EFFECT OF *MONODORA MYRISTICA* (AFRICAN NUTMEG) AS FEED ADDITIVE ON RABBIT'S CARCASS COMPOSITION AND SERUM LIPID PROFILE

OKON, Utibe Mfon, EKPO, Joseph Sylvester and CHRISTOPHER, Grace Idiong
Department of Animal Science, Akwa Ibom State University, Obio Akpa Campus,
Akwa Ibom State, Nigeria.

Corresponding Author: Okon, U. M. Department of Animal Science, Akwa Ibom State University, Obio Akpa Campus, Akwa Ibom State, Nigeria. **Email:** utibeokon93@gmail.com **Phone:** +234 7012931397

Received *June 20, 2023;* ***Revised*** *July 05, 2023;* ***Accepted*** *July 07, 2023*

ABSTRACT

The effect of Monodora myristica as feed additive on the performance, carcass composition and serum lipid profile of rabbits were investigated using a total of 48 weaner rabbits for a period of 12 weeks. The rabbits were allotted to four experimental diets in a completely randomized design. Each group was replicated three times with four rabbits per replicate. Treatment 1 (T_1) received basal diet only, T_2 received basal diet with 1% inclusion of M. myristica, T_3 received basal diet plus 2% M. myristica, while T_4 was given basal diet and 3% M. myristica inclusion. Results revealed significantly higher ($p<0.05$) feed intake and weight gain, compared to those on the control group. Rabbits in T_3 group recorded the highest values for all parameters assessed. Rabbits fed 2% levels of the test ingredient recorded the lowest and best FCR. Inclusion of M. myristica significantly improved ($p<0.05$) carcass characteristics without any deleterious effect on the internal organs. The serum lipid profiles of the rabbits were significantly improved ($p<0.05$) as the high density lipoprotein increased, while low density lipoprotein levels reduced. There was also a significant reduction ($p<0.05$) in abdominal fat and an increase in muscle protein of the rabbits as inclusion levels of M. myristica increased across treatments. The study revealed that up to 2% of M. myristica can be included in the diets of rabbits without adverse effect on the performance, carcass composition and serum lipid profile. Hence, it can be used as an alternative to antibiotic growth promoter in weaner rabbits.

Keywords: Additives, Cholesterol, Dressing percentage, Growth promoter, Protein

INTRODUCTION

Antibiotic growth promoters have over the years been used by farmers to achieve growth in livestock and also for the treatment and prevention of certain livestock diseases and infections. However, following the recent ban on their usage by many countries due to a reduced social acceptance by consumers of animal products for fear of residual deposits, there has been a search for alternative replacements (Onunkwor *et al.* 2022). To fill this gap, the use of natural feed additives from plant origin as growth promoters has been employed. These natural additives have been scientifically proven to be safer, cleaner, healthier, less hazardous and above all, do not leave residual effect on the animal products (Okon *et al.,* 2022). Many herbs and spices, including *Monodora myristica* (Gaertn.) Dunal (Magnoliales: Annonaceae) are rich in antibiotic, antioxidant and antimicrobial properties, which make them, fit for use as natural feed additive (Agiriga and Siwela, 2017; Okon *et al*., 2022). *M. myristica* is used as a spice in the preparation of hot soup for new born mothers to prevent haemorrhage and to

facilitate the flow of milk immediately after childbirth (Onyenibe *et al.,* 2015). Myristicin, the active ingredient in African nutmeg has several pharmacological and therapeutic benefits including the prevention of oxidative damage through its antioxidant activity (Ansory *et al*., 2019). It has antimicrobial properties and is used in many food industries as a preservative and flavouring agent (Enabulele *et al*., 2014; Agiriga and Siwela, 2017). Myristicin, although very beneficial, can have toxic effects when used in higher amounts, leading to mental confusion and degeneration of the liver, and damages to the central nervous system (Jaiswal *et al*., 2009). Studies on wistar rats administered *M. myristica* revealed a significant increase in appetite and weight gain of the rats after ingestion of the essential oil component of the plant (Onyenibe *et al*., 2015). The essential oil in *M. myristica* has been reported by Vangoori *et al*. (2019) in a study on wistar rats to stimulate lipid metabolism, which produces an anti-obesity effect in the animals.

According to Christopher *et al*. (2023), rabbit production is a livestock enterprise that can help achieve food security, reduce poverty, and contribute to meeting the growing demand for animal protein. Investing in rabbit production is advantageous due to its low capital requirements and high reproductive rate (Pascual and Gómez, 2020). Compared to other meat sources, rabbit meat is regarded as highly nutritious, as noted by Nistor *et al*. (2013). Meat sourced from rabbits and other micro livestock are abundant in protein and minerals, as reported by Para *et al.* (2015). Hence, rabbit production presents significant potential as a source of sustainable, proteinous and nutritious food.

