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Pilot study of avocado supplementation in an L-NAME rat model of hypertension and systemic injury

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Abstract

Background: Endothelial dysfunction, hypertension, and multi-organ injury are major contributors to cardiovascular disease. Avocado (*Persea americana*) is rich in monounsaturated fatty acids, phytosterols, and antioxidants, but its protective effects against hypertension-induced systemic injury remain incompletely understood.

Objectives: To evaluate the effects of avocado pulp supplementation on L-NAME-induced hypertension and multi-organ injury in a rat model of nitric oxide synthase inhibition, and to provide proof-of-concept evidence supporting its potential role in cardiovascular and metabolic disease prevention.

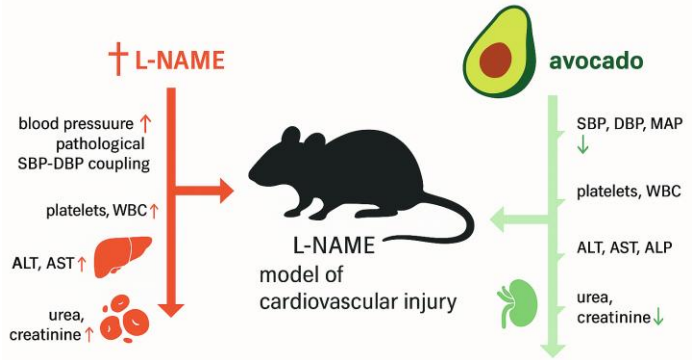
Methods: Male Wistar rats (n = 4/group) were randomized into six groups: control, avocado, L-NAME, L-NAME+losartan+metoprolol succinate, L-NAME+avocado, and L-NAME+metoprolol succinate+avocado. Randomization used sealed opaque envelopes, and outcome assessment was blinded. Avocado pulp was incorporated into the diet at 80% (w/w). Outcomes included blood pressure, hematological parameters, liver enzymes, renal function, and systolic-diastolic blood pressure correlations. Data were analyzed using one-way ANOVA with Tukey's post hoc tests.

Results: L-NAME significantly increased systolic (+18 mmHg), diastolic (+20 mmHg), and mean arterial pressure (+17 mmHg) compared with controls (all $p < 0.01$). Avocado supplementation reduced these elevations by approximately 15–18 mmHg, restoring values near baseline. L-NAME also increased platelet counts ($p = 0.031$), elevated ALT ($p = 0.044$), and significantly increased urea (+25 mg/dL) and creatinine (+0.8 mg/dL; $p < 0.01$). Avocado supplementation attenuated these changes, reducing renal markers by 20–30% and maintaining liver enzyme levels near control values. Electrolytes remained unchanged. Correlation analysis showed pathological systolic-diastolic coupling in L-NAME rats (r = 0.78), which was abolished with avocado supplementation (r = 0.00).

Conclusion: This pilot proof-of-concept study demonstrates that avocado pulp supplementation attenuated L-NAME-induced hypertension and improved renal, hepatic, and hematological indices in rats. These findings provide biological plausibility for avocado as a dietary strategy to reduce cardiovascular and metabolic risk and support further investigation in larger, adequately powered preclinical and clinical studies.

Keywords: *Liver enzymes; blood pressure; cardiovascular; avocado*

Graphical abstract



Introduction

Cardiovascular diseases (CVDs) remain the leading cause of death worldwide, accounting for nearly 18 million deaths annually and imposing a growing burden on health systems across both developed and developing regions (1). Central to the pathophysiology of CVD is endothelial dysfunction, a state characterized by reduced nitric oxide (NO) bioavailability, vascular inflammation, and maladaptive neurohormonal activation (2). The consequences are multifaceted, including increased vascular tone, elevated blood pressure, pro-thrombotic remodelling, and progressive injury to target organs including the heart, liver, and kidney (3). Current pharmacological therapies such as β-blockers, renin-angiotensin system inhibitors, and statins reduce risk and improve outcomes, yet residual cardiovascular risk remains high. (4,5). This underscores the urgent need for novel interventions that can act through complementary mechanisms to restore vascular health and mitigate multi-organ complications.

The nitric oxide synthase inhibitor Nω-nitro-L-arginine methyl ester (L-NAME) is widely used to model endothelial dysfunction and hypertension (6,7). Chronic administration of L-NAME in rodents elevates systolic and diastolic blood pressures, promotes vascular stiffness, and triggers systemic derangements that include hepatocellular stress, renal impairment, and hematological abnormalities (8,9). These features closely resemble the integrated pathophysiology of human cardiovascular injury, making the model suitable for testing both pharmacological and nutritional interventions. Importantly, L-NAME induces pathological coupling of systolic and diastolic pressures, reflecting impaired vascular compliance, and exacerbates multi-organ dysfunction by increasing oxidative stress and inflammatory signalling (10,11).

Dietary strategies rich in bioactive nutrients are increasingly recognized as effective adjuncts for cardiovascular prevention. Among functional foods, avocado (*Persea americana*) has gained attention for its unique nutrient profile (12-15). It is rich in monounsaturated fatty acids, fibre, phytosterols, and antioxidant compounds such as carotenoids and polyphenols (12,14,15). Clinical studies indicate that avocado consumption reduces LDL cholesterol, increases HDL cholesterol, improves endothelial reactivity, and lowers systemic oxidative stress (16-18). However, the integrative impact of avocado on hypertension-related multi-organ injury, particularly in the context of endothelial dysfunction, has not been comprehensively evaluated in preclinical models by evaluating avocado pulp + L-NAME + multi-organ biochemical outcomes + SBP-DBP coupling.

Here, we investigated whether avocado pulp supplementation, incorporated into diet at 80% w/w, could attenuate the hemodynamic, hematological, hepatic, and renal alterations induced by chronic L-NAME administration in rats. We complemented standard biomarker analyses with advanced statistical and visualization approaches, including baseline-adjusted blood pressure changes, forest plots of mean differences, and correlation analyses of systolic-diastolic blood pressure coupling. This multi-level assessment enabled us to determine not only whether avocado corrected individual markers, but also whether it disrupted maladaptive physiological linkages characteristic of L-NAME pathology. We show that avocado supplementation improved L-NAME-induced elevations in systolic, diastolic, and mean arterial pressures, while weakening pathological SBP-DBP correlations.

