J I T A A
Journal of the Indonesian Tropical Animal Agriculture
Accredited by Ditjen Riset, Teknologi dan Pengabdian
kepada Masyarakat No. 164/E/KPT/2021

J. Indonesian Trop. Anim. Agric.
pISSN 2087-8273 eISSN 2460-6278
http://ejournal.undip.ac.id/index.php/jitaa
51(2): 106-113, June 2026
DOI: 10.14710/jitaa.51.2. 106-113

Phytogenic modulation of reproduction in rabbit does using *Gmelina arborea* leaf extract under tropical conditions

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Received January 27, 2026; Accepted April 29, 2026

ABSTRACT

The present study evaluated the effects of aqueous *Gmelina arborea* leaf extract (GALE) on reproductive, postpartum and lactation performances of rabbit does under tropical conditions. A total of 80 chinchilla rabbits (aged 7–8 months with average body weight of 1.10–1.14 kg) were used in the 16-week study. The study was laid out in a completely randomized design (CRD) with rabbits randomly assigned to four dietary treatments (GALE0 = 0 ml GALE /l of water, GALE 300= 300 ml GALE /l of water, GALE 600 = 600 ml GALE /l of water, and GALE 900= 900 ml GALE /l of water), replicated four times with five rabbits per replicate. Results revealed that GALE significantly ($P < 0.01$) influenced reproductive, postpartum, and lactation parameters. Does administered GALE 600 recorded the highest conception rate (95%), kit survival to weaning (84.4%) and lowest pre-weaning mortality (15.6%). GALE 900 inclusion reduced feed and water intake and depressed litter survival. Postpartum body weights, feed and water intake were improved at GALE 600 with reduced lactation weight loss (90.60 g). Similarly, kits from GALE 600 exhibited the highest birth and weaning weights and greatest pre-weaning daily gain (11.26 g/kit/day). In conclusion, GALE 600 optimized reproduction in rabbit does under tropical conditions.

Keywords Antioxidant, Fertility, Lactation, Phytochemicals, Tropical environment

INTRODUCTION

The rising demand for animal protein in tropical developing countries such as Nigeria continues to outpace supply, creating a nutritional gap that calls for innovative and sustainable livestock production systems. Rabbit production has become increasingly attractive due to its short generation interval, rapid growth rate, high prolificacy, and ability to efficiently convert forages and agricultural by-products into high-quality meat rich in protein but low in fat and cholesterol (Jimoh *et al*., 2023). Beyond its nutritional value, rabbit farming offers socio-economic benefits to smallholder farmers because of its low input requirement and adaptability to diverse environments.

Despite these advantages, reproductive inefficiencies remain a major constraint to optimal rabbit production, particularly under tropical conditions where heat stress, oxidative imbalance, nutritional deficiencies, and infectious diseases compromise fertility, gestation, and lactational performance (Gonzalez-Rivas *et al*., 2020; Roychoudhury *et al*., 2021). Traditionally, antibiotics and synthetic hormones have been used to mitigate these challenges, enhance reproduction, and control infections. However, the global restrictions on antibiotic use due to rising antimicrobial resistance and drug residues in meat has necessitated the search for safer, eco-friendly, and cost-effective alternatives (Sapsuha *et al*., 2021). Plant-derived extracts rich in bioactive compounds have recently gained prominence as natural modulators of animal health and productivity. These plant-based substances contain phytochemicals such as flavonoids, saponins, tannins, phenols, and alkaloids, which exhibit antimicrobial, antioxidant, anti-inflammatory, and hormone-regulating properties capable of improving reproductive and metabolic functions in animals (Abarikwu *et al*., 2020; George and Liske, 2021). Plant extracts have been shown to enhance feed efficiency, fertility, and immune status while supporting intestinal health and mitigating oxidative stress, making them promising alternatives to conventional antibiotics in sustainable animal production (Dixit *et al*., 2024; Wang *et al.,* 2024).

Gmelina arborea from the family Verbenaceae is a fast-growing tropical tree widely distributed across West Africa and used in traditional medicine for its rich phytochemical content and pharmacological properties. Its leaves, bark, and fruits contain potent bioactive compounds including flavonoids, phenols, saponins, and tannins that exhibit antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory activities (Iswarya *et al*., 2017). The high crude protein and mineral content of the plant suggest it could provide additional nutritional and reproductive benefits when incorporated into livestock diets (Pius *et al.,* 2019; Abdullahi *et al*., 2020). Recent reports have demonstrated that *Gmelina arborea* leaf meal can improve nutrient digestibility and growth performance in rabbits (Jiwuba *et al*., 2016; Obinna *et al*., 2024), while its extract has been linked to enhanced hormonal and reproductive responses in small livestock species (Pius *et al*., 2019; Adetunji *et al*., 2025).

