Nigerian Journal of Pharmaceutical and Biomedical Research
Vol. 10 Issue.2 August, 2026. p-ISSN: 2579-1419 e-ISSN: 2814-1423

EFFECTS OF AQUEOUS EXTRACT OF *GONGRONEMA LATIFOLIUM* ON CARDIOVASCULAR AND BIOCHEMICAL RESPONSES TO SALT LOADING IN MALE WISTAR RATS

Abidoye A. Oladele[1*], Elijah A. Sarah[1]and Ogungbemi S. Idowu[2]

[1]Department of Physiology, Lagos State University College of Medicine, Ikeja, Lagos
[2]Department of Physiology, College of Medicine, University of Lagos, Idi-Araba, Lagos
Author Email: adebayo.abidoye@lasucom.edu.ng DOI 10.5281/zenodo.24005940

ABSTRACT

Background: Excessive salt consumption has been associated with cardiovascular dysfunction. While salt-induced hypertension represents one of the most prevalent and modifiable forms of hypertension in Nigeria, the role of aqueous *Gongronema latifolium* extract on salt-induced hypertension has not been fully investigated.
Objective: The study investigated effects of aqueous *Gongronema latifolium* extract on cardiovascular and biochemical responses to salt loading in male Wistar rats.
Methods: Thirty adult male Wistar rats were randomly assigned into five groups of six rats each namely: the control, salt-loaded (8% salt diet), salt loaded + low dose extract (200 mg/kg), salt loaded + high dose extract (400 mg/kg) and extract only (400 mg/kg). *Gongronema latifolium* extract was administered by oral gavage for six weeks. Cardiovascular parameters (systolic, diastolic, mean arterial blood pressure and heart rate) were measured via an invasive method while biochemical parameters (plasma total cholesterol, triglycerides, low-density lipoprotein, high-density lipoprotein, sodium, potassium, aspartate aminotransferase, and alanine aminotransferase levels) were determined via assays.
Results: Salt loading significantly elevated systolic and diastolic blood pressure ($p < 0.01$), mean arterial blood pressure ($p<0.001$), heart rate ($p<0.01$), plasma sodium ($p<0.001$), total cholesterol ($p<0.05$), low-density lipoprotein levels ($p<0.01$) and significantly reduced high-density lipoprotein cholesterol levels ($p<0.01$). However, concomitant administration of the extract significantly attenuated the salt-induced increases in blood pressure ($p<0.05$; $p<0.01$), sodium ($p<0.05$; $p<0.01$) in dose-dependent manner and LDL ($p< 0.01$). Plasma triglyceride concentrations were also significantly lowered ($p<0.05$) while high- density lipoprotein cholesterol concentrations were appreciably raised ($p < 0.05$) by the extract.
Conclusion: These findings suggest that aqueous *Gongronema latifolium* extract ameliorates salt-induced hypertension by suppressing hypernatremia and improving dyslipidaemia.

Keywords: Salt-induced hypertension, cardiovascular system, lipid profile, *Gongronema latifolium*

INTRODUCTION

Dietary salt, known as sodium chloride, plays a key role in fluid maintenance, nerve and muscle functions (Strazullo and Leclercq, 2014). However, excessive salt consumption has been consistently associated with increased blood pressure (Grillo *et al*., 2019; Han *et al.,* 2025). Out of about 1.3 billion people that hypertension affects, worldwide (Nehme *et al.,* 2025), persistent elevation of blood pressure is a major risk factor responsible for heart, blood vessel, brain, retina and kidney damages (Mensah, 2016); causing

more than 10 million avoidable deaths, yearly, globally (Patel *et al.*, 2016).