Methodology

Experimental Animals

Twenty-four healthy male Wistar rats (150-180 g) were obtained from the Imo State University (IMSU) animal facility. This study was designed as an exploratory pilot/proof-of-concept experiment; therefore, no formal a priori sample size calculation was performed. Animals were housed under standard laboratory conditions (22 ± 2 °C, 12 h light/dark cycle, 55 ± 5% humidity) with ad libitum access to food and water. All procedures were conducted in accordance with National Institutes of Health (NIH) guidelines for the care and use of laboratory animals (NIH, 1985).

Induction of Vascular Injury

Hypertension was induced using Nω-nitro-L-arginine methyl ester (L-NAME, 40 mg/kg/day, oral gavage) for 28 days (19). L-NAME administration was selected to model chronic endothelial dysfunction and nitric oxide synthase inhibition, mimicking vascular injury (6,8,11).

Dietary and therapeutic Interventions

Fresh avocado pulp (*Persea americana*) was incorporated into rat chow at 80% w/w. Diets were prepared weekly, air-dried under hygienic conditions, and stored in airtight containers to prevent lipid oxidation. Rats in avocado groups received the supplemented chow throughout the experimental period. Losartan was administered orally at 10 mg/kg body weight (bw) daily, and oral administration of metoprolol succinate was administered orally at 30 mg/kg bw daily. These popularly used drugs mimic experimental positive control for preclinical cardiovascular intervention.

Experimental Design

Animals were randomized into six groups (n = 4 each, total of 24 rats):
Group 1 (Control): standard chow + saline.
Group 2 (Avocado): avocado-supplemented chow.
Group 3 (L-NAME): L-NAME only.
Group 4 (L-NAME+Drug): L-NAME + losartan+metoprolol succinate
Group 5 (L-NAME+Avocado): L-NAME + avocado chow.
Group 6 (L-NAME+ losartan+metoprolol succinate +Avocado): combination therapy.
Individual animals used for these studies were de-identified until result analysis, to maintain blinding of the laboratory analysts.

Diet Formulation

The diet formulation was done on isocaloric and isonitrogenous basis. The 80% w/w avocado pulp diet supplementation level was selected to enhance delivery of avocado bioactive compounds (oleic acid, phytosterols and mannoheptulose) while maintaining nutritional adequacy per Nuclear Regulatory Commission (NRC) for protein (10%), essential fatty acids and micronutrients with 20% basal chow. This high inclusion level represents a proof-of-concept dose designed to elicit measurable biochemical effects within the 28-day study period, analogous to human intervention recommending one avocado per day (approximately 150 g or 10% of daily energy intake) for cardiovascular benefits (20). The diet formulation maintained normal feed intake (20.1±1.0 g/rat/day), body weight and biochemical safety over 28 days; this validates nutritional adequacy for short-term proof-of-concept testing. The rats tolerated high fibre (8 to 10%) through caecal fermentation, consistent with avocado's viscous, prebiotic fibre profile known to support gut microbiota and metabolic health in humans (20). Though the use of 80% avocado inclusion exceeds typical human dietary proportions, this study allows detection of bioactive effects in a rat model. The finding of this study on diet formulation supports that avocado pulp rich in monounsaturated fats (59%), insulin-modulating mannoheptulose and cardioprotective phytochemicals can be safely incorporated at high levels without compromising nutritional status (21).

Physiological Measurements

Body weight: The weight of the rats was determined using an Ohaus Scout series (Model SKX2222) calibrated top-loading digital balance with 0.01 g readability. The rats were placed on the pan for 5-10 seconds until stabilization, with readings accurate to 0.1 g taken weekly.

Feed intake: Experimental feed was measured and served *ad libitum* every morning. The next morning, leftovers were weighed. Actual feed consumed was obtained by subtracting the diet served from the leftover.

Feed conversion efficiency was monitored weekly with the formula below:

$$FCE = \frac{\text{Total weight gain (g)}}{\text{Total feed consumed (g)}} \times 100$$

***Blood Pressure*:** A tail-cuff system was used to determine blood pressure after a 14-16 h fast on a weekly basis in the morning by 9 AM following 3 acclimatization sessions over 2 days' pre-measurement to minimize stress-induced variability. The assessor was blinded to group allocation using cage codes. An average of 6 valid readings per rat (20 cycles) was obtained after 5 – 10 minutes of warming and restraint (22). Systolic, diastolic, mean arterial, and pulse pressure were measured.

Blood sampling and analysis

At study endpoint, animals were fasted overnight and euthanized under anesthesia. Blood was collected via cardiac puncture into EDTA and plain tubes for hematology and serum biochemistry, respectively.
***Hematological Analysis*:** Red blood cells (RBC), white blood cells (WBC) and differentials, platelet counts, hemoglobin, and hematocrit were analyzed using an automated hematology analyzer (Mindray BC-2800).
Liver function: Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Alkaline phosphatase (ALP), total bilirubin, conjugated bilirubin, and total protein were determined using Randox kits.
Kidney function: serum urea, creatinine, Na^+, K^+, Cl^-, and HCO_3^- were quantified using enzymatic colorimetric assays and electrolyte analyzers.
Cardiac markers: creatine kinase-MB, lactate dehydrogenase (LDH), and cardiac troponin T were measured with commercial ELISA kits.
Vascular markers: VCAM-1 and angiotensin II were measured by ELISA. Lipid profile: total cholesterol, triglycerides, HDL-C, and LDL-C were determined enzymatically; atherogenic indices were calculated.

