European Journal of Veterinary Medicine
www.ej-vetmed.org

Amelioration of Reproductive and Productive Performance in Animal and Poultry by Moringa OleiferaFree or Nano-Encapsulated

Jehan A. Gafer, Ghada H. Abd El-Rahman Hassan, Hanaa A. M. Ghneim, and Marwa F. Mahmoud

ABSTRACT

Improvement of reproductive performance is an honorable goal and is closely associated with increasing productivity. Therefore, as the reproductive efficiency improves, the herd net return and national income increase. The high cost of animal forage especially in dry or semi-arid countries, is a main limitation to animal production which is raised under extensive systems. Hence, utilization of alternative feed resources may be a reasonable and appropriate approach in low-input systems. Moringa Oleifera is a natural plant referred to as a nutrient, which contains substances that might have a favorable influence on animal reproduction and production. Leafy Moringa is considered a virtuous origin of proteins that are very consumable. Moreover, they are rich in Vitamin C, Vitamin A, iron, and Calcium which are necessary for the growth of livestock animals. Moreover, they include the percentage of fatty acid which is greater as compared to any woody plant fodder. Principally, almost all of the fatty acids present in Moringa are unsaturated fatty acids which are highly susceptible. Nowadays, nano-encapsulation technology is considered a promising strategy for drug delivery and is efficient in preserving bioactive components in products rich in nutrients. So that this review affords a collection of significant data and enlightens the information on the development of Moringa Oleifera Free or its nano-encapsulated form in amelioration of animal and poultry reproduction and production performance.

Keywords: Lab. animals, Moringa Oleifera, nano-encapsulated form, poultry, productive performance, reproductive.

Published Online: September 19, 2023

ISSN: 2736-6596

DOI: 10.24018/ejvetmed.2023.3.5.83

J. A. Gafer
Agriculture ResearchCenter (ARC), Egypt
(e-mail: Jehan.gafer@gmail.com)
G. H. Abd El-Rahman Hassan
Agriculture ResearchCenter (ARC), Egypt
(e-mail: ghada_hassan1971@yahoo.com)
H. A. M. Ghneim
Agriculture ResearchCenter (ARC), Egypt
(e-mail: Hanaa201297@yahoo.com)
M. F. Mahmoud*
Animal Reproduction Research Institute ARRI, Agriculture ResearchCenter (ARC), Egypt.
(e-mail: asiamarwa2022@gmail.com)

****Corresponding Author***

I. Introduction

The suboptimum reproductive performance or infertility increases veterinary costs, decreases milk production, raises veterinary and medicine costs, and increases the cost of artificial insemination (the number of bulls required) higher semen costs, and slower genetic progress. Although it has plenty of reasons, the costs of poor fertility can be due to binary factors: involuntary culling and increased calving interval [1], [2].

As there is an antagonistic effect of fertility and milk production on economic impact [3]. Therefore, as reproductive efficiency and milk production improve, the herd net return and national income increase. Thus, reproductive and productive performance are important factors in the success of the livestock industry. The cost of animalfeed in semi-arid areas is a major restriction to animal production which is raised under extensive systems. Therefore, the utilization of other feed resources may be a reasonable and appropriate plan in low-input systems [4]. Some natural plants are known as nutraceuticals, which include functional agents and could have a good effect on animal reproduction [5].

The poultry sector is increasingly using phytogenic ingredients. as well since it has been demonstrated that these materials are both safe and efficient at enhancing laying performance [6]. Taking into account the aforementioned factors, Moringa oleifera has attracted significant interest for usage as a feed supplement in the cattle industry.

II. Nutritional Description of MoringaOleifera

Moringa trees are known as miracle trees because they have a fast-growing habit, reduced need for irrigation and fertilisers, anda high capability for resprouting after harvest. Generally, Moringa leaves are considered exclusive because of their great amounts of nutrients with minimum harmful composites. Moringa is preferable to several other livestock feeds including soybean, cotton seed cake, and range grasses, which require significant watering to increase livestock output because it has comparatively low irrigation requirements [7]. In our previous study conducted in Animal Reproduction Research Institute (ARRI), Giza /Egypt Moringa oleifera leaves were analyzed for detection of their effective composition. The analysis disclosed that Moringa Oleifera contains substantial levels of important nutrients (Table I) [8].

Moringa oleifera contains significant levels of fatty acids, vitamins, minerals, and crude protein. It can deliver nine times the protein of yoghurt, seventeen times the calcium of milk, seven times the vitamin C of oranges, ten times the vitamin A of carrots, twenty-five times the iron of spinach, and fifteen times the potassium of bananas (Fig. 1) [9]. Furthermore, it is rich in phenolic and oxycaroteniod which are considered building blocks of animal bodies and could have potential for adoption as forage for ruminant fodder

resource[10], [11].

TABLE I: PROXIMATE COMPOSITION PERCENTAGE (%) OF MORINGA OLEIFERA

Nutrients	As fed basis %	As drymatter basis%
Dry matter	90.51	100
Moisture	9.49	-
Crude protein	23.44	25.9
NDF	31.29	34.58
ADF	13.45	14.86
Hemicellulose	17.85	19.72
Cellulose	9.50	10.50
Lignine	3.95	4.36
Ash	12.99	14.36
NFC	17.69	19.55
Ether extract	5.08	5.61
TDNix	58.44	64.57
DE(Mcal/kg)	2.75	3.04
ME(Mcal/kg)	2.37	2.62
NEL(Mcal/kg)	1.32	1.46

NDF and ADF: fiber of nutrient detergent and acid detergent, NFC: Carbohydrates not fibrous, DE: digestibleenergy, ME: Metabolizable energy, NEL: Net energy of Lactation.

Fig. 1. The nutritional characteristics of Moringa oleifera.

Furthermore, these plants are rich in copper, chromium, manganese, phosphorus, magnesium, Zinc, and vitamin B-complex. Moreover, it includes apercentage of fat which is also greater as compared to any woody plant fodder. Principally, almost all of the fatty acids present in Moringa are unsaturated fatty acids [12].

In mammals, fatty acids (FAs) have a variety of essential biological roles and are considered one of the functional nutrients and chemicals. Triglycerides, for example, are employed as precursors for the production of vital energy-producing metabolites [13] and oocytes and embryos use it as an energy substrate for differentiation, development, and immune system activity [14]. FAs serve as useful chemicals for a variety of reproductive processes. However, due to high susceptibility to lipid oxidation, gastrointestinal tract (GIT) absorption, and limited stability during processing and storage, polyunsaturated fatty acids (PUFAs) lose most of their nutritional value and biological impacts.

Antinutritional factors are chemicals produced by plants' metabolism that interfere with digestion and can result in malnutrition. These elements are crucial indicators for figuring out whether a plant leaf is appropriate for use as animal feed. They include saponins, tannin, lignin, and lectins [15]. Moringa oleifera leaf contains only 4.7–5% of saponins and 5.9% fiber content or lignin especially (in dry matter) which provides a bitter taste, but this quantity cannot cause any adverse effects to the animals or may be negligible [16].

