International Journal of Global Affairs , Research and Development (IJGARD) Vol.3, No.2, 2025,368-381
ISSN 2992-2488

PHYSIOLOGICAL RESPONSE AND SEMEN QUALITY OF RABBIT BUCKS FED GRADED LEVELS OF Moringa (*Moringa oleifera*) LEAF MEAL

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ABSTRACT

This study investigated the physiological responses and semen quality of rabbit bucks fed graded levels of Moringa oleifera leaf meal (MOLM). Thirty (30) sexually mature rabbit bucks aged 5–7 months were randomly assigned to five dietary treatments containing 0.00, 0.50, 1.00, 1.50, and 2.00% MOLM in a Completely Randomized Design with three replicates per treatment. Data were collected on rectal temperature, respiratory and pulse rates, and semen characteristics.Results revealed that rectal temperature (39.14–40.03°C) was not significantly affected (P>0.05) by dietary treatments, indicating absence of heat stress. However, respiratory rate (75.91–77.50 breaths/min) and pulse rate (209.80–251.03 beats/min) increased significantly (P<0.05) with rising MOLM inclusion, suggesting enhanced metabolic activity. Semen quality indices improved notably with MOLM supplementation. Normal sperm morphology increased from 44.00% in the control to 53.00% at 2.00% inclusion, while abnormal sperm declined from 56.00% to 47.00%. Actively motile sperm rose from 39.00% to 49.00%, and live sperm cells increased from 66.00% to 80.00% at 0.50% inclusion. The highest semen concentration (25.30 × 10^9/ml) occurred at 1.00% MOLM, whereas semen volume (0.15–0.25 ml) and colour were unaffected (P>0.05).These improvements are attributed to the antioxidant and bioactive compounds in Moringaoleifera, which enhance sperm viability and testicular function. In conclusion, inclusion of Moringaoleifera leaf meal up to 2.00% supports normal physiological function and significantly enhances semen quality in rabbit bucks, with optimal reproductive benefits at 0.50–1.00% inclusion levels.

Keywords: *Moringa oleifera*, Rabbit Bucks, Physiological Response, Semen Quality, Phytogenic Feed Additive

1.0 INTRODUCTION

Rabbit consumption has gained increasing recognition in Nigeria as an important source of affordable, high-quality animal protein, particularly in light of the country’s growing population and rising nutritional demands (Samuel *et al*., 2018). Rabbit meat is highly valued for its rich nutritional profile, which includes essential protein, iron, and B vitamins, along with low fat content. This makes it a healthier alternative to more traditional meats, such as beef and chicken (Mohammed *et al*., 2018). Additionally, rabbits are efficient at converting feed into meat, requiring minimal space and resources for production. These characteristics make rabbit farming a viable option for small-scale farmers, particularly in rural areas, offering opportunities for food security and income generation (Dyavolova*et al*., 2013).

However, despite its potential, the rabbit farming sector in Nigeria faces several obstacles, particularly related to genetic limitations and disease outbreaks, which can severely impact production (El-Harairy*et al*., 2016). Diseases such as viral hemorrhagic disease (VHD), myxomatosis, and coccidiosis pose significant threats to rabbit populations, leading to high mortality rates and substantial financial losses for farmers (Mohammed *et al*., 2018). The use of veterinary drugs to manage rabbit health, while effective, presents several risks when improperly managed (Prabsttroo*et al*., 2015). Overuse of antibiotics and other medications can contribute to antibiotic resistance, making these drugs ineffective for both animals and humans (Ewuola*et al*., 2012). Additionally, drug residues may remain in rabbit meat, posing health risks to consumers if the proper withdrawal period before slaughter is not observed (Mohammadi*et al*., 2013).