One of the first indexes to be considered in animal production is the carcass yield, as it relates directly to the commercial value of the animal. Usually, it is expressed as the ratio of carcass weight to live weight (Casey and Webb, 2010). A well-proportioned development of the various anatomical regions is attributed to a proper carcass conformation, which is deemed optimal when the parts with the highest market value are adequately produced (Maciel *et al*., 2015). Livestock carcass is affected by factors such as nutrition, management, sex, age and breed (Sam *et al*., 2019). Feeding livestock with herbs and spices such as *M. myristica* has potential for improving their carcass characteristics which is a direct product of increased feed intake and weight gain (Okon *et al*., 2022). Despite the potential health and nutritional benefit of *M. myristica*, limited research has been conducted to investigate its effects as a feed additive on the performance, carcass characteristics, and serum lipid profile of rabbits. Therefore, there is a need to evaluate the impact of incorporating *M. myristica* into rabbit diets and its potential for use in the rabbit production industry. This study therefore seeks to investigate the effect of *M. myristica* on the performance, carcass composition and serum lipid profile of rabbits.

MATERIALS AND METHODS

Experimental Location: The study was conducted between February 14th and May 9th, 2023 at the Department of Animal Science Teaching and Research Farm, Akwa Ibom State University, Obio Akpa Campus for a period of twelve weeks. The Teaching and Research Farm is situated between latitude 4^{o}30'N and 5^{o}00'N and longitude 7^{o}30'E and 8^{o}00E (Wikipedia, 2022).

Experimental Sample Preparation: The seeds of *M. myristica* were purchased from Itam market in Uyo Local Government Area of Akwa Ibom State. They were thoroughly washed under running water and sundried. The dried seeds of *M. myristica* were ground into powder form after toasting to obtain *M. myristica* seed powder (MMSP). The ground material was stored in polythene bags under room temperature pending use (PMFME, 2023).

Experimental Diet: Four experimental diets designated as T_1, T_2, T_3 and T_4 were formulated. T_1 was basal diet without additive, T_2 was basal diet with 1% inclusion of *M. myristica*, T_3 was basal diet with 2% *M. myristica* while T_4 was basal diet with 3% *M. myristica* inclusion. The formulated standard diet which was carefully examined to ensure

that the nutritional demands of growing rabbits (Table 1); encompassing proteins, energy, minerals and vitamin requirements were sufficiently met in line with the directives of the National Research Council (NRC, 1997).

Table 1: Ingredient and nutrient composition of the experimental diets for rabbits

Ingredients (%)	T_1 (0% MMSP)	T_2 (1% MMSP)	T_3 (2% MMSP)	T_4 (3% MMSP)
Maize	27.00	27.00	27.00	27.00
Soya bean meal	9.00	9.00	9.00	9.00
Wheat offal	60.00	60.00	60.00	60.00
Bone meal	3.00	3.00	3.00	3.00
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Vitamin-mineral premix*	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Chemical composition (%)				
Crude protein (%)	16.68	16.68	16.68	16.68
Crude fibre	6.23	6.23	6.23	6.23
Ether extract	3.54	3.54	3.54	3.54
M.E. (kcal/kg)	2675.70	2675.70	2675.70	2675.70

**Vitamin-mineral premix provided per kg the following: Vitamin A 1500 IU; Vitamin D3 3000 IU; Vitamin E 30 IU; Vitamin K 2.5 mg; Thiamine B1 3 mg; Riboflavin B2 6 mg; Pyrodoxine B6 4 mg; Niacin 40 mg; Vitamin B12 0.0 mg; Pantothenic acid 10 mg; MMSP = Monodora myristica seed powder*

Management of Experimental Animals and Design: A total of 48 cross bred weaner rabbits were purchased from reputable farms in Uyo, Akwa Ibom State. The animals were weighed and randomly allotted into four treatment groups of 12 rabbits each in a randomized complete block design. The treatments were replicated three times with four rabbits making a replicate. Prior to the commencement of the study, preconditioning and acclimatization of the animals was carried out for two weeks to ensure that they adapt to the experimental environment. Feed and drinking water were offered *ad libitum* to the experimental animals. The experiment lasted for a period of 12 weeks.

Carcass Traits Evaluation: At the end of the feeding trial (84 days), a total of twenty four rabbits (n = 2 rabbits per replicate) were randomly selected, weighed and starved overnight of feed and not water. Afterwards, the animals were euthanized in accordance with normal farming practice. The rabbits were skinned, and the viscera cut opened and washed after being dislodged of the viscerals. The carcasses were prepared according to the method outlined by Blasco and Ouhayoun (1996).