A. Nano-Encapsulated Form of Moringa Oleifera

Encapsulation processes can overcome all problems of instability and susceptibility of bioactive constituents because nano-encapsulation, considered an expert modernized drug delivery technique has confirmed its effectiveness at keeping functionality and magnifying metabolism of products rich in bioactive components especially PUFAs protecting them from the reactions that take place when they get in contact with oxygen, metal ions, hot temperatures, and light [17]–[19].

El-desoky [20] stated that moringa treated rabbits had improved litter size, conception, and parturition rates with a significant increase in colostrum immunoglobulin concentrations, milk production, and milk USFAs (omega-3 and 6) to the Control group. Also, further enhancement of the reproductive parameters in rabbits supplemented with nano-encapsulated moringa at lower doses, proving how nano-encapsulation technology enhances moringa's leaf ethanolic extract (MLEE) accessibility. Similarly, El-desoky [21] explored the outcome of the supplementation of MLEE on tolerance to heat parameters and the ability of rabbits who were reared in hot temperatures to reproduce. Also, investigate how nano-encapsulation technology affects MLEE's biological effectiveness. The results revealed that MLEE reduced heat-stress-indicators, e.g., respiratory and heart rates, and rectal temperatures; increased prolactin, progesterone levels, redox state, and hematochemical characteristics; and enhanced the birth weight, kindling rate, birth litter size, and total litter size. Additionally, the Administration of MLEE can mitigate the adverse effects of high-temperature stress through enhancing pregnancy's hormonal balance and metabolism. However, the use of nano-encapsulated MLEE permitted a dose decrease of 80% with satisfyingly favorable effects on the ability to reproduce denoting the importance of nano-encapsulation technology to permit bioavailability for target sites.

III. EFFECT OF MORINGA OLEIFERA ON THE PRODUCTIVITY OF ANIMALS AND POULTRY

A. Outcome of Moringa on Performance in Large Animals

Low libido and bad semen are contributing factors affecting bulls' reproductive efficiency. Subfertile bulls with poor semen quality and low libido will postpone conception, raise the number of culled cows diminish calf weaning weights, extend the calving season, and all of which cause economic losses [22].

A bull's nutritional state affects sperm quality, sperm production, gonadotropin secretion, and sexual development. As the seminiferous tubules and Leydig cells are stimulated by the hormones follicle stimulating hormone (FSH) and luteinizing hormone (LH), the ability of the testes to generate sperm and testosterone is affected accordingly [23].

Methionine and cysteine, two essential amino acids, are needed for the process of spermatogenesis to produce high-

quality semen [24], and arginine [25], Moreover, linolenic acid, vitamins A, C, and E, zinc, and selenium [26]. Numerous sex hormones, including testosterone and gonadotropin-releasing hormone (GnRH), are produced in large part because to zinc (Zn). Zn causes the testis' Leydig cells to make testosterone. Saponin, alkaloid, flavonoid, ferulic acid, and chlorogenic acid are among the bio-substances found in herbs that are responsible for boosting sexual activity [27]. Moringa oleifera is one of the plants that contain all of these substances.

In the experiment of Syarifuddin *et al.* [28] The experimental Bali bulls supplied with Moringa leaves did not consume additional dry matter or total digestible nutrients (TDN) than the control Bali bulls, who did not receive any Moringa leaf supplementation. However, the experimental Bali bulls supplied with Moringa leaves consumed significantly more crude protein, calcium, and phosphorus ($P<0.05$) than the control group. In the same context, the experimental Bali bulls' libido and plasma testosterone levels' alterations throughout the day are presented in Fig. 2 and 3. Plasma testosteroneconcentrations in these bulls were higher throughout the day than in the control group. In addition, the time required for ejaculation (libido) was significantly shorter ($P<0.05$) in bulls supplemented with Moringa leaves compared to the control group.

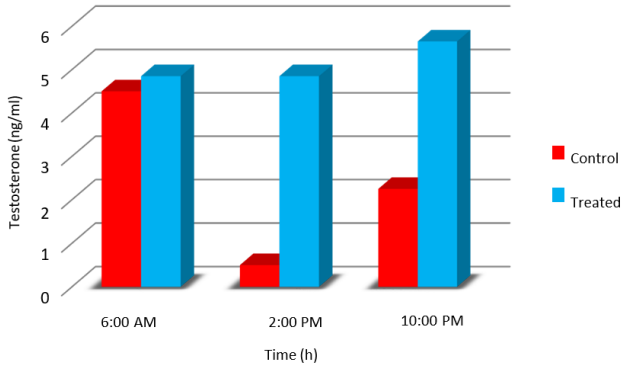

Fig. 2. Quotidian variations of testosterone concentrations in bulls without (control) and with (treated) supplementation of Moringa.

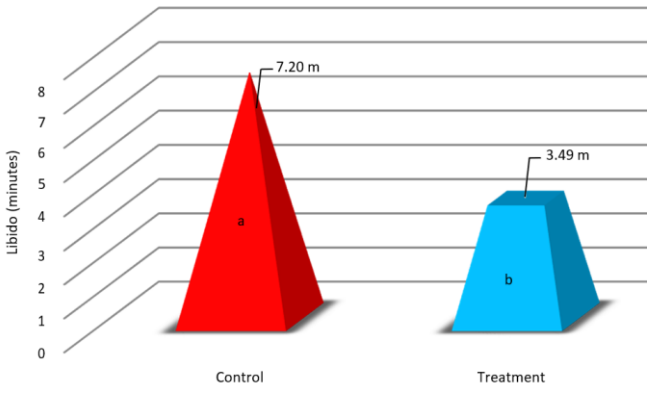

Fig. 3. Libido of the control and treated bulls with Moringa leaves.

In crossbreed cattle (Bos indicus Bos taurus) bulls, Zn supplementation significantly enhanced serum testosterone, according to research by Kumar *et al.* [29]. Also added that Zn is a crucial part of proteins involved in the production and secretion of testosterone. One possibility that may have contributed to the greater level of testosterone as a result of supplementing with Moringa is the high Zn content of the Moringa leaf [28]. Roy *et al.* [30] reported a similar outcome in cattle and buffalo.

In their investigation on Bali bull, Syarifuddin *et al.* [28] hypothesised that the high protein content of Moringa leaves may stimulate testosterone synthesis and secretion. so that the a significant increase in consumption of crude protein during the treatment period.

There was a discrepancy between results as Moringa oleiferafailure to raise the sperm concentration in bull [28], [31] and thesignificantly increased sperm concentration with moringa in hyperglycaemic mice and stressed rats [32], [33] but this couldbe as a result of the amount of Moringa leaves consumed relative to body weight.