In response to these challenges, there has been growing interest in the use of phytogenics—plant-based additives such as herbs, spices, and essential oils—as natural alternatives to antibiotics in rabbit farming (Priyadarshani*et al*., 2014). Phytogenics possess antimicrobial, antioxidant, and anti-inflammatory properties, which can enhance rabbit health by boosting immune function, improving digestion, and promoting growth. Supplementing rabbit diets with phytogenics like garlic, Moringa, oregano, and turmeric has been shown to reduce intestinal infections, improve digestion, and enhance growth rates (Shinkut*et al*., 2016).

Moringaoleifera, commonly known as the "drumstick tree," has emerged as a promising phytogenic feed additive for rabbits, offering a natural alternative to antibiotics (Salah *et al*., 2014). Its antimicrobial properties help maintain a healthy gut microbiota, promoting better digestion, improve physiological function and promote reproductive health (Onu and Aja, 2011).

This study aims to investigate the physiological response of rabbit bucks fed graded levels of Moringaoleifera leaf meal, focusing environmental physiology and semen quality.

- To evaluate the proximate composition of experimental diets for rabbits produced with varied inclusion level of *Moringaoleifera* leaf meal
- To determine the physiological response of rabbits fed graded levels of *Moringaoliefera* leaf meal.

- To determine the influence of graded levels of *Moringaoleifera* leaf meal on the semen quality of rabbit bucks.

2.0 MATERIALS AND METHODS

2.1 Experimental Location

This study was carried out at the Rabbit Unit of the Teaching and Research Farm of the Department of Animal Production, Prince AbubakarAudu University, AnyigbaKogi State, Nigeria.

2.2 Test Ingredient

Moringaoleifera leaves used for this study were harvested from mature *Moringa* trees at the Teaching and Research Farm of Prince AbubakarAudu University, Anyigba. The harvested *Moringaoleifera* leaves were washed with clean water, sliced, and dried under shade until crispy. They were then ground using an attrition mill, sieved through a 0.50 µm sieve, and bagged for use in the compounding of feed for the rabbits.

2.3 Experimental Animals, Design, and Management

Thirty growing rabbits between the ages of five (5) to seven (7) months were purchased from a reputable rabbit breeder and used for the study. They were allotted based on similar weight into five treatments (T1, T2, T3, T4, and T5) with three replicates each, such that there were two rabbits per replicate, in a Completely Randomized Design. T1, T2, T3, T4, and T5 contained 0, 0.50, 1.00, 1.50, and 2.00% of *Moringaoleifera* leaf meal respectively. The rabbits were housed in rabbit hutches. Feed and water were supplied *ad libitum*.

2.4 Experimental Animal Management

The rabbits were housed in hutches constructed with galvanized wire, with dimensions of 40 × 50 × 35 cm, and were provided with feeders and a watering system in a well-ventilated building. They were kept under uniform managerial, hygienic, and environmental conditions (Shanoon, 2011). Feed and water were available at all times *ad libitum* during the experimental period. The respective diets were formulated to meet the nutrient requirements of 16.00–18.00% crude protein, 11.00–14.00% crude fiber, 3.00–4.00% ether extract, and 2800–3100 kcal/kg energy. The diets were supplemented with all required vitamins and minerals, as recommended by Mohamad-Radzi*et al*. (2021). Clean, fresh water was available to the rabbits at all times. Waste that dropped from the cages to the floor through the net mesh was collected and removed daily.

Table 1: Gross Composition of Experimental Diet

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	28.00	27.50	27.00	26.50	26.00
Cassava peel meal	13.00	13.00	13.00	13.00	13.00
Moringaoliefera leaf meal	0.00	0.50	1.00	1.50	2.00
FFSB	22.00	22.00	22.00	22.00	22.00
Maize offal	33.50	33.50	33.50	33.50	33.50
Bone Meal	2.50	2.50	2.50	2.50	2.50
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25

2.5 Data collection

2,5,1 Semen Collection

The bucks were trained for semen collection using an artificial vagina for a period of two weeks prior to the actual semen collection. Semen was collected fortnightly between 8:00 and 10:00 am using an artificial vagina and a teaser non-pregnant mature rabbit doe. Immediately after collection, the semen was taken to the laboratory for analysis of pH, semen volume, semen colour, gross motility, sperm concentration, percentage of live sperm, and sperm abnormalities.

