Research Article

Impact of Tithonia, Parkia and Synedrella Leaf Meals in Kit Rabbits' Diets: Growth Performance, Carcass Indices and Meat Quality

Razaq Animashahun[1], Funmilayo Okeniyi[1], Olayinka Alabi[1], Samuel Olawoye[1], Precious Oluwafemi[1], Princess Odhe[1], Oluwatola Akintola[1], Adedeji Animashahun[2]

[1]Department of Animal Science, College of Agricultural Sciences, Landmark University, P.M.B. 1001, Omu Aran, Kwara State, Nigeria; [2]Department of Animal Breeding and Genetics, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria.

Abstract | A ten-week study on the impact of adding tithonia, parkia, and synedrella leaf meals on the growth, carcass, and meat qualities of New Zealand male kit rabbits was conducted. The rabbits, aged eight weeks, were assigned in a Completely Randomized Design into five dietary treatments, each containing 12 rabbits per group with 3 replicates. Treatment 1 served as the control, while treatments 2, 3, and 4 included 6% tithonia, parkia, and synedrella leaf meal, respectively. Treatment 5 consisted of 2% each of these three leaf meals. The results indicated a significant impact ($p < 0.05$) on the growth performance due to the addition of these leaf meals. The highest weight gain (2.95 kg) was observed in treatments 1 and 4, while the least feed conversion ratio (5.63) was noted in treatment 4. Although the carcass indices were not influenced ($p > 0.05$) by the leaf meals, there was a significant ($p < 0.05$) effect on visceral organs. The general acceptability of the meat across the treatment groups showed similarity ($p > 0.05$). The study suggests that all three leaf meals have the potential to be used in growing rabbit diets, with Synedrella demonstrating the highest potential. Additionally, the results imply that a mixture of leaves should be encouraged.

Keywords | Feed, Weight gain, Fodder, Peroxidation, Production, Shelf life

Received | January 18, 2024; **Accepted** | June 26, 2024; **Published** | August 09, 2024
***Correspondence** | Precious Oluwafemi, Department of Animal Science, College of Agricultural Sciences, Landmark University, P.M.B. 1001, Omu Aran, Kwara State, Nigeria; **Email:** precious.toluwalodaraju@lmu.edu.ng
Citation | Animashahun R, Okeniyi F, Alabi O, Olawoye S, Oluwafemi P, Odhe P, Akintola O, Animashahun A (2024). Impact of tithonia, parkia and synedrella leaf meals in kit rabbits' diets: growth performance, carcass indices and meat quality. Adv. Anim. Vet. Sci. 12(9): 1731-1739.
DOI | https://dx.doi.org/10.17582/journal.aavs/2024/12.9.1731.1739
ISSN (Online) | 2307-8316; **ISSN (Print)** | 2309-3331

INTRODUCTION

Nigeria, like many developing nations, faces a protein deficiency, leading to nutritional inadequacies across all age groups (De Vries-Ten Have *et al*., 2020). This insufficiency contributes to severe health conditions and increased mortality rates within the Nigerian population (Ubesie and Ibeziakor, 2012). Food is a fundamental human need, crucial for survival and integral to achieving UN Sustainable Development Goal 2, which aims for zero hunger, food security, nutrition enhancement, and sustainable agriculture. The overreliance on large animal species like cattle, sheep, and goats exacerbates insufficient protein intake in countries like Nigeria, highlighting the need to transition to animals with shorter production cycles, easier maintenance, and lower capital requirements, with rabbits emerging as a viable option.

Rabbits are the most cost- and profit-effective livestock due to their ability to thrive on poor-quality food while yielding high-quality meat and fur. Their digestive system can handle up to 30% crude fiber, promoting efficient feed conversion into meat compared to other poultry species (Odedire and Oloidi, 2018).

Various agricultural byproducts in Nigeria, including sweet potato foliage, Garcinia kola seed meal, *Acacia albida* pods, *Solanum nigrum* L. Var Virginicum leaf and seed meal, *Stylosanthes guianensis*, *Lablab purpureus*, sunflower leaf, *Moringa oleifera* leaf, and *Tridax procumbens* leaf, have been studied as potential substitutes for rabbit diets (Gbenge, 2022). These alternatives are protein-rich and may replace soybeans in adult rabbit diets.

