



**GROWTH, REPRODUCTIVE AND HORMONAL RESPONSES OF RABBITS
ADMINISTERED GRADED DOSES OF AQUEOUS *TERMINALIA CATAPPA* LEAVES
EXTRACT**

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ABSTRACT

*This study evaluated the growth and reproductive performance of rabbits administered graded levels of aqueous extract of almond (*Terminalia catappa*) leaves. Thirty-five rabbits, comprising thirty does and five bucks, were randomly allotted to five treatments of seven rabbits each in a completely randomised design. Treatments involved oral administration of 0, 0.5, 1.0, 1.5, and 2.0 mL of aqueous almond leaf extract per kilogram body weight once weekly for 12 weeks. Data were collected on growth parameters, body weight during pregnancy, and reproductive traits, and were analysed using one-way analysis of variance. Initial body weight, final body weight, weight gain and feed conversion ratio did not differ significantly among treatments, although feed intake was significantly lower in rabbits given 1.5 mLs per kilogram. During pregnancy, does receiving moderate levels of the extract recorded significantly higher body weight by the fourth week than the control and the highest dose group. Litter size and litter weight were significantly higher in does given 0.5 and 1.0 mL per kilogram, while does in the control and highest-dose group failed to kindle despite conception. Stillbirth incidence increased at 1.5 mLs per kilogram, and postnatal mortality was recorded among kits born in all extract-treated groups that kindled. Moderate levels of aqueous almond leaf extract (0.5-1.0 mL/kg) reduced feed intake at 1.5 mL/kg without significantly affecting weight gain, feed conversion ratio, or reproductive traits, without compromising growth. However, 0.5–1.0 mL/kg was associated with greater litter size and litter weight. Complete pre-weaning mortality among kits born in the extract-treated groups indicates that these apparent reproductive benefits did not translate into improved reproductive success.*

Keywords: Growth performance; Phytogetic supplement; Rabbit; Reproductive performance; *Terminalia catappa*

INTRODUCTION

Rising demand for animal protein in developing countries has renewed interest in non-ruminant species such as the rabbit, which offers a prolific reproductive rate, short gestation period, early sexual maturity, and efficient feed conversion (Fellous *et al.*, 2012; Apori *et al.*, 2014). Rabbit meat is increasingly recognised for its high nutritional quality and low fat and cholesterol content, making rabbit production a viable pathway toward closing the animal-protein gap in resource-poor communities (Petracci *et al.*, 2009; Herbert, 2011). Reproductive efficiency remains the single most important determinant of profitability in commercial rabbit enterprises, since output depends directly on conception, litter size, litter weight and kit survival (Apori *et al.*, 2014). Nutritional inadequacy and oxidative stress are recognised causes of reproductive failure in rabbit does, underscoring the value of feed additives that support both growth and reproductive function without the drawbacks associated with synthetic growth promoters (Dekkiche *et al.*, 2024).

Terminalia catappa (tropical almond) is a widely distributed tree whose leaves have been reported to contain flavonoids, phenolic acids, tannins and saponins, compounds that have been associated in the literature with antioxidant, antimicrobial and endocrine-modulating properties in various biological systems (Habibullah *et al.*, 2023; Ahmed *et al.*, 2005). At this stage, these reported bioactivities remain phytochemical and pharmacological associations drawn from prior literature rather than mechanisms established in the present experiment, and are presented here only as the biological rationale for selecting *T. catappa* as a candidate feed additive. Most existing work on *T. catappa* has, however, been conducted in species other than the rabbit, and even within the wider livestock literature, the plant has been examined largely as dried leaf meal rather than as an aqueous extract. Direct inclusion of the dried leaf meal in livestock diets is often limited by reduced palatability and antinutritional effects associated with its tannin and fibre content (Abd El-Aziz, 2025). Aqueous extraction has therefore been proposed as a means of concentrating the beneficial phytochemicals of the leaves while minimising these antinutritional drawbacks (Ukoh *et al.*, 2022). Even where aqueous extracts of *T. catappa* have been evaluated, such work has largely addressed general growth or health outcomes rather than reproductive performance. Evidence specifically linking graded doses of aqueous *T. catappa* leaf extract to reproductive outcomes in rabbits, such as pregnancy-associated body weight change, litter traits and reproductive hormone profiles, remains absent from the literature. This study addresses this gap by using the rabbit as the test species, the aqueous extract as the delivery form, and reproductive performance as the outcome of interest.