Sarastina *et al.* [34] indicated that 60% is the bare requirement for good progressive motility. The study of Jamili *et al.* [35] reveals that the bulls' progressive motility increased after receiving supplements containing moringa oleifera leaf (MOL), above the expected rate (78.74%) and attributed factor influence this progressive motility to the content of L-carnitine in the MOL. Similarly, the total and progressive motilities of the sperm were recorded as 84.96±3.09% and 67.03±3.74%, respectively. The high Ca and P content in Moringa leaves might be assumed to be the reasonfor the elevated sperm motility throughout the period of Moringa supplementation due to the large increase in Ca andP consumption [28].

Additionally, arginine, carnitine, zinc, vitamin B12, vitamin C, vitamin E, glutathione, and selenium all support sperm motility [36]. The Moringa leaf contains these nutrients. Therefore, these dietary elements may be the cause of the enhanced sperm motility observed in bulls that were fed Moringaleaves.

Average path velocity (VAP), and curvilinear velocity (VCL) a reliable indicators of sperm's capacity for in vitro fertilization [37]. Therefore, it has the potential to produce more viable sperm when these parameters at the moringa treatment are higher than during the pretreatment period [28]. The food consumed by the bulls had an effect on the quality of their sperm. MOL is nutritious since it contains protein, minerals, vitamins, and other nutrients that might increase ejaculation volume [35].

In the study of Jamili *et al.* [35] The percentage of sperm lost during thawing of bulls' sperm before and after MOL supplementation differs significantly ($P<0.01$, 38.32% vs. 54.34%). According to Toelihere [38], the post-thawing motility of frozen sperm acceptable for artificial insemination is around 40%. It is apparent that the sperms of the bulls supplemented with MOL were 54.34%; with this percentage of post-thawing motility, artificial insemination is still effective. Hence, the high incidence of post-thawing sperm motility in bulls supplemented with MOL is thought to be due to the presence of Moringa Vitamins C and E. This is because vitamin C optimises the pace of fructolysis so that energy requirements for motility are met. Furthermore, Vitamin C is known to be an antioxidant, preventing the production of lipid peroxidation, which can decrease glycolysis and motility [39]. Also, in cows Moringa oleifera Leaf (MOL) supplementation may boost the fertility rate of Bali cows [40]. Furthermore, moringa seed meal (MSM) is a high- protein

source that may effectively replace soybean and rapeseed meals in ruminant diets while also improving microbial protein synthesis in the rumen [41].

Concerning to milk yield: although, Tadeo *et al.* [42] demonstrated varying the quantity of Moringa leaf meal (MLM) in dairy cow rations had no significant effect on daily average milk output Many studies found that partial replacement of MOLM and MOL powder blocks boosted milk output, indicating that Moringa has a positive influence on the rumen environment and has good rumen by pass protein properties [43], [44]. Dong *et al.* [45] suggest that dietary Moringa oleifera could improve milk fat content in lactating dairy cows.

Regarding buffaloes, it can be concluded that MLM can substitute up to 10 % of calf starter and concentrate mixture to gain better body weight of Murrah buffalo calves [46]. Likewise, in a preprint of [47] during their study on lactating Murrah buffalo it is deduced that the inclusion of up to 150 g of MOLM to a diet enhances milk production and improves milk composition. Similarly, in Nili-Ravi buffaloes the milk yield was observed to be increased with the treatments since Moringa oleifera leaf meal as part of their concentrate [48].

In terms of pig addition of Moringa oleifera could enhance reproduction, elevate proteins in the colostrum, and improve the serum antioxidant indices in sows and/or piglets [49].

B. Impact of Moringa Oleifera on Sheep and Goat Performance

In the experiment targeted Beetal goots (started 2 months before parturition and continued till the first month of lactation) the results revealed that supplementation of Moringa oleifera leaf powder (MOLP) 2% (M2%) and 3% (M3.5%) increase amount of vitamin C significantly compared to non-supplemented group. Also, the plasma flavonoids were significantly increased in the M3.5% group during the entire period, whereas the total phenolic contents and catalase activity were influenced only during the lactation period. They added the results of reproductive parameters showed that the time for shedding the placenta and the time of onset of 1st postnatal estrus was less in the goats of M3.5% and M2% groups in comparison to the goats of the control (M0). Furthermore, the survival rate and birth weight of the kids of M3.5%- and M2%-supplemented goats were higher than (M0) group Conclusively, the inclusion of 3.5% MOLP in the diet improves antioxidant status, milk yield, and reproductive performance in Beetal goats [50].

Another study of AL-Juhaimi *et al.* [51] on Aardi goats proved the transmission of bioactive components, particularly antioxidants and vitamin C from fodder to milk, M. oleifera leaves could improve milk and serum quality as well as both animal and consumer immune systems. As indicated for Najdi ewes, the increased catalase concentrations in milk and serum of goats fed M. oleifera may also contribute to a decrease in the malondialdehyde (MDA) value, hence protecting milk from further oxidation deterioration [52]. This could assist in extending the shelf life of goat's milk and dairy products.

The results of our own previous study on Barki ewes revealed that the Moringa leaves can be used as a supplement for increasing reproductive performance with no adverse effects on their health. The experiment continued for 45 days, blood samples were taken every 2 weeks for evaluation of the hemogram and biochemical studies. High significant changes ($P< 0.05$) were observed in 30-day and 45-day post-treatment in the supplemented group compared with the control (Fig. 4–7) [8].

Regarding goats Red Sakoto, Raji, and Njidda [53] showed that 50% Moringa leaf feed supplementation can improve sperm count. M. oleifera can replace sesame flour as a protein source in lactating goat feed. The addition of moringa leaf meal (MLM) boosted feed intake, ruminal fermentation and digestibility, and milk output, and positively affected the milk fatty acid profile. For nursing goats, a diet supplementation of 15% MLM (replacing 75% sesame meal) was most appropriate. [54]. Fortunately, supplementing fattening Barki lambs with moringa seed showed no negative effects on blood biochemical concentrations or hepatic enzymes [55]. Dina *et al.* [56] during their investigation on Barki rams, discovered that Moringa oleifera leaves extract might improve the characteristics of fresh sperm by boosting seminal volume,

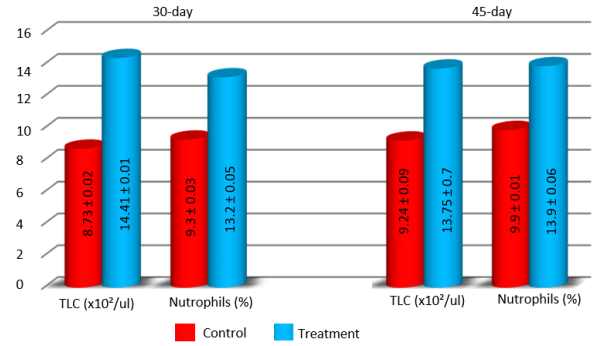

Fig. 4. Values of hemogram demonstrate a significant difference in total leucocytic count (TLC) and neutrophils at 30 and 45-days post-treatment with moringa oleifera.