Leaf meals, in particular, have higher crude protein content compared to other byproducts (Sugiharto *et al*., 2018). Incorporating leaf meals in monogastric rations may reduce the need for expensive protein-rich feed components. Additionally, leaf meals are rich in minerals and bioactive compounds such as vitamins, flavonoids, phenolic acids, tannins, isothiocyanates, and saponins, contributing to the health benefits of monogastric animals (Achilonu *et al*., 2018). Despite their advantages, the high crude fiber content in leaf meals limits their use in broiler diets (Ubua *et al*., 2019). Utilizing leaf meals in feed formulations offers cost-effective and health advantages for animal nutrition.

The specific objectives of this study therefore were to assess and evaluate the impact of leaf meals from *Parkia biglobosa* (*P. biglobosa*), *Tithonia diversifolia* (*T. diversifolia*), and *Synedrella nodiflora* (*S. nodiflora*) on:

- The growth performance of growing rabbits
- The carcass indices, and
- Some meat quality (meat peroxidation and sensory organoleptic properties) of growing rabbits.

MATERIALS AND METHODS

Research Location

The study was conducted at the Omu Aran Teaching and Research Farm of Landmark University in Kwara State, Nigeria. Located at 50.61 degrees East and 8.9 degrees north.

Sources of Feed Ingredients

The leaves of *P. biglobosa, S. nodiflora, T. diversifolia,* and *T. procumbens* were collected from Landmark University's Teaching and Research Farm, and the other ingredients were procured from Omu-Aran Market in Kwara State, Nigeria

Proximate Analysis for Leaves and Feeds

The Proximate analysis was carried out using Association of Official Analytical Chemists (AOAC, 2006).

Determination of Moisture (AOAC Method: 925.10)

The moisture content of the samples was assessed by subjecting them to drying in an oven at 105°C until a consistent weight was attained. An accurate 2 g of the sample was measured using an analytical balance. The oven was preheated to 105°C before drying the samples until a stable weight was reached, signifying the complete removal of moisture. Subsequently, the moisture content was calculated using the following formula:

$$Moisture\ (\%) = \frac{initial\ weight - final\ weight}{initial\ weight} \times 100$$

Crude Protein (CP) Analysis

Kjeldahl Method (AOAC Method 968.06). The determination of nitrogen content is a crucial step in calculating crude protein, involving the digestion, distillation and titration of each test ingredient. For each sample, 1g was carefully measured into a digestion tube, and specks of selenium (acting as a catalyst) were added. Subsequently, 10ml of concentrated sulfuric acid was added with precision. The tubes were arranged in digestion chambers set at 420°C, and the samples were considered fully digested when a clear solution was achieved, typically within about 1 hour. After cooling, the digested samples were distilled into boric acid solution, and the resulting distillate was titrated with HCl. The titration values served as indicators of the nitrogen content in the sample. The calculation of crude protein involved multiplying the nitrogen content by a conversion factor (6.25).

$$Crude\ protein\ (\%) = N \times 6.25$$

Crude Fiber (CF) Analysis

AOAC method 978.10. Through sequential acid and alkali extractions, this method primarily eliminates protein, sugar, starch, lipids, as well as segments of structural carbohydrates and lignin. The process involves digesting the sample with a sulfuric acid solution to extract sugar and starch. Subsequently, a second alkaline digestion is conducted using a sodium hydroxide solution, targeting the removal of proteins along with some hemicellulose and lignin. The determination of crude fiber is achieved gravimetrically by analyzing the residue that remains after the acid and alkaline digestions.

Ash Analysis

Dry Ashing (AOAC Method 942.05). The organic material underwent complete combustion, resulting in the formation of inorganic residue (ash). One gram of the sample was heated in a muffle furnace set at 550°C until combustion was thorough. Following the cooling phase, the ash was measured using a precise weighing scale.