This study was therefore designed to evaluate the effects of graded oral doses of aqueous *Terminalia catappa* leaf extract on growth performance, pregnancy-associated body weight, reproductive performance and selected reproductive hormones in rabbits, to identify a dose that optimises productivity while preserving reproductive function.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the Teaching and Research Farm, Department of Animal Production, School of Food Science and Agricultural Technology, Federal University of Technology, Minna (Gidan Kwano Campus), Niger State, Nigeria. The site lies between latitude 9°37' and 9°61' North and longitude 6°33' and 6°56' East, with a mean annual rainfall of about 1,300 millimetres and temperatures ranging from 17.2°C to about 40°C.

Source and Processing of Almond Leaves Extract

Fresh green almond leaves were harvested within Minna metropolis, gently rinsed, and air-dried for 72 hours before oven-drying at 40°C for two hours and milling into a fine powder using a laboratory blender. 100g of the powdered leaves were soaked in 1,000 mLs of distilled water at a ratio of 1:10 for 72 hours with intermittent agitation, after which the mixture was filtered using Whatman No. 1 filter paper and concentrated in an evaporating dish over a water bath at 60°C until a final volume of approximately 100 mLs was obtained, following the method of Ukoh et al. (2022). This yielded a stock concentration of 1g plant material equivalent per mL. The stock extract was diluted 1:10 with distilled water immediately before administration, giving a working concentration of 0.1 g plant material equivalent per mL, from which the graded doses (0, 0.5, 1.0, 1.5 and 2.0 mL/kg body weight) were calculated. A fresh batch of extract was prepared weekly throughout the twelve-week trial to maintain phytochemical potency, and each batch was stored in an amber bottle at 4°C, with administration completed within 24 hours of preparation.

Experimental Animals, Diets and Design

Thirty-five growing rabbits, comprising thirty does and five bucks aged three to four months, were sourced from a reputable farm and acclimatised for two weeks before the twelve-week trial began. The animals were individually housed in wooden hutches (65 × 65 × 65 centimetres) raised 75 centimetres above floor level and fed the same basal formulated ration across all five

treatment groups, comprising 16% crude protein at the growing stage and 18% crude protein at the gestation and lactation stage and water supplied *ad libitum* (Table 1). The thirty does were weighed and randomly allotted to five treatments of six does each, with each doe constituting an independent experimental unit (replicate) for growth and reproductive measurements. One buck was randomly assigned to each treatment group solely as a mating male;. However, the buck received the same dose of aqueous almond leaf extract as the does in its assigned treatment; it was not considered an experimental replicate because its role was limited to natural mating with the does in its group. Aqueous almond leaf extract was administered orally once weekly per kilogram body weight to both does and their corresponding buck as follows: T1, 0 mLs (control); T2, 0.5 mLs; T3, 1.0 mL; T4, 1.5 mLs; and T5, 2.0 mLs

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Table 1: Composition of the Experimental Diet at the Growing, Gestation and Lactation Stages

Ingredient (%)	Growing Stage	Gestation/Lactation Stage
Maize	54.99	52.30
Groundnut cake	12.01	15.70
Rice husk	20.00	20.00
Maize husk	6.50	5.00
Fish meal	2.00	3.00
Bone meal	3.50	3.00
Methionine	0.25	0.25
Lysine	0.25	0.25
Premix	0.25	0.25
Salt	0.25	0.25
Total	100.00	100.00
Crude protein (%)	16.00	18.00
Metabolisable energy (kcal/kg)	2655.20	2622.54
Crude fibre (%)	9.60	9.61
Calcium (%)	0.85	0.91
Phosphorus (%)	0.50	0.40

Source: Calculated from experimental diet formulation.

Growth Performance

Initial body weight, final body weight, feed intake and average body weight gain were recorded weekly. Feed conversion ratio was calculated as average feed intake divided by average weight gain, following Ugwu et al. (2024).

Reproductive Performance

Each doe was introduced into a buck's cage for mating, after which gestation period (days between mating and parturition), conception rate, stillbirth incidence, litter size, litter weight and pre-weaning mortality were recorded. Conception rate was calculated as the number of does that conceived divided by the number of does mated, multiplied by 100.