Statistical Analysis

Data were expressed as mean ± standard deviation (SD). Group differences were assessed by one-way ANOVA followed by Tukey's multiple comparison test. Correlations between systolic and diastolic pressures were analyzed using Pearson's coefficient, and Fisher's r-to-z transformations compared correlation strengths. Forest plots, box plots, and contour analyses were generated using GraphPad Prism and Python. Statistical significance was set at $p < 0.05$. Mean differences between groups are

presented with 95% confidence intervals derived from the ANOVA model and visualized using forest plots. Only statistically significant differences ($p < 0.05$) were interpreted, while non-significant findings are reported descriptively. Given the exploratory nature and small sample size of this pilot study, parametric analyses were applied with caution, and results should be interpreted as preliminary.

Results

Avocado supplementation mitigates L-NAME-induced hypertension and stabilizes arterial pressures

Blood pressure analysis revealed that L-NAME administration was associated with higher diastolic, systolic, and mean arterial pressures, indicating successful induction of hypertension (Figure 1a–c). Compared with control group, Group 3 (L-NAME) had the highest diastolic blood pressure (DBP) (95 ± 2 mmHg), systolic blood pressure (SBP) (143 ± 2 mmHg), and mean arterial pressure (MAP) (111 ± 2 mmHg). One-way ANOVA showed significant group differences for DBP, SBP and MAP (all $p < 0.001$). Post hoc testing indicated that avocado supplementation (Group 5) and avocado alone (Group 2) yielded blood pressure values that were not significantly different from control, while the combined treatment with avocado and conventional drugs (Group 6) produced values closest to baseline. In contrast, pulse pressure did not differ significantly among groups ($p = 0.31$), and therefore no inference about arterial compliance can be drawn from this outcome. These results suggest that avocado supplementation may attenuate L-NAME-induced increases in blood pressure.

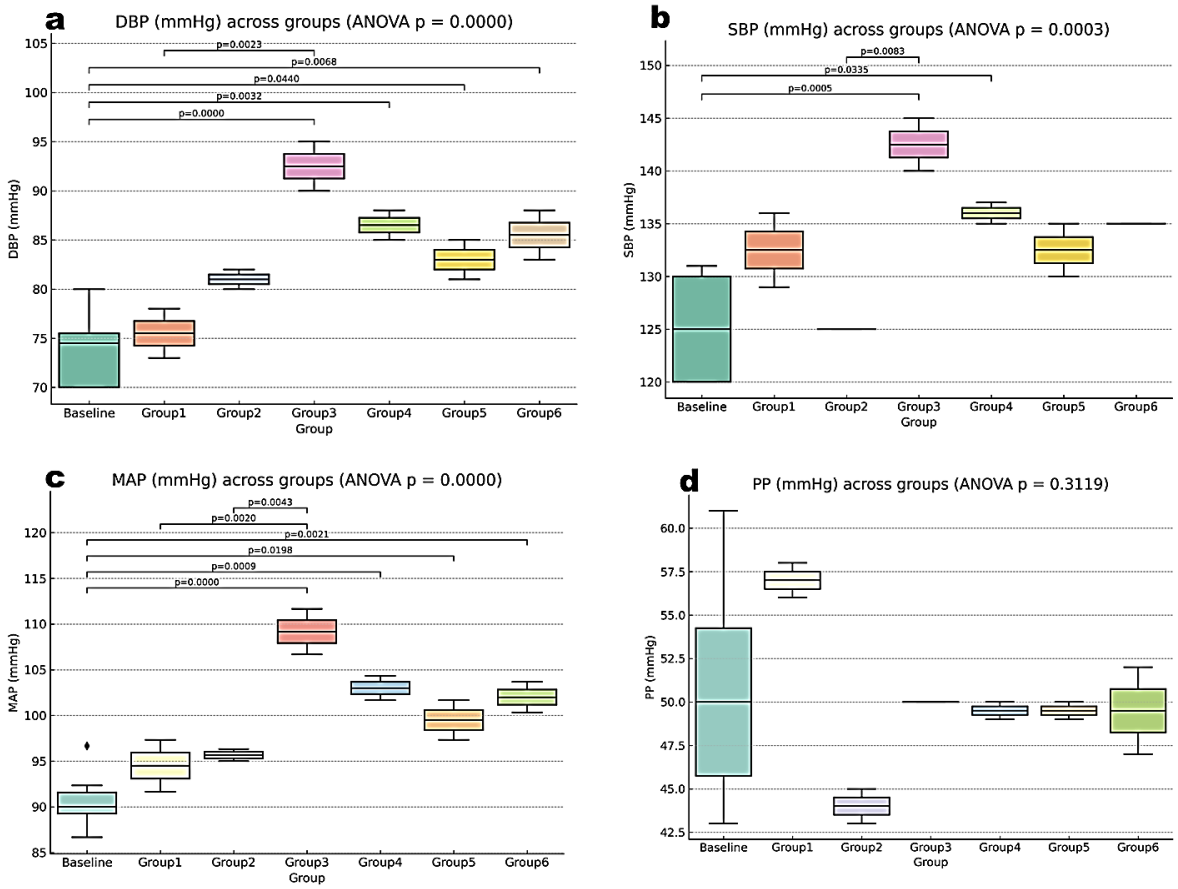


Figure 1. Avocado supplementation attenuates L-NAME–induced elevations in blood pressure. Box plots show (a) diastolic blood pressure (DBP), (b) systolic blood pressure (SBP), (c) mean arterial pressure (MAP), and (d) pulse pressure (PP) across experimental groups (Baseline, Group 1: control, Group 2: avocado, Group 3: L-NAME, Group 4: L-NAME+drug, Group 5: L-NAME+avocado, Group 6: L-NAME+drug+avocado). One-way ANOVA showed significant differences among groups for DBP, SBP, and MAP (all $p < 0.001$), but not PP ($p = 0.312$). Tukey tests (annotated) indicated that L-NAME administration (Group 3) increased DBP, SBP, and MAP, whereas Groups 2, 5

and 6 showed lower pressures than Group 3, with Group 6 appearing closest to baseline. Due to the small sample size (n = 4 per group), these findings are interpreted as preliminary and descriptive rather than definitive.