Ether Extract (EE) Analysis

Soxhlet Extraction (AOAC Method 920.39) Principle: Lipids were extracted from the sample through solvent extraction using an organic solvent. One gram of the sample was placed in a thimble and subjected to extraction with petroleum ether in a Soxhlet extractor. The solvent underwent vaporization, condensation, and dripped back into the sample, facilitating the extraction of fat. The extraction process persisted until all the fat was completely removed. Following this, the solvent was evaporated, and the resulting residue was weighed. The Ether Extract (EE) was then calculated using the provided formula:

$$EE\ (\%) = \frac{initial\ weight - final\ weight}{initial\ weight} \times\ 100$$

Nitrogen-Free Extract (NFE): The AOAC method for determining Nitrogen-Free Extract (NFE) involves a calculation wherein other proximate components are subtracted from 100%, as illustrated below:

$$NFE\ (\%) = 100 - (Moisture + CP + EE + CF + Ash)$$

Experimental animals, design, diets, management and duration

A total of sixty (60) unsexed growing rabbits, comprising mixed breeds, were obtained from a reputable rabbitry in Osun State, Nigeria. These rabbits, had an average weight ranging from 3.1 to 3.4 kg.

Experimntal design

The study employed a Completely Randomized Design (CRD). There were five treatment groups, each with three replicates Employing a weight equalization approach, 12 rabbits were assigned to each treatment group, with each replicate consisting of four rabbits.

Experimental animal management

The experiment adhered to the protocols established by the Landmark University Ethical Committee for Experimental Animal Use, and also in accordance with EU Directive 2010/63/EU on the protection of animals used for scientific purposes (Olsson et al., 2017). Prior to the animals' arrival, the hutches, feeders, and drinkers were thoroughly cleaned and disinfected. To acclimate the animals to the environment and minimize stress, they were initially fed a commercial feed before the commencement of the study. Each animal was individually housed in hutches measuring 80 cm by 80 cm by 60 cm, elevated four feet above the ground, and arranged in a well-ventilated house. Every hutch was equipped with both a feeder and a drinker to ensure the well-being of the rabbits. Upon arrival, the animals received oral anti-stress medication. Throughout the study, access to portable water was provided, and routine management practices, as well as biosecurity measures, were diligently maintained.

Experimental diets

Five diets were formulated, designating T1 as the control diet. The subsequent treatments, T2, T3, and T4, each incorporated a different leaf meal, while T5 comprised a consortium of all three leaf meals. *Tridax procumbens* was provided daily as forage across all treatments. The breakdown of the diets is as follows:

- T1: Rabbit concentrate with 0% leaf meal
- T2: Concentrate with 6% *Tithonia diversifolia* leaf meal (TDLM)
- T3: Concentrate with 6% *Parkia biglobosa* leaf meal (PBLM)
- T4: Concentrate with 6% *Synedrella nodiflora* leaf meal (SNLM)
- T5: Concentrate with a 6% mixture of leaf meals (2% TDLM + 2% PBLM + 2% SNLM).

Growth Performance Indices Evaluation

To assess the feed intake of the rabbits, the experimental diet was provided *ad libitum* in separate metal feeders each morning at 0800 h, while common forage (*Tridax procumbens*) was given in the evening at 0500 h. Leftover feed was weighed daily before the subsequent feeding, and water in plastic jugs was consistently accessible. Each rabbit underwent weekly weighing to measure weight gain before their morning meal. The feed intake was calculated as the difference between the feed supplied and the feed leftover, expressed by the formula.

$$Feed\ intake\ = Feed\ supplied - Feed\ remnant$$

Weight gain= Final weight at the end of the week – Initial weight at the beginning of the week.

The feed conversion ratio, representing the efficiency of converting feed into weight gain, was calculated by dividing the weight gained from the feed intake:

$$Feed\ Conversion\ Ratio = \frac{Feed\ intake}{Weight\ gain}$$

Carcass Indices Assessment

At the conclusion of the feeding trial, one rabbit from each replication was selected, weighed, and subjected to an overnight fast. The subsequent morning, the post-fast weight was recorded. Following this, the rabbits were stunned and euthanized by severing their jugular veins. Subsequently, the animals' fur was singed off after thorough bleeding, achieved by suspending their heads through their rear legs on rails. In the process of dissection, internal organs were extracted from the carcass to determine both dressed weight and eviscerated weight. The dressing percentage, computed as the ratio of the dressed carcass weight to the live weight of the animal, was then calculated (Pophiwa, 2017).

