UTILIZATION OF DIETARY *MORINGA OLEIFERA* (DRUMSTICK TREE): ITS EFFECT ON ANIMAL PERFORMANCE AND PRODUCTIVITY

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ABSTRACT
The present review article gives a detailed discussion on the utilization and the effect of the inclusion of Moringa oleifera in animal diets on performance and productivity. Moringa has been fed to cattle, goats, sheep, poultry, pigs, rabbits and fish. The inclusion of moringa leaf meals as a supplement to low-quality livestock fodder has led to improved dry matter intake as well as the better digestibility of the fodder by livestock. It has also been used for the bright colouration of egg yolk, broilers skin, wattles, beaks, combs and shank, for improving meat quality, higher weight gain, better egg shell quality, higher egg weight and production, improved haematological profile, better milk production and quality and general improvement in animal health. It has been reported to reduce the cost of production when incorporated into the ration of animals as a partial replacement for conventional sources of protein.

Key words: *Moringa oleifera,* ruminants, monogastrics, fish, performance, productivity

INTRODUCTION

Conventional feed ingredients are costly in many developing countries that is the reason why researchers and farmers are in search of cheap and affordable alternative sources which are nutritious and also readily available (Moreki and Gabanakgosi, 2014; Akande *et al*., 2016). Browse plants have been used for livestock animals for many years. *Moringa oleifera* is an evergreen browse plant, which is drought tolerant and capable of adapting to a wide range of soils and climatic conditions. *Moringa oleifera* tree is a multipurpose plant also called drumstick tree, horseradish tree and ben oil tree (Afuang *et al*., 2003; Fahey, 2005; Bhupendra and Neikuozo, 2015). The production of *Moringa oleifera* is advantageous because it can be cultivated and managed with ease. Moringa leaves can serve as a good quality supplement in animal diets (Moreki and Gabanakgosi, 2014). Many leaf meals have been incorporated into animal feeds. Among many of these leaf meals, thus used is moringa leaf meal, an excellent leaf protein feedstuff (Abbas, 2013). All parts of the *Moringa oleifera* plant are considered to be edible and useful (Makkar and Becker, 1999). Over many years, research work has been carried out on how *Moringa oleifera* can be used to improve livestock production. Interestingly, success has been reported in this regard by several researchers globally (Aregheore, 2002; Adegun *et al*., 2011; Fayomi *et al*., 2014; Oliver *et al*., 2015; Sebola *et al*., 2015; Sultana *et al*., 2015; Briones *et al*., 2017).

Moreki and Gabanakgosi (2014) stated that *Moringa oleifera* is one of the plants that can be integrated with livestock production, a cheap protein source which can be used to boost the feed quality as well as used to enhance the digestibility of other diets. The fresh leaves of moringa plants are readily consumed by cattle, sheep, goats, pigs and rabbits. The leaf meal of moringa has been incorporated into the diets of poultry, fish and other animals in many countries. Nouman *et al*. (2014) recommended the use of *Moringa oleifera* as a good alternative for substituting commercial rations for livestock. Most countries and communities where moringa plant was not common have started growing it, due to its multiple uses and benefits. There is a lot of advocacy in Nigeria and other developing countries to encourage the planting and utilization of moringa for nutritional, medicinal, agricultural, industrial and economic purposes. The claim that *Moringa oleifera* enhances the productivity of animals may be associated with the increased and widespread research interest in various aspects of the moringa plant over several decades in the field of animal science.

Feeding ruminants with moringa: Several researchers have suggested and recommended the utilization of moringa as an alternative source of protein in ruminant diets (Kakengi *et al*., 2005; Sanchez *et al*., 2006; Mendieta-Araica *et al*., 2010; Gutierrez *et al*., 2012). Table 1 shows the dietary effect of *Moringa oleifera* on the performance and productivity of ruminants. Additionally, this leaf protein and its organic matter are digestible in the rumen (Kakengi *et al*., 2005; Gutierrez *et al*., 2012). Soliva *et al*. (2005) reported that moringa leaves enhance the microbial protein synthesis in the rumen due to the presence of readily fermentable nitrogen and substantial energy content it possesses. It can become a useful supplement for inclusion in animal

feeds, a source of nutritive food as well as serving as a medicinal plant.