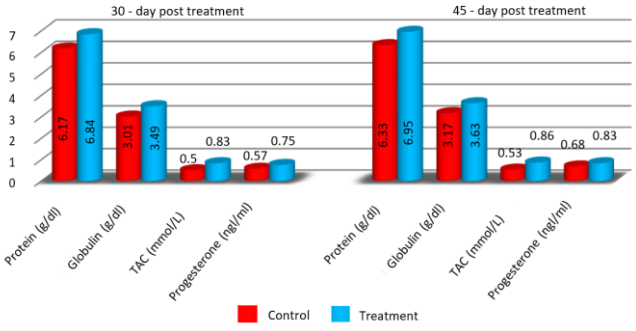

Fig. 5. Values of biochemical parameters at 30 and 45-days post-treatment by moringa oleifera (total protein, globulin, total antioxidants capacity (TAC), and progesterone.

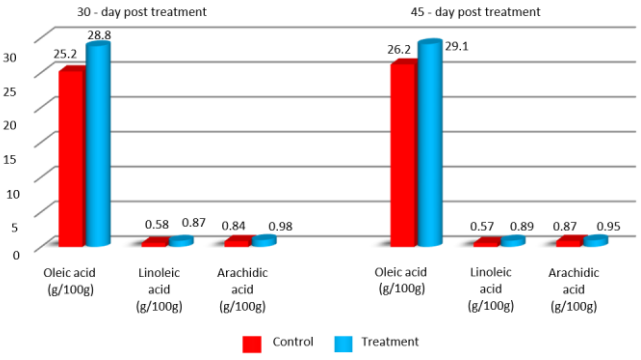

Fig. 6. Values of free unsaturated fatty acids revealed a significant increase at 30 and 45 days post-treatment bymoringa oleifera.

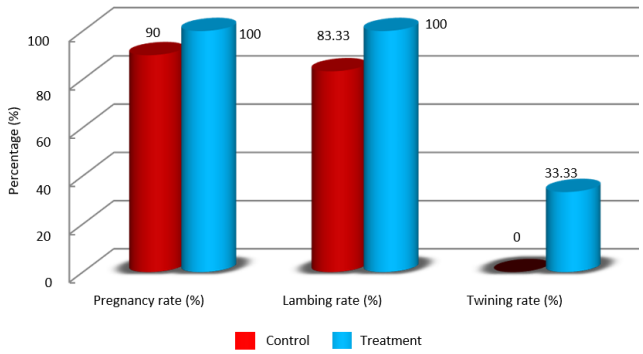

Fig. 7. The effect of Moringa on pregnancy, lambing, and twining rates.

sperm concentration, and antioxidantdefense system activity. Furthermore, it improves cryopreserved sperm by strengthening the seminal plasma antioxidant defence mechanism, shielding spermatozoa from oxidative stress, DNA damage, and abnormalities. Furthermore, it was claimed that MOLE is a promising agentfor improving the fresh and cryopreserved rams' sperm.

C. Value of the Use of Moringa on the Performance of Lab Animals

Nara *et al*. [57] concluded the usefulness of Moringa seed extract on stimulating fertility hormones and improving semen quality in male albino rats. In the same context, higher plasma testosterone concentrations with Moringa leaf supplementation were found in investigations by Prabsatroo *et al.* [34] and Dafaalla *et al.* [58] on rats they attributed this to the increase of Leydig cells, and the FSH and LH values. The ability of Leydig cells in the testes to synthesize testosterone is dependent on Zn levels in the diet [31].

However, Attah *et al*. [59] observed during their work on Wister rat an inimical effect on conception and some pregnancy outcomes by using hot (boiling) and cold aqueous extract of Moringa leaf as they detected in vitro significant ($p< 0.05$) uterine contraction with different intensities whereas in vivo administration of cold extract of moringa before and after mating produce 100% and 80% conception inhibition respectively, while the hot extracts record 96.6% and 58% comparatively. Zeng *et al*. [60] adopted for the first time dietary moringa oleifera leaf (MOL) to recognize its effect on long-term (six repeated gestations) reproductive performance of mice and revealed that MOL feeding might improve litter size, litter birth weight, and litter survival.

In rabbits, Abu *et al*. [61] showed that the Moringa leaf meal did not hurt the quality of sperm or testicular morphometry. These results indicate that Moringa leaves can be used as feed for rabbit bucks at an inclusion level of up to 15%. Similarly, El-Desoky *et al*. [62] during their study on New Zealand White does and their kids) stated that Moringa oleifera leaf meal can play a vital role in rabbit nutrition since it improves some productive and reproductive performance without any adverse effects. Ewuola *et al.* [63] recommended the addition ofmoringa oleifera leaf meal (MOLM) up to 2.5% improved sperm production and sperm reserves in rabbit bucks howeverhigher percentage could reduce daily sperm production and storage.

D. Effect of Moringa on Reproductive and Productive Performance in Poultry

Massive literature reported the general increase in hen body weight implies that the therapy had no negative effect on hen growth and body weight. [64]–[66]. MOLM is known to include bioactive chemicals, and the synergy between them may be a vital aspect of their action, influencing nutrient absorption and processing as well as immunity [67]. There was a discrepancy in the results of improvement of sperm concentration with the supplementation of Moringa to the mash of the cockerels. Some studies found that integrating fish oil and dietary M. oleifera leaf meal into the diet of turkey roosters had a substantial effect on sperm concentration. [68], [69] and others stated the non-significant effect although higher sperm concentrations [67]. Tutubalang *et al.* [67] denoted that the better mean pH (7.37) in Potchefstroom Koekoek (PK) roosters offered moringa 70% in their study could progress sperm velocity. Similarly, the literature of [70], [71] states that sperm motility and velocity were increased at alkaline pH in domestic roosters.

Also, moringa positively affected sperm motility by supplying the necessary substrate (ATP) [67]. Moreover, the higher progressive motility observed in PK roosters fed MOLM may be due to vitamin E and selenium found in MOLM [72], [73]. To make high-quality sperm, the process of spermatogenesis requires amino acids such as methionine and cysteine [74] and arginine [26], a fatty acid α-linoleic, vitamin A, C and E as well as zinc and selenium [27]. Moreover, it has been observed that dietary selenium increases sperm concentration, motility, and capacity in farm animals and poultry species [75], [76].

Fertility and hatchability are the most susceptible to genetic and environmental effects [77]. When compared to the control group, chickens fed MOLM70% had significantly improved fertility and hatchability of viable eggs [67]. According to Amen and Al-Daraji [78], vitamin E and zinc may have an important role in egg hatchability. Zinc aids in the protection of DNA chromatin in the sperm nucleus, which is necessary for healthy fertilization. Additionally, Durmus *et al.* [79] distinguished that increasing zinc in the diets of brown parent stock layers increases hatchability.