$$Dressing\ percentage = \frac{dressed\ weight}{live\ weight} \times 100$$

Meat Quality Evaluation

Lipid Peroxidation: A total of 0.4 ml of tissue supernatant was mixed with 1.6 ml of phosphate buffer, 0.5 ml of 30% trichloroacetic acid (TCA), and 0.5 ml of 75% thiobarbituric acid (TBA). The resulting mixture underwent centrifugation at room temperature for 10 minutes at 3000 rpm. Subsequently, the mixture was subjected to a water bath for 45 minutes at 80 °C. The absorbance of the clear supernatant was then measured against a blank (distilled water) at 532 nm using a spectrophotometer (Varshney and Kale, 1990).

$$MDA\ (units/mg\ protein) = \frac{DOD\ X\ V\ X\ 1}{Molar\ absorbancy\ index\ for\ MDA\ X\ v\ X\ mg\ protein}$$

Where;
Molar absorbancy index for MDA= $1.56 \times 10^5\ M^{-1}\ CM^1$ = $1.56 \times 10^5\ M^{-1}\ CM^1$
DOD = Absorbance at 532nm
V = Total volume of reaction mixture
v = Volume of sample.

Sensory Evaluation: Samples of rabbit meat taken from the thighs and fore limbs from each replicate was chopped into pieces of an average of 30 g and labeled. This was boil at 100 °C in a water bath until an inner tissue temperature of 75 °C was obtained. For sensory and palatability assessment, ten trained panelists participated, utilizing a nine-point Hedonic Scale (ranging from 9 - extremely liked to 1 - extremely disliked). To prevent flavor carryover, the panelists were provided with bottled water and a tasteless biscuit to chew after each sample, effectively rinsing their mouths.

Statistical Analysis

The results are presented as the mean values of three replicates each. All generated data underwent one-way analysis of variance with the treatment group effect using the general linear model procedure in SAS version 9.4 program, expressed by the equation:

$$Yij = \mu + Ti + eij$$

Where:
Yij = Observed measurement,
μ = Overall mean,
Ti = Effect of leaf meals (TDLM, PBLM, SNLM, and the combined leaf meals),
eij = Experimental error.

Significant differences between treatment means were determined using Duncan's Multiple Range Test (Duncan, 1955). Results were considered significantly different if p<0.05.

SAS version 9.4 features PROC GLM for ANOVA analysis. PROC GLM facilitates one-way ANOVA for completely randomized designs, enabling mean comparisons across treatment groups. It offers various post-hoc test options through the LSMEANS statement for detailed group mean comparisons. SAS offers a user-friendly interface and streamlined syntax for ANOVA analyses.

Table 1: Proximate composition of leaf meals.

Parameters (%)	TDLM	PBLM	SNLM	±SEM
Moisture	8.75^b	11.63^a	6.25^c	0.78
Crude Protein	25.17^a	12.15^c	17.76^b	1.89
Ether Extract	6.83^b	8.33^a	6.33^b	0.35
Crude Fiber	24.43^a	5.81^b	2.39^c	3.59
Ash	18.77^a	7.67^b	18.27^a	1.79
Nitrogen Free Extract	15.05^c	54.32^a	49.00^b	6.15

Means (in same row) with different letters in superscripts differ significantly (*P < 0.05*); **SEM:** Standard Error of means; **TDLM:** *Tithonia diversifolia* leaf meal; **PBLM:** *Parkia biglobosa* leaf meal; **SNLM:** *Synedrella nodiflora* leaf meal.

RESULTS SAND DISCUSSION

Proximate Composition of the Test Leaf Meals

The results presented in Table 1 for the proximate components of TDLM, PBLM, and SNLM indicate a significant (p < 0.05) difference among the three leaf meals. TDLM exhibited the highest levels of crude protein (CP), crude fiber (CF), and ash, while PBLM showed the highest content in ether extract (EE) and nitrogen-free extract (NFE). The lowest CF was observed in SNLM. The CP content of TDLM in this study was comparable to the value of 27.69% reported by (Omolola, 2020), whereas the CP for PBLM and SNLM was lower than the values of 18.40% and 30.16% documented by (Soetan *et al.*, 2014) and (Onyeka *et al.*, 2021), respectively. Also, The CP of PBLM in this study was lower than 16.23% reported by (Afolayan et al., 2019).