Hormonal Assay

At the eighth week of the trial, before mating, two mLs of blood were collected from the cephalic vein of each doe into plain bottles and analysed for serum progesterone and oestrogen concentrations using enzyme-linked immunosorbent assay kits, following the manufacturer's protocol as described by El-Sawy et al. (2018).

Data Analysis

Data on growth performance and continuous reproductive variables (body weight, weight gain, feed intake, litter weight) were analysed using one-way analysis of variance (ANOVA) in IBM SPSS Statistics version 27.0, with the individual doe as the experimental unit. Where significant treatment effects were detected at the 5% probability level, we separated means using Duncan's Multiple Range Test (DMRT). Proportional reproductive outcomes (conception rate, kit survival rate) were arcsine-transformed before ANOVA to stabilise variance, with back-transformed means reported for clarity. Kit mortality, a zero-inflated count variable, was analysed using a generalised linear model with Poisson distribution rather than standard ANOVA, as this better suits count data with many zero values. Differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Growth Performance

Table 2 presents the growth performance of rabbits administered aqueous almond leaf extract. Initial body weight, final body weight, total weight gain, average weight gains and feed conversion ratio did not differ significantly among treatments ($P > 0.05$). Total and average feed

intake, however, were significantly lower in rabbits receiving 1.5 mLs per kilogram than in the other groups ($P < 0.05$). In contrast, feed intake of rabbits receiving 2.0 s per kilogram was intermediate.

The absence of significant differences in body weight gain and feed conversion ratio suggests that the extract did not enhance growth beyond what was achieved with the basal diet. Still, the reduced feed intake at 1.5 mL/kg, without a significant reduction in weight gain, suggests that rabbits maintained growth despite lower feed consumption; however, the feed conversion ratio did not differ significantly among treatments (Abdelsalam *et al.*, 2023). The decline in intake at higher doses may reflect reduced palatability associated with the extract’s tannin and saponin content, which has been linked to appetite suppression in other phytogenic feeding trials (Yakubu *et al.*, 2009). Comparable reductions in feed intake without loss of growth performance have been reported for rabbits fed other leaves-based phytogenic additives (Akinmoladun and Akinrinlola, 2017).

Table 2: Growth Performance of Rabbits Administered Aqueous Almond Leaves Extract

Parameter	T1	T2	T3	T4	T5	SEM	P-value
Initial body weight (g)	1190.00	1202.00	1202.00	1318.00	1288.00	33.36	0.684
Final body weight (g)	1570.00	1578.00	1586.00	1702.00	1658.00	31.38	0.634
Total weight gain (g)	380.00	376.00	384.00	384.00	370.00	10.17	0.993
Average weight gain (g)	47.50	47.00	48.00	48.00	46.25	1.27	0.993
Total feed intake (g)	3799 ^a	3796 ^a	3658 ^a	3335 ^b	3610 ^{ab}	54.29	0.027
Average feed intake (g)	77.54 ^a	77.48 ^a	74.65 ^a	68.06 ^b	73.68 ^{ab}	1.11	0.027
Feed conversion ratio	1.63	1.65	1.56	1.42	1.59	0.05	0.545

^{ab}Means within the same row bearing different superscripts differ significantly ($P<0.05$). SEM = standard error of mean. T1 = 0 mL (control); T2 = 0.5 mL; T3 = 1.0 mL; T4 = 1.5 mL; T5 = 2.0 mL of aqueous almond leaves extract per kg body weight.

Body Weight of Does During Pregnancy

Body weight of does during pregnancy is presented in Table 3. Initial weight and weight from week one to week three did not differ significantly among treatments ($P > 0.05$). By the fourth week, however, does receiving 0.5 to 1.5 mLs per kilogram recorded significantly higher body weight than the control and the 2.0 mL per kilogram group ($P < 0.05$).