Extra protein in the hen's diet was found to increase chick weight [80]. MOLM is recognized to be a valuable source of protein so chick weight was improved in hens fed with moringa supplement [81], [82], [67].

It has been reported that combining multiple feed supplements in animal diets can result in a synergistic impact. In marine carnivorous fish species, Goncalves *et al.* [83] discovered an interaction link between fishmeal and a phytogenic substance. Miao *et al.* [84] discovered that mulberry leaves and a bamboo charcoal addition had a combined effect on farmed tilapia growth performance, lipid metabolism, and antioxidant levels. In this context, Goncalves *et al.* [83] discovered an interacting link between fishmeal and a phytogenic product in marine carnivorous fish species. Miao *et al.* [84] reported that mulberry leaves and a bamboo charcoal addition had a combined effect on growth performance, lipid metabolism, and anti-oxidant in farmed tilapia [6].

Shen *et al.* [85] approved that supplementation of 2.5% Moringa Oleifera Leaf Powder (MOLP) is valuable for laying

hens and has potential effects on reproductive hormone synthesis and gene regulation, and thus has an ongoing major impact on laying performance.

However, an extra dose of moringa oleifera leaf powder (MOLP) showed a negative impact on performance, particularly the laying rate [86]. According to Olugbemi *et al.* [87], the negative effects of high quantities of leaf meal in poultry diets could be due to the protein's low digestion. This conclusion is reinforced by Kakengi *et al.* [88], who discovered that laying hens fed diets containing 10% and 20% moringa leaf meal had considerably lower egg production and total egg weight.

Mahfuz and Shu [89] recommend upcoming study with M. oleifera as an alternative for antibiotics in poultry to be used as an effective approach for organic egg and meat production.

The antibacterial activity of M. oleifera seed extracts could be attributed to their inclusion of lipophilic chemicals, which can bind to the cytoplasmic membrane. Antibiotic metabolites such as carboxylic acid, 2,4-diacetylphloroglucinol, cell wall-degrading enzymes, and chitinases may also be found in moringa seed ethanol extract. [90], [91].

In terms of ducks, 4 percent (4%) moringa stem meal supplementation level significantly boosted the laying rate, egg weight, and daily feed intake in laying ducks [92].

IV. Conclusion

The present review emphasizes the worthy impact of moringa on performance in reproducing as well as production in large animals, small ruminants, Lab. animals, and poultry. As moringa leaves are characterized by having great amounts of nutrients but lower amounts of harmful component it is important index denote that moringa leaf is appropriate as an animal feed and enhance reproductive and productive performance without adverse effect. However, inclusion with high amounts may cause an inimical effect and reduce performance. Moringa combination with other vegetation could improve livestock performance, as well as a high yield of high-quality products but this aspect is still waiting for more investigation. Nano-encapsulation, technology with moringa confirmed its efficiency in preservation and has positive effects on reproductive performance denoting the importance of nano-encapsulation technology to permit bioavailability for target sites. However, studies about nano-encapsulated moringa till now are scarce.

V. Future Prospective

This review article will motivate upcoming researchers to explore the secrets of the miracle tree and encourage its supplementation with other fodders or grasses to assist in improved livestock performance and high yield of good quality products. Also, investigation of nano-encapsulated moringa could be a future concept of research in the area of enhancement of production and reproduction of livestock and poultry.

Acknowledgment

The authors thank Fatma Gamal Azzam for her fruitful assistance in this research

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

This research did not receive any specific grant from fundingagencies in the public, commercial, or not-for-profit sectors.

Reference

[1] Giordano JO, Kalantari AS, Fricke PM, Wiltbank MC, Cabrera VE. daily herd Markov-chain model to study the reproductive and economic impact of reproductive programs combining timed artificial insemination and estrus detection. *J Dairy Sci*. 2012 Sep 1;95(9):5442–5460.

[2] Galvao KN, Federico P, De Vries A, Schuenemann GM. Economic comparison of reproductive programs for dairy herds using estrus detectiontimed artificial insemination, or a combination. *J Dairy Sci*. 2013 Apr 1;96(4):2681–93.

[3] Leblanc S. Assessing the association of the level of milk production with reproductive performance in dairy cattle. *J Reprod Develop*. 2010; 56(S):S1-7.

[4] Amirteymouri, E, Khezri, A, Tahmasbi, R, Dayani, O, Mohammadabadi, MR. Comparison of the nutritive value of Madder, Rubiatinctorum L. and Alfalfa, Medicago sativa. Using in vitro and in situ measurements. *J. Liv. Sci. Technol*. 2015; 3(2):27–32.

[5] Allan, P, and Bilkei, G (5) Oregano improves reproductive performance of sows. Theriogenology 2006; 3:716–721.

[6] Shen MM, Li T, Lu J, Wang KH, Qu L., Hou QR, Zhao WG, Wu P. Effect of dietary supplementation with mulberry and moringa leaves on chicken reproductive performance. *Czech J. Anim. Sci*. 2022; 67:339–347.

[7] Nouman W., Shahzad M. A. B. and Muhammad T. S. Potential of Moringa oleifera L. as livestock fodder crop: a review. *Turkish Journal of Agriculture and Forestry*, 2014;38:1–14.

[8] Ghattas TA1, Ghada H Abdel Rahman H. Effect of moringa oleifera supplementation on the reproductive performance in Barki ewes. *J. Egypt vet. Med. Assoc*. 2019; 79(4):929–944.

[9] Gopalakrishnan L, Doriya K, Kumar DS. Moringa oleifera: a reviewon nutritive importance and its medicinal application. *Food Sci Hum Welln*. 2016; 5:49–56.

[10] Deshmukh, P. Antibacterial and immune modulatory activity of Moringa oleifera in albino rats. M.V.Sc. thesis (Department of Veterinary Pharmacology and Toxicology), Nanaji Deshmukh Veterinary Science University, Jabalpur, M.P. India. 2014.

[11] Pradhan BC. Valuation of hematological and biochemical parameters of goats of central Odisha environment fed on natural grazing land of Odisha. *The Pharma Innovation Journal*. 2016; 5(5):83–90.

[12] Muhammad JA, Haseeb A, Ammar MS. Moringa as a Feed Stuff. *Acta Scientific Veterinary Sciences*. 2022; 4.1:172–178.

[13] Nielsen S Karpe F. Determinants of VLDL-triglycerides production. *Curr. Opin. Lipidol*. 2012; 23: 321–326.

[14] Hadjadj I, Hankele AK, Armero E, Argente MJ, de la Luz, García M. Fatty Acid Profile of Blood Plasma at Mating and Early Gestation in Rabbit. *Animals*. 2021; 11:3200. DOI: 10.3390/ani11113200.

