3% MOLM supplementation in broiler chicks while Elkloub *et al.* (2015) found that the lowest feed consumption (P≤0.01), best feed conversion ratio and European Production Efficiency Index (EPEI) were obtained by using 0.2% MOLM as compared to control group in Japanese quail chicks. Similarly Khalifa *et al.*(2018) showed that birds fed on *Moringa oleifera* meal @ 5% in diet gained significantly higher body weight gain than birds fed the control diet, but the lowest feed consumption (P≤0.01) and best feed conversion ratio were obtained by using 20%

Moringa oleifera meal treated group as compared to control group. Likewise Fouad and Raye (2019) showed that bird fed with 7g MOL/kg of diet had significantly (P<0.05) higher body weight gain, feed intake and improved (P<0.05) FCR as compared with the other dietary treatments. Similarly Talukdar *et al*. (2020) observed that *Moringa oleifera* leaf meal as feed additive in Japanese quail diet at the level of 0.25 to 0.50% improved the body weight, body weight gain, FCR and increased gross profit of Japanese quail. Likewise Baloch ***et al.*** (2021) showed that the maximum chicken body weight and feed intake in 2.5% *Moringa oleifera* leaf meal supplementation as compared to other groups. Feed intake was minimum in control group and feed conversion ratio was significantly (P<0.05) better in 2.5% *Moringa oleifera* leaf meal supplemented group followed by other group of broiler chicken. Furthermore Varalakshmi *et al*. (2021) revealed that a significant increased (P<0.01) in body weight gain, overall feed intake and improved (P<0.01) FCR with incorporation of *Moringa oleifera* leaf meal at a level of 3.0% in the diet as compared to other treatment groups of Japanese quails.

B) EFFECT ON NUTRIENT UTILIZATION

According to Tijani *et al*. (2016) showed higher (P<0.05) values of crude protein (CP) digestibility and ether extract digestibility in fed 15% *Moringa* leaf meal in diet. The lowest CP digestibility was obtained in broiler chickens fed 20%*Moringa* leaf meal in diet. This could be attributed to the high percentage of *Moringa* leaf meal in the diet and by implication higher concentration of anti-nutritional factors in the diet. Furthermore Fouad and Raye (2019) showed that Japanese quail treated with 7g MOL/kg in diet had the best digestibility of nutrients (DM, CP, CF, EE and NFE) as compared with other dietary treatments. Likewise Siti *et al*. (2019) found that administration of *Moringa* leaf powder @ 4-6% in the diet of laying bird's increased dry matter and organic matter digestibility. Similarly Harshini *et al*. (2022) observed inclusion of *Moringa oleifera* leaf powder (0%, 5%, 10%, and 15%) to the basal diet of Kadaknath chicken had no significant (P>0.05) variation in the apparent digestibility of nutrients and the reduction in feed intake of supplemented groups did not affect their retention of nutrients.

C) EFFECT ON HAEMATO-BIOCHEMICAL CONSTITUENTS

According to Ebenebe *et al*. (2013) showed a significantly (P>0.05) higher value of PCV and Hb with diet incorporated with 10% *Moringa* leaf meal in broiler chickens. Likewise Divya *et al*. (2014) showed that *Moringa* leaves powder @ 1.5% in diet had