2.5.2 pH Evaluation:

The pH of each semen sample was measured to assess its acidity or alkalinity. A calibrated pH meter was used, and the semen sample was gently mixed for uniformity before immersing the electrode of the meter. The pH reading was recorded.

2.5.3 Semen Volume:

The total volume of each semen sample was measured using a sterile graduated cylinder. The semen was transferred into the container after collection, and the volume was recorded.

2.5.4 Semen Colour:

The colour of each semen sample was visually assessed. It was observed immediately after collection and compared with a standard colour chart to detect any abnormalities.

2.5.5 Gross Motility:

Semen motility was assessed by evaluating the percentage of sperm exhibiting active movement. A drop of semen was placed on a warm microscope slide, covered with a coverslip, and examined under 200x magnification. Sperm motility was graded as:

- Grade A: Excellent (% number sperm with rapid and linear movement)
- Grade B: Good (% number sperm with moderate and progressive movement)
- Grade C: Slow (% number sperm with sluggish movement)
- Grade D: Non-motile (% number sperm with no movement)

  The percentage of sperm in each grade was calculated and recorded.

2.5.6 Sperm Concentration:

Sperm concentration was determined by counting the number of sperm cells in a known volume of diluted semen, using an automated sperm counter for precision. The semen sample was diluted with saline, and concentration was calculated by multiplying the sperm count by the dilution factor and the volume.

2.5.7 Percentage Live Sperm:

Live sperm percentage was assessed using trypan blue staining. Live sperm remained unstained while dead sperm absorbed the dye. A stained smear was prepared and air-dried, then examined under 400x magnification. The percentage of live sperm was calculated by dividing the number of live sperm by the total number counted and multiplying by 100.

2.5.8 Sperm Abnormalities:

Sperm morphology was assessed by preparing a smear stained with Wright's stain and examining it under 1000x magnification with oil immersion. Two hundred sperm cells were observed per sample, and abnormalities were categorized as head, midpiece, or tail defects. The percentage of abnormal sperm was calculated and recorded.

2.6 Physiological Response

The physiological responses of the rabbits fed *Moringaoleifera* leaf were evaluated as follows:

a) **Rectal Temperature:**

A clinical thermometer was used to measure rectal temperature by inserting it into the rabbit's rectum for one minute, timed with a stopwatch.

b) **Respiratory Rate:**

Measured at 6:00 am by counting flank movements for one minute using a stopwatch.

c) **Pulse Rate (beats/min):**

A stethoscope was placed under the forelimb of the rabbit, and the pulse was counted for one minute.

2.7 Statistical analysis

All the data that were obtained from the study were subjected to one-way analysis of variance (ANOVA) using SPSS (version 20). Where there are significant means, they will be separated using Duncan Multiple Range Test (DMRT).

3.0 RESULTS AND DISCUSSION

3.1 The proximate composition of experimental diets containing varied inclusion levels of *Moringaoleifera* leaf meal

The proximate composition of experimental diets containing varied inclusion levels of *Moringaoleifera* leaf meal is presented in Table 1. The results indicate slight variations in nutrient composition across the different dietary treatments, with no drastic shifts in overall nutritional balance.

Dry matter content ranged from 88.81% in the 1.50% inclusion diet to 92.51% in the 2.00% *Moringaoleifera* inclusion group, suggesting slightly higher moisture retention in lower inclusion diets. Crude protein levels increased marginally from 17.54% in the control group (0%) to 17.91% in the 2.00% inclusion, indicating that *Moringaoleifera* contributed positively to dietary protein content.

Crude fibre also showed a gradual increase with higher inclusion levels, ranging from 14.83% in the control group to 15.19% at 2.00%, reflecting the fibrous nature of *Moringa* leaves. Ether extract (fat content) decreased slightly from 3.42% in the control group to 3.25% at the highest inclusion level.