Although, pathophysiology of salt-induced hypertension is multifactorial (Maaliki *et al*., 2022), excessive salt intake promotes water retention, increasing plasma volume and cardiac output; over time, compensatory vasoconstriction raises peripheral vascular resistance, resulting in sustained elevation of blood pressure (Kazi, 2025).Besides, hypertension induces progressive biochemical alterations that serve as indicators of organ damage (Rubattu *et al.,* 2015). These include disturbances in electrolytes balance, dyslipidaemia, and elevated liver enzyme activities such as alanine aminotransferase. (ALT); aspartate aminotransferase (AST), resulting from hepatic oxidative stress and compromised circulation (Harrison *et al.,* 2021). Therefore, assessing these biochemical parameters alongside cardiovascular measurements, provides a complete picture of the hypertensive disease burden and the effectiveness of any therapeutic intervention (Harrison *et al* 2021).

While conventional antihypertensive drugs are effective, long-time patient's compliance with the medications still remains poor due to the drugs' adverse effects, high cost of purchase, especially in low- income countries such as ours, Nigeria (Park *et al*., 2020; Ojangba *et al*., 2023). Hence, these have rekindled scientific interests in medicinal plants as safer, more affordable alternatives *Gongronema latifolium* is a rain forest, leafy green plant, commonly used for its nutritional and medicinal values in traditional medicine (Amrelia, 2022). The phytochemical evaluation of the plant shows the presence of flavonoids, saponin, alkaloids, steroids, glycosides among others (Agwaramgbo *et al*., 2014). It is locally called Utazi in the Eastern part of Nigeria (Gabriel *et al.,* 2014). The nutritional composition includes carbohydrates, protein, amino acids, vitamins, minerals and fats (Amrelia, 2022).

It is well documented in literature for its antioxidant, hypoglyaecemic and antimicrobial properties (Eleyinmi, 2007; Aba and Ifeanyi, 2018; Ojo *et al*., 2020), There is paucity of data regarding its effect on salt-induced hypertension. Although, salt-induced hypertension represents one of the most prevalent and modifiable forms of hypertension in Nigeria (Ojangba *et al.,* 2023), yet no study has specifically examined how aqueous *Gongronema latifolium* extract influences physiological responses to salt loading. This study therefore investigated effects of aqueous *Gongronema latifolium* extract on cardiovascular and biochemical responses to salt loading in male Wistar rats.

METHODS: Thirty male Wistar rats, weighing 100-150g were purchased from a local laboratory animal breeder in Lagos State, Nigeria. The experimental rats were housed in clean plastic cage under standard laboratory conditions with adequate ventilation. They were acclimatized for two weeks before the commencement of the experiment and had free access to standard pellet feed and clean drinking water throughout the study. All experimental procedures were conducted in accordance with internationally accepted principles for the care and use of laboratory animals. Fresh leaves of *Gongronema latifolium were* spurchased from Mile 12 Market, Lagos State, Nigeria. The plant was identified and authenticated by a botanist at the Department of Botany, Lagos State University.

Ethical Approval

The study was conducted in accordance with internationally accepted principles for laboratory animals use and care, as outlined in the Guide for the Care and Use of Laboratory Animals, published by the National Institutes of Health (NIH, 2011) and ethical approval was obtained from Lagos State University College of Medicine-Health Research Committee with Reg. No: NHREC/LASUCOM-HREC/10/10/25

Experimental Design

A total of thirty adult male Wistar rats were used for the study, the rats were acclimatized for two weeks and housed in separate cages and were divided into five groups of six animals each.Group 1 rats were the control. They were fed with standard rat diet and water throughout the experimental period.Group 2 rats received a formulated rat feed, containing 8% salt to induce hypertension without extract treatment for six weeks (Zheng *et al.,* 2023). Group 3 rats were administered with formulated rat feed, containing 8% salt and aqueous *Gongronema latifolium* extract at a dose of 200mg/kg body weight orally, daily for six weeks (JohnKennedy and Adamma, 2011). Group 4 rats received a formulated rat feed, containing 8% salt and aqueous *Gongronema latifolium* extract at a dose of 400mg/kg body weight orally, daily for six weeks (JohnKennedy and Adamma, 2011) while group 5 animals were administered with standard rat diet and aqueous *Gongronema latifolium* extract orally, daily for six weeks.. Extract was administered by oral gavage using an appropriate-sized cannula throughout the experimental period.

