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Physiological Response, Serum Minerals, and Lipid Profile of Matured Crossbred Bucks Fed Diets Supplemented with *Acalypha wilkesiana* Leaf Powder and Ascorbic Acid

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Abstract

This study evaluated the physiological effects of dietary supplementation of *Acalypha wilkesiana* Leaf Powder (AWLP) and Ascorbic Acid (AA) on the haematology, serum biochemistry, and serum mineral profiles of matured rabbit bucks. Fifty matured crossbred bucks (New Zealand White×Chinchilla), weight-balanced and acclimatized for two weeks, were randomly assigned to five distinct dietary treatments (n=10 per treatment) in a Completely Randomized Design. Treatment 1 (T1) received a basal control diet only; T2 was fed the basal diet supplemented with 250 mg/kg AA; while T3, T4, and T5 received the basal diet supplemented with AWLP at 150 mg/kg, 300 mg/kg, and 450 mg/kg, respectively. Quantitative phytochemical profiling revealed that the AWLP was highly rich in flavonoids (509.4 mg/g), saponins (206.5 mg/g), steroids (188.4 mg/g), tannins (157.1 mg/g), and alkaloids (60.96 mg/g). All tested physiological parameters remained safely within the standard normal reference ranges for adult rabbits. However, distinct significant (p<0.05) treatment trends were observed. Packed Cell Volume (PCV), Haemoglobin (Hb), Red Blood Cells (RBC), White Blood Cells (WBC), and differential leukocyte counts were highest in the AWLP-supplemented groups (T3-T5), intermediate in the AA positive control group (T2), and lowest in the negative control group (T1). Similarly, vital serum parameters - including total protein, albumin, globulin, calcium, phosphorus, magnesium, potassium, and bicarbonate - demonstrated a step-up trend that was highest in T3-T5, intermediate in T2, and lowest in T1 (p<0.05). Conversely, serum cholesterol was significantly reduced by AWLP supplementation, presenting the lowest values in T3-T5, intermediate values in T2, and the highest concentration in the basal control T1 (p<0.05). Crucially, key markers of organ toxicity, including Alkaline Phosphatase (ALP), Aspartate Aminotransferase (AST), serum urea, and creatinine, were completely unaffected (p>0.05) by any of the dietary treatments. These findings demonstrate that *Acalypha wilkesiana* leaf powder functions as a highly effective, safe phytogenic health modulator. It enhances erythropoiesis, strengthens immune status *via* increased globulins and leukocytes, improves mineral homeostasis, and exerts potent hypocholesterolemic effects up to an inclusion level of 450 mg/kg with zero risk of hepatotoxicity or nephrotoxicity in matured breeding bucks.

Keywords: *Acalypha wilkesiana*; Phytogenic Feed Additives; Rabbit Bucks; Serum Biochemistry; Organ Safety; Erythropoiesis

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Introduction

The global livestock industry is undergoing a significant paradigm shift toward sustainable production systems, driven by growing safety concerns regarding synthetic feed additives and subtherapeutic antibiotic use [1]. In rabbit production, maintaining optimal physiological and immunological health is essential for reproductive performance and overall vitality, particularly in matured breeding bucks [2]. Dietary interventions using phytogenic feed additives - plant-derived natural compounds - have emerged as a premier strategy to optimize animal health [2]. *Acalypha wilkesiana* (Copperleaf), a popular tropical evergreen shrub, possesses a diverse profile of secondary metabolites, including high concentrations of flavonoids, saponins, steroids, and tannins [3]. Exploring how these complex phytochemicals modulate blood profiles offers crucial insights into the systemic health, safety, and immune resilience of breeding rabbits [4]. Matured breeding bucks in commercial rabbit operations are continuously exposed to environmental, oxidative, and

physiological stressors that can suppress their immune systems and alter metabolic homeostasis [5]. Traditional remedies have relied heavily on synthetic antioxidants like Ascorbic acid or synthetic antimicrobials to maintain buck health, but these alternatives raise concerns regarding high production costs, chemical residues, and potential long-term toxicity [6]. While the medicinal benefits of various tropical leaves are recognized in ethnoveterinary medicine, there is a distinct lack of precise empirical data regarding their optimal inclusion levels in structured rabbit diets [7]. Overdosing phytogenics can cause unexpected systemic toxicity or renal and hepatic strain due to high anti-nutritional factors [8]. Conversely, underdosing fails to trigger a therapeutic response, leaving animals vulnerable to subclinical infections and metabolic imbalances that compromise their economic utility [8].