Ash content, which indicates total mineral composition, ranged from 4.42% in the control diet to 4.21% at 2.00% inclusion, with a slight downward trend. Nitrogen Free Extract (NFE), calculated by difference, varied across the diets, with the highest value recorded at 2.00% inclusion (51.95%) and the lowest at 1.50% (48.42%), reflecting shifts in non-fiber carbohydrate content.

Table 2: Proximate composition of experimental diets containing varied inclusion of *Moringaoleifera* leaf meal

Parameter (%)	0.00%	0.50%	1.00%	1.50%	2.00%
Dry Matter	90.58	90.00	89.17	88.81	92.51
Crude Protein	17.54	17.60	17.70	17.73	17.91
Crude fibre	14.83	14.90	15.03	15.11	15.19
Ether extract	3.42	3.37	3.34	3.30	3.25
Ash	4.42	4.35	4.33	4.25	4.21
Nitrogen Free Extract	50.37	49.78	48.77	48.42	51.95

3.2 Physiological response of rabbits fed varying dietary levels of *Moringaoleifera*

The physiological responses of rabbits fed diets containing different inclusion levels of *Moringaoleifera* leaf meal are presented in Table 3. Rectal temperature was not significantly affected (P>0.05) by the dietary treatments. Values ranged from 39.14°C in the control group to 39.55°C at 1.50% inclusion, indicating only minor fluctuations across treatments.

In contrast, respiratory rate showed a significant response (P<0.05) to increasing *Moringaoleifera* levels. The lowest rate was recorded in the control group (75.91 breaths/min), while the highest was observed at 2.00% inclusion (77.50 breaths/min). Rabbits fed 1.00% and 1.50% also showed elevated respiratory rates (76.80 and 77.10 breaths/min, respectively), which were significantly higher than the control.

Similarly, pulse rate was significantly influenced (P<0.05) by the dietary inclusion of *Moringaoleifera*. Pulse rates increased progressively from 209.80 beats/min in the control group to a peak of 251.03 beats/min at 2.00% inclusion.

The rectal temperature of rabbits across all dietary treatments remained within a narrow range of 39.14°C to 39.55°C which was however, not significant different (P>0.05). These results are consistent with findings by Ahemen*et al*. (2013), who reported that dietary fiber sources generally do not disrupt thermoregulation in rabbits. Furthermore, the observed temperatures fall within the established normal physiological range for rabbits (37.0°C to 42.0°C) as reported by El-Desoky*et al*. (2017), indicating that inclusion of *Moringaoleifera* leaf meal, even at higher levels, does not exert thermal stress or interfere with homeostatic temperature control.

In contrast, respiratory rate showed a significant increase (P<0.05) with increasing dietary levels of *Moringaoleifera*. The control group recorded the lowest respiratory rate of 75.91 breaths/min, while higher inclusion levels, particularly at 2.00% had 77.50 breaths/min and 1.50% having 77.10 breaths/min, resulted in elevated rates. This increase may reflect a metabolic adjustment prompted by the bioactive and fibrous components of *Moringaoleifera*. As noted by Adeniji*et al*. (2014) and Gidenne (2000), diets rich in fiber can stimulate digestive activity and metabolic turnover, potentially increasing respiratory demand as part of the body's physiological adaptation.

Similarly, pulse rate was significantly affected (P<0.05) by the dietary treatments. A progressive increase in pulse rate was observed from the control group having 209.80 beats/min up to the 2.00% inclusion level (251.03 beats/min), suggesting a dose-dependent cardiovascular response likely tied to increased metabolic activity. Gidenne and Perez (2000) explained that shifts in digestion or nutrient utilization due to dietary fiber and bioactive compounds often lead to elevated heart rates. This trend is further supported by Omole and Ajayi (2006), who reported similar cardiovascular responses in rabbits fed phytogenic diets.