hypocholesterolaemic effect in broiler chicks. Furthermore Makanjuola *et al.* (2014) revealed a non significant difference in the values of serum total protein, albumin, globulin, and AST levels with 0.2%, 0.4%, and 0.6% *Moringa* leaf meal in diet of laying birds. Similarly Elkloub *et al. (*2015) found that plasma cholesterol, plasma AST and ALT decreased with 0.2, 0.4 and 0.6% of MOLM in diet of Japanese quail while total protein and globulin percentage increased with 0.6 and 0.4% MOLM treated group as compared to control group. In this context Hassan *et al.* (2016) observed that the supplementation of MOLM in broiler chickens were significantly ($P<0.05$) enhanced the concentration of Hb in 0.3% and 0.2% MOLM treated groups as compared with control group. Similarly Abbas *et al.* (2018) found that *Moringa oleifera* leaf meal @ 0.25, 0.50, 0.75 and 1.0%, respectively in broiler chicken significantly enhanced red blood cell in treated group while packed cell volume, white blood cell, lymphocyte, hetrophil and H/L ratio were similar among the groups. Haemoglobin was improved ($P<0.05$) by *Moringa oleifera* leaf meal @ 0.75 and 1.0% inclusion rate. Albumin to globulin ratio was highest at 0.25 and 0.50% inclusion rate as compared to other groups. Serum total cholesterol, LDL and VLDL levels were decreased significantly in all treatments groups as compared to control group. Furthermore Fouad and Rayes (2019) observed the increased blood constituents like RBCs, Hb, PCV, WBCs, total protein, albumin, Ca and HDL with 3, 5 and 7g of MOL/ kg supplementation while plasma cholesterol, total lipids, LDL, AST, ALT and glucose were decreased in 3, 5 and 7g of MOL/kg supplementation in diet of Japanese quail. Similarly Ajantha *et al*. (2020) showed that lowest serum cholesterol and triglycerides in *Moringa oleifera* leaf meal (MOLM) treated group in broiler. While HDL content in MOLM supplemented group was significantly ($P<0.01$) higher than control group in broiler chicken. Furthermore Farhana Sharmin *et al.* (2021) noticed that dietary addition of 1.5% MOL meal significantly reduced serum total cholesterol and triglyceride content as compared to the control in laying birds. Likewise Garcia *et al.* (2021) found increases ($P<0.05$) serum alkaline phosphatase level in 4% *Moringa oleifera* leaf meal in diet of laying Japanese quail. While lower level of cholesterol and triglycerides content was observed at 6% *Moringa* leaf meal treated group as compared to control group. Furthermore Meel *et al.* (2022) found a significantly higher ($P<0.01$) level of Hb, PCV, TEC and lymphocytes in broiler birds fed with 1.5% MOLM. However, the heterophils and H/L ratio decreased significantly ($P<0.01$) with an increase in MOLM levels across the treatment also significant reduction ($P<0.05$) in albumin, globulin and total protein upon *Moringa*

supplementation and a significantly (P<0.01) low blood glucose, triglyceride, ALT and creatinine as compared to control diet.

D) EFFECT ON CARCASS CHARACTERISTICS AND QUALITY

According to Zanu *et al.* (2012) noticed that none of the parameters measured for carcass characteristics were affected significantly (P>0.05) by inclusion of MLM @ 0, 5, 10 and 15% in broilers. Similarly Tesfaye *et al.* (2013) found a significantly (P<0.05) lowered yield of most parameters such as dressed weight, eviscerated weight, breast, thighs and drumstick weight in broiler birds fed diet with 0, 5, 10, 15, and 20% MOLM. Likewise Safa and Tazi (2014) revealed that 5% MOLM supplementation in the diet boosted the carcass yield percentage when compared to the control group in broiler chicken. Similarly Elkloub *et al.* (2015) reported that MOLM significantly (P<0.05) reduced abdominal fat in Japanese quail, and indicated that 0.2, 0.4 or 0.6% MOLM improved the proportion of spleen without significant differences as compared with control group. Furthermore Karthivashan *et al.* (2015) investigated that MOLM extracts supplementation @ 0, 0.5, 1.0, and 1.5% in broiler had significantly (P<0.05) higher dressing percentage as compared to control group, while 1.0% MOLM showed the highest dressing rate in broiler. Likewise Tijani *et al.* (2016) found *Moringa oleifera* leaf meal upto 15% in diets significantly (P<0.05) improved dressing percentage in treated birds. While lower values of breast, wings, and abdominal fat were obtained by using 10 and 20% *Moringa oleifera* leaf meal in broiler chickens. Similarly Khalifa *et al.* (2018) showed an increased the weight of heart and liver (P<0.05) than other groups by using 20% MOLM. But there were no significantly (P>0.05) differences in gizzard, carcass and edible parts weights of the growing Japanese quails in the other treated group. Furthermore Fouad and Rayes (2019) found that Japanese quails treated with 7g MOL/kg diet had the best carcass weight as compared with other dietary treatments. Also Ajantha *et al.* (2020) revealed the MOLM supplemented groups had significantly (P<0.01) reduced cholesterol level in thigh and breast muscle than control group in birds. Also **Baloch** *et al.* (2021) observed that the *Moringa oleifera* leaf meal at 1.25%, 2.5%and 3.75% in diet of broilers had a significant (P<0.05) difference in dressing percentage as compared to control group. Furthermore Varalakshmi *et al.* (2021) observed that the *Moringa oleifera* leaf meal at 3.0% level had increased carcass yield and ready to cook yield (P<0.05) as compared to control group in birds. Similarly Harshini *et al.* (2022) indicated the inclusion of *Moringa oleifera* leaf powder (0, 5, 10 and 15%) to the basal diet resulted in an increased in the crude