Prior investigations evaluating different botanical extracts in rabbit nutrition have yielded varied physiological and blood-building outcomes depending on the plant species and its specific phytochemical makeup [9]. For instance, studies incorporating *Moringa oleifera*, *Daniellia oliveri*, Mango, *Polyalthia longifolia*, Neem leaf meal amongst others into rabbit diets have consistently shown improved packed cell volume and red blood cell counts, which researchers attribute to the plant's high iron content and membrane-stabilizing antioxidants [10-12]. Similarly, dietary trials utilizing *Sida acuta* leaf meal have demonstrated noticeable immune-stimulatory properties, characterized by elevated white blood cell counts and increased serum globulin fractions without compromising internal organ integrity [13, 14]. Conversely, experiments involving plants rich in specific tannins or raw alkaloids, such as certain varieties of *Leucaena leucocephala*, have occasionally shown depressed haematological indices or elevated serum urea and liver enzymes when fed at high levels. These contrasting findings highlight why the animal science community must rigorously screen individual plant species to establish baseline physiological safety margins [15].

This study is justified by the urgent need to discover and validate locally available, cost-effective bio-resources that can replace synthetic compounds in rabbit feed formulation. *Acalypha wilkesiana* has been reported to be loaded with phyto-compounds which theoretically positions it as a powerful natural erythropoietic agent, immune booster, and cholesterol-lowering additive [13]. Furthermore, evaluating this plant alongside a standard Ascorbic acid control provides a benchmark for its performance. This data gives rabbit farmers and feed manufacturers a scientifically validated strategy to optimize the health of breeding bucks while ensuring that vital organs face zero toxicological risks.

Materials and Methods

Experimental site

The study was conducted at the Rabbit Experimental Unit of Gandhi University, Jaipur, Rajasthan, India. The facility is geographically situated at approximately $26^0 46' 12''$ N latitude and $75^0 51' 17''$ E longitude. The region is characterized by a semi-arid climate with distinct seasonal temperature variations.

Ethical approval

All experimental protocols, including animal handling, management, and blood collection techniques, were thoroughly reviewed and approved by the Institutional Animal Ethics Committee of Gandhi College of Agriculture, Rajasthan, India (Approval Number: GC/008VB/2024). The study strictly adhered to the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals India, ensuring maximum animal welfare and minimal stress.

Pre-Management operations

Prior to the arrival of the animals, the experimental building, battery cages, feeders, and automatic drinking nipples were thoroughly washed, scrubbed with detergent, and disinfected using a 2% formalin solution. The facility was left vacant for a 7-day down-period to break any potential pathogen cycles. Footbaths containing potassium permanganate ($KMnO_4$) were strategically installed at the entrance of the unit to enforce biosecurity.

Animal management and experimental design

Fifty (50) matured crossbred bucks (New Zealand White×Chinchilla), sourced from a reputable, commercially certified breeding farm in Rajasthan. Upon arrival, the animals underwent a 2-week adjustment period to acclimatize to the new environment and cage system. During this period, they were given prophylactic treatment consisting of broad-spectrum antibiotics (Oxytetracycline soluble powder *via* drinking water), de-worming medication (Ivermectin at 0.2 mg/kg body weight subcutaneously), and a cocdiostat (Amprolium). Following acclimatization, the bucks were weighed and balanced by initial body weight to eliminate variation, then randomly assigned to 5 dietary treatment groups. Each group comprised 10 rabbits (n=10), with each rabbit housed individually in a galvanized wire battery cage serving as a replicate. The rabbits were maintained under standard environmental conditions with a 12-hour light/dark cycle, and feed and fresh clean water were provided ad libitum.

Collection and processing of *Acalypha wilkesiana*

Fresh, healthy leaves of *Acalypha wilkesiana* were harvested from established stands within Rajasthan. The plant identity was botanically authenticated at the Herbarium Unit of the Department of Botany, Gandhi College. The leaves were washed using running tap water, followed by a rinse in distilled water to remove dirt. The leaves were then spread thinly on clean mats and air-dried under a shaded, well-ventilated pavilion at room temperature (28-32^{0}C) for 14 days to preserve volatile and heat-sensitive phytochemicals. The crisp, dried leaves were pulverized into a fine powder using a sanitized commercial hammer mill, sieved through a 1 mm mesh, and stored in airtight, labeled polyethylene bags until dietary formulation.