[15] Soetan KO, Oyewole OE. The need for adequate processing to reduce the antinutritional factors in plants used as human foods and animal feeds: a review. *Afr J Food Sci*. 2009; 3:223–232.

[16] Moyo B, Masika PJ, Hugo A, Muchenje V. Nutritional characterization of Moringa (Moringa oleifera Lam.) leaves. *Afr J Biotechnol*. 2011; 10:12925–12933.

[17] Nedovic V, Kalusevic A, Manojlovic V, Levic S, Bugarski B. An overview of encapsulation technologies for food applications. *Procedia Food Sci*. 2011; 1:1806–1815.

[18] Banerjee A, Qi J, Gogoi R, Wong J, Mitragotri S. Role of Nanoparticle Size, Shape and Surface Chemistry in Oral Drug Delivery. *Journal of Controlled Release*. 2016; 238:176–185.

[19] Ruiz PA, Morón B, Becker HM, Lang S, Atrott K, Spalinger MR, Scharl M, Wojtal KA, Fischbeck-Terhalle A, FreyWagner I. Titanium dioxide

nanoparticles exacerbate DSS-induced colitis: Role of the NLRP3 inflammasome. *Gut*. 2017; 66:1216–1224.
[20] El-Desoky N, Hashem NM, Elkomy AG, Abo-Elezz ZR. Improving Rabbit Doe Metabolism and Whole Reproductive Cycle Outcomes via Fatty Acid-Rich Moringa oleifera Leaf Extract Supplementation in Free and Nano-Encapsulated Forms. *Animals*. 2022; 12:764. doi.org/10.3390/ani12060764.
[21] El-Desoky N, Hashem NM, Gonzalez-Bulnes A, Elkomy AG Abo-Elezz ZR. Effects of a nano-encapsulated moringa leaf ethanolic extract on the physiology, metabolism and reproductive performance of rabbit does during summer. *Antioxidants*. 2021;10:1326. doi.org/10.3390/antiox10081326.
[22] Kastelic J P. Male involvement in fertility and factors affecting semen quality in bulls. *Animal Frontiers*. 2013; 3:20–25.
[23] Martin G B, Blache D Miller D W, Vercoe E. Interactions between nutrition and reproduction in the management of the mature male ruminant. *Animal*. 2010 ;4:1214–1226.
[24] Young S S, Eskenazi B, Marcheti F M, Block G, Wyrobek A J. The association of folate, zinc and antioxidant intake with sperm aneuploidy in healthy nonsmoking men. *Hum. Reprod*. 2008; 23:1014–1022.
[25] Wu G, Bazer FW, Davis TA, Kim SW, Li P, Marc Rhoads J, Carey Satterfield M, Smith SB, Spencer TE, Yin Y. Arginine metabolism and nutrition in growth, health, and disease. *Amino Acids*. 2009; 37:153–168.
[26] Cheah Y, Yang W. Functions of essential nutrition for high quality spermatogenesis. *Adv Biosci Biotechnol*. 2011; 2:182–197.
[27] Chauhan N S, Sharma V, Dixit VK, Thakur M. A review on plants used for improvement of sexual performance and virility. *BioMed. Res. Int.* 2014; Article ID 868062, 19 pages. htps://doi.org/10.1155/2014/868062.
[28] Syarifuddin A, Toleng AL, Rahardja DP, Ismartoyo I, Yusuf M. Improving libido and sperm quality of Bali bulls by supplementation of Moringa oleifera leaves. *Media Peternakan*. 2017; 40:88–93.
[29] Kumar N, Verma RP, Singh LP, Varshney VP, Dass RS. Effect of different levels and sources of zinc supplementation on quantitative and qualitative semen attributes and serum testosterone level in crossbred cattle (Bos indicus × Bos taurus) bulls. *Reprod. Nutr. Dev*. 2006; 46:663–675.
[30] Roy B, Baghel R P S, Mohanty TK, Mondal G. Zinc and male reproduction in domestic animals: A Review. *Indian J. Anim. Nutr*. 2013; 30:339–350.
[31] Setchell BP. Semen and its Constituents. In: Chenoweth, P. J. & S. P. Lorton (Eds). Animal Andrology: Theories and Applications. CAB International, Boston, USA. 2014; p.3–11.
[32] Priyadarshani, N & M. C.Varma. Effect of Moringa oleifera leaf powder on sperm count, histology of testis and epididymis of hyperglycaemic mice Mus musculus. *Am. Int. J. Res. Form. Appl. Nat. Sci*. 2014; 7:07–13.
[33] Prabsatroo T J Watanathorn S, Iamsaard P S, Sritragool O, Thukhummee W, Muchimapura S. Moringa oleifera extract enhances sexual performance in stressed rats. *J. Zhejiang Univ. Sci*. 2015; B 16 179–190.
[34] Sarastina S T, Ciptadi. Analisa beberapa parameter motilitas spermatozoa pada berbagai bangsa sapi menggunakan computer assisted semen analysis (CASA) *J. Ternak Tropika*. 2007; 6:1–12.
[35] Jamili MA, Toleng A L, Yusuf M, Sahiruddin M, Hasrin M. The effect of Moringa oleifera leaves on the quality of Bali bulls semen. *IOP Conf. Ser.: Earth Environ. Sci*. 2021; 788 012146 doi:10.1088/1755 1315/788/1/012146
[36] Begum H, Moniruddin A, Nahar K. Environmental and nutritional aspect in male infertility. *J. Medicine*. 2009; 10:16- 19. htps://doi.org/10.3329/jom.v10i1.1997
[37] Susilawati T. Spermatologi (In Indonesian). Universitas Brawijaya Press (UB Press), Malang 2011.
[38] Toelihere MR. Inseminasi Buatan Pada Ternak (Angkasa: Bandung) 1993.
[39] Aurich J E, Schoneher U, Hoppe H, Aurich C. Effect of antioxidants on motility and membrane integrity of chilled stored stallion semen. *Theriogenology*. 1997; 48:185–192.
[40] Hasrin, Toleng A L, Yusuf Sahiruddin M, Hasbi H. Conception rate of Bali cows inseminated with semen of the bull supplemented with Moringa oleifera Leaf (MOL) powder block. *IOP Conf. Ser.: Earth Environ. Sci.* 2020; 492 012071.