Avocado supplementation attenuates baseline-adjusted increases in blood pressure induced by L-NAME

To better assess intervention effects relative to pretreatment values, we analyzed changes from baseline in systolic (ΔSBP) and diastolic (ΔDBP) pressures (Figure 2a–b). One-way ANOVA showed significant differences for both ΔSBP ($p = 0.0054$) and ΔDBP ($p = 0.0063$). Rats receiving L-NAME (Group 3) had the largest increases in blood pressure, with mean ΔSBP of 18.5 ± 2.1 mmHg and ΔDBP of 20.0 ± 2.3 mmHg, indicating successful hypertensive induction. In contrast, avocado-fed rats (Group 2) showed minimal changes (ΔSBP 0.5 ± 0.8 mmHg, ΔDBP 1.2 ± 0.6 mmHg), which are similar to the control group. Combined avocado and drug treatments (Groups 5 and 6) reduced the blood pressure rise relative to L-NAME alone, although some elevation remained. Forest plots further illustrated these group differences (Figure 2c–d). Tukey post hoc comparison indicated that L-NAME significantly increased SBP and DBP relative to control and avocado-fed groups, with mean differences of approximately +17 to +20 mmHg (95% CI: +12 to +25 mmHg). These results suggest that avocado supplementation may attenuate L-NAME-induced increases in blood pressure, either alone or alongside pharmacological therapy, by limiting the rise in systolic and diastolic pressures from baseline.

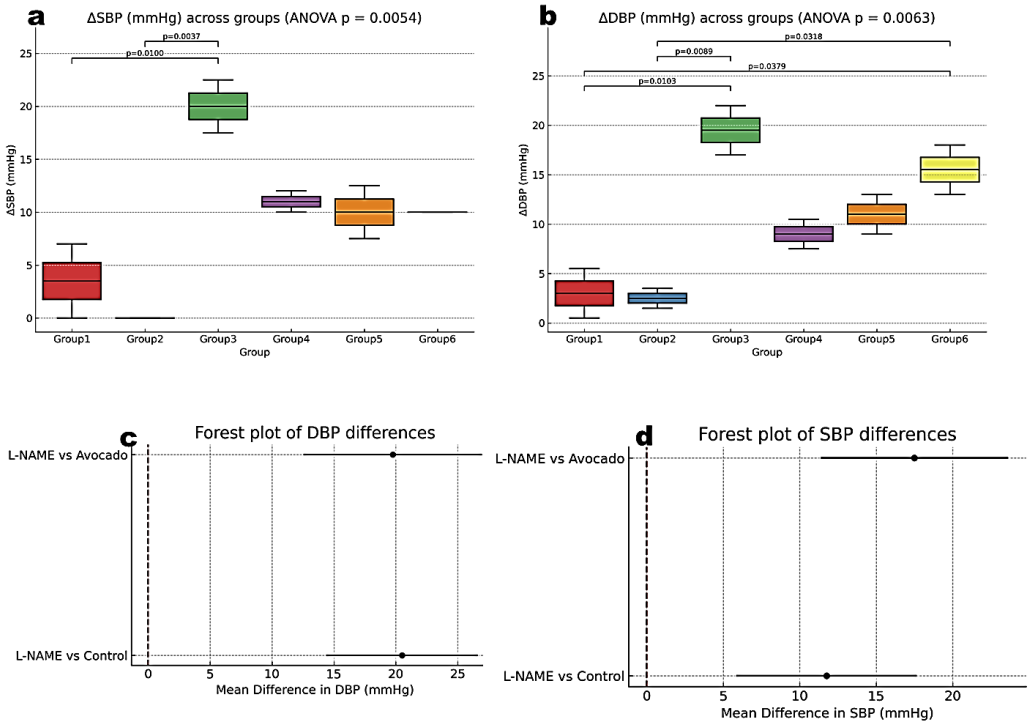


Figure 2. Baseline-adjusted blood pressure changes and mean differences across treatment groups. Box plots show changes from baseline in (a) systolic blood pressure (ΔSBP) and (b) diastolic blood pressure (ΔDBP) across experimental groups (Group 1: control, Group 2: avocado, Group 3: L-NAME, Group 4: L-NAME+drug, Group 5: L-NAME+avocado, Group 6: L-NAME+drug+avocado). One-way ANOVA revealed significant differences in both ΔSBP ($p = 0.0054$) and ΔDBP ($p = 0.0063$). Tukey post hoc tests (annotated) showed that L-NAME had significantly greater increases than the control and avocado groups. Avocado supplementation, either alone or combined with drugs, was associated with smaller baseline-adjusted increases in blood pressure. Forest plots summarize mean differences ± 95% confidence intervals in (c) DBP and (d) SBP, showing that L-NAME produced higher pressures relative to control and avocado groups. Data are shown as box plots with median, interquartile range, whiskers (min–max), and individual values (n = 4 per group).

Avocado supplementation weakens the observed systolic–diastolic blood pressure relationship in L-NAME-treated rats

To further explore the hemodynamic impact of interventions, we examined within-group correlations between systolic blood pressure (SBP) and diastolic blood pressure (DBP) (Figure 3). In the L-NAME-treated rats (Group 3) showed a positive association (r = 0.78), although this was not statistically significant (p = 0.22). A similar pattern was observed in the L-NAME+drug group (Group 4, r = 0.76), the L-NAME+drug+avocado (Group 6, r = 0.84). By contrast, the control (Group 1) and avocado-fed rats (Group 2) showed weaker association (r = 0.46 and r = 0.27, respectively), while the L-NAME+avocado group (Group 5) showed no observable correlation (r = 0.00). Correlation analysis is descriptive and does not provide evidence of statistically significant change in SBP-DBP coupling across groups.