Despite its abundance and wide use in traditional medicine, scientific information on the reproductive response of rabbit does administered *Gmelina arborea* leaf extract (GALE) under tropical conditions remains limited. Given the increasing need to identify effective phytogenic alternatives to synthetic reproductive enhancers and antibiotics, evaluating the influence of GALE on rabbit reproduction is both timely and relevant. Therefore, this study was designed to investigate the effects of *Gmelina arborea* leaf extract on the reproductive, postpartum and lactational performance of rabbit does under tropical environmental conditions.

MATERIALS AND METHODS

Ethical Consideration

This study was designed to conform with ethical guidelines for humane handling and use of animals in research. Prior to commencing the study, approval was obtained from The Institutional Animal Care and Use Committee (IACUC) of the University of Nigeria (Approval ID: UNN/CO.67ANS14.7.06.2021).

Experimental Site and Duration

The experiment was carried out at the Rabbit Farm of the Department of Animal Science, University of Nigeria, Nsukka, located in Enugu State, Southeastern Nigeria. The experiment lasted for 16 weeks: comprising 8 weeks of extract administration and mating, 4 weeks of gestation, and 4 weeks of lactation.

Preparation of *Gmelina arborea* Leaf Extract

Fresh *Gmelina arborea* leaves were harvested from healthy trees within the Nsukka environment. The leaves were thoroughly rinsed with clean water to remove dust and impurities, then air-dried under shade at ambient temperature (25 –28°C) to preserve heat-labile phytochemicals. The dried leaves were milled using a hammer mill to obtain a fine powder. Weighed samples (200 g) of the powdered leaves were soaked in 1.5 L of distilled water for 24 hours, after which the mixture was filtered through Whatman No. 1 filter paper. The filtrate was stored in airtight containers and refrigerated at 4°C until use. Portions of the extract were analyzed for proximate composition using standard procedures of the Association of Official Analytical Chemists (Quadri *et al.,* 2021), while the phytochemical screening was carried out as outlined by Balamurugan *et al.* (2019). Table 1 presents the proximate and phytochemical compositions of the test GALE.

Experimental Animals and Management

A total of 80 Chinchilla rabbits (aged 7–8 months) with average body weights of 1.10–1.14 kg were used for the study. The rabbits were ob-

Table 1. Proximate and Phytochemical Compositions of the Test *Gmelina arborea* Leaf

Proximate	(%)
Crude protein	18.45
Crude fibre	2.73
Ash	3.97
Moisture	8.89
Fat	2.07
Nitrogen-free extract	63.89
Phytochemicals	
Saponins	+++
Alkaloids	++
Tannins	++
Flavonoids	++
Phenol	+

+++ = highly present; ++ = moderately present; + = least present

Table 2. Ingredient and Nutrient Composition of the Experimental Diets

Ingredients	(%)
Maize	48.10
Soy bean meal	28.25
Wheat offal	20.60
Bone meal	2.50
Salt	0.30
Premix	0.25
Total	100.00
Proximate composition	
Crude protein	21.45
Ether extract	2.00
Moisture	10.00
Crude fibre	11.50
Ash	10.60
Nitrogen-free extract	44.45
Metabolizable energy (kcal/kg)	2490.73

tained from a batch of 100 rabbits weaned from the Teaching and Research Farm of the Department of Animal Science, University of Nigeria, Nsukka. The rabbits were randomly allotted to four treatment groups, replicated four times with each replicate containing five rabbits, housed individually in hutches (with dimensions of 60 cm × 60 cm × 60 cm) equipped with feeders and drinkers. The hutch floor was made of wire that allowed for uninterrupted passage of feces and urine. Feed and water were provided *ad libitum*, as management practices including mating, nest preparation, and weaning followed standard procedures (Chah *et al.,* 2017). The test GALE was administered in the drinking water as follows: GALE0 (control)= water only; GALE300= rabbits receiving 300 ml GALE per liter of water; GALE600= rabbits receiving 600 ml GALE per liter of water; GALE900= rabbits receiving 900 ml GALE per liter of water. A standard pelleted diet was formulated and served to rabbits in all groups. The nutrient composition of the diet was calculated using standard values (Marles, 2017), while the proximate composition was determined by standard procedures (Quadri *et al.,* 2021) and is presented in Table 2.