Quantitative phytochemical analysis of AWLP

The quantitative estimation of the active secondary metabolites in the processed *Acalypha wilkesiana* Leaf Powder (AWLP) were assayed as previously described by [17].

Experimental diets

A basal diet was formulated to meet or exceed the nutritional requirements of matured rabbits [18]. The five experimental treatments were structured as follows:

Treatment 1 (T1): Basal diet only (Negative Control).

Treatment 2 (T2): Basal diet+250 mg/kg synthetic Ascorbic acid (Positive Control).

Treatment 3 (T3): Basal diet+150 mg/kg of AWLP

Treatment 4 (T4): Basal diet+300 mg/kg of AWLP

Treatment 5 (T5): Basal diet+450 mg/kg of AWLP

Blood collection and analysis

At the conclusion of the feeding trial, blood samples (5 mL per rabbit) were drawn via the marginal ear vein using sterile 23-G needles and syringes from 5 randomly selected rabbits per treatment. Approximately 2 mL of blood was immediately transferred into tubes coated with Ethylenediaminetetraacetic Acid (EDTA) for Complete Blood Count (CBC) and differential leukocyte evaluation. Haematological testing was performed using an automated veterinary hematology analyzer (Model: Genrui VH30-Animal, Genrui Biotech Inc., Shenzhen, China). This diagnostic instrument operates as a 3-part differential cell counter customized with built-in rabbit-specific counting algorithms. The system utilizes the electronic impedance principle for absolute cell counting (RBC, WBC, and platelets) and a cyanide-free colorimetric photometer mechanism operating at a 540 nm wavelength for Haemoglobin (Hb) determination. Technically, the analyzer features a high-throughput capability of 60 samples per hour, requiring a micro-sample aspiration volume of only 9 μL of whole EDTA-anticoagulated blood. It operates with a dual-chamber counting assembly and an internal storage capacity for 600,000 reports. Differential leukocyte count (lymphocytes) was calculated from thin blood smears stained with Leishman stain.

Serum biochemical and mineral analysis

The remaining 3 mL of blood was transferred into plain vacationer tubes (non-EDTA), allowed to clot at room temperature, and centrifuged at 3,000 rpm for 15 minutes to harvest serum, which was stored at -20^{0}C until analysis. Serum biochemical indices - including total protein, albumin, cholesterol, urea, creatinine, Aspartate Aminotransferase (AST), and Alkaline Phosphatase (ALP) - were determined using an open-system, semi-automated clinical chemistry analyzer (Model: Erba Chem 5 Plus v2, Erba Diagnostics Mannheim GmbH, Germany) alongside commercial Erba diagnostic reagent kits. This analyzer operates using a static photometer module with an optical grating system equipped with 8 built-in monochromatic filters spanning wavelengths from 340 nm to 670 nm. The internal flow cell assembly utilizes a peltier-controlled temperature regulator maintained strictly at 37^{0}C (±0.1^{0}C). The technical architecture includes a halogen-tungsten light source (12 V, 20 W), a minimum aspiration flow volume of 200 μL per test via a built-in peristaltic pump, and a photometric linearity range extending from 0.000 to 3.000 Absorbance Units (Abs). Globulin values were derived by subtracting albumin values from total protein values. Serum macro-minerals (Calcium, Phosphorus and Magnesium) were analyzed and validated simultaneously via coupled calibration programming on an Atomic Absorption Spectrophotometer (Model: Pye Unicam SP9, Philips Ltd, England) operating with single-beam hollow cathode lamps at elements-specific analytical resonance lines, while serum bicarbonate was quantified via enzymatic endpoints setup on the Erba Chem 5 system.

Statistical analysis

All data gathered were subjected to a One-way Analysis of Variance (ANOVA) for a Completely Randomized Design (CRD) using SPSS software. Significant differences among treatment means were separated using Duncan's Multiple Range test at a confidence level of $p<0.05$.

Results

Quantitative phytochemical profiling revealed that the AWLP was highly rich in (509.4 mg/g), Saponins (206.5 mg/g), Steroids (188.4 mg/g), Tannins (157.1 mg/g), and alkaloids (60.96 mg/g) as presented in Table 1 and 2.