Cattle: Cohen-Zinder *et al*. (2016) substituted wheat silage with *Moringa oleifera* silage in the diets of lactating Holstein cows. Cows fed supplements of ensiled *Moringa oleifera*, had 1.91% increase in milk yield as well as a 20% increase in milk anti-oxidative activity. These research authors also recommended the ensiling mixture of *Moringa oleifera* with soy hulls or corn grains as a higher digestible additive for lactating dairy cows. Creole Reyna breed dairy cows fed *Moringa oleifera* supplement of 2 and 3kg dried *Moringa oleifera* leaves per day had an increased ($P<0.05$) milk yield by 58% and 65%, respectively, in addition, the dairy cows recorded improved ($P<0.05$) dry matter intake and digestibility of the diet (Sanchez *et al*., 2006). Olorunnisomo (2014) reported improved ($P<0.05$) milk production and feed utilization by Sokoto Gudali cows with a higher proportion of moringa forage in the supplementary silage. Additionally, Olorunnisomo (2014) posited that the use of *Moringa oleifera* silage has the potential for increasing local milk production. Mendieta-Araica *et al*. (2010) established from their research findings that dairy cows fed moringa silage were able to produce the similar quantity and quality of milk as dairy cows fed conventional diets. Cows fed moringa supplement were reported to produce a significant ($P<0.05$) increase in daily milk yield as well as improved ($P<0.05$) milk composition (Khalel *et al*., 2014).

Sheep: The dietary inclusion of *Moringa oleifera* stem in the ration of growing Rahmani lambs was found to enhance ($P<0.05$) feed efficiency. In addition, it can also effectively serve as a replacement for clover hay and concentrate feed mixture in the diet of growing lambs without any detrimental effect on performance (Mahmoud, 2013). Fayomi *et al*. (2014) recommended the incorporation of *Moringa oleifera* leaf meal for producing multi-nutrient blocks for sheep diet (Yankasa ram) for improved performance and haematological profile. Adegun *et al*. (2011) suggested the use of *Moringa oleifera* as a protein supplement for improved performance of sheep in south-western Nigeria. Fadiyimu *et al*. (2010) from their research asserted that the inclusion of *Moringa oleifera* in the diets of West African Dwarf (WAD) sheep resulted in the improvement of the haematological profile, nitrogen balance and nitrogen retention. They recommended 25% inclusion of *Moringa oleifera* as the optimum level for the replacement of *Panicum maximum* in the diet of West African Dwarf (WAD) sheep.

Goat: Aregheore (2002) documented that the inclusion of up to 50% of moringa leaf in a low-quality forage ration produced increase in daily weight gain and diet digestibility of goats (Anglo-Nubian x Local Fiji). According to Moyo *et al*. (2014), the inclusion of moringa leaf meal in the diets of crossbred Xhosa lop-eared goats produced better ($P<0.05$) meat quality attributes when compared with the control group. *Moringa oleifera* leaf meal has a positive effect on milk composition and milk yield of Anglo-Nubian goats (Basitan and Jarcia, 2013). Kholif *et al*. (2015) conclusively stated that *Moringa oleifera* can serve as a replacement for sesame meal up to 75% (that is, an inclusion level of 15% *Moringa oleifera* leaf meal) in the diet of lactating Anglo-Nubian goats. These researchers reported that the incorporation of *Moringa oleifera* leaf meal led to higher ($P<0.05$) intake of feed, improvement ($P<0.05$) in nutrient digestibility and rumen fermentation and more ($P<0.01$) milk production. They further reported that the inclusion of moringa had a positive effect on the fatty acid composition of goat milk by producing an increase ($P<0.05$) in unsaturated fatty acid and a decrease ($P<0.05$) in saturated fatty acid. The lactation-enhancing effect of *Moringa oleifera* leaves was demonstrated from the increase of maternal serum prolactin levels (Dela-Cruz, 2012). Basitan and Jarcia (2013) pointed out from their research that *Moringa oleifera* has galactagogue effect, which can cause the increase in the production of milk. They further stated that the galactagogue effect of moringa can be obtained by feeding lactating goats 30 to 40% *Moringa oleifera* forage. Sultana *et al*. (2015) recommended moringa foliage (leaves, petiole, and soft stem) as a cheap substitute for conventional concentrate in the diet of growing Bengal goats. Their research report demonstrated that the highest average daily live weight gain of 63.45g/day was found in Bengal goats fed 75% moringa foliage plus 25% concentrate mixture diet while the lowest average daily live weight gain of 33.02g/day was recorded by goats fed 100% concentrate mixture diet. According to Briones *et al*. (2017), feeding goats with *Brachiaria mutica* (para grass) and moringa resulted in higher ($P<0.05$) dry matter intake and consequently increase ($P<0.05$) in weight gain