Table 2: Performance indices of grower rabbits fed different leaf meals and mixture.

Parameters	T_1	T_2	T_3	T_4	T_5	±SEM
Initial weight (kg)	3.12	3.33	3.20	3.33	3.32	0.03
Final weight (kg)	6.07^{a}	5.92^{ab}	5.50^{b}	6.28^{a}	5.98^{ab}	0.09.
Average weekly weight gain (kg)	0.33^{a}	0.29^{ab}	0.26^{b}	0.33^{a}	0.30^{ab}	0.01
Total weight gain (kg)	2.95^{a}	2.58^{ab}	2.30^{b}	2.95^{a}	2.67^{ab}	0.09
Total feed intake (kg)	16.91^{a}	16.34^{ab}	16.07^{b}	16.61^{a}	16.32^{ab}	2.64
Feed Conversion Ratio	5.73^{a}	6.33^{ab}	6.99^{b}	5.63^{a}	6.11^{ab}	4.10

a, b: Values in the same row but with different superscripts differ significantly ($p < 0.05$); *SEM* = Standard Error of means; **T1:** Dietary treatment containing 100 % Concentrate, **T2:** Dietary treatment containing 6 % *Tithonia diversifolia* leaf meal (TDLM), **T3:** Dietary treatment containing 6 % *Parkia biglobosa* leaf meal (PBLM), **T4:** Dietary treatment containing 6 % *Synedrella nodiflora* leaf meal (SNLM), **T_5:** Dietary treatment containing 2 % TDLM + 2 % PBLM + 2 % SNLM.

The observed variations in the proximate components could be attributed to factors such as biotic and abiotic stress signals, as well as time-scale variability, as reported by (Ashapkin *et al*., 2020) and (Aguree *et al*., 2023). Notably, all the test leaves exhibited high CP levels, making them suitable for inclusion in kit rabbit diets. (Sugiharto *et al*., 2019) previously noted the high protein content in leaf meals, which has led to their incorporation into broiler diets. In addition to their protein richness, leaf meals also encompass a diverse array of biologically active components that may function as growth-promoting and health-improving agents for broiler chickens. Moreover, the crude protein values observed for the three leaf meals in this study fell within the range deemed appropriate for rabbits, as indicated in the literature on suitable forages for rabbits (Lebas, 2013).

Impact of the Leaf Meals on the Growth Performance

The results presented in Table 2 highlight that the growth performance of growing rabbits was significantly influenced ($p < 0.05$) by the type of leaf meal. The highest weight gain was observed in both T1 and T4, followed by T5, while T3 recorded the lowest value. Similarly, the rabbits fed the control diet (T1) and those fed PBLM (T3) exhibited the highest and lowest feed intake, respectively. The most favorable feed conversion ratio (FCR) of 5.63 was obtained in the SNLM group (T4). The values of feed intake and weight gain observed in rabbits fed TDLM relative to those of control, were consistent with the report of (Khan et al., 2019), who reported low feed intake and weight gain at < 25% TDLM and higher values at diet containing ≥ 25% TDLM. Trend of weight gain in rabbit fed diet containing PBLM was at variance with the trend reported by (Afolayan *et al*., 2019), who observed better weight gain than the control, and no effect (P>0.05) on feed intake. The higher CP of PBLM reported by the later authors which may have impacted on the diet could be responsible for this difference. The latter authors opined that the inclusion of LBLM in rabbit's diets has no negative effects on the growth performance of rabbits and can be used as alternative feed resource in rabbit nutrition.

Although rabbits fed the control diet (T1) and those fed diets containing SNLM (T4) displayed similar ($p > 0.05$) weight gains, total feed intake, and feed conversion ratios, the values were improved in the rabbits fed SNLM. According to (Orwa *et al*., 2009; Khan *et al*., 2019) the ant-nutrient components of the leaves may be responsible for the relatively low performance observed in rabbits fed PBLM. Feed palatability, influencing both feed consumption and growth efficiency, suggests that a rabbit's high feed intake accelerates their growth rate. The FCR in this study was consistent with the range of 4.09 to 6.33 reported by (Makinde, 2016).