The muscle to bone ratio was determined by dissecting the hindleg cut into distinct muscle and bone components. Furthermore, the breast muscle was separated and subjected to an oven-drying process. Once dried, it was pulverized into a fine powder, which was subsequently utilized to evaluate the levels of crude protein as described by AOAC (2003).

Lipid Profile Analysis: At the conclusion of the 84-day trial, a serum sample of 5 ml was obtained from the marginal veins of each of two rabbits per replicate (i.e. six rabbits per treatment) to evaluate their lipid profiles. Blood was collected into plain bottles and subjected to centrifugation at 3000 rpm for 15 minutes. Total cholesterol, triglyceride levels, and high density lipoprotein cholesterol were assayed using the methods Wybenga *et al.* (1970), Bucolo and David (1973) and Seigler and Wu (1981) respectively, while Friedewald *et al.* (1972) formula was utilized to determine low density lipoprotein cholesterol and very low density lipoprotein cholesterol levels.

Other Experimental Data Collection: At the commencement of the study, the rabbits were weighed in grammes using an electronic scale to obtain their initial weights. Weekly body weights were afterwards taken and recorded. Feed intake per rabbit was calculated as the difference between the feed offered and left over after a 24-hour feeding. Live weight gain per rabbit was calculated as the difference between previous weight and weights recorded in the following week. The ratio of feed taken to weight gained after a week of feeding was used to calculate the feed conversion ratio. The formula is thus stated, Feed conversion ratio = feed intake/weight taken (Nuamah *et al.* 2019).

Statistical Analysis: Data collected were subjected to analysis of variance (ANOVA) according to Steel and Torrie (1980) and mean were separation using Duncan's Multiple Range Test (Duncan, 1955). Significant differences between means were accepted at $p \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

The effect of *M. myristica* on the feed intake, weight gain and feed conversion ratio of rabbits is presented in Table 2. Significant differences ($p<0.05$) were observed in total weight gain, average daily weight gain, average daily feed intake and feed conversion ratio of the rabbits across the treatments. Rabbits fed T_3-based diet recorded the highest total weight gain and average daily weight gain values. The increase in weight of T_3 group was attributed to an increased feed intake as well as the different biological activities of the spices such as antibacterial, antifungal, antioxidants, and as a growth promoter. The findings of this study were in agreement with Ukoha and Onunkwo (2017) and Guru *et al*. (2022) who fed *M. myristica* and ginger extracts to Japanese quails and broiler chickens respectively. Significant differences ($p<0.05$) were also recorded in the feed intake of the experimental animals across treatment groups. Rabbits fed T_3 and T_4 based diet recorded highest feed intake values while the lowest was observed for those placed on the control (T_1) diet. The high feed intake may be attributed to the increased flavonoids from the essential oil components in the seed which led to the acceptability of the feed and stimulation of appetite in the animals. This is in line with the report of Onunkwo and Ukoha (2017) who fed broiler birds with *M. myristica*. Also, the rich mineral and vitamin components of *M. myristica* were responsible in the stimulation of appetite in the animals fed the test ingredient. This was in consonance with the report of Adepoju and Oyewole (2008). Feed conversion ratio was significantly higher ($p<0.05$) in the control group (12.37 ± 3.47) compared to other treatments. Rabbits in T_3 group however, recorded the least and best FCR. This observation strengthens the report of Hassan *et al*. (2004) that the addition of spice additives in the diets of livestock brings about an improvement in their feed conversion ratios.

The result of carcass characteristics of rabbits fed *M. myristica* as additive indicated that significant differences ($p<0.05$) were recorded in all major cut parts assessed (Table 3). Rabbits fed T_3-based diet recorded significantly higher ($p<0.05$) dressed weight values, while those in the control group recorded the least. Likewise, foreleg, hindleg and loin weights were observed to be significantly higher ($p<0.05$) in rabbits in T_2 group. This indicated that the test diet supported carcass yield in relation to the amount of feed consumed in each treatment group as the quantity of *M. myristica* increased. Likewise, the increased feed intake in the rabbits fed *M. myristica* may have contributed to an optimize muscle growth and development. This further supported the findings of Oko and Etukudo (2011) who reported a significant ($p<0.05$) improvement in the carcass composition of broiler chickens fed single leafy spices. The finding of this study supports the report of Ekpo *et al.* (2020) in weaned pigs. Values obtained for internal organs of the rabbit showed no significant differences ($p>0.05$) across treatments. This was indicative of the fact that *M. myristica* additive had no detrimental effect on the organs of the rabbits (Okon *et al*., 2022).