Mating

After eight weeks of feeding the extract, the does from each treatment group were taken to the hutches of untreated, proven fertile bucks for natural mating. Successful mating was confirmed by observation of mating behavior. Pregnancy was checked by abdominal palpation on day 14 post-mating, and does not confirmed as pregnant were returned for a subsequent mating to ensure conception.

Data Collection

The following parameters were recorded:

Reproductive performance

The weight at doe mating (g) was recorded as the body weight of the doe measured 24 hours prior to mating. Conception rate (%) was calculated as the number of does that became pregnant divided by the number of does mated, multiplied by 100. Gestation length (days) was determined as the interval between the date of kindling and the date of mating. Kit survival to weaning (%) was computed as the total number of kits weaned divided by the total number of kits born, multiplied by 100. Pre-weaning mortality (%) was obtained by subtracting the kit survival percentage from 100.

Postpartum performance

Weight at kindling (g): body weight recorded within 24 h of parturition.; Weight at weaning (g): weight recorded at 28 days post - kindling; Lactation weight loss (g): difference between weight at kindling and at weaning; Feed and water intake: total feed or water consumed per doe over the lactation period, computed as total quantity offered minus leftover; Average daily intake was obtained by dividing total intake by 28 days.

Pre-weaning litter performance

Litter size at birth and weaning (n): number of live kits per doe immediately after kindling and at 28 days; Kits birth and weaning weights (g): mean body weight of kits at birth and at weaning; Pre-weaning weight gain (g/kit/day): calculated as (kit weaning weight – kit birth weight) / 28 days.

Statistical Analysis

Data collected were subjected to one way analysis of variance (ANOVA) for a completely randomized design using IBM SPSS software, version 23.0 (IBM Corporation, USA). Significantly different means were separated using Duncan's new multiple range test–at 1% probability level ($P < 0.01$).

RESULTS AND DISCUSSION

Reproductive Performance

The reproductive indices presented in Table 3 revealed significant ($P < 0.01$) differences among treatment groups. Pre-mating weights were comparable across treatments, although rabbits in GALE600 recorded the highest value (3375.00 g). Conception rate and kit survival to weaning were positively influenced by GALE, with optimal performance at GALE600 (95.0% and 84.4%, respectively), while GALE900 recorded the lowest values (80.0% and 71.80%). Gestation length was not affected by treatment. Pre-weaning mortality increased markedly in GALE900 (28.2%) compared to GALE600 (15.6%).

These improvements in reproductive indices at moderate GALE inclusion (GALE600) could be attributed to the rich phytochemical composition of *Gmelina arborea*, particularly flavonoids and phenolic compounds known for their antioxidant properties (Iswarya *et al.,* 2017; Njoku and Abarikwu, 2021). Antioxidants play a crucial role in mitigating oxidative stress, which is a major factor impairing fertility under tropical conditions (Roychoudhury *et al*., 2021). Reduced oxidative stress likely enhanced ovarian function, embryo survival, and overall reproductive efficiency. These results are consistent with the findings of Pius *et al.* (2019), who reported enhanced reproductive performance in rabbits fed *Gmelina arborea* leaves. Similarly, Jimoh *et al*. (2023) demonstrated that phytogenic supplementation improves reproductive physiology in rabbits, particularly under stressful tropical conditions.

The enhanced reproductive outcomes also align with reports by Abarikwu *et al*. (2020), who noted that plant-derived bioactive compounds can modulate reproductive hormones and improve fertility. Additionally, the immunomodulatory and antimicrobial effects of phytochemicals such as saponins and alkaloids (George and Liske, 2021) may have reduced subclinical infections, thereby improving conception, embryo survival and overall reproductive efficiency.

The decline in performance at GALE900 suggests a dose-dependent effect, whereby excessive phytochemicals may exert anti-nutritional effect. This finding is in line with the findings of Jiwuba *et al*. (2016), who reported that excessive inclusion of *Gmelina arborea* can introduce anti-nutritional effects, particularly due to tannins. High tannin levels are known to reduce nutrient digestibility and interfere with protein utilization which may explain the increased pre-weaning mortality and reduced reproductive performance observed at this level. This observation is further corroborated by Adli *et al.* (2024), who documented a dose-dependent decline in performance at high phytogenic inclusion levels.