Preparation of the Aqueous Extract

Fresh leaves of *Gongronema latifolium* were washed thoroughly with clean tap water and air-dried at room temperature (25-27°C) for three weeks. The dried leaves were pulverized into coarse powder using an electric blender. Two hundred grams (200g) of the powdered leaves were soaked in 2L of distilled water and allowed to macerate for 72 hours at room temperature with intermittent stirring. The resulting mixture was filtered through a clean white handkerchief. The filterate was concentrated using a water bath maintained at 50 – 55°C until a dry extract was obtained. The dried extract was weighed to determine the percentage yield, transfer into an airtight container, and stored at 4°C until use. The required dose was freshly reconstituted in distilled water before oral administration.

Determination of Cardiovascular Parameters

The cardiovascular parameters measured in the study were carried out in the laboratory of Physiology Department of College of Medicine University of Lagos, Blood pressure in mmHg was measured invasively at the end of experimental period (6 weeks).Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were determined by cannulating carotid artery of each of the anaesthetized rats and connecting the catheter to a Force transducer (Labscribe). Heart rate in beats per minute was simultaneously recorded from the pressure transducer. Mean arterial pressure (MABP) was calculated from SBP and DBP readings, using the formula: MABP = DBP+ 1/3(SBP - DBP) (Octavio *et al*., 2025).

Collection of Blood Samples and Determinations of Laboratory Parameters

At the end of the six-week experimental period, the rats were fasted overnight. The animals were anaesthesized using urethane and blood samples were collected through the carotid artery cannulation and emptied into heparinized sample bottles. The samples were centrifuged at 3000 rpm for 15 minutes, after which the plasma was transferred into clean labelled red-top sample bottles and stored at -20°C until biochemical analyses. The biochemical parameters that were determined were plasma sodium, potassium, total cholesterol, low density lipoprotein cholesterol (LDL) high density lipoprotein cholesterol (HDL), triglyceride, aspartate aminotransferase (ASP) and alanine aminotransferase (ALT) levels. Plasma sodium and potassium concentrations were determined colorimetrically using the Fortress Diagnostic Sodium Monoliquid kit (Cat No. BXC0146 and Cat. No BX 132, respectively), according to the manufacturer's instructions. Total

cholesterol was determined by CHOD-PAP enzymatic colorimetric method using the Fortress Diagnostic Cholesterol kit (Cat No. BXC0261), according to manufacturer instructions. High-density lipoprotein cholesterol (HDL-C) was determined directly using the Fortress Diagnostic HDL Cholesterol kit (Cat No. BXC0421). Plasma triglyceride levels were determined by the enzymatic GPO-PAP colorimetric method using Fortress Diagnostic Triglycerides Monoliquid kit (Cat No. BXC0271), according to manufacturer's instruction. LDL cholesterol was calculated indirectly from the values of total cholesterol, HDL cholesterol, and triglycerides using the Friedewald equation (Friedewald *et al.,* 1972). AST activity was determined kinetically by the IFCC method using the Fortress Diagnostic AST (GOT) kit (Cat No. BXC0203). ALT activity was determined kinetically by the International Federation of Clinical Chemistry (IFCC) method, using the Fortress Diagnostic ALT (GPT) kit (Cat No. BXC0213)

Statistical Analysis

Data Analysis was carried out using GraphPad statistical software, version 8.02 Window (GraphPad Software CA, USA). Data were expressed as mean ± standard error of mean (SEM). Variations in data among the experimental groups were analyzed using One-way analysis of variance (ANOVA), followed by Tukey's post-hoc test for multiple comparisons. Statistical significant was accepted at $p < 0.05$.