The result of serum lipid profile of rabbits fed *M. myristica* as additive indicated that cholesterol, LDL-C, TG and VLDL-C levels decreased with increased levels of MMSP (Table 4). Spices such as garlic, cinnamon, ginger and turmeric have been shown to have potential cholesterol-lowering effects in animals (Saeid *et al*., 2010; Islam *et al*., 2016; Sidhu *et al*., 2018; Kumar *et al*., 2019). These spices and herb contain active compounds that may inhibit the synthesis of cholesterol and other fats in the liver, thereby reducing serum lipid levels (Ekpo and Okon, 2022; Essien *et al*., 2022). Across the treatment, the result showed a significant reduction ($p<0.05$) in cholesterol, low density lipoprotein cholesterol (LDL-C), triglycerides (TG) and very low density lipoprotein cholesterol (VLDL-C).

Table 2: Effect of *Monodora myristica* feed additive on rabbits' performance indices and mortality

Parameters	T_1 (0% MMSP)	T_2 (1% MMSP)	T_3 (2% MMSP)	T_4 (3% MMSP)
Initial weight (g)	689.50 ± 45.58	698.81 ± 35.63	701.05 ± 30.71	703.00 ± 26.63
Final weight (g)	1750.75 ± 50.50^{a}	1796.00 ± 36.34^{ab}	1987.75 ± 21.83^{c}	1826.00 ± 34.44^{b}
Total weight gain (g)	501.13 ± 55.32^{a}	663.31 ± 46.32^{ab}	700.71 ± 39.32^{b}	674.50 ± 35.63^{ab}
ADWG (g)	8.04 ± 1.01^{a}	9.48 ± 1.25^{ab}	10.01 ± 0.80^{b}	9.64 ± 1.53^{ab}
ADFI (g)	99.48 ± 1.06^{a}	106.45 ± 1.01^{b}	110.91 ± 0.35^{c}	112.76 ± 0.86^{c}
FCR	12.37 ± 3.47^{b}	11.23 ± 0.85^{a}	11.08 ± 1.25^{a}	11.69 ± 1.47^{a}
Mortality (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00

abc: Means with different letter superscripts on the same row are significantly different (p<0.05), ADWG = Average daily weight gain, ADFI = Average daily feed intake, FCR = Feed conversion ratio, g = grams, MMSP = Monodora myristica seed powder

Table 3: Effect of *Monodora myristica* feed additive on rabbit's carcass characteristics

Parameters	T_1 (0% MMSP)	T_2 (1% MMSP)	T_3 (2% MMSP)	T_4 (3% MMSP)
Live weight (g)	1740.75 ± 50.50^{a}	1776.00 ± 36.34^{ab}	2010.75 ± 21.83^{c}	1865.00 ± 34.44^{b}
Dressed weight (g)	1598.00 ± 47.78^{a}	1591.75 ± 37.36^{a}	1821.00 ± 35.31^{b}	1646.75 ± 30.92^{ab}
Dressing %	91.81 ± 1.06	89.65 ± 1.47	90.54 ± 0.85	88.36 ± 1.96
Foreleg (g)	143.75 ± 8.91^{a}	154.75 ± 4.57^{ab}	163.75 ± 4.21^{b}	156.50 ± 5.19^{ab}
Hindleg (g)	242.25 ± 2.95^{a}	251.50 ± 3.43^{b}	264.75 ± 2.48^{bc}	270.00 ± 2.56^{c}
Loin (g)	229.25 ± 1.89^{a}	246.00 ± 10.43^{a}	283.75 ± 3.24^{b}	289.00 ± 5.01^{b}
Head (g)	126.75 ± 3.47^{a}	129.75 ± 0.85^{ab}	132.00 ± 1.25^{ab}	134.75 ± 1.47^{b}
Neck (g)	50.50 ± 0.65^{a}	60.00 ± 1.08^{b}	56.75 ± 3.52^{ab}	52.50 ± 2.87^{ab}
Liver (g)	36.00 ± 0.41	35.75 ± 0.48	36.25 ± 0.48	35.75 ± 0.48
Kidney (g)	11.25 ± 0.48	10.75 ± 0.48	11.00 ± 0.48	11.25 ± 0.41
Heart (g)	3.75 ± 0.48	4.25 ± 0.48	4.00 ± 0.71	4.00 ± 0.41

abc: Means with different letter superscripts on the same row are significantly different (p<0.05), MMSP = Monodora myristica seed powder

Table 4: Effect of *Monodora myristica* feed additive on rabbit's serum lipid profile