Feeding non-ruminants with moringa: The moringa leaf meal is a good source of protein for non-ruminant animals. There are interesting research reports on the effect of the inclusion of moringa in diets of monogastrics and several research authors have recommended its usage in monogastric nutrition. Table 2 presents the dietary effect of

moringa on the performance and productivity of non-ruminant animals.

Poultry: Moringa can be incorporated into poultry feeds, particularly by small-scale farmers, as natural and healthy feed replacements to synthetic feed supplements (Paguia *et al*., 2014). According to the reports of Donkor *et al*. (2013), the availability of *Moringa oleifera* in several rural areas in Ghana makes its use as a commercial poultry feed ingredient an economically viable one. *Moringa oleifera* can perform a key role in the economy of poultry production. Notably, the partial replacement of fish meal with *Moringa oleifera* leaf meal has been found to reduce feed cost (Zanu *et al*., 2012). Moringa is suitable for usage in poultry feeds (Foidl *et al*., 2001). *Moringa oleifera* leaves contain major nutrients required for healthy growth of poultry birds. Additionally, the dietary inclusion of moringa leaf meal in poultry diets has led to increase in weight gain, the bright colouration of chicken wattles, beaks, combs as well as the improvement in the yellow colouration of egg yolk, broilers skin and shank colour (Donkor *et al*., 2013). According to Ebenebe *et al*. (2013) the incorporation of moringa leaf meal in the diets of layers at lower levels improved egg production and egg quality but higher levels of inclusion resulted in lower productivity and poorer egg quality indices. Nkukwana *et al*. (2014) included *Moringa oleifera* leaf meal up to 25g/kg of feed and reported no negative effect on nutrient utilization efficiency and growth performance of broiler chickens. Feeding chickens with *Moringa oleifera* leaf meal resulted in better carcass characteristics and enhanced growth performance (Sebola *et al*., 2015). The use of *Moringa oleifera* as a feed additive for broilers resulted in the production of chicken breast with light appearance (Wapi *et al*., 2013). Allam *et al*. (2016) posited that *Moringa oleifera* leaf extract has played the role of an antioxidant, immune booster, growth promoter, anti-bacterial agent and also had a positive effect on haemato-biochemical parameters of broiler chickens. The utilization of *Moringa oleifera* seed meal in poultry diets is not so common. However, the high dietary levels of moringa seed meal in the diet of broiler chicks was reported by Ochi *et al*. (2015) to negatively affect the performance and carcass characteristics of the birds. Briones *et al*. (2017) reported that the inclusion of 5% moringa leaf meal in the ration of layer quails resulted in higher egg production, increased egg weight, better egg yolk colour and improved feed conversion ratio ($P<0.05$). Similar result was obtained for White leghorn chickens given drinking water mixed with 100ml moringa leaf extract. In addition, Briones *et al*. (2017) reported that the incorporation of *Moringa oleifera* seed meal in the diet of Babcock layer birds led to decrease ($P<0.05$) in the percentage of broken eggs as a result of the improvement of egg shell quality.