The higher growth rates observed in kits fed SNLM in this study align with the findings of (Omoikhoje *et al*., 2006; Isah *et al*., 2012), who respectively observed increased growth rates in kits fed concentrate and SNLM. Additionally, the study indicates that the mixture of the three leaf meals positively influenced growth performance, surpassing the effects of either TDLM or PBLM.

Influence of the Leaf Meals on the Carcass Quality

Table 3 indicates carcass and organs' sizes of kit rabbits fed the experimental diets. The carcass indices of the kit rabbits remained unaffected by the test leaf meals and their type ($p > 0.05$). This may suggests that the diets across the groups provided similar levels of nutrition to the animals. This can be a positive outcome, indicating that alternative feed resources using these leaf meals options may be as effective as more expensive ones in terms of producing desired carcass characteristics. Producers can potentially opt for these leaf meals without sacrificing the quality of the final product. This can lead to cost savings in feed expenditures while maintaining production quality. It could indicate that the animals efficiently utilized the nutrients provided in all diets, leading to similar carcass characteristics regardless of

Table 3: Carcass and relative organ sizes of grower rabbits fed the experimental diets.

Parameters	T1	T2	T3	T4	T 5	±SEM
Live weight (kg)	1.73	1.75	1.95	1.98	1.83	0.05
Slaughter weight (kg)	1.63	1.63	1.80	1.85	1.75	0.05
Singe weight (kg)	1.58	1.58	1.75	1.80	1.70	0.05
Dressed weight (kg)	985.30	954.26	1103.22	1066.39	1043.62	39.47
Dressed %	54.90	54.50	56.50	57.00	56.60	2.40
Visceral weights (g)						
Heart	4.70^{b}	6.23^{a}	6.78^{a}	6.18^{a}	4.34^{b}	0.35
Lung	18.04^{a}	15.34^{a}	12.63^{ab}	11.66^{b}	9.01^{b}	1.09
Kidney	10.75	11.02	10.01	8.37	9.49	0.40
Stomach	10.75	11.02	10.01	8.37	9.49	0.40
Small intestine	149.43^{a}	112.27^{b}	110.56^{b}	139.82^{a}	142.61^{a}	3.42
Abdominal fat	6.50^{a}	0.20^{c}	2.87^{b}	2.72^{b}	0.20^{c}	0.76

a, b, c = Means (in same row) but with different letters in superscripts differ significantly ($p < 0.05$); *SEM* = Standard error of means. T_1 = Dietary treatment containing 100% Concentrate, T_2 = Dietary treatment containing 6 % *Tithonia diversifolia* leaf meal (TDLM), T_3 = Dietary treatment containing 6 % *Parkia biglobosa* leaf meal (PBLM), T_4 = Dietary treatment containing 6 % *Synedrella nodiflora* leaf meal (SNLM), T_5 = Dietary treatment containing 2 % TDLM + 2 % PBLM + 2 % SNLM

the diets. Additionally, consistency in carcass indices across different diets suggests that the animals responded consistently to the varying nutritional inputs. This consistency can be valuable for producers in terms of predicting outcomes and managing production processes.

Visceral organ sizes, except for kidneys and small intestines, changed significantly (p < 0.05). (Muhammad *et al*., 2018) found similar kidney and stomach sizes in developing rabbits fed morning glory leaf meal. Heart (4.70 - 6.18 g), lung (8.01 - 12.04 g), and kidney (8.01 - 11.02 g) weights aligned with reported values when kits were fed soybean milk residue, cowpea testa, and corn starch residue (Odeyinka *et al*., 2007) and *Moringa oleifera* leaf meal (Abubakar *et al*., 2015), suggesting no harmful ingredients in the test leaf meals causing organ hypertrophy. Alternatively, the amount of leaf meals fed might not have been high enough to induce such a reaction (Fatufe *et al*., 2010). In contrast, (Fakolade and Adetomiwa ,2018) found that 50% TDLM in rabbit diets lowered carcass parameters, possibly due to higher inclusion levels. Dressed percentage (54.50 – 57.00%) in this study exceeds 42.49 – 45.96% reported by (Abubakar *et al*., 2015) but falls within 53 - 58% obtained by (Amata, 2010) for tropical rabbits, possibly due to breed and processing differences. Notably, abdominal fat on the control diet was highest (6.50 g), while on combined leaf meal and TDLM diets was lowest (0.20 g). Dietary elements may influence fat deposition, with feed additives like leaf meals containing polyphenols, polysavone, and flavonoids possibly reducing fat deposition (Fouad and El-Senousey, 2014).