Parameters	T_1 (0% MMSP)	T_2 (1% MMSP)	T_3 (2% MMSP)	T_4 (3% MMSP)
Cholesterol	133.65 ± 0.97^{d}	126.56 ± 1.07^{c}	105.54 ± 2.29^{b}	95.09 ± 1.90^{a}
HDL-C	53.70 ± 0.47^{a}	58.80 ± 1.45^{ab}	61.76 ± 0.93^{b}	60.58 ± 2.02^{b}
LDL-C	51.17 ± 2.39^{c}	37.35 ± 0.84^{b}	21.26 ± 0.86^{a}	16.23 ± 2.57^{a}
TG	63.10 ± 1.11^{c}	59.32 ± 1.03^{b}	55.77 ± 1.86^{ab}	55.35 ± 0.46^{a}
VLDL-C	13.01 ± 0.22^{b}	11.64 ± 0.22^{a}	11.72 ± 0.16^{a}	11.17 ± 0.34^{a}

abcd: Means with different letter superscripts on the same row are significantly different (p<0.05), HDL-C = High density lipoprotein cholesterol, LDL-C = Low density lipoprotein cholesterol, TG = Triglyceride, VLDL-D = Very low density lipoprotein cholesterol, MMSP = Monodora myristica seed powder

This reduction may be attributed to the antioxidant properties of *M. myristica,* which helps to reduce oxidative stress and inflammation in the body, which can contribute to high cholesterol levels. Myristicin, the active ingredient in this spice may be responsible in inhibiting the synthesis of cholesterol and other fats in the liver, thereby reducing LDL-C, VLDL-C and TG levels. Similarly, this active ingredient may also have been responsible for the improvement of insulin sensitivity which could have helped to reduce triglyceride levels and prevent the accumulation of fat in the liver. The findings of this study was in agreement with previous studies by Imasuen *et al*. (2022), Essien *et al*. (2022) and Ekpo and Okon (2023) on rabbit, broiler chickens and pigs respectively, fed different spices and herbs. HDL-C levels were observed to be on the increase across the treatments. This further emphasized and strengthened the findings of Okon *et al.* (2022) who reported an increase in HDL-C and a corresponding decrease in LDL-C, VLDL-C, and TG of weaner rabbits fed *M. myristica* and *Xylopia aethiopica.*

The result of protein, abdominal fat and muscle to bone ratio of rabbits fed *M. myristica* as additive showed that protein obtained in this study was within the normal range (20 – 25%) (Table 5) for normal rabbits as described by (Nistor *et al*., 2013).

Table 5: Effect of *Monodora myristica* feed additive on rabbit's abdominal fat, protein and muscle to bone ratio

Parameters	T_1 (0% MMSP)	T_2 (1% MMSP)	T_3 (2% MMSP)	T_4 (3% MMSP)
Protein (%)	21.35 ± 0.49^{a}	23.64 ± 0.54^{ab}	24.74 ± 0.41^{b}	24.12 ± 1.02^{b}
Abdominal fat (%)	11.79 ± 0.32^{c}	10.32 ± 0.24^{b}	8.04 ± 0.62^{ab}	7.93 ± 0.60^{a}
Muscle (%)	63.54 ± 1.14^{a}	66.76 ± 2.17^{a}	74.53 ± 2.01^{b}	78.30 ± 0.95^{b}
Bone (%)	27.87 ± 0.50^{a}	27.64 ± 0.43^{a}	29.80 ± 0.29^{b}	30.78 ± 0.43^{b}
Muscle/bone ratio	2.35 ± 0.07	2.42 ± 0.09	2.50 ± 0.09	2.54 ± 0.05

abc: Means with different letter superscripts on the same row are significantly different (p<0.05), MMSP = Monodora myristica seed powder

The increased protein may have been a result of the appetite stimulating attributes of the spice which may have added flavour and variety to the feed, making it more interesting for the rabbits to eat (Okon *et al*. 2022).

Result for abdominal fat revealed a decrease across treatment. This may be attributed to the active ingredient, myristicin, in the spice which helps to promote metabolic rate and increase fat burning. This finding was in agreement with the report of Abd El-Hack *et al*. (2019) who reported a reduction in lipid accumulation in the liver, improved glucose and lipid metabolism in rabbits fed black and red pepper oils as a natural growth promoter. Similarly, this report suggested that black and red pepper oils had anti-obesity effect in rabbits by increasing energy expenditure and lipid accumulation reduction in adipose tissues.