Rabbit: The dietary replacement of *Centrosema pubescens* with *Moringa oleifera* was reported by Odeyinka *et al*. (2008) not to have any negative effect on the reproductive performance of rabbits. Nuhu (2010) documented that *Moringa oleifera* leaf meal is naturally very nutritive and can efficiently serve as a replacement for soybean meal in the diet of weaner rabbits without adversely affecting blood indices and productive performance. Moringa leaf meal can be included up to 20% in the diets of weaner rabbits with no detrimental effect on performance (Nuhu, 2010). Ewuola *et al*. (2012) likewise replaced soybean meal with 15% moringa leaf meal in the diets of growing rabbits and achieved significant ($P<0.05$) increase in apparent nutrient digestibility.

Pig: Research carried out by Acda *et al*. (2010) demonstrated that performance of growing pigs fed diets containing 10% inclusion level of moringa leaf meal was not negatively affected. However, Mukumbo *et al*. (2014) reported that feeding increasing levels of *Moringa oleifera* leaf meal to finisher pigs resulted in a significant ($P<0.05$) decrease in intramuscular fat and stearic acid content of the pork. The authors concluded that moringa can be incorporated up to 5% in the diets of finisher pigs without adversely affecting feed conversion efficiency, meat quality and may also lead to improvement in the shelf life of the meat. The variation in the level of dietary inclusion of moringa recommended by the authors cited above may be attributed to the difference in the ages of the experimental pigs used (early growth phase versus late growth phase). Oliver *et al*. (2015) suggested the use of fermented extracts of *Moringa oleifera* as a promising natural growth promoter alternative for use in pig production.

Moringa in fish diet: Egwui (2013) recommended the use of moringa as an alternative source of protein in aquaculture feeds and advocated the need for further research on other aspects of the utilization of *Moringa oleifera* in aquaculture. In the experiment conducted by Olaniyi *et al*. (2013), they established that 12.5% inclusion level of *Moringa oleifera* leaf meal can efficiently replace groundnut cake in the diets of fish (*Clarias gariepinus*). In another study, Karpagam and Krishnaveni (2014) affirms that feeding fish, particularly, Tilapia (*Oreochromis mossambicus*) with moringa leaf resulted in a

significant (P<0.01) increase in weight gain and specific growth rate. Foidl *et al*. (2001) reported that moringa can be used in fish nutrition. Afuang *et al*. (2003) reported that inclusion level of up 33% solvent-extracted moringa leaf meal in the diet of Tilapia fish (*Oreochromis niloticus* L.) had no adverse effect. They further reported a significant (P<0.05) reduction in the carcass lipid and plasma cholesterol levels of fish fed higher levels of moringa (raw and methanol-extracted leaf meals). This is an evidence of the hypolipidaemic and hypocholesterolaemic properties of moringa.

CONCLUSION

In countries where there is the experience of a prolonged dry season or when there is a shortage of most forage plants, moringa will be an available and suitable substitute for feeding livestock animals. Various livestock species have in one way or another benefited from the utilization of moringa plant as documented in the literature by several research authors. The use of *Moringa oleifera* in animal feeding has resulted in improved performance, increased digestibility of feed, enhanced meat quality, brighter egg yolk colour, increased milk yield and improved haematological profile of animals. This plant protein has great potential as a feedstuff for future inclusion in the production of commercial livestock feed.

REFERENCES

Abbas, T.E. (2013). The use of *Moringa oleifera* in poultry diets. *Turkish Journal of Veterinary and Animal Sciences*, 37: 492-496. DOI: 10.3906/vet-1211-40.

Acda, S.P., Masilungan, H.G.D. & Moog, B.A. (2010). Partial substitution of commercial swine feeds with malunggay (*Moringa oleifera*) leaf meal under backyard conditions. *Philippine Journal of Veterinary and Animal Sciences*, 36 (2): 137-146.