Table 3: Body Weight of Does Administered Aqueous Almond Leaves Extract During Pregnancy

Parameter	T1	T2	T3	T4	T5	SEM	P-value
Initial weight (g)	1700	1600	1650	1750	1800	0.17	0.439
Week 1 weight (g)	1750	1650	1700	1700	1830	0.17	0.467
Week 2 weight (g)	1830	1750	1780	1800	1880	0.18	0.475
Week 3 weight (g)	1800	1900	1930	1950	1800	3.60	0.494
Week 4 weight (g)	1700 ^{ab}	2100 ^a	2150 ^a	2150 ^a	1310 ^b	0.13	0.045

^{ab}Means within the same row bearing different superscripts differ significantly ($P < 0.05$). SEM = standard error of mean. T1 = 0 mL (control); T2 = 0.5 mL; T3 = 1.0 mL; T4 = 1.5 mL; T5 = 2.0 mL of aqueous almond leaves extract per kg body weight.

The superior weight gain of does at moderate dosage by the fourth week of gestation supports the view that plant extracts often exert their most beneficial effects at moderate inclusion levels, with higher concentrations losing efficacy or causing mild adverse effects (Adli *et al.*, 2024). These findings align with reports that graded doses of phenolic-rich leaf extracts (e.g., ginkgo and guava) enhance growth performance, nutrient utilisation and antioxidant status in rabbits (Abdelghani *et al.*, 2023; Lu *et al.*, 2025). This improvement may be linked to the extract’s antioxidant and hormone-modulating actions, which have been associated with enhanced maternal metabolism and reduced oxidative stress during pregnancy in other phytogetic feeding studies (Ogunsola *et al.*, 2018).

Reproductive Performance

Table 4 presents reproductive performance. Conception rate did not differ significantly among treatments ($P > 0.05$), although does in the control and T2, T3, and T4 achieved 100% conception, while conception rate declined numerically to 50% at the highest dose (2.0 mL/kg). Despite achieving full conception, does in the control and the highest dose group failed to kindle,

so that gestation length, litter size and litter weight for these two groups were effectively zero, whereas does receiving 0.5 to 1.5 mLs per kilogram carried pregnancies to term within the normal gestation range of 29 to 30 days and produced litters. Litter size and litter weight were significantly higher in T2 and T3 than in T4 ($P < 0.05$), and stillbirth incidence was significantly higher at 1.5 mLs per kilogram than in the other groups that kindled ($P < 0.05$).

Table 4: Reproductive Performance of Does Administered Aqueous Almond Leaves Extract

Parameter	T1	T2	T3	T4	T5	SEM	P-value
Conception rate (%)	100.00	100.00	100.00	100.00	50.00	10.00	0.486
Gestation length (days)*	0.00 ^b	30.50 ^a	30.50 ^a	29.00 ^a	0.00 ^b	4.91	0.000
Stillbirth (no.)	0.00 ^b	0.00 ^b	0.50 ^b	2.00 ^a	0.00 ^b	0.27	0.005
Litter size (no.)	0.00 ^c	6.00 ^a	5.00 ^{ab}	3.50 ^b	0.00 ^c	0.86	0.004
Litter weight (g)	0.00 ^c	25.25 ^a	23.35 ^a	18.60 ^b	0.00 ^c	4.24	0.004
Pre-weaning mortality (%)†	0.00 ^b	100.00 ^a	100.00 ^a	100.00 ^a	0.00 ^b	16.33	0.001

^{abc}Means within the same row bearing different superscripts differ significantly ($P<0.05$). SEM = standard error of mean. T1 = 0 mL (control); T2 = 0.5 mL; T3 = 1.0 mL; T4 = 1.5 mL; T5 = 2.0 mL of aqueous almond leaves extract per kg body weight. *Gestation length is reported as zero for T1 and T5 because no doe in these groups kindled despite conception. †Pre-weaning mortality is expressed as a percentage of kits born alive and applies only to groups in which litters were produced; it is reported as zero for T1 and T5 because no litters were produced in these groups.