Postpartum Performance of Rabbit Does

Results on postpartum performance of the rabbit does as presented in Table 4 showed that GALE significantly ($P < 0.01$) influenced body weight at kindling and weaning, lactation weight loss, and feed and water intake. Does administered GALE600 recorded the highest kindling and weaning weights (3478.20 g and 3387.60 g, respectively), alongside the lowest lactation weight loss (90.60 g). Feed intake increased with GALE supplementation up to GALE600 but declined at GALE900, while water intake decreased progressively with increasing GALE levels.

The improved body weight and reduced lactation weight loss at GALE600 indicate enhanced nutrient utilization and metabolic efficiency. This may be linked to the antioxidant properties of GALE, which help maintain cellular integrity and reduce metabolic stress during lactation (Iswarya *et al.,* 2017). Efficient nutrient partitioning during lactation ensures adequate energy availability for milk production while minimizing body reserve depletion.

The current results agree with the findings of Obinna *et al.* (2024), who reported enhanced growth performance in rabbits administered *Gmelina arborea* extract. Similar improvements in nutrient utilization and physiological efficiency following phytogenic supplementation have been reported by Wang *et al.* (2024), who highlighted improved digestion and metabolic function in livestock receiving plant-based additives.

Furthermore, the enhanced performance observed in this study is consistent with the metabolic benefits reported by Attanayake *et al.* (2016), who demonstrated improved glucose metabolism in animals treated with *Gmelina arborea* extracts. Improved glucose utilization may enhance energy availability for lactation, thereby reducing body weight loss and supporting better postpartum recovery.

The reduction in water intake with increasing GALE concentration may be due to changes in palatability or taste associated with higher phytochemical concentrations. Similar findings have been reported for phytogenic additives where high inclusion levels reduce voluntary intake (Adli *et al.,* 2024). The decline in feed intake and increased weight loss at GALE900 further supports the notion of reduced palatability and possible metabolic burden at excessive inclusion levels. Jiwuba *et al.* (2016) noted that high levels of phytochemicals, particularly tannins, can reduce feed intake and nutrient digestibility.

Pre-Weaning Litter Performance

Table 5 shows the effect of GALE on pre-weaning litter performance. The extract significantly ($P<0.01$) influenced all measured parameters. Litter size at birth and at weaning increased with GALE supplementation up to GALE600 then declined at GALE900. Similarly, kit birth and weaning weights, as well as average pre-weaning weight gain, were highest in GALE600. Kits from does administered GALE600 achieved 11.38 g day^{-1} pre-weaning gain compared with

Table 3. Reproductive Performance of Rabbit Does Fed GALE

Parameters	Treatments				SEM	P-value
	GALE0	GALE300	GALE600	GALE900		
Weight at doe mating (g)	3200.00^{c}	3260.00^{a}	3375.00^{a}	3240.00^{b}	30.00	0.002
Conception rate (%)	85.00^{b}	90.00^{a}	95.00^{a}	80.00^{c}	2.20	0.001
Gestation length (days)	30.00	29.80	29.60	30.30	0.12	0.759
Kit survival to weaning (%)	83.40^{a}	84.30^{a}	84.40^{a}	71.80^{b}	2.80	0.001
Pre-weaning mortality (%)	15.60^{b}	15.70^{b}	15.60^{b}	28.20^{a}	2.80	0.002

^{abc}means on the same row with different superscript are significantly different ($P < 0.01$) SEM = standard error of mean; GALE = Gmelina arborea leaf extract.

Table 3. Reproductive Performance of Rabbit Does Fed GALE

Parameters	Treatments				SEM	P-value
	GALE0	GALE300	GALE600	GALE900		
Weight at doe mating (g)	3200.00^{c}	3260.00^{a}	3375.00^{a}	3240.00^{b}	30.00	0.002
Conception rate (%)	85.00^{b}	90.00^{a}	95.00^{a}	80.00^{c}	2.20	0.001
Gestation length (days)	30.00	29.80	29.60	30.30	0.12	0.759
Kit survival to weaning (%)	83.40^{a}	84.30^{a}	84.40^{a}	71.80^{b}	2.80	0.001
Pre-weaning mortality (%)	15.60^{b}	15.70^{b}	15.60^{b}	28.20^{a}	2.80	0.002

^{abc}means on the same row with different superscript are significantly different (P < 0.01) SEM = standard error of mean; GALE = Gmelina arborea leaf extract.