Adegun, M.K., Aye, P.A. & Dairo F.A. (2011). Evaluation of *Moringa oleifera, Gliricidia sepium* and *Leucaena leucocephala*-based multi-nutrient blocks as feed supplements for sheep in South Western Nigeria. *Agriculture and Biology Journal of North America*, 2 (11): 1395-1401.

Afuang, W., Siddhuraju, P. & Becker, K. (2003). Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of Moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.). *Aquaculture Research,* 34: 1147-1159.

Akande, K.E., Abubakar, M.M., Adegbola, T.A. & Bogoro, S.E. (2016). Nutritional Composition of Some Unconventional Plant Protein Sources. *Journal of Animal Production Research,* 28(2):1-10. Avaliable online: http://www.naprijapr.org/index.php/japr/article/download/104/186

Allam, H., Abdelazem, M.A., Salah, H. & Hamed, A. (2016). Some hemato-biochemical, bacteriological and pathological effects of *Moringa oleifera* leaf extract in broiler chickens. *International Journal of Basic and Applied Sciences*, 5 (2): 99-104.

Aregheore, E.M. (2002). Intake and digestibility of *Moringa oleifera* - batiki grass mixture by growing goats. *Small Ruminant Research*, 46 (1): 23-28. http://dx.doi.org/10.1016/S0921-4488(02)00178-5

Basitan, I.S. & Jarcia, E.G. (2013). Yield, quality and feed cost efficiency of milk produced by anglo-nubian goats fed different mixtures of napier (*Pennisetum purpureum*) grass and malunggay (*Moringa oleifera*). *Philippine Journal of Veterinary and Animal Sciences*, 39 (2): 193-200

Bhupendra, K. & Neikuozo, C. (2015). *Moringa oleifera* Lam.: Panacea to several maladies *Journal of Chemical and Pharmaceutical Research*, 7(6):687-707

Briones, J., Leung, A., Bautista, N., Golin, S., Caliwag, N., Carlos, M.A., Guevarra, J., Miranda, J., Guevarra, J.K., Pili, N.L., Mendoza, D. & De Jesus, N. (2017). Utilization of *Moringa oleifera* Lam. in animal production. *Acta Horticulturae*, 1158, 467-474. DOI:10.17660/ActaHortic.2017.1158.54

Cohen-Zinder, M., Leibovich, H., Vaknin, Y., Sagi, G., Shabtay, A., Ben-Meir, Y., Nikbachat, M., Portnik, Y., Yishay, M. & Miron, J. (2016). Effect of feeding lactating cows with ensiled mixture of *Moringa oleifera*, wheat hay and molasses, on digestibility and efficiency of milk production. *Animal Feed Science and Technology*, 211: 75–83

Dela-Cruz, R.T. (2012). Cattle produces more milk with Malunggay. *Agriculture Monthly Magazine* 16 (5): 34.

Donkor, A.M., Glover, R.L.K., Addae, D. & Kubi, K.A. (2013). Estimating the Nutritional Value of the Leaves of *Moringa oleifera* on Poultry. *Food and Nutrition Sciences*, 4: 1077-1083. http://dx.doi.org/10.4236/fns.2013.411140

Ebenebe, C.I., Anigbogu, C.C., Anizoba, M.A. & Ufele, A.N. (2013). Effect of various levels of Moringa Leaf Meal on the Egg Quality of Isa Brown Breed of Layers. *Advances in Life Science and Technology*. www.iiste.org. 14: 45-49.

Egwui, P.C., Mgbenka, B.O. & Ezeonyejiaku, C.D. (2013). Moringa Plant and it use as Feed in Aquaculture Development: A Review. *Animal Research International*, 10 (1): 1673-1680.

Ewuola, E.O., Jimoh, O.A, Atuma, O.V & Soipe, O.D. (2012). Growth indices and Apparent Nutrient Digestibility in Rabbits fed Graded levels of Moringa (*Moringa oleifera*) leaf meal. *Nigerian Journal of Animal Science,* 14 (1): 92-100.