[41] Soliva C.R. Kreuzer M, Foidl N, Foidl G, Machmüller A, Hess HD. Feeding value of whole and extracted Moringa oleifera leaves for ruminants and their effects on ruminal fermentation in vitro. *Animal Feed Science and Technology*. 2005; 118(1–2):47–62.
[42] Tadeo N, Abellera V, Vega R, Sulabo R, Rayos A, Baconguis R, Saludes T, Tadeo F. Yield and composition of milk and detection of plasma ghrelin and IGF-1 in dairy buffalo fed with Moringa oleifera leaf leal (MoLM) supplement. *Earth Envir Sci.* 2019; 230(1):012039.
[43] Sarwatt SV, Milang'ha MS, Lekule FP, Madalla N. Moringa oleifera and cottonseed cake as supplements for smallholder dairy cows fed Napier grass. *Liv Res Rural Development*. 2004; 16(6) 12–18.
[44] Rika N, Toleng A L, Yusuf M, Sahiruddin and Ako A. Increasing milk production and milk chemical composition in dairy cows by a supplementation of Moringa oleifera leaf (MOL) powder block. *IOP Conf. Ser.: Earth Environ. Sci.* 2020; 492 012072.
[45] Dong L, Zhang T, Diao Q. Effect of Dietary Supplementation of Moringa Oleifera on the Production Performance and Fecal Methanogenic Community of Lactating Dairy Cows. *Animals*. 2019; 9, 262. doi:10.3390/ani9050262.
[46] Bhavna A, Biswajit R, Lakhani GP, Baghel RPS, Kiran PS S, Aayush Y. Effect of Moringa oleifera leaf meal on feed intake and growth performance of murrah buffalo calves. *Int. J. Curr. Microbiol. App. Sci*. 2018; 7 (9) 1960–1973.
[47] Sandeep D, Devender SB, Sajjan S, Vishal S, Man S, Narender S. Study of effect of supplementation of Moringa Oleifera leaf meal (MOLM) on the production performance of lactating Murrah buffalo under loose housing system. *Research square*, priprent, 2022; DOI: https://doi.org/10.21203/rs.3.rs-1838156/v1.
[48] Imran M, Mobashar M, Irfan M, Hanif S, Hanif S, Abubakar M. Potential of Moringa oleifera leaf meal as partially replacement of cotton seed cake in diet of Nili-Ravi buffaloes in semi-arid areas. *Vet Sci: Res and Reviews*. 2016; 2(1):1–5.
[49] Sun JJ, Peng W, Guo P C, Jun YL, Qian Y X, Geng YC, Jia HW, Bin Z, Yue QX, Qing YJ, Ting C, Yong LZ. Effect of Moringa oleifera supplementation on productive performance, colostrum composition and serum biochemical indexes of sow. *J Anim Physiol Anim Nutr*. 2020; 104:291–299.
[50] Afzal A, Hussain T, Hameed A, Shahzad M, Mazhar MU, Yang G. Dietary Moringa oleifera Alters Periparturient Plasma and Milk Biochemical Indicators and Promotes Productive Performance in Goats. *Front. Vet. Sci.* 2022; 8:787719. doi: 10.3389/fvets.2021.787719.
[51] Al-Juhaimi FY, Alsawmahi ON, Abdoun KA, Ghafoor K, Babiker EE. Antioxidant potential of Moringa leaves for improvement of milk and serum quality of Aardi goats. *South African Journal of Botany*. 2020; 129:134–137.
[52] Babiker EE, AL Juhaimi F, Kashif G, Mohamed HE, Abdoun KA. Effect of partial replacement of alfalfa hay with Moringa species leaves on milk yield and composition of Najdi ewes. *Tropical Animal Health and Production*. 2016;48:1427–1433.
[53] Raji AY, Njidda AA. Gonadal and extra-gonodal sperm reserves of the red sokoto goats fed Moringa oleifera supplemented diets *Int. J. Agri Biosci*. 2014;3:61–64.
[54] Kholif AE, Gouda GA, Morsy TA, Salem AZM, Lopez S, Kholif AM. Moringa oleifera leaf meal as a protein source in lactating goat's diets: feed intake, digestibility, ruminal fermentation, milk yield and composition, and its fatty acids Profile. *Small Ruminant Research*. 2015; 129:129–137.
[55] EL-Hedainy DK, El-Wakeel E, Rashad AMA. Effect of Moringa seed meal as a feed additive on performance of fattening male Barki sheep. *Int J Vet Sci Res*. 2020; 6(2):184–187.
[56] Dina M S, Magdy RB, Sahar H O, Hanem KK, Hesham R El-Seedi, Mabrouk A. A. Moringa oleifera leaves extract enhances fresh and cryopreserved semen characters of Barki rams. *Theriognology*. 2020; 153:133–142.
[57] Nara V, Kopuri GD, Gunji V, Akula MSS. Effect of Hydroalcoholic Extract of Moringa Oliffra Leaves on Fertility Hormone and Sperm quality of Male albino Rats. *World Journal of Current Medicaland Pharmaceutical Research*. 2019;1 (3):83–87.
[58] Dafaalla MM, Hassan A W, Idris OF, Abdoun S, Modawe GA, Kabbashi A S. Effect of ethanol extract of Moringa oleifera leaves on fertility hormone and sperm quality of Male albino rats. *World J. Pharm. Res*. 2016; 5:1–11.
[59] Attah AF, Moody JO, Sonibare MA, Salahdeen HH, Akindele OO, Nnamani PO. Aqueos extract of Moringa Oleifera leaf used in Nigerian ethnomedicine alter conception and some pregnancy outcomes in wister rat. *South African Journal of Botany* 2020; 129:255–262.
[60] Zeng B., Junyi L., Peng W., Lin Y., Ting C., Jiajie S., Meiying X., Meng L., Haojie Z., Jiajian H., Yongliang Z. and Qianyun X. The beneficial effects of Moringa oleifera leaf on reproductive performance in mice. *Food Sci Nutr*. 2019; 7:738–746.
[61] Abu AH, Ahemen T, Ikpechukwu P. The testicular morphometry and sperm quality of rabbit bucks fed grad-ed levels of Moringa oleifera leaf meal (MOLM). *Agrosearch*. 2013;13:49–56.
[62] El-Desoky A M I, Alazab AM, Bakr ELO, Elseady YA. Effect of dding moringa leaf meal to rabbit diets on some productive and reproductive