protein and decreased in crude fat content of meat, however, there was no significant difference with the control (P>0.05). The oxidative stability of meat was significantly increased (P<0.05) with the increased in dietary inclusion level *Moringa oleifera* leaf powder in diet of Kadaknath chicken.

E) EFFECT ON OXIDATIVE STRESS MARKERS IN SERUM AND MEAT

Cowan (1999) reported that the presence of caffeic acid and cinnamic acid in *Moringa oleifera* gives it antioxidant qualities. Saini *et al.*(2014) found that *Moringa oleifera* is high in dietary antioxidants, such as ascorbic acid and tocopherol, which help birds to cope with stress. Rao *et al.* (2019) observed that *Moringa oleifera* reduces lipid peroxidation and thereby reduces stress in birds. Similarly Elkloub *et al.* (2015) reported the total antioxidant capacity values, in plasma were significantly high in 0.6% followed by 0.4% and 0.2% MOLM as compared to control group in Japanese quail. Furthermore Mousa *et al.* (2016) found the total antioxidant capacity values, in plasma were significantly high in 0.6% followed by 0.4% MOLM as compared to control group in Japanese quail during laying period. Also Cui *et al.* (2018) reported a gradual increased the plasma total antioxidative capacity, total superoxide dismutase, glutathione peroxidase activities whereas MDA decreased quadratically in breast muscle, in response to dietary MOL supplementation in broilers. Furthermore Khan *et al.* (2021) noticed the stress levels in broilers exhibited a significant response to *Moringa oleifera* leaf extract supplementation when compared to the antibiotic group, as seen by lower blood MDA concentrations during the finisher phase of broiler.

F) EFFECT ON IMMUNE STATUS IN SERUM

According to **Chollom *et al.* (2012)** revealed that *Moringa oleifera* seed extract had a strong antiviral activity against ND in *ovo*. Likewise **Eze *et al.* (2013)** indicated that methanolic extract of *Moringa oleifera* @ 200 mg/kg body weight increased ND HI titer in the vaccinated and un-vaccinated chicken groups and they recommended it as an immune-booster against ND in non-vaccinated birds. Similarly **Liaqat *et al.* (2016)** suggested that replacement of canola meal with *Moringa oleifera* leaf meal as a vegetable protein source can enhance the immune response to Newcastle disease and Infectious bursal disease vaccination without any change in weight gain, body organ weight, and blood hematology in broilers. Furthermore **Ramadan (2017)** revealed a significant (P <0.05) increased in antibody titer

against New-castle disease (ND) by using 3, 5 and 8% of *Moringa oleifera* leaf meal in feed of birds as compared to un-supplemented birds. Also **Khan *et al.* (2021)** observed a significant ($P< 0.05$) increased in antibody titer against New-castle (ND) and Infectious-bronchitis (IB) after 60, 90 and 120 ml/litre of *Moringa oleifera* in drinking water of bird. Likewise **Kumar *et al.* (2021)** indicated that *Moringa oleifera* leaf extract and different levels of ascorbic acid increased antibody titre on response to ND vaccinations and improved the immune response, thus causing better disease resistance of broiler birds. Similarly **Kumari *et al.* (2022)** observed that *Moringa* leaf extract supplementation in drinking water significantly ($P< 0.05$) increased antibody titre in treated group than the non-supplemented control group in birds.