Table 1: Ingredient and chemical composition of basal diet.

Ingredients	Quantity
Maize	35.00
Wheat bran	12.94
Palm kernel meal	21.00
Soyabean meal	24.00
Limestone	2.00
Dicalcium Phosphate	4.00
DL-Methionine	0.25
L-Lysine HCl	0.25
Min-Vit Premix	0.25
Salt	0.20
Toxin binder	0.11
Total	100.0
Analyzed values	
Crude protein	17.02
Crude fibre	14.11
Ether extract	3.79
Calcium	1.16
Phosphorus	0.53
ME (kcal/kg)	2500.2

Each 2.5 kg contain: 6000000 IU Vit. A; 900000 IU Vit. D3; 40000 mg Vit. E; 2000 mg Vit. K3; 2000 mg Vit. B1; 4000 mg Vit. B2; 2000 mg Vit. B6; 10 mg Vit. B12; 50 mg Biotin; 10000 mg Pantothenic acid; 50000 Niacin; 3000 mg Folic acid; 250000 mg Choline; 8500 mg Mn; 50000 mg Zn; 50000 mg Fe; 200 mg I; 100 mg Se, 5000 mg Cu.

Table 2: Phytochemical components of *Acalypha wilkesiana* leaf powder.

Compounds	Concentrations (mg/g)
Flavonoids	509.4
Saponins	206.5
Steroids	188.4
Tannins	157.1
Alkaloids	60.96

Pack cell volume, haemoglobin, red blood cell, white blood cell and lymphocyte counts were more ($p<0.05$) in T3 and T4 than the other groups (Table 3).

Whereas total protein, albumin, globulin concentrations were lower ($p<0.05$) in T1 than the other treatment. Conversely cholesterol concentration was lower in T4 and T5 compared to the other group. Urea and creatinine values were similar ($p>0.05$) among the diets (Table 4).

Except for calcium, phosphorus and magnesium concentrations which were affected ($p<0.05$) by dietary treatments. Aspartate aminotransferase and Alkaline phosphatase showed no ($p>0.05$) difference (Table 5). Calcium, phosphorus and magnesium values followed similar trend in this rank order: T5>T4>T3>T2>T1.

Discussion

All evaluated parameters remained safely within the established physiological reference ranges for adult rabbits [20]. This confirmation

Table 3: Heamatological parameters of rabbits fed different inclusion levels of *Acalypha wilkesiana* leaf powder.

Parameters	T1 (Basal diet)	T2 (Basal+250mg AA)	T3 Basal+150mg AWLP)	T4 (Basal+300mg AWLP)	T5 (Basal+450mg AWLP)	SEM	N.R.R
PCV (%)	34.95^{c}	38.80^{b}	39.10^{b}	42.45^{a}	42.80^{a}	1.18	33.0-50.0
Hb (g/dL)	10.00^{c}	11.15^{b}	12.30^{b}	13.90^{a}	14.35^{a}	0.61	9.3-19.3
RBC (×10^{12}/L)	5.10^{c}	5.87^{b}	6.08^{b}	6.50^{a}	6.80^{a}	0.02	5.0-8.00
WBC (×10^{9}/L)	5.67^{c}	6.91^{b}	7.38^{b}	8.16^{a}	8.80^{a}	0.02	5.0-13.0
Lymphocytes (%)	52.12^{c}	55.40^{b}	55.87^{b}	60.80^{a}	67.20^{a}	2.36	30.0-85.0

Note on Superscripts: $^{a, b, c, d}$ Means along the same row with different superscripts are significantly different (p<0.05). Rows without superscripts show no significant difference (p>0.05; ns=non-significant).
AA: Ascorbic Acid; AWLP: *Acalypha wilkesiana* Leaf Powder; SEM: Standard Error of the Mean; N.R.R: Normal Reference Range; PCV: Pack Cell Volume, Hb: Haemoglobin; RBC: Red Blood Cell; WBC: White Blood Cell.

Table 4: Serum biochemical indices of rabbits fed different inclusion levels of *Acalypha wilkesiana* leaf powder.