Fadiyimu, A.A., Alokan, J.A. & Fajemisin, A.N. (2010). Digestibility, Nitrogen balance and haematological profile of West African dwarf sheep fed dietary levels of *Moringa oleifera* as supplement to *Panicum maximum*. *Journal of American Science*, 6 (10): 634-643.

Fahey, J.W. (2005). *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Part 1. *Trees for Life Journal*, 1:5 available online at: http://www.tfljournal.org/article.php/20051201124931586

Fayomi, A., Ahmed, A., Musa, U., Salami-Shinaba, J.O., Ogedegbe, S.A. & Akanni, K. (2014). Moringa multi-nutrient blocks: formulation, production, and feeding trial under a tropical environment. *International Journal of Science, Environment and Technology*, 3 (1): 67-84

Foidl, N., Makkar, H.P.S. & Becker, K. (2001). The potential of *Moringa oleifera* for Agriculture and Industrial uses. In: The Miracle Tree-The Multiple Attributes of Moringa. Fuglie, L.J. (Ed.). CTA, USA, pp 45-76.

Gutierrez, P., Rocha, L., Reyes Sánchez, N., Paredes, V. & Mendieta-Araica, B. (2012). Ruminal degradation rate of *Moringa oleifera* foliage in Reyna cattle using in sacco technique. *La Calera*, 12 (18): 37-44.

Kakengi, A.M.V., Shem, M.N., Sarwatt, S.V. & Fujihara, T. (2005). Can *Moringa oleifera* be used as a protein supplement for ruminants? *Asian-Australasian, Journal of Animal Science*, 18 (1): 42-47.

Karpagam, B. & Krishnaveni, N. (2014). Effect of Supplementation of Selected Plant Leaves as Growth Promoters of Tilapia Fish (*Oreochromis mossambicus*). *Research Journal of Recent Sciences*, 3 (ISC-2013): 120 – 123. International Science Congress Association. Available online at: www.isca.in, www.isca.me

Khalel, M.S., Shwerab, A.M., Hassan, A.A., Yacout, M.H., El-Badawi, A.Y. & Zaki, M.S. (2014). Nutritional evaluation of *Moringa oleifera* fodder in comparison with *Trifolium alexandrinum* (berseem) and impact of feeding on lactation performance of cows. *Life Science Journal*, 11 (10): 1040-1054.

Kholif, A.E., Goudaa, G.A., Morsya, T.A., Salemb, A.Z.M., Lopezc, S. & Kholif, A.M. (2015). *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*, 129: 129–137.

Mahmoud, A.E.M. (2013). Effect of Feeding on *Moringa oleifera* Stems on Productive Performance of Growing Lambs. *Egyptian Journal of Nutrition and Feeds*, 16(2): 281-292.

Makkar, H.P.S. & Becker, K. (1999). Plant toxins and detoxification methods to improve feed quality of tropical seeds-review. *Asian-Australasian Journal of Animal Science*, 12 (3): 467-480. DOI: 10.5713/ajas.1999.467

Mendieta-Araica, B., Spörndly, R., Reyes-Sánchez, N. & Spörndly, E. (2010). Moringa (*Moringa oleifera*) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. *Livestock Science*, 137 (1-3): 10–17.

Moreki, J.C. & Gabanakgosi, K. (2014). Potential Use of *Moringa oleifera* in Poultry Diets. *Global Journal of Animal Scientific Research*, 2 (2): 109-115.

Moyo, B., Masika, P.J. & Muchenje, V. (2014). Effect of feeding Moringa (*Moringa oleifera*) leaf meal on the physiochemical characteristics and sensory properties of goat meat. *South African Journal of Animal Science*, 44 (1): 64-70.