Muscle to bone ratio did not show significant difference (p>0.05) across the treatments. However, values obtained for muscle and bone, independently, showed significant increase (p<0.05). This increase in values may be attributed to the indirect influence of the test diet on the digestion and nutrient utilization of the rabbits. This culminated to an improvement in nutrient digestibility and absorption in the rabbits, which may have helped to optimize muscle growth and development. This finding was in agreement with the findings of Dalle Zotte *et al*. (2016) and Abdelsalam and Fathi (2023) who fed different dietary and herbal spices to rabbits. Additionally, *M. myristica* have antioxidant and anti-inflammatory effect which potentially improves meat quality by reducing oxidative stress and inflammation in the muscle tissue. The result was in agreement with the report of Eze-Steven *et al.* (2013).

Conclusion: The results of this study indicated that the supplementation of rabbit diets with *M. myristica* increased the weight gain and improved feed intake significantly. Likewise, the carcass composition and serum lipid profile of the rabbits were observed to improve. The study revealed that up to 2% of *M. myristica* can be included in the diets of rabbits without adverse effect on the performance, carcass composition and serum lipid profile. Hence, *M. myristica* is recommended as an excellent substitute to synthetic additive in rabbit diet.

ACKNOWLEDGEMENTS

The authors would like to extend their appreciation to the management and staff of the Department of Animal Science, Akwa Ibom State University for their invaluable support and provision of facilities for this research. The access provided to research facilities greatly contributed to the successful completion of this study.

REFERENCES

ABD EL-HACK, M. E., ALAGAWANY, M. and ABDELNOUR, S. (2019). Responses of growing rabbits to supplementing diet with a mixture of black and red pepper oils as a natural growth promoter. *Journal of Animal Physiology and Animal Nutrition*, 103(2): 509 – 517.

ABDELSALAM, M. and FATHI, M. (2023). Improving productivity in rabbits by using some natural feed additives under hot environmental conditions - a review. *Animal Bioscience*, 36(4): 540 – 554.

ADEPOJU, O. T. and OYEWOLE, E. O. (2008). Nutritional importance and micronutrients potential on non-conventional indigenous

green leafy vegetable from Nigeria. *Agricultural Journal,* 3(5): 362 – 365.

AGIRIGA, A. and SIWELA, M. (2017). *Monodora myristica* (Gaertn.) Dunal: a plant with multiple food, health and medicinal applications: a review. *American Journal of Food Technology,* 12(4): 271 – 284.

ANSORY, H. M., SARI, E. N., NILAWATI, A., HANDAYANI, S. and AZNAM, N. (2019). Sunscreen and antioxidant potential of myristicin in nutmeg essential oils (*Myristicin fragrans*). Pages 138 – 142. *In: Proceedings of the 2nd Bakti Tunas Husada-Health Science International Conference (BTH-HSIC 2019), Jawa Barat, Indonesia*. 5 – 6 October 2019, Atlantis Press, Paris, France.

AOAC (2003). *Official Methods of Analysis.* 17th Edition, Association of Official Analytical Chemists, Washington, DC., USA.

BLASCO, A. and OUHAYOUN, J. (1996). Harmonization of criteria and terminology in rabbit meat research. Revised proposal. *World Rabbit Science*, 4(2): 93 – 99.

BUCOLO, G. and DAVID, H. (1973). Quantitative determination of serum triglycerides by the use of enzymes. *Clinical Chemistry*, 19(5): 476 – 482.

CASEY, N. H. and WEBB, E. C. (2010). Managing goat production for meat quality. *Small Ruminant Research*, 89(2-3): 218 – 224.

CHRISTOPHER, G. I., IDIONG, C. I., EKPO, J. S., OKON, U. M. and UWEM, U. U. (2023). Growth performance and economics of feeding sole concentrate, sole forage, and their mixtures to weaner rabbits. *Nigerian Journal of Animal Science,* 49(5): 87 – 93.

DALLE ZOTTE, A., CELIA, C. and SZENDRŐ, Z. (2016). Herbs and spices inclusion as feedstuff or additive in growing rabbit diets and as additive in rabbit meat: A review. *Livestock Science*, 189: 82 – 90.

DUNCAN, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, 11: 1 – 42.

EKPO, J. S. and OKON, U. M. (2022). Performance and lipid profile of growing pigs fed *Vernonia amygdalina* and *Jathropha tanjorensis* leaf meal supplementation. *Livestock Research for Rural Development,* 34(12): 1 – 6.

EKPO, J. S. and OKON, U. M. (2023). Organoleptic quality, pork characterization and hematological indices of growing pigs fed supplemental diets containing bitter leaf and hospital too far. *AKSU Journal of Agriculture and Food Science,* 7(1): 9 – 20.