Table 3: Effect of varied inclusion levels of *Moringaoleifer* on the physiology of rabbits

Parameters	0.00%	0.50%	1.00%	1.50%	2.00%	SEM	LOS
Rectal Temperature (^{0}C)	39.14	39.23	39.24	39.55	40.03	0.69	NS
Respiratory Rate (b/min)	75.91^b	76.32^a	76.80^a	77.10^a	77.50^a	0.52	*
Pulse rate (b/min)	209.80^c	218.12^{bc}	231.06^b	243.12^{ab}	251.03^a	6.82	*

a,b = Means on the same row with different superscripts differ significantly (P<0.05).
SEM = Standard error of the Means. LOS = Level of Significance

3.3 Semen Quality of Rabbits Fed Diets Containing Varied Inclusion Levels of *Moringaoleifera* Leaf Meal

The impact of varying dietary inclusion levels of *Moringaoleifera* leaf meal on semen quality parameters of rabbits is summarized in Table 4. Significant differences (P<0.05) were observed among treatment groups for all semen quality traits, except for semen volume, which remained statistically unaffected (P>0.05).

Rabbits in the control group (0.00% inclusion) recorded the lowest proportion of normal sperm morphology (44.00%), while those fed the highest inclusion level (2.00%) showed a significant increase to 53.00%. Correspondingly, abnormal sperm morphology declined significantly from 56.00% in the control to 47.00% at 2.00% inclusion, suggesting an improvement in sperm structure with increased levels of *Moringa*.

Sperm motility was also enhanced by *Moringa* supplementation. The proportion of actively motile sperm rose significantly from 39.00% in the control to 49.00% in the 2.00% group, while sluggishly motile sperm decreased markedly from 40.00% in the 0.50% inclusion group to 21.00% at the 2.00% level. Dead sperm cells were highest in the control (34.00%) and significantly reduced to 20.00% at 0.50% inclusion. In contrast, the percentage of live sperm cells increased significantly from 66.00% in the control to a peak of 80.00% at 0.50%, with values remaining consistently higher in all supplemented groups compared to the control.

Although semen volume ranged between 0.15 and 0.25 ml across treatments, no significant differences (P>0.05) were detected. However, semen concentration showed significant variation (P<0.05), with the highest value recorded at 1.00% inclusion level (25.30×10^9/ml), indicating optimal spermatogenic response at this level.

The increase in normal sperm morphology and the corresponding decrease in abnormal forms observed in this study are consistent with the findings of Mohammed *et al*. (2018), who reported improved semen quality in rabbit bucks fed MOLM-based diets supplemented with natural additives. Similar improvements in sperm structure have been attributed to the antioxidant properties of *Moringaoleifera*, which protect developing germ cells from oxidative damage (Abu *et al*., 2013; Ewuola*et al*., 2019). The positive changes in morphology reflect enhanced spermatogenesis and testicular health, which have also been confirmed by Adeyemi*et al*. (2014) in their study on semen characteristics of rabbits fed MOLM.

Actively motile sperm significantly increased, while sluggishly motile sperm decreased with higher MOLM inclusion, indicating enhanced sperm vigor and energy metabolism. Ewuola*et al*. (2019) similarly reported that MOLM improved sperm motility and overall reproductive efficiency in rabbit bucks under heat stress. Alemede*et al*. (2014) also observed a dose-dependent improvement of 12.10% in semen traits of rabbits fed *Moringa* leaf meal.

Live sperm cells increased notably, especially at lower inclusion levels (0.50–1.00%), while dead sperm cell counts declined, suggesting enhanced sperm viability. These observations are in line with Abu *et al*. (2013), who found that graded levels of MOLM significantly reduced dead sperm cells and increased the proportion of live sperm. Odeyinka*et al*. (2008) likewise confirmed improvements in reproductive performance in rabbits with live sperm increasing from 44.03 to 71.00% when they were fed *Moringa* as a replacement for traditional forages.