Mukumbo, F.E., Maphosa, V., Hugo, A., Nkukwana, T.T., Mabusela, T.P. & Muchenje, V. (2014). Effect of *Moringa oleifera* leaf meal on finisher pig growth performance, meat quality, shelf life and fatty acid composition of pork. *South African Journal of Animal Science*, 44 (4): 388-400

Nouman, W., Basra, S.M.A., Siddiqui, M.T., Yasmeen, A., Gull, T. & Alcayde, M.A.C. (2014). Potential of *Moringa oleifera* L. as livestock fodder crop: a review. *Turkish Journal of Agriculture and Forestry*, 38: 1-14 DOI:10.3906/tar-1211-66.

Nuhu, F. (2010). Effect of Moringa leaf meal (MOLM) on nutrient digestibility, growth, carcass and blood indices of weaner rabbits. MSc Thesis, Faculty of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 107 pages

Ochi, E.B., Elbushra, M.E., Fatur, M., Abubakr, O.I. & Hafiz, A. (2015). Effect of Moringa (*Moringa oleifera* Lam) Seeds on the Performance and Carcass Characteristics of Broiler Chickens. *Journal of Natural Sciences Research*, 5 (8): 66-73.

Odeyinka, S.M., Oyedele, O.J., Adeleke, T.O. & Odedire, J.A. (2008). Reproductive performance of rabbits fed *Moringa oleifera* as a replacement for *Centrosema pubescens*. Proceedings of 9th World Rabbit Congress – June 10-13: 2008 – Verona Italy: 411-415.

Olaniyi, C.O., Ajani, N.O. & Adetomi, M.N. (2013). Growth Performance and Nutrient Utilization of *Clarias gariepinus* fed *Moringa oleifera* Leaf Meal. *Journal of Natural Sciences Research*, 3 (8): 99-104.

Oliver, P., De los Santos, F., Fernández, F., Ramos, I. & Abukarma, B. (2015). Effect of a liquid extract of *Moringa oleifera* on body weight gain and overall body weight of weaning pigs. *International Journal of Livestock Production*, 6 (5): 69-73. DOI: 10.5897/IJLP2014.0246

Olorunnisomo, O.A. (2014). Intake and milk yield of Zebu cows fed Moringa forage ensiled with cassava peel. *African Journal of Livestock Extension*, 14: 72-76.

Paguia, H.M., Paguia, R.Q., Balba, C. & Flores, R.C. (2014). Utilization and Evaluation of *Moringa oleifera* L. As Poultry Feeds. Asia-Pacific Chemical, Biological & Environmental Engineering Society. APCBEE Procedia (8): 343-347. DOI: 10.1016/j.apcbee.2014.03.051.

Sanchez, R.N., Sporndly, E. & Ledin, I. (2006). Effect of feeding different levels of foliage of *Moringa oleifera* to creole dairy cows on intake, digestibility, milk production and composition. *Livestock Science*, 101 (1-3): 24-31.

Sebola, N.A., Mlambo, V., Mokoboki, H.K. & Muchenje, V. (2015). Growth performance and carcass characteristics of three chicken strains in response to incremental levels of dietary *Moringa oleifera* leaf meal. *Livestock Science*, 178: 202–208. DOI: 10.1016/j.livsci.2015.04.019.

Soliva, C.R., Kreuzer, M., Foidl, N., Foidl, G., Machmüller, A. & Hess, H.D. (2005). Feeding value of whole and extracted *Moringa oleifera* leaves for ruminants and their effects on ruminal fermentation in vitro. *Animal Feed Science and Technology*, 118 (1-2): 47-62.