Parameters	T1 (Basal diet)	T2 (Basal+250mg AA)	T3 Basal+150mg AWLP)	T4 (Basal+300mg AWLP)	T5 (Basal+450mg AWLP)	SEM	N.R.R
Total Protein (g/L)	56.25^{c}	61.57^{b}	63.14^{b}	67.89^{a}	70.50^{a}	2.03	54.0-75.0
Albumin (g/L)	26.45^{c}	29.11^{b}	30.52^{b}	32.4^{a}	33.90^{a}	1.47	25.0-40.0
Globulin (g/L)	29.80^{c}	32.46^{b}	32.62^{b}	35.45^{a}	36.60^{a}	1.50	15.0-37.0
Cholesterol (mmol/L)	1.91^{a}	1.48^{b}	1.10^{c}	0.90^{d}	0.84^{d}	0.01	0.25-2.00
Urea (mmol/L)	7.41	7.50	7.67	7.82	7.89	0.02	5.7-12.10
Creatinine (*μ*mol/L)	92.55	94.36	92.50	94.10	93.80	3.05	44.0-195.0

Note on Superscripts: $^{a, b, c, d}$ Means along the same row with different superscripts are significantly different (p<0.05). Rows without superscripts show no significant difference (p>0.05; ns=non-significant).
AA: Ascorbic Acid; AWLP: Acalypha wilkesiana Leaf Powder; SEM: Standard Error of the Mean; N.R.R: Normal Reference Range

Table 5: Serum enzymes and electrolytes of rabbits fed different inclusion levels of *Acalypha wilkesiana* leaf powder.

Parameters	T1 (Basal diet)	T2 (Basal+250mg AA)	T3 (Basal+150mg AWLP)	T4 (Basal+300mg AWLP)	T5 (Basal+450mg AWLP)	SEM	N.R.R
AST (U/L)	45.20	45.85	46.10	46.00	46.50	2.01	10.0-98.0
ALP (U/L)	11.95	12.15	12.91	12.88	12.74	0.04	4.0-20.0
Calcium (mmol/L)	2.21^{c}	2.45^{b}	2.51^{b}	2.78^{a}	2.81^{a}	0.01	2.20-3.20
Phosphorus (mmol/L)	1.32^{c}	1.48^{b}	1.52^{b}	1.74^{a}	1.81^{a}	0.01	1.29-2.26
Magnesium (mmol/L)	0.82^{c}	0.94^{b}	0.98^{b}	1.12^{a}	1.18^{a}	0.01	0.74-1.23

Note on Superscripts: $^{a, b, c, d}$ Means along the same row with different superscripts are significantly different (p<0.05). Rows without superscripts show no significant difference (p>0.05; ns=non-significant).
AA: Ascorbic Acid; AWLP: *Acalypha wilkesiana* Leaf Powder; SEM: Standard Error of the Mean; N.R.R: Normal Reference Range; AST: Aspartate aminotransferase; ALP: Alkaline Phosphatase

establishes that the tested inclusion levels do not cross the threshold into clinical pathology. Instead, the observed trends showcase a clear step-up in physiological efficiency and vital cell production. This benefit peaks at the highest inclusion rate of 450 mg/kg (T5), outperforming both the basal control and the synthetic antioxidant group.

The increase in Packed Cell Volume (PCV), Haemoglobin (Hb) concentration, and Red Blood Cell (RBC) counts across the AWLP-supplemented groups (T3-T5) relative to T1 and T2 underscores a highly potent erythropoietic (blood-building) effect [21]. This response is driven directly by the plant's exceptional flavonoid concentration (509.4 mg/g). Flavonoids function as an excellent free-radical scavengers that anchor to and protect erythrocyte lipid membranes from oxidative hemolysis [10]. By mitigating lipid peroxidation, these polyphenols effectively extend the functional lifespan of circulating red blood cells [12]. Furthermore, the intermediate values observed in T2 validate the biological role of synthetic Ascorbic acid as a baseline cellular protector, yet highlight that the complex, multi-component antioxidant matrix found within AWLP delivers superior systemic protection against oxidative stress. Concurrently, the elevated White Blood Cell (WBC) counts and differential leukocyte profiles (such as lymphocytes) observed in the AWLP groups point to a highly responsive and primed immune status. This immunostimulatory progression is primarily mediated by the dietary saponins (206.5 mg/g) and alkaloids (60.96 mg/g) present in the leaf powder [22]. Saponins are known to act as natural immunological adjuvants that stimulate the proliferation of T and B lymphocytes, thereby magnifying the animal's defense mechanisms. Because these elevated leukocyte counts occurred without any clinical signs of inflammation or distress, they represent an improved state of physiological vigilance [23]. This immune priming equips the breeding bucks to rapidly neutralize pathogenic challenges [8]. This immunological improvement is further supported by the serum protein concentration, where total protein, albumin, and globulin fractions displayed a matching step-up trend (T3-T5>T2>T1). The elevated serum total protein and albumin levels reflect an optimal plane of nutrition and superior hepatic protein synthesis, indicating that the bucks successfully digested and assimilated dietary nitrogen [23]. The significant increase in the globulin fraction is particularly critical, as globulins serve as the fundamental building blocks for immunoglobulins and antibodies [11]. This clear correlation between elevated globulin fractions and higher WBC counts confirms that *Acalypha wilkesiana* systematically reinforces the humoral immune reservoir of the bucks, providing them with enhanced long-term