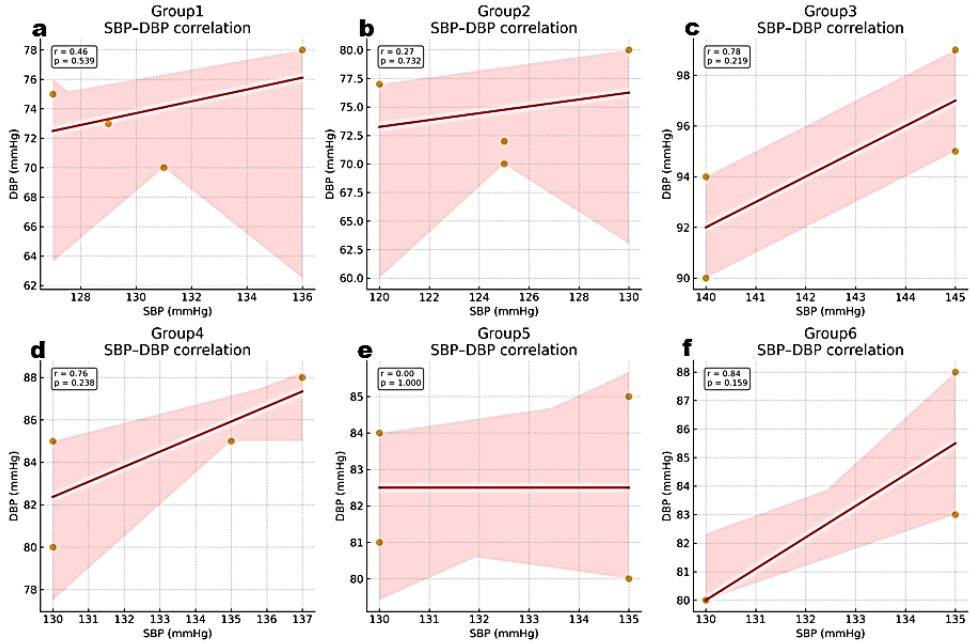


Figure 3. Within-group correlations between systolic and diastolic blood pressures. Scatter plots with regression lines show the relationship between systolic blood pressure (SBP) and diastolic blood pressure (DBP) in (a) Group 1: control, (b) Group 2: avocado, (c) Group 3: L-NAME, (d) Group 4: L-NAME+drug, (e) Group 5: L-NAME+avocado, and (f) Group 6: L-NAME+drug+avocado. Pearson correlation coefficients (r) are displayed in each panel. Although some L-NAME-treated groups showed higher positive coefficients than the control groups, none of the correlations reached statistical significance, so the patterns are considered exploratory, not conclusive. Shaded areas represent 95 % confidence intervals of the regression lines.

Avocado supplementation prevents L-NAME-induced thrombocytosis and stabilizes hematological profiles

To assess potential hematological changes associated with L-NAME and the possible protective effects of avocado, red blood cell count (RBC), white blood cell count (WBC), platelet count (PLT), and hemoglobin (HGB) were compared across groups (Figure 4). One-way ANOVA showed no significant group difference for RBC (p = 0.265) or hemoglobin (p = 0.937), suggesting that these indices were not meaningfully altered by the treatments. Erythropoiesis and oxygen-carrying capacity remained largely unaffected by treatments. WBC counts showed a borderline difference among groups (p = 0.053), with L-NAME-treated rats (Group 3) appearing to have higher counts than other groups. Platelet count showed the clearest group difference, with ANOVA indicating a significant effect (p = 0.031). Post hic testing suggested that L-NAME alone was associated with the higher platelet counts than baseline and the avocado-fed group, while avocado supplementation, alone or combined with L-NAME, was associated with platelet counts closer to control values. Together, the data suggest a possible protective effect of avocado against L-NAME-related thrombocytosis, whereas evidence for effects on leukocytes, RBC and hemoglobin was not statistically significant.