Influence of the Leaf Meals on the Meat Quality of Kit Rabbits

Impact of Leaf Meals on Lipid Peroxidation: Lipid peroxidation inversely affects meat shelf life and oxidative stability. Lower levels of lipid peroxidation imply better meat quality and longer shelf life. Malondialdehyde (MDA) levels serve as indicators of oxidative stability and meat shelf life, with lower MDA levels indicating improved stability and prolonged shelf life.

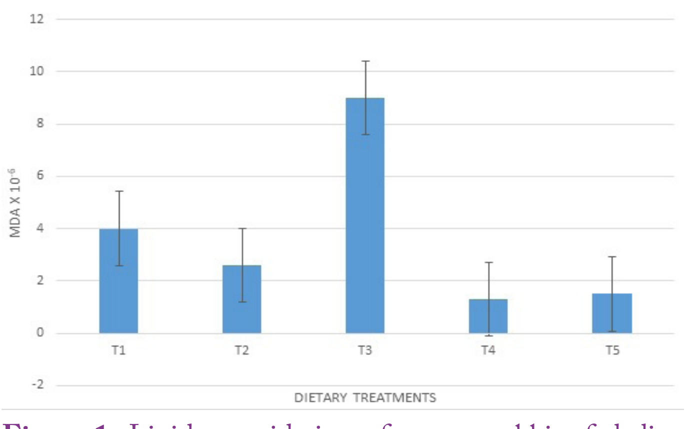

Figure 1: Lipid peroxidation of grower rabbits fed diets containing different leaf meals.

T_1: Dietary treatment containing 100% Concentrate; **T2:** Dietary treatment containing 6 % *Tithonia diversifolia* leaf meal (TDLM); **T3:** Dietary treatment containing 6 % *Parkia biglobosa* leaf meal (PBLM); **T4:** Dietary treatment containing 6 % *Synedrella nodiflora* leaf meal (SNLM); **T5:** Dietary treatment containing 2 % TDLM + 2 % PBLM + 2 % **SNLM, MDA:** Malondialdehyde.

Figure 1 illustrates lipid peroxidation results in rabbit meat in this study. The 6% PBLM diet (T3) showed the highest peroxidation, evidenced by elevated MDA levels, followed by T1, while T4 demonstrated the lowest peroxidation (lowest MDA). Mixtures of these leaf meals resulted in better oxidative stability, suggesting superior shelf life compared to diets containing only T1, T2 (TDLM), or T3 (PBLM).

Higher lipid concentrations increase meat susceptibility to peroxidation and degradation, reducing shelf life (Bou *et al*., 2004). In general, leaf meal inclusion decreased MDA levels in this study (except for T3), indicating potential to enhance growing rabbit meat quality.

Lower MDA levels in rabbit meat from leaf meal diets (T2, T4, and T5) suggest enhanced antioxidant capabilities, improving meat quality (Cui et al., 2018; Manessis et al., 2020). The high lipid content in *Parkia biglobosa* leaf in T3 may account for elevated MDA levels.

Impact on Sensory Organoleptic Indices: Lipid oxidation affects meat sensory and practical attributes. Prevention is crucial for human health and meat quality. Sensory organoleptic test results revealed significant effects of leaf meals on aroma and tenderness (P < 0.05), but no impact on appearance, juiciness, taste, or general acceptability (Table 4). Consumers equally preferred control and leaf diet-fed rabbit meat. Incorporating a leaf mixture (T5) enhanced juiciness and overall acceptability, suggesting benefits in incorporating mixed leaves. T1, T2, T4, and T5 received high ratings for taste and aroma, while tenderness and general acceptability were favorable across all treatments, with T5 showing the most promise.

Table 4: Sensory organoleptic test of grower rabbits fed the experimental diets.