Sultana, N., Alimon A.R., Huque, K.S., Sazili, A.Q., Yaakub, H., Hossain, J. & Baba, M. (2015). The feeding value of Moringa (*Moringa oleifera*) foliage as replacement to conventional concentrate diet in Bengal goats. *Advances in Animal and Veterinary Sciences*, 3 (3): 164-173. DOI: 10.14737/journal.aavs/2015/3.3.164.173

Wapi, C., Nkukwana, T.T., Hoffman, L.C., Dzama, K., Pieterse, E., Mabusela, T. & Muchenje, V. (2013). Physico-chemical shelf-life indicators of meat from broilers given *Moringa oleifera* leaf meal. *South African Journal of Animal Science*, 5(1): 43-47. DOI: 10.4314/sajas.v43i5.8

Zanu, H.K., Asiedu, P., Tampuori, M., Abada, M. & Asante, I. (2012). Possibilities of using Moringa (*Moringa oleifera*) leaf meal as a partial substitute fish meal in broiler chickens. *Journal of Animal Feed Research*, 2: 70-75.

Table 1: Dietary effect of *Moringa oleifera* on the performance and productivity of ruminant animals

Animal type	Moringa part fed	Dietary effects	References
Cow	Moringa leaf	Higher milk yield and increase in milk antioxidant activity	Cohen-Zinder *et al*. (2016)
Cow	Moringa leaf	Increased milk yield and improved dry matter intake and digestibility	Sanchez *et al*. (2006)
Cow	Moringa leaf	Increased milk production	Olorunnisomo (2014)
Cow	Moringa leaf	Improved milk yield and improved composition	Khalel *et al*. (2014)
Sheep	Moringa stem	Enhanced feed efficiency	Mahmoud (2013)
Sheep	Moringa leaf	Improved haematological profile and performance	Fayomi *et al*. (2014)
Sheep	Moringa leaf	Improved animal performance	Adegun *et al*. (2011)
Sheep	Moringa leaf	Improved nitrogen balance, nitrogen retention and haematological profile.	Fadiyimu *et al*. (2010)
Goat	Moringa leaf	Increased daily weight gain and diet digestibility	Aregheore (2002)
Goat	Moringa leaf	Better meat quality attributes	Moyo *et al*. (2014)
Goat	Moringa leaf	Improved milk composition and milk yield	Basitan and Jacia (2013)
Goat	Moringa leaf	Higher feed intake, improvement in nutrient digestibility, rumen fermentation, increased production of milk with increase in unsaturated fatty acid and decrease in saturated fatty acid of milk	Kholif *et al*. (2015)
Goat	Moringa leaf	Improved performance (weight gain)	Sultana *et al*. (2015)
Goat	Moringa leaf	Higher dry matter intake and increased weight gain	Briones *et al*. (2017)

Table 2: Dietary effect of *Moringa oleifera* on the performance and productivity of non-ruminant animals

Animal type	Moringa part fed	Dietary effects	References
Poultry (Chicken)	Moringa leaf meal	Improved egg quality and production	Ebenebe *et al*. (2013)
Poultry (Chicken)	Moringa leaf meal	Better carcass characteristics and improved growth performance	Sebola *et al*. (2015)
Poultry (Quail)	Moringa leaf meal	Better feed conversion ratio, better yolk colour, increased egg production and weight	Briones *et al*. (2017)
Poultry (Chicken)	Moringa leaf meal	Produced light appearance of chicken breast meat	Wapi *et al*. (2013)
Poultry (Chicken)	Moringa leaf extract	Increased growth and produced positive effect on haemato-biochemical parameters	Allam *et al*. (2016)
Poultry (Chicken)	Moringa seed meal	Improvement in egg shell quality which resulted in decrease in the number of broken eggs	Briones *et al*. (2017)
Rabbit	Moringa leaf meal	Produced positive effect on reproductive performance	Odeyinka *et al*. (2008)
Rabbit	Moringa leaf meal	Increased apparent nutrient digestibility	Ewuola *et al*. (2012)
Rabbit	Moringa leaf meal	Positive effect on blood indices and productive performance	Nuhu (2010)
Pig	Moringa leaf meal	Improvement of shelf life of the meat, decrease in intramuscular fat and stearic acid content of the pork.	Mukumbo *et al*. (2014)
Pig	Moringa leaf meal	Positive performance	Acda *et al*. (2010)
Pig	Fermented extracts of moringa leaf	Promotes growth	Oliver *et al*. (2015)