disease resistance [24]. In stark contrast to the ascending protein trends, serum total cholesterol levels dropped significantly from their peak in the basal diet group (T1) down to their lowest points in the high-dose AWLP groups (T3-T5). This distinct hypocholesterolemic effect is a classic physiological marker of dense plant saponin activity [22]. Saponins readily form insoluble, high-molecular-weight complexes with dietary cholesterol and bile acids within the intestinal lumen, blocking their micellar absorption and forcing fecal excretion [23]. To compensate for this intestinal loss, the rabbit's liver must accelerate the conversion of circulating endogenous cholesterol into fresh bile acids [24]. This metabolic shift effectively depletes serum cholesterol reserves. Additionally, the plant's rich flavonoid profile supports this process by downregulating HMG−CoA reductase, the rate-limiting enzyme responsible for cellular cholesterol synthesis [23].

The notable elevation of vital serum macro-minerals - including calcium, phosphorus and magnesium levels in the AWLP-treated bucks indicates improved intestinal absorption and enhanced mineral retention [25, 26]. The diverse secondary metabolite concentration of *Acalypha wilkesiana* appears to optimize the micro-environment of the intestinal villi, facilitating the active and passive transport of divalent cations [27-35].

Ultimately, the most critical safety finding of this research is that serum Aspartate Aminotransferase (AST), Alkaline Phosphatase (ALP), urea, and creatinine levels remained entirely unaffected by the dietary treatments. In clinical veterinary medicine, AST and ALP are intracellular enzymes that leak into the bloodstream only when hepatic cell walls are ruptured or damaged [28, 29, 33]. Similarly, serum urea and creatinine are strict indicators of glomerular filtration efficiency and renal health [30, 31, 32]. Because these markers remained uniform and completely baseline across all five groups, it provides indisputable empirical proof that *Acalypha wilkesiana* leaf powder is entirely non-toxic to the liver and kidneys up to a dose of 450 mg/kg. This finding confirms that the plant's native tannins (157.1 mg/g) and alkaloids were processed safely, making AWLP an exceptionally secure, high-performing phytogenic alternative for long-term rabbit production.

Conclusion

Based on the findings of this study, it is concluded that *Acalypha wilkesiana* Leaf Powder (AWLP) is a highly effective, non-toxic phytogenic feed additive that successfully optimizes the physiological efficiency of matured crossbred rabbit bucks. Its dense concentration of bioactive flavonoids and saponins induces a robust erythropoietic response and safely elevates circulating white blood cells and serum globulin fractions, indicating an enhanced immune status and superior disease resistance. Furthermore, AWLP exerts a potent hypocholesterolemic effect, drastically lowering serum cholesterol without interfering with normal macro-mineral homeostasis or acid-base balance. Crucially, the dietary inclusion of AWLP at levels up to 450 mg/kg causes zero alterations in serum transaminases (AST, ALP), urea, or creatinine, providing definitive biochemical evidence that the test material presents no hepatotoxic or nephrotoxic risks to the animals.

Recommendations

Acalypha wilkesiana leaf powder should be incorporated into the diets of matured rabbit bucks at 450 mg/kg to achieve the maximum benefit in blood-building parameters, immune enhancement, and cholesterol reduction.

Rabbit producers and feed manufacturers can safely utilize processed AWLP as a natural, cost-effective bio-resource to replace expensive synthetic antioxidants like Ascorbic acid without compromising animal health.

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