EKPO, J. S., SAM, I. M. and OKON, U. M. (2020). Performance, carcass and relative organ weights of young boars fed graded dietary levels of raw *Icacinia manni* (earth ball). *Journal of Agriculture, Resources and Development*, 19: 18 – 24.

ENABULELE, S. A., OBOH, F. O. and UWADIAE, E. O. (2014). Antimicrobial, nutritional and phytochemical properties of *Monodora myristica* seeds. *IOSR Journal of Pharmacy and Biological Sciences*, 9(4): 01 – 06.

ESSIEN, C. A., SAM, I. M., OKON, U. M. and NDAK, U. U. (2022). Effect of moringa (*Moringa oleifera*) leaf meal on the performance, carcass characteristics and lipid profile of finisher broiler chickens. *AKSU Journal of Agriculture and Food Science*, 6(3): 213 – 223.

EZE-STEVEN, P. E., ISHIWU, C. N., UDEDI, S. C. and OGENEH, B. O. (2013). Evaluation of antioxidant potential of *Monodora myristica* (African nutmeg). *International Journal of Current Microbiology and Applied Sciences*, 2(11): 373 – 383.

FRIEDEWALD, W. T., LEVY, R. I. and FREDRICKSON, D. S. (1972). Estimation of the on centration of low density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical Chemistry*, 18(6): 499 – 502.

GURU, E. M., OTU, B. O. and EGENA, S. S. A. (2022). Response of broiler chickens orally administered varying levels of undiluted ginger (*Zingiber officinale*) extract. Pages 1171 – 1175. *In: Proceedings of the 47th Annual Conference of Nigerian Society for Animal Production (NSAP),* 13th – 17th March, 2022.

HASSAN, I. I., ASKAR, A. A. and EL-SHOURBAGY, G. A. (2004). Influence of some medicinal plants on performance, physiological and meat quality traits of broiler chickens. *Egyptian Journal of Poultry Science*, 24: 247 – 266.

IMASUEN, J. A., OBATTA, L. O., IMHANKON, F. O. and ATANDA, A. O. (2022). Haematological and lipid profile of rabbits fed ginger and turmeric additives to correct crude oil induced antioxidant challenges. *Nigerian Journal of Animal Production*, 49(2): 101 – 111.

ISLAM, M. S., SIDDIQUI, M. N., SAYED, M. A., TAHJIB-UL-ARIF, M., ISLAM, M. A. and HOSSAIN, M. A. (2016). Dietary effects of buckwheat (*Fagopyrum esculentum*) and black cumin (*Nigella sativa*) seed on growth performance, serum lipid profile and intestinal microflora of broiler chicks. *South African Journal of Animal Science*, 46(1): 103 – 111.

JAISWAL, P., KUMAR, P., SINGH, V. K. and SINGH, D. K. (2009). Biological effects of *Myristica fragrans*. *Annual Review of Biomedical Sciences*, 11: 21 – 29.

KUMAR, F., TYAGI, P. K., MIR, N. A., BISWAS, A. K., DEV, K., TYAGI, P. K., MANDAL, A. B., BHANJA, S. K. and SAHU, B. (2018). Optimizing of time duration of flaxseed meal feeding for optimum growth performance, carcass characteristics, and cost economics of broiler chicken meat production. *Indian Journal of Poultry Science*, 53(1): 44 – 48.

MACIEL, M. V., CARVALIHO, F. F. R., BASTISTA, A. M. V., GUIM, A., SOUZA, E. J. O., MARCIEL, L. P. A. A., PEREIRA-NETO, J. D. and LIMA-JUNIOR, D. M. (2015). Carcass and non-carcass characteristics of sheep fed on cassava. *Chilean Journal of Agricultural Research,* 75(3): 307 – 312.

NISTOR, E., BAMPIDIS, V. A., PĂCALĂ, N., PENTEA, M., TOZER, J. and PRUNDEANU, H. (2013). Nutrient content of rabbit meat as compared to chicken, beef and pork meat. *Journal of Animal Production Advances*, 3(4): 172 – 176.

NRC (1997). *Nutrient Requirements of Rabbits*. National Academy of Science, National Research Council (NRC), Washington, DC, USA.

NUAMAH, E., TEYE, M., ODIO, F. N. A. and TEYE, P. K. (2019). Growth performance and carcass characteristics of cross-bred rabbits fed diets containing palm kernel oil residue. *African Journal of Agricultural Research,* 14(33): 1764 – 1771.

OKO, O. O. K. and ETUKUDO, N. M. (2011). Effects of single leafy spices on growth and carcass characteristics of broilers. *Nigerian Journal of Animal Science*, 13: 114 – 123.