RESULTS

Effects of *Gongronema latifolium* on Cardiovascular Responses to Salt Loading

Salt loading significantly ($P < 0.01$) raised systolic blood pressure (SBP). However, upon administration of aqueous extract of *Gongronema latifolium*, the salt-induced elevation in blood pressure fell significantly ($P < 0.01$). The extract did not have a significant effect on SBP in a normotensive state (Figure 1). Besides, salt loading more appreciably elevated ($p < 0.001$) diastolic blood pressure (DBP) but upon administration of the extract, the blood pressure decreased significantly. The reductions in DBP were dose- dependent with greater decreased ($p < 0.01$) in rats administered with 400 mg/kg than those ingested 200 mg/kg ($P < 0.05$; Figure 2). Furthermore, salt ingestion significantly ($p < 0.001$) elevated mean arterial blood pressure but the extract appreciably lowered ($p < 0.001$)(Figure 3). The heart rate was also significantly ($p < 0.01$) raised by salt loading. However, the salt-induced increase in heart rate fell ($p < 0.05$) (Figure 4).

Effects of *Gongronema latifolium* on Biochemical Parameter Responses to Salt Loading

Plasma sodium concentration levels were significantly ($p < 0.001$) increased by salt consumption but the elevations were significantly lowered by 200 mg//kg ($P < 0.05$) and 400 mg/kg ($p < 0.01$) of the extract (Table 1). However, salt did not significantly lower plasma potassium levels. Besides, the extract did not significantly elevate the plasma potassium concentrations. Furthermore, salt loading did not have any significant increase on AST and ALT levels and the extract did not appreciably decrease the concentrations. However, salt loading significantly ($p <0.05$) raised total cholesterol levels but these concentrations were not significantly lowered by the extract. On low density lipoprotein (LDL) cholesterol cholesterol levels, salt ingestion significantly ($P < 0.01$) raised the concentrations but the levels significantly fell upon administrations of the high dose of the extract. Similarly, salt loading appreciably lowered high density lipoprotein cholesterol ($p < 0.01$) levels but the concentrations were increased significantly ($p < 0.05$) upon administrations of high dose (400 mg/kg) of the extract. Salt loading did not have a significant effect on plasma triglyceride levels. However, upon administration of the

extracts, the concentrations were significantly ($p < 0.05$) reduced. In this study, however; the extract did not have any significant effects on the plasma sodium, potassium, AST, ALT, Total cholesterol, LDL cholesterol, HDL cholesterol and triglyceride levels.

DISCUSSION

On blood pressure, salt loading significantly raised SBP, DBP and MABP. These findings were not quite surprising as excessive salt consumption has been associated with increased blood pressure (Grillo *et al.,* 2019; Kazi, 2025). Prolonged sodium intake promotes expansion of blood volume which can be associated with water retention (Kazi, 2025; Surma *et al.,* 2025), increased peripheral resistance, altered endothelial dysfunction and sympathetic activity (Grillo, *et al.,* 2025; Kazi, 2025). Cardiovascular diseases are the leading cause of premature deaths, worldwide (Flora and Nayak, 2019) and sustained elevation of blood pressure is the most important risk factor (Kjeldsen, 2018). Besides, salt loading appreciably increased heart rate. Elevated resting heart rate is associated with increased blood pressure (Reule and Dawz, 2012), since blood pressure is the product of peripheral resistance and cardiac output (Madger, 2018; Shahoud *et al.,* 2026)). Also, salt consumption significantly elevated plasma sodium, total cholesterol, low density lipoprotein (LDL) cholesterol concentrations and decreased high density lipoprotein (HDL) cholesterol levels. Abnormally increased plasma sodium level is an independent risk factor for stroke (Gardener *et al.,* 2012) and chronic kidney disease (Kuwabara *et al*., 2017; Mei *et al.,* 2025).There are nearly 12 million cases of stroke every year, globally; and 1 out of 4 people more than age 25 years, will have a stroke in their lifetime (Feigin *et al.,* 2025). Chronic kidney disease is a progressive worsening medical condition that affects more than 10% of the general population, worldwide (Kovesdy *et al*., 2022). Abnormally elevated plasma total cholesterol and LDL cholesterol concentrations imply hypercholesterolemia which has been associated with early developments of atherosclerosis and coronary heart disease (Abera *et a*l., 2024). Infiltration and retention of apoB, the main structural protein of LDL, in the artery wall, is a critical initiating event that sparks an inflammatory response and promotes the development of atherosclerosis (Linton *et al.,* 2019). Hypercholesterolemia is the underlying cause for one-third of ischemic heart disease and responsible for about 2.6 million deaths, globally (Nelson, 2013; Abera *et al.,* 2024). From epidemiological studies, there is an inverse relationship between risk for atherosclerotic cardiovascular events and HDLcholesterol levels (Cho and Jung, 2021; Linton *et al*., 2019).