This trial produced two distinct reproductive outcomes. First, moderate supplementation (0.5 to 1.0 mL/kg) was clearly associated with successful pregnancy outcomes, higher litter size and higher litter weight than the higher dose, supporting the view that phytogetic compounds such as flavonoids and steroidal glycosides in *Terminalia catappa* can exert endocrine-modulating effects favourable to reproduction (Adetunji *et al.*, 2025). Comparable improvements in doe reproductive performance following leaf-extract supplementation have been reported for *Moringa oleifera* (El-Desoky *et al.*, 2022). The complete failure of does in the control and the 2.0 mL/kg groups to kindle despite full or partial conception, alongside the elevated stillbirth incidence at 1.5 mL/kg, points toward embryonic resorption or pseudopregnancy. This pattern has been documented in other studies of rabbit reproduction under nutritional or phytochemical stress (Hashem *et al.*, 2021). At the highest dose, the inhibitory effect is consistent with reports that excessive concentrations of tannins and other secondary metabolites in medicinal plant extracts can disrupt the hormonal milieu or impair uterine receptivity (Jimoh *et al.*, 2023), while the outcome in the untreated control may instead reflect the small number of does per treatment (six), which makes reproductive traits such as litter size highly sensitive to the fate of individual

animals. This is consistent with broader evidence that phytogetic feed additives influence reproductive hormone profiles and fertility outcomes in livestock in a dose-dependent manner (Swelum *et al.*, 2021). This biphasic pattern mirrors observations in other phytogetic supplementation trials, where low to moderate levels of plant extract improved conception while higher levels produced embryotoxic effects (Oyewumi *et al.*, 2015).

A finding that requires caution is the complete pre-weaning mortality recorded among kits born in the 0.5, 1.0 and 1.5 mL/kg groups. Although these same groups produced the largest litters and heaviest litter weights, every kit born in a treated group that kindled died before weaning. This outcome tempers the otherwise favourable interpretation of litter size and litter weight data. It indicates that, in this trial, gains in prenatal reproductive traits did not translate into postnatal survival. The mechanism underlying the failure to kindle was not determined in the present study because only six does were used per treatment; this result should be treated as a hypothesis-generating observation rather than a definitive conclusion, and it should be verified in a larger-scale trial with closer monitoring of kit management and nursing behaviour before any recommendation on kit survival can be made.

Hormonal Profile

Serum progesterone concentration differed significantly among treatments ($P < 0.05$), with the highest value recorded at 2.0 mL/kg (0.91 ng/mL) and the lowest at 1.0 mL/kg (0.63 ng/mL). In contrast, oestrogen concentration did not differ significantly among treatments ($P = 0.051$), although it was numerically highest at 1.0 mL/kg (71.25 pg/mL) and lowest in the control (67.55 pg/mL).

Table 5: Hormonal Profile of Does Administered Aqueous Almond Leaves Extract

Parameter	T1	T2	T3	T4	T5	SEM	P-value
Progesterone (ng/mL)	0.75 ^b	0.66 ^c	0.63 ^c	0.70 ^{bc}	0.91 ^a	0.03	0.001
Oestrogen (pg/mL)	67.55	69.60	71.25	70.80	69.85	0.52	0.051

^{abc}Means within the same row bearing different superscripts differ significantly ($P < 0.05$). SEM = standard error of mean. T1 = 0 mL (control); T2 = 0.5 mL; T3 = 1.0 mL; T4 = 1.5 mL; T5 = 2.0 mL of aqueous almond leaves extract per kg body weight.

The elevated pre-mating progesterone concentration observed at 2.0 mL/kg coincided with subsequent reproductive failure; however, the temporal design does not establish a causal relationship between progesterone concentration and failure to kindle. The elevated progesterone

concentration at the highest dose, occurring alongside failure to kindle in the same group, suggests hormonal overstimulation rather than straightforward hormonal benefit, since progesterone must be maintained within an appropriate physiological range to sustain gestation rather than elevated (Kumar *et al.*, 2016). The comparatively higher, though non-significant, oestrogen concentration at moderate doses is consistent with the improved conception and litter outcomes observed in those groups and supports the proposition that flavonoids and saponins in *Terminalia catappa* can modulate ovarian steroidogenesis (Adetunji *et al.*, 2025).

CONCLUSION

Aqueous *Terminalia catappa* leaf extract at 0.5 to 1.0 mL/kg was associated with larger litter size and litter weight and supported maternal body weight during pregnancy, without significantly affecting overall growth performance or feed conversion ratio. However, complete pre-weaning mortality among kits born in extract-treated groups indicates that these apparent reproductive advantages did not translate into improved reproductive success, so we cannot recommend the extract for routine rabbit production until further studies clarify the cause of kit mortality.

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