OKON, U. M., EKPO, J. S., ESSIEN, C. A. and EYOH G. D. (2022). Influence of *Monodora myristica* and *Xylopia aethiopica* seed as feed additives on the performance of New Zealand weaned rabbits. *Nigerian Journal of Animal Science and Technology*, 5(1): 76 – 83.

ONUNKWO, D. N. and UKOHA, O. A. (2017). Effect of African nutmeg (*Monodora myristica*) spice in aflatoxin-infected diets on growth performance of broilers. *Nigerian Journal of Animal Production*, 44(2): 179 – 186.

ONUNKWOR, D. N., UDOKWU, I. U., EKUNDAYO, E. O., EZENYILIMBA, B. N., OMUMUABUIKE, J. N. and EZEOKE, F. C. (2022). Serum biochemical assay of broiler chickens administered water containing various medicinal plant leaf methanol extract. *Nigerian Journal of Animal Production*, 49(2): 95 – 100.

ONYENIBE, N. S., FOWOKEMI, K. T. and EMMANUEL, O. B. (2015). African nutmeg (*Monodora myristica*) lowers cholesterol and modulates lipid peroxidation in experimentally induced hypercholesterolemic male Wistar rats. *International Journal of Biomedical Science: IJBS*, 11(2): 86 – 92.

PARA, P. A., GANGULY, S., WAKCHAURE, R., SHARMA, R., MAHAJAN, T. and PRAVEEN, P. K. (2015). Rabbit meat has the potential of being a possible alternative to other meats as a protein

source: a brief review. *International Journal of Pharmacy and Biomedical Research*, 2(5): 17 – 19.

PASCUAL, M. and GÓMEZ, E. A. (2020). Profitability in rabbit breeding. *In*: ARGENTE, M. J., PARDO, M. L. G. and DALTON, K. (Eds.). *Lagomorpha Characteristics*. IntechOpen, London. https://dx.doi.org/10.5772/intechopen.93260

PMFME (2023). *Reading Manual for Nutmeg Processing Under PMFME Scheme*. National Institute of Food Technology Entrepreneurship and Management, Ministry of Food Processing Industries, HSIIDC, Industrial Estate, Kundli, Sonipat, Haryana-131028. https://niftem.ac.in/site/pmfme/lmnew/nutmegwriteup.pdf Accessed February 10, 2023.

SAEID, J. M., MOHAMED, A. B. and AL-BADDY, M. A. (2010). Effect of aqueous extract of ginger (*Zingiber officinale*) on blood biochemistry parameters of broiler. *International Journal of Poultry Science*, 9(10): 944 – 947.

SAM, I. M., RUFUS, E. M., EKPO, J. S. and EYOH, G. D. (2019). Influence of sex on accuracy of estimating carcass traits of broilers from non-invasive body measurements. *AKSU Journal of Agriculture and Food Sciences,* 3(2): 90 – 96.

SEIGLER, L. and WU, W. T. (1981). Separation of serum high-density lipoprotein for cholesterol determination: ultracentrifugation vs precipitation with sodium phosphotungstate and magnesium chloride. *Clinical Chemistry*, 27(6): 838 – 841.

SIDHU, N. S., SINGH, U. and SETHI, A. P. S. (2018). Effects of black pepper, jaggery supplementation and feed restriction on carcass traits and haemato-biochemical profile of broilers. *Indian Journal of Poultry Science,* 53(1): 54 – 59.

STEEL, R. G. D. and TORRIE, J. H. (1980). *Principles and Procedures of Statistics. A Biometrical Approach*. 2nd Edition, McGraw-Hill Publications, New York, USA.

UKOHA, O. A. and ONUNKWO, D. N. (2017). Effects of African nutmeg (*Monodora myristica*) spice in aflatoxin-infected diets on growth performance of Japanese quails (*Cortunix cortunix*). *Nigerian Journal of Animal Production*, 44(1): 290 – 295.

VANGOORI, Y., DAKSHINAMOORTHI, A. and KAVIMANI, S. (2019). Effect of *Myristica fragrans* extract on lipid profile, glucose, body weight, food intake, liver and renal functions in experimental obese rats. *Biomedical and Pharmacology Journal*, 12(2): 677 – 682.

WIKIPEDIA (2022). *Akwa Ibom State*. https://en.wikipedia.org/wiki/AkwaIbomState Accessed July 23, 2022.

WYBENGA, D. R., PILEGGI, P. H., DIRSTINE, J. and GIORGIO, J. D. (1970). Direct manual determination of serum total cholesterol with a single stable reagent. *Clinical Chemistry*, 16(12): 980 – 984.