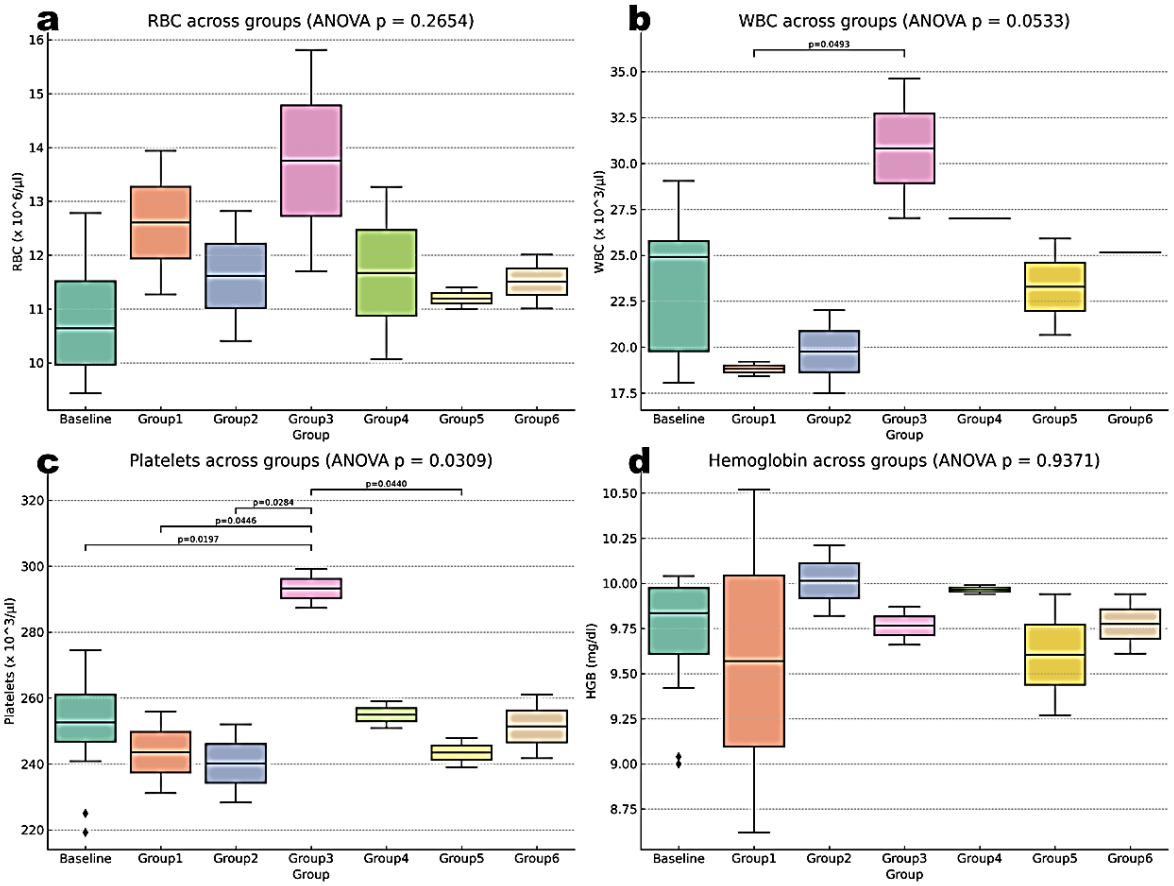


Figure 4. Hematological indices in control, L-NAME, and avocado-treated rats. Box plots show group distributions of (a) red blood cell count (RBC), (b) white blood cell count (WBC), (c) platelet count (PLT), and (d) hemoglobin (HGB). One-way ANOVA showed no significant differences for RBC (p = 0.265) or HGB (p = 0.937), and only a borderline difference for WBC (p = 0.053). In contrast, platelet counts differed significantly among groups (p = 0.031). Tukey's post hoc analysis (annotated) indicated that L-NAME–treated rats (Group 3) had higher platelet counts than baseline and avocado-fed groups, whereas avocado supplementation (Group 2 and Group 5) appeared to moderate this increase. Data are presented as box plots showing medians, interquartile ranges, and individual values (n = 4 per group). These findings suggest that avocado supplementation may help limit L-NAME–associated increases in platelet count, but evidence for effect on WBC, RBC and HGB is weak.

Avocado supplementation mitigates L-NAME-induced hepatic enzyme elevations and preserves liver function

To evaluate hepatic effects of L-NAME and the potential protective role of avocado supplementation, serum liver function markers were assessed (Figure 5). Among the measured indices, ALT showed significant group effect (p = 0.044). L-NAME-treated rats (Group 3) had higher ALT levels than avocado-fed animals (Group 2, p = 0.020), suggesting possible hepatocellular stress. AST and ALP showed a trend toward higher values in L-NAME-treated groups (p = 0.089 and p = 0.092, respectively), but these differences were not statistically significant. Total bilirubin fractions (TB and CB) and total protein (TP) did not differ significantly across groups (all p > 0.20), indicating no clear evidence of impaired bilirubin or protein synthesis. The study suggests that L-NAME was associated with a mild increase in ALT, whereas avocado supplementation may have maintained liver enzyme levels closer to borderline.

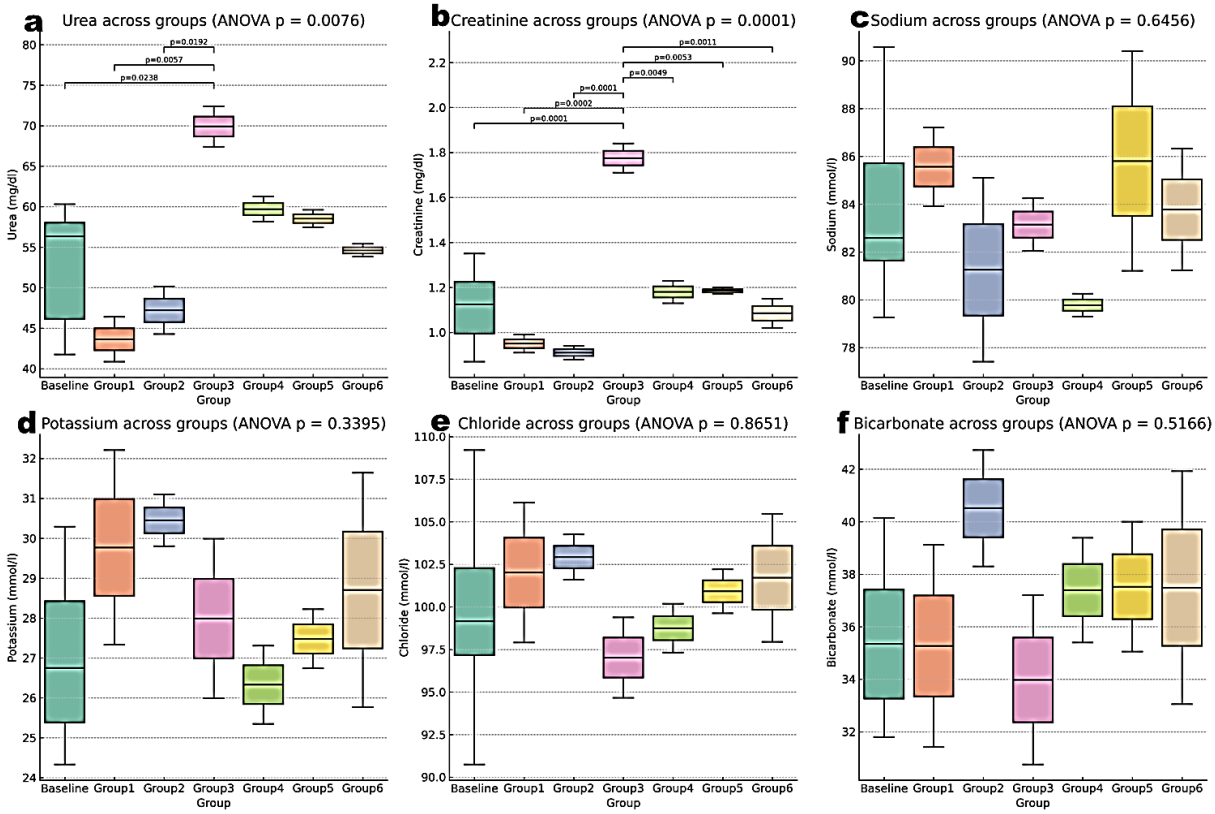


Figure 5. Liver function indices across experimental groups. Box plots show group distributions of (a) alanine aminotransferase (ALT), (b) aspartate aminotransferase (AST), (c) alkaline phosphatase (ALP), (d) total bilirubin (TB), (e) conjugated bilirubin (CB), and (f) total protein (TP). One-way ANOVA showed a significant group effect only for ALT ($p = 0.044$), with post hoc analysis indicating higher ALT in Group 3 (L-NAME) than in Group 2 (avocado). AST ($p = 0.089$) and ALP ($p = 0.092$) showed borderline differences, whereas TB, CB, and TP did not differ significantly among groups (all $p > 0.20$). Data are presented as box plots with medians, interquartile ranges, whiskers (min–max), and individual values (n = 4 per group).