G) EFFECT ON EGG PRODUCTION AND EGG QUALITY

According to Kwari *et al.,* (2011) found that no significant effects on feed conversion and egg weight was observed by using *Moringa oleifera leaf meal* at a level of 1–2% in the diet of Vanaraja laying hens. Furthermore Ebenebe *et al.* (2013) reported that adding MOL had no effect on egg shape index that's correlated with the strength of an eggshell and the grade of eggs. Likewise Etalem *et al*. (2014) found that the hatchability percentage in the 5% *Moringa oleifera* leaf meal supplemented group was significantly higher than that of the control group. Also Makanjuola *et al.* (2014) found that *Moringa oleifera* seed meal supplementation @ 5 and 7.5% was equally effective for eggshell thickness in laying hen. Similarly Alebachew (2016) observed that *Moringa oleifera* leaf have higher levels of zinc and vitamin E, which could be useful to the hatchability of eggs and seed contains antioxidants, essential oils, minerals such as Ca, Mg, K, Se, P, and Zn, and vitamins such as A, C, D, K, and E, so it could improved egg quality and improved most of the egg quality parameters. Likewise Riry *et al.* (2016) found that feeding Japanese quails on a diet with 5% *Moringa oleifera* seed meal led to a decreased in feed intake in contrast to the control birds. Also Mousa *et al.* (2017) observed that 0.4% MOLM supplementation in diet of Japanese layer quails improved hatchability per total egg, while level 0.6% MOLM improved hatchability per fertile egg. Similarly Abdelnour *et al.* (2018) postulated the use of *Moringa* leaves upto 10% had no negative effects on the egg production of laying birds, but levels greater than 10% led to adverse effects possibly due to increasing the level of anti-nutritional factors and dustiness of *Moringa* leaves and low digestibility of energy and protein. Likewise Tesfaye *et al.*(2018) revealed that *Moringa oleifera* leaf meal utilization at 5% in the poultry industry may serve the sector by enhancing the product quality as a feed additive besides serving as

protein feed. Furthermore Akinola and Ovotu (2018) found that HDL of the eggs was influenced by the diets significantly (P<0.05) as it was higher in 1% MOLM and 1.5% MOLM, of the fresh eggs and favored the good cholesterol, HDL of the eggs after seven days (end of the first week) of storage. Likewise Siti *et al.* (2019) showed better (P< 0.05) yolk colour of eggs by administration of 2-6% *Moringa* leaves powder in diets of laying birds. Also Ashour *et al.* (2020) noticed the unaffected feed conversion ratio, egg weight, fertility and hatchability from fertile eggs, egg and yolk index, and haugh unit by dietary treatments with *Moringa oleifera* leaves. However, egg production, egg mass, eggshell thickness, and hatchability were significantly increased by adding *Moringa oleifera* seed meal as compared to the control diet. The results showed that fertility and hatchability from fertile eggs were not affected by dietary*Moringa* leaves (ML1g/kg), *Moringa* seeds (MS1g/kg) and their combination (1 ML g/kg +1 MS g/kg) in laying Japanese quails. Furthermore Atuahene *et al.* (2020) added *Moringa oleifera* leaf meal in Japanese quail diets upto 15% as partial replacement for soybean meal with no adverse effects on egg quality, fertility and hatchability of quail eggs. But enhancement of yolk colour in eggs by administration of *Moringa oleifera* leaf meal in diet of Japanese quail laying birds was observed. Similarly Talukdar *et al.*(2020) found that the Japanese quail egg quality traits like egg weight, shape index, albumen index and yolk index did not differ significantly (P>0.05) except yolk colour which showed significantly (P<0.05) higher value at 1% MOLM group as compared to the other groups. The various organoleptic parameters of quail egg like colour, flavour, texture, juiciness and overall acceptability did not differ significantly (P>0.05) among different experimental groups. Furthermore Farhana Sharmin *et al.* (2021) reported the quality, weight, length and width of eggs were not altered by the addition of 1.5% MOL to the diet in laying birds but significantly (P<0.05) reduced cholesterol content was found in 1.5% MOLM as compared to the control. Also 1.0- 1.5% MOLM supplementation increased W-3 fatty-acid levels in egg yolk of laying bird was noticed. Likewise Garcia *et al.* (2021) noticed that the inclusion of *Moringa* in diets reduces the quadratic feed intake up to the level of 1.2%, increases weight of eggs with a quadratic behavior up to 3.80%, and linearly increases yolk weight. Yolk color changes with higher levels of inclusion of *Moringa* and resulted in more intense colors.

8: CONCLUSION

Moringa oleifera is a "Miracle trees" and *Moringa oleifera* leaf meal having countless benefits for sustainable poultry production and thus should be taken as a high quality gift of nature at very low price.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (Chat GPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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