performance traits. *Egyptian Journal of Rabbit Science* 2018;28(2):263–286.
[63] Ewuola E O, Adeyemi A A, Adeyinka AD, Akabuike C F. Potential of Moringa oleifera leaf meal in improving reproductive efficiency of rabbit bucks in hot climate. *Nigerian J. Anim. Sci*. 2019; 21 (1):80–86.
[64] Olugbemi TS, Mutayoba SK, Lekule FP. Effect of Moringa (Moringa oleifera) inclusion in cassava-based diets fed to broilers chickens. *Inter J Poult Sci.* 2010; 9:363–367.
[65] Sebola NA, Mlambo V, Mokoboki HK, Muchenje V. Growth performance and carcass characteristics of three chicken strains in response to incremental levels of dietary Moringa oleifera leaf meal. *Livest. Sci*. 2015; 178:202–208.
[66] Tutubalang K, Nthabiseng A. Sebola, Hilda K. Mokoboki, Katlego. Inclusion of Moringa oleifera leaf meal in the diet of locally bred chickens: effects on growth performance, semen and hatchability traits. *Journal of Applied Animal Research*. 2022; 50(1):239–245.
[67] Mbikay M. Therapeutic potential of Moringa oleifera leaves in chronic hyperglycemia and dyslipidemia: a review. *Front Pharmacol*. 2012;3:1–12.
[68] Cerolini S, Zainiboni L, Maldjian A, Gliozzi T. Effect of docosahexaenoic acid and -tocopherol enrichment in chicken sperm on semen quality, sperm lipid composition and susceptibility to peroxidation. *Theriogenology*. 2006; 66:877–886.
[69] Yusuf M. Semen quality and egg hatchability in local turkey fed diets containing Moringa oleifera and Gongronema latifolium leaf meal [M.Sc. thesis]. Nsukka: Department of Animal Science, University of Nigeria. 2014.
[70] Ashizawa K, Wishart GJ. Resolution of the sperm motility stimulating principle of fowl seminal plasma into Ca2þ and an unidentified low molecular weight factor. *J Reprod Fertil*. 1987; 81:495–499.
[71] Ashizawa K, Hashimoto K, Tsuzuki Y. Regulation of fowl sperm flagellar motility by protein phosphatase type 1 and its relationship with dephosphorylation of axonemal and/or accessory cytoskeletal proteins.
[72] *Biochem Biophys Res Commun* 1997; 235:108–112.
[73] Sebola NA, Mlambo V, Mokoboki HK. Chemical characterisation of Moringa oleifera (MO) leaves and the apparent digestibility of MO leaf meal- based diets offered to three chicken strains. *Agroforest Syst*. 2017; 93:149–160.
[74] Fuglie LJ. New uses of Moringa studied in Nicaragua. *Echo Development Notes* 2013; 68:1–6.
[75] Fouad AM, Kasem HAK, Ruan D, Xia W, Chen W, Wang S, Zheng C. Nutritional modulation in fertility in male poultry. *Poult Sci*. 2020; 99:5637–5646.
[76] Young ID, Leymaster KA, Lunstra DD. Genetic variation in testicular development and its relationship to female reproductive traits in swine. *J Anim Sci.* 1986; 63:17–26.
[77] Hansen JC, Deguchi Y. Selenium and fertility in animals and man – a review. *Acta Vet Scand*. 1996; 37:19–30.
[78] Peters SO, Shoyebo OD, Ilori BM, Ozoje MO, Ikeobi CON, Adebambo OA. Semen quality traits of seven strain of chickens raised in the humid tropics. *Int J Poult Sci*. 2008; 7:949–953.
[79] Amen HMM, Al-Daraji HJ. Effects of dietary supplementation with different levels of zinc on sperm egg penetration fertility traits of broiler breeder chicken. *Pak J Nutr*. 2011; 10 1083–1088.
[80] Durmus İ, Ataşoğlu C, Mizrak C, Ertaş S, Kaya M. Effect of increasing zinc 196 concentration in the diets of brown parent stock layers on various production and 197 hatchability traits. *Archiv fuer Tierzucht Dummerstorf.* 2004; 47:483–489.
[81] Lesuisse J, Li C, Schallier S, Leblois J, Everaert N, Buyse J. Feeding broiler breeders a reduced balanced protein diet during the rearing and laying period impairs reproductive performance but enhances broiler offspring performance. *Poult Sci*. 2017; 96:3949–3959.
[82] Alebachew W, Etalem T, Berhan T. Effects of feeding different dietary levels of Moringa oleifera leaf meal on egg production, fertility and hatchability of dual purpose Koekoek hens. *Middle-East J Sci Res.* 2016; 24:2909–2920.
[83] Etalem T, Getachew A, Mengistu U, Tadelle D. Cassava root chips and Moringa oleifera leaf meal as alternative feed ingredients in the layer ration. *J Appl Poult Res*. 2014; 23:614–624.
[84] Goncalves RA, Serradeiro R, Machado M, Costas B, Hunger C, Dias JAS. Interactive effects of dietary fishmeal level and plant essential oils supplementation on European sea bass, Dicentrarchus labrax: Growth performance, nutrient utilization, and immunological response. *World Aquacul Soci.* May 2019; 7,50(6):1078–1092.
[85] Miao L, Charles O, Lin Y, Gong Y, Zhu W, Wang L, Fu J, Zhang Z, Dong Z. Interactive effects of mulberry leaf meal and bamboo charcoal additive on growth performance, anti-oxidant capacity, and disease resistance of genetically improved farmed tilapia (GIFT) juvenile (Oreochromis niloticus). *Aquacult Rep*. Nov. 2020;1(18):8. https://doi.org/10.1016/j.aqrep.2020.100483.
[86] Shen M, Li T, Lu J, Qu L, Wang K, Hou Q, Zhang Z, Guo X, Zhao W, Wu P. Effects of Supplementation of Moringa Oleifera Leaf Powder on Some Reproductive Performance in Laying Hens. *Brazilian Journal of Poultry Science.* 2021. http://dx.doi.org/10.1590/1806-9061-2021-1537.
[87] Lu W, Wang J, Zhang HJ, Wu SG, Qi GH. Evaluation of Moringa oleifera leaf in laying hens: Effects on laying performance, egg quality, plasma biochemistry and organ histopathological indices. *Ital J Anim Sci*. 2016; 1,15(4):658–65.
[88] Olugbemi TS, Mutayoba SK, Lekule FP. Moringa oleifera leaf meal as a hypocholesterolemic agent in laying hen diets. *Livest. Res. Rural Dev.* 2010; 22:84.
[89] Kakengi A, Kaijage J, Sarwatt S, Mutayoba S, Shem M, Fujihara T. Effect of Moringa oleifera leaf meal as a substitute for sunflower seed meal on performance of laying hens in Tanzania. *Int. J. Poult. Sci*. 2007; 9:363–367.
[90] Mahfuz S, Shu X P. Application of Moringa (Moringa oleifera) as Natural Feed Supplement in Poultry Diets. *Animals* 2019; 9, 431; doi:10.3390/ani9070431.
[91] Bukar A, Uba A, Oyeyi TI. Antimicrobial profile of Moringa oleifera lam. Extracts against some food born microorganism. *Bayero J. Pure Appl. Sci*. 2010; 3:43–48.
[92] Jabeen R, Shahid M, Jamil A, Ashraf M. Microscopic of the antimicrobial activity of seed extracts of Moringa. *Pak. J. Bot*. 2008; 40:1349–1358.
[93] Yang SL, Yang RC, Zhou X, Yang SH, Luo LL, Zhu YC, Boonanuntan S. Effects of feeding diets with processed Moringa oleifera stem meal on growth and laying performance, and immunological and antioxidant activities in laying ducks. *Poult* Sci. 2020; 1,99(7):3445–3451.