Table 4. Postpartum Performance of Rabbit Does Fed GALE

Parameters	Treatments				SEM	P-values
	GALE0	GALE300	GALE600	GALE900		
Weight at kindling (g)	3280.40^{a}	3345.60^{a}	3478.20^{a}	3332.70^{b}	32.80	0.002
Weight at weaning (g)	3108.50^{b}	3194.20^{b}	3387.60^{a}	3098.30^{c}	40.30	0.001
Lactation weight loss (g)	171.90^{b}	151.40^{b}	90.60^{c}	234.40^{a}	11.20	0.001
Total feed intake (g/doe)	5710.80^{b}	5893.20^{a}	6124.60^{a}	5532.50^{c}	69.50	0.001
Average feed intake (g/day)	203.90^{b}	210.50^{a}	219.40^{a}	197.60^{c}	2.60	0.001
Total water intake (ml/doe)	19842.70^{a}	18947.50^{b}	17653.20^{c}	16138.90^{d}	185.70	0.001
Average intake (ml/day)	709.40^{a}	676.70^{b}	603.50^{c}	576.40^{d}	7.30	0.001

^{abcd}means on the same row with different superscript are significantly different (P < 0.01) SEM = standard error of mean; GALE = *Gmelina arborea* leaf extract

Table 5. Effect of GALE on Pre-weaning Litter Performance

Parameters	Treatments				SEM	P-value
	GALE0	GALE300	GALE600	GALE900		
Litter size at birth (n)	4.50^{b}	5.10^{a}	5.45^{a}	3.90^{c}	0.18	0.001
Litter size at weaning (n)	3.80^{b}	4.30^{a}	4.60^{a}	2.80^{b}	0.21	0.001
Kit birth weight (g)	42.80^{b}	45.10	47.60	40.30^{a}	0.95	0.001
Kit weaning weight (g)	285.40^{b}	312.60^{a}	362.90^{a}	260.00^{c}	9.80	0.001
Pre-weaning weight gain (g/kit/day)	8.66^{b}	9.55^{a}	11.28^{a}	7.87^{c}	0.42	0.001

^{abc}means on the same row with different superscript are significantly different (P < 0.01) SEM = standard error of mean; GALE = Gmelina arborea leaf extract.

8.10 g day^{-1} in the control group. However, excessive inclusion (GALE900), negatively affected kit growth and survival, reducing palatability at high extract levels.

The improved litter performance at GALE600 could be attributed to enhanced milk production and quality resulting from better maternal nutrition and metabolic status. These improvements are in agreement with the findings of Pius *et al.* (2019), who reported enhanced reproductive output in rabbits fed *Gmelina arborea*. Phytogenic compounds present in GALE may stimulate digestive efficiency and nutrient absorption, leading to improved milk yield and composition, which directly influences kit growth (Wang *et al*., 2024). Comparable improvements in offspring growth following phytogenic supplementation have also been reported by Adetunji *et al.* (2025), who highlighted the role of plant extracts in enhancing reproductive efficiency and offspring viability.

In addition, the antioxidant and immunomodulatory properties of GALE likely improved neonatal survival and growth by enhancing the immune status of both does and kits. Reduced oxidative stress and improved maternal health contribute to better uterine environment, fetal development, and postnatal growth (Roychoudhury *et al.,* 2021).

The decline in litter performance at GALE900 further supports the dose-dependent effects reported by Adli *et al.* (2024), were excessive phytogenic inclusion negatively affected growth and survival. This is also consistent with Jiwuba *et al.* (2016), who attributed reduced performance at high inclusion levels to anti-nutritional factors such as tannins.

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CONCLUSION

Administration of GALE to rabbits produced dose-dependent effects on reproduction, postpartum and pre-weaning litter performance. GALE600 consistently optimized outcomes, improving conception rate, reducing lactation weight loss and enhancing kit birth and weaning weights and pre-weaning growth without adverse effects compared to GALE300. However, GALE900 reduced feed and water intake and lowered kit survival, suggesting excessive phytochemical levels may be harmful. Hence, GALE600 is recommended as effective, and safe phytogenic strategy to enhance doe productivity under tropical conditions. Further studies should investigate antioxidant profile, hormonal concentration and milk yield to clarify the mechanisms behind these benefits.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Ifeanyi Pascal Eze and Izuchukwu Collins Eze for assisting with feeding of the experimental rabbits.

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