The peak semen concentration observed at 1.00% MOLM inclusion supports earlier work by Adeyemi*et al*. (2014), who reported improved spermatogenic activity and testosterone levels in rabbits supplemented with MOLM. This suggests that moderate dietary inclusion enhances testicular function and sperm output, possibly through improved nutrient bioavailability and hormonal balance (Adeyemi*et al*. 2014).

Despite these improvements in semen quality, no significant difference was observed in semen volume across all treatment groups. This agrees with findings by Mohammed *et al*. (2018) and Ewuola*et al*. (2015), who also reported that MOLM supplementation did not affect semen volume, as rabbits were observed to have similar ejaculate volume. The stability in volume indicates that MOLM does not disrupt the function of accessory sex glands responsible for seminal fluid production (Khalifa*et al*., 2016).

While the benefits of MOLM are clear at low to moderate inclusion levels, Ajuogu*et al*. (2019) noted that excessive supplementation may lead to diminished returns or even negative effects due to potential anti-nutritional compounds, a pattern that may explain the non-linear responses observed in certain parameters like semen concentration.Odeyinka*et al*. (2008) reported no significant differences in semen concentration when rabbits were fed *Centrosemapubescens.* Ewuola*et al*. (2019) reported value range of 22.00 to 31.41 x 10^9/m when rabbits were fed diets containing *Moringaoleifera* leaf meal.

Table 4: semen quality of rabbits fed diets containing varied inclusion level *Moringaoleifera* leaf meal

Parameter	0.00%	0.50%	1.00%	1.50%	2.00%	SEM	LOS
Colour	Creamy-white	Creamy-white	Creamy-white	Creamy-white	Creamy-white		
Normal morphology (%)	44.00^d	45.00^d	48.00^c	51.00^b	53.00^a	0.94	*
Abnormal morphology (%)	56.00^a	55.00^a	52.00^b	49.00^c	47.00^c	1.37	*
Actively motile (%)	39.00^d	40.00^c	45.00^b	48.00^a	49.00^a	1.16	*
Sluggishly motile (%)	27.00^a	40.00^b	23.00^c	22.00^c	21.00^c	1.90	*
Dead cells (%)	34.00^a	20.00^c	32.00^b	30.00^b	30.00^b	1.49	*
Live sperm cell	66.00^d	80.00^a	68.00^c	70.00^b	70.00^b	2.05	*
Semen Volume	0.19	0.25	0.15	0.15	0.25	0.09	**NS**
Semen concentration (x 10^9/m)	16.02^b	15.11^b	25.30^a	15.00^b	16.00^b	2.01	*

a,b = Means on the same row with different superscripts differ significantly (P<0.05).
SEM = Standard error of the Means. LOS = Level of Significance

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

Based on the observed results in this study, the following conclusions are drawn:

- Physiological parameters such as rectal temperature remained unaffected across treatments, indicating that MOLM did not induce thermal stress. However, significant increases in respiratory and pulse rates suggest heightened metabolic activity and cardiovascular responses as dietary MOLM levels increased.
- In terms of reproductive performance, MOLM significantly enhanced semen quality. Normal sperm morphology, sperm motility, live sperm percentage, and semen concentration improved notably, especially at inclusion levels between 0.50% and 1.00%. These improvements are likely due to the antioxidant and bioactive compounds in Moringa, which promote testicular function and protect against oxidative damage.
- Although semen volume remained statistically unchanged across treatments, the quality-related parameters consistently improved, demonstrating the positive effect of MOLM on reproductive health.

4.2 Recommendation

It is therefore recommended that *Moringaoleifera* leaf meal (MOLM) be included in rabbit diets at up to 2.00%**,** as this level significantly enhances growth performance, blood parameters, carcass yield, and semen quality without adversely affecting physiological parameters or organ development, making it a safe and effective natural supplement for improving rabbit productivity.

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