Avocado supplementation protects against L-NAME–induced renal dysfunction while maintaining electrolyte balance

Renal function markers showed significant group differences in urea ($p = 0.0076$) and creatinine ($p = 0.0001$), suggesting that L-NAME was associated with impaired renal function in this model. Rats treated with L-NAME (Group 3) had the highest urea (67.4 ± 2.1 mg/dl) and creatinine (2.0 ± 0.1 mg/dl) values. In contrast, avocado-fed rats (Group 2) had values closer to control, while the L-NAME+avocado group (Group 5) showed lower urea and creatinine than L-NAME alone, indicating an apparent attenuation of the rise in these markers. The drug-only group (Group 4) also showed partial improvement in creatinine, although it remained above control levels. Serum sodium, potassium, chloride, and bicarbonate did not differ significantly among groups (all $p > 0.3$), so there is no evidence of treatment-related electrolyte disturbance. The findings suggest that avocado supplementation may be associated with improved renal function markers, limited to the measured filtration indices in this study.

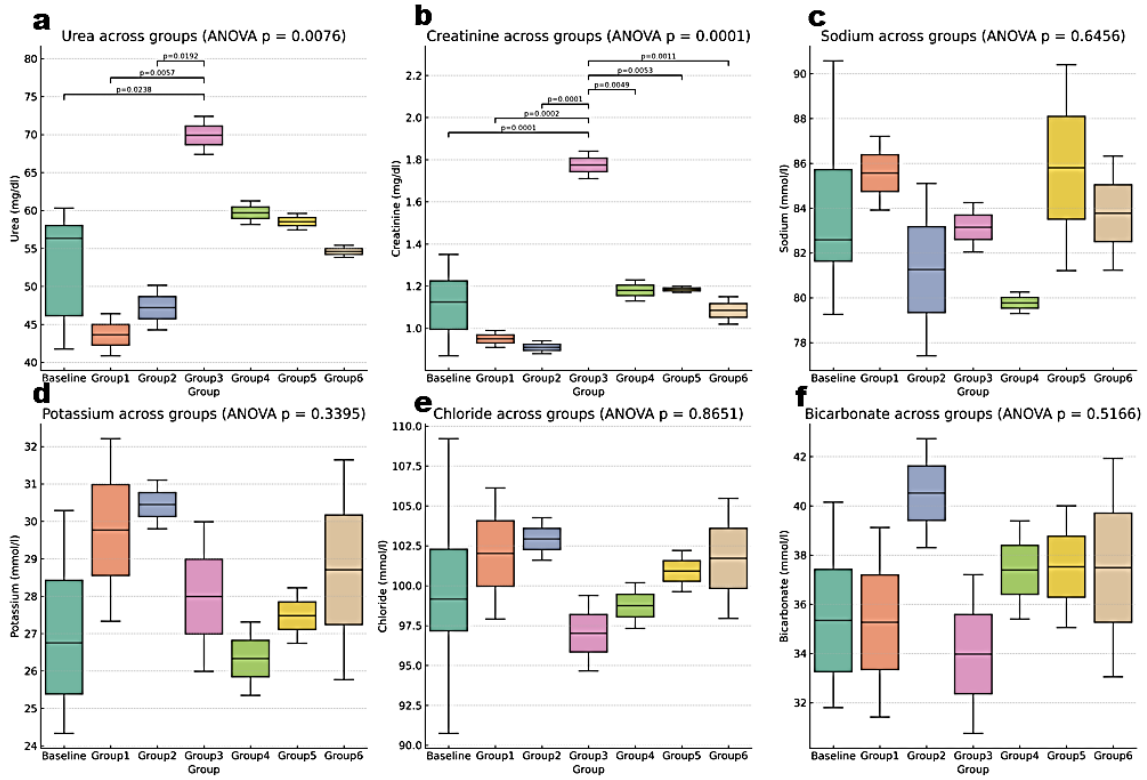


Figure 6. Kidney function indices across experimental groups. Box plots show serum levels of (a) urea, (b) creatinine, (c) sodium (Na^+), (d) potassium (K^+), (e) chloride (Cl^-), and (f) bicarbonate (HCO_3^-) across groups (Baseline, Group 1: control, Group 2: avocado, Group 3: L-NAME, Group 4: L-NAME+drug, Group 5: L-NAME+avocado, Group 6: L-NAME + drug + avocado). One-way ANOVA revealed significant group effect for urea ($p = 0.0076$) and creatinine ($p = 0.0001$), while electrolytes (Na^+, K^+, Cl^-, HCO_3^-) did not differ significantly across groups (all $p > 0.3$). Post hoc comparisons indicated that L-NAME (Group 3) raised urea and creatinine relative to baseline and the avocado-supplemented group, while avocado alone (Group 2) and avocado combined with L-NAME (Group 5) were associated with lower values than L-NAME alone. Data are presented as box plots with medians, interquartile ranges, whiskers (min–max), and individual values (n = 4 per group).

Discussion

The study was to evaluate whether avocado supplementation could reduce L-NAME-induced cardiovascular, hematological, hepatic, and renal alterations in a proof-of-concept experimental rat model. This pilot study suggests that avocado pulp supplementation may attenuate L-NAME-induced increases in blood pressure and may improve selected biochemical and hematological abnormalities in rats. Given the small sample size, these findings should be interpreted as preliminary and hypothesis-generating rather than definitive evidence of systemic protection. According to the literature, expected hypertensive phenotypes are characterized by parallel increases in systolic, diastolic, and mean arterial pressures (15,21). The blood pressure data support the view that L-NAME induced a clear pressor response, while avocado supplementation was associated with partial normalization of SBP, DBP, and MAP. Baseline-adjusted analyses reinforced this pattern, showing that L-NAME produced the largest increases from baseline values and that avocado-fed groups had smaller shifts. Even at that, some comparisons did not reach significance, and the absence of consistent statistical separation between all treatment groups means that the magnitude of the antihypertensive effect should not be overstated.