Treatments	T1	T2	T3	T4	T5	±SEM
Appearance	8.00	7.95	7.83	7.72	8.17	0.08
Taste	7.45	7.62	7.33	7.72	7.34	0.25
Aroma	7.22^{b}	7.78^{a}	7.44^{ab}	7.67^{a}	7.50^{ab}	0.25
Tenderness	7.67^{a}	7.22^{bc}	7.00^{c}	7.39^{ab}	7.61^{a}	0.31
Juiciness	7.33	7.39	7.18	7.61	7.61	0.07
General Acceptability	7.50	7.72	7.39	7.72	7.78	0.06

a, b = Means (in same row) with different letters in superscripts differ significantly (*p < 0.05*);
SEM = Standard Error of means. T_1 = Dietary treatment containing 100% Concentrate, T_2 = Dietary treatment containing 6 % *Tithonia diversifolia* leaf meal (TDLM), T_3 = Dietary treatment containing 6 % *Parkia biglobosa* leaf meal (PBLM), T_4 = Dietary treatment containing 6 % *Synedrella nodiflora* leaf meal (SNLM), T_5 = Dietary treatment containing 2 % TDLM + 2 % PBLM + 2 % SNLM

CONCLUSIONS AND RECOMMENDATIONS

Based on the outcomes of this study, incorporating the leaves of *Tithonia diversifolia*, *Synedrella nodiflora*, *Parkia biglobosa*, and their combination into rabbit diets does not adversely affect the animals' growth, carcass, or meat quality. The inclusion of *Tithonia diversifolia*, *Synedrella nodiflora* leaf meals, and the composite of all the leaf meals studied as supplements in rabbit production is associated with an extended shelf life of the meat due to a low rate of peroxidation (higher oxidative stability). Among the studied leaves, a diet containing *Synedrella nodiflora* appears to hold the most promise, while advocating for the mixing of all these leaves as a consortium, especially during the dry season, is recommended.

Possible Study Limitations

Short Duration: A 10-week study might overlook long-term effects on rabbit growth and carcass qualities, warranting longer studies for deeper insights into sustained dietary impacts.
Sample Size and Statistics: The study's sample size and statistical power could affect result reliability and applicability; increasing both could improve result validity.
Dietary Composition: The study focused solely on specific leaf meal percentages; future research should explore diverse compositions for optimal rabbit growth and carcass quality.
Limited Evaluation Parameters: Broadening evaluation criteria to include blood biochemical profiles, histological analyses, and immune responses could offer a more holistic understanding of dietary effects.
Leaf Diversity in Rabbit Diets: Mixing all studied leaves, especially Syedrenella nodiflora, as a consortium, especially in dry seasons, is recommended.
Research Insights: Further research can unravel why certain diets yield similar outcomes, enlightening animal metabolism and dietary needs.
Market Reassurance: Consumers may find reassurance in these findings, suggesting that different feeding methods produce similar end products.
Environmental Reflection: Similar effects on carcass indices prompt discussions on the environmental impact of feed sources, urging producers to consider sustainability.
Adaptive Considerations: Despite no significant differences in carcass indices, future adjustments may be necessary considering changing conditions and advancements in nutritional science

ACKNOWLEDGEMENTS

The authors appreciate the Management of Landmark university for the use of their facilities.

NOVELTY STATEMENT

This study pioneers the exploration of *Tithonia diversifolia*, *Parkia biglobosa*, and *Synedrella nodiflora* leaf meals as dietary supplements for New Zealand male kit rabbits. It uniquely demonstrates their potential to enhance growth performance and improve meat quality while ensuring oxidative stability, without adverse effects on carcass indices. Particularly noteworthy is the identification of *Synedrella nodiflora* as a highly promising supplement, and the novel recommendation of a mixed leaf meal diet to optimize rabbit production, especially during the dry season. This research provides a valuable foundation for sustainable and nutritious rabbit farming practices.

AUTHOR'S CONTRIBUTION

Razaq Animashahun, Funmilayo Okeniyi, and Olayinka Alabi designed the study, the protocol, and wrote the first draft of the manuscript. Precious Oluwafemi and Samuel Olawoye managed the literature review, Princess Odhe and Oluwatola Akintola, while Adedeji Animashahun managed the analyses of the study. All authors read and approved the final manuscript.

Conflict of interest

The authors declare no conflict of interest.

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