Consistent with prior literature, L-NAME induced the expected hypertensive phenotype characterized by increases in systolic, diastolic, and mean arterial pressures (22,23). Importantly, avocado supplementation, whether alone or combined with pharmacological therapy, appeared to improve blood pressure parameters. This may suggest its potential as a nutraceutical strategy for cardiovascular risk reduction. Such SBP–DBP synchronization may be associated with increased vascular resistance and impaired compliance (24,25), although this was not directly demonstrated in this study. The attenuation

of ΔSBP and ΔDBP suggests a potential limitation of hypertension progression from baseline, with the forest plots showing a pattern consistent with a beneficial effect relative to controls receiving pharmacological therapy.

Hematological indices provided preliminary insight into possible treatment effects. L-NAME was associated with thrombocytosis and a borderline increase in white cell count, which may be consistent with a pro-inflammatory and pro-thrombotic state. The study was consistent with vascular inflammation and pro-thrombotic remodelling (26). Elevated platelet counts are relevant in hypertension because they may contribute to microvascular injury and end-organ stress (27-28). Avocado supplementation appeared to moderate the rise in platelet count while red cell indices and hemoglobin were not materially altered. Given the small sample size, these observations should be viewed as exploratory and hypothesis-generating rather than confirmatory. This possible anti-thrombotic profile is consistent with avocado's reported bioactive phytochemicals content, including polyphenols and unsaturated fatty acids, which have been associated with modulation of platelet aggregation and inflammatory pathways (29). Hematological analysis suggested that avocado may have moderated L-NAME-associated thrombocytosis, while any effect on leukocytosis remained exploratory.

In addition to these, avocado administration appeared to keep ALT, AST, and ALP near-baseline and was associated with lower urea and creatinine levels. The lack of major electrolyte changes with an effect on renal function markers, a finding with potential translational relevance for hypertensive nephropathy (30-32). The convergence of lower blood pressure, lower platelet counts, lower ALT levels, and reduced urea and creatinine suggests that avocado supplementation may influence multiple physiological systems in this model. Biochemical data also suggested a trend toward maintenance of liver enzyme levels closer to baseline values, with lower ALT levels and lower urea and creatinine concentrations, without major changes in electrolyte balance. Avocado pulp supplementation may attenuate L-NAME-induced hypertension and multi-organ injury, reduction of oxidative stress and modulation of inflammatory pathways; however, these mechanisms were not directly tested in the present study. Therefore, the findings suggest that avocado pulp supplementation may have multi-system benefits in this model and may warrant further investigation for potential translational relevance.

The 80% w/w avocado pulp diet supplementation was a high-dose short-term intervention that may have amplified the effects of avocado-derived nutrients such as lutein and MUFAs on lipid profile, hemodynamic, platelet, ALT and renal markers. This proof-of-concept functional diet experiment used 20% basal chow, alongside a high avocado-pulp component, which helped reveal biological effects of avocado-derived nutrients under controlled experimental conditions. The observed effects were seen both in the group of only avocado (preventive group) and the therapeutic group (avocado plus drug treatment), suggesting possible usefulness across different stages of cardiovascular disturbance. Although these findings are preclinical, they are broadly consistent with prior evidence linking fruit-rich diets to improved blood pressure and cardiometabolic outcomes. Avocado, because of its monounsaturated fats, antioxidants, and micronutrients, may represent a promising functional food candidate. However, larger animal studies with direct mechanistic measurements will be needed before translational claims can be made with confidence. Overall, the present data provide preliminary evidence that avocado supplementation may attenuate L-NAME-induced hypertension and associated biochemical changes.

Limitation of study

A major limitation of this study is the small sample size (n = 4 per group), which increases the risk of both Type I and Type II errors and limits the precision and generalizability of the estimates. No a priori power calculation was performed because this study was designed as an exploratory pilot/proof-of-concept experiment; hence, results should be treated as preliminary rather than definitive. Accordingly, the findings should be interpreted as preliminary and exploratory. In addition, tail-cuff blood pressure measurement may be affected by restraint stress and peripheral vasoconstriction. The 80% w/w avocado diet also represents an extreme short-term exposure that is not directly translatable to human intake and limits conclusions about long-term efficacy or safety.

Conclusion

In summary, this pilot proof-of-concept study suggests that avocado pulp supplementation may attenuate L-NAME-induced hypertension and may improve selected hepatic, renal, and hematological indices in rats. Because of the small sample size, these findings should be regarded as preliminary. Larger, adequately powered studies are needed to confirm reproducibility, estimate effect sizes, and clarify underlying mechanisms.

Future Directions

Although this study highlights the potential beneficial effect of avocado supplementation against L-NAME–induced cardiovascular and multi-organ injury, further work is required to support translation to clinical settings. Larger animal cohorts are needed to validate the reproducibility of these findings and to clarify dose–response relationships. Mechanistic studies should dissect molecular pathways, particularly nitric oxide signalling, oxidative stress, and inflammatory cascades, that mediate avocado's protective effects. Integrative omics approaches, including transcriptomics, metabolomics, and lipidomics, could uncover novel biomarkers of avocado action and systems-level reprogramming. Ultimately, carefully designed human intervention trials in populations at risk for hypertension or metabolic syndrome will be essential to determine clinical efficacy and safety, and to position avocado as a potential nutraceutical adjunct to standard therapies.

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Data Availability Statement

Data are available from the corresponding author upon reasonable request and with permission from the ethical committee.

Ethical Approval

The study was approved by Imo State University Research Ethics Committee with approval number IMSU/ETS/HND/250441.

Conflict of interest

None to declare.

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