However, upon the concomitant administration of aqueous extract of *Gongronema latifolium*, the salt induced increases in SBP, DBP, MABP and heart rate were all significantly ameliorated. These findings suggest that the extract has antihypertensive and antiarrhythmic effects. The ameliorative effects on the cardiovascular function could be due to active phytochemical constituents of the plant as it has been documented that *Gongronema latiforium* possesses flavonoids, oleanolic acid derivatives, saponin and tannis among others. The combined effects of these bioactive constituents reduce blood pressure (Bachheti *et al*., 2022).Flavonoids are active polyphenolic compounds that promote cardiovascular function especially in a hypertensive state as they mediate their antihypertensive actions by promoting nitric oxide bioavailability, lwering endothelial cell oxidative stress or possibly regulating vascular ion channel activity ((Maaliki *et* **al.**, 2019; Wan *et al*., 2024). Oleanolic acid on the other hand, aside a role that it plays in nitric oxide (NO) restoration in blood vessels, it also regulates lipid metabolism (Zhang *et al.,*

2020). Saponin lowers arterial blood pressure and blocks the circulating and tissue rennin-angiotensin- aldosterone system (Chen *et al*., 2013). The plant did not have a hypotensive effect, as evident by no significant changes in the cardiovascular parameters, measured in this study. This finding is inconsistent with previous report by Beshel and co-workers (2019). that revealed the plant did. The variation in this regard might be due to sample size as a larger sample size was used in their study. It has been documented that using a larger samplein a medical research increases statistical power (Gan, 2026). Besides, ethanol was their solvent of extraction. Ethanolic extract is said to yield to wider spectrum amd more lipophilic phytochemicals such as flavonoid and alkaloids (Cieniak *et al*., 2015).

Furthermore, the increased plasma sodium levels observed were also significantly decreased by the extract. The ameliorative effects were dose-dependent. Also, elevated circulating total cholesterol and LDL cholesterol concentrations fell significantly with an appreciable improvement in HDL cholesterol levels. This extract exacts its antidyslipidaemic effects possibly via its active phytochemical substances, most especially phenolic compounds and flavonoids (Ugwu *et al.,* 2009; Bjune *et al.,* 2024). They are reported to reduce plasma levels of low-density lipoprotein cholesterol through an upregulation of the LDL receptor. which facilitates the clearance of LDL cholesterol particles through receptor-mediated endocytosis (Goldstein and Brown, 2009). From meta- analyses, it has been well documented that flavonoid treatments or consumption of flavonoid-rich diets improves lipid profiles by decreased LDL-cholesterol concentrations and elevated HDL-cholesterol levels (Micek *et al*, 2021, Grijalvia, 2023; Liaos *et al.*, 2023).The Gongronema latifolium's active compounds are absorbed through the gastrointestinal tract, following oral administration (Johnkennedy, 2026). We did not find any significant effect of high sodium consumption on liver enzymes, ALT and ASP levels and the extract did not have any significant effect on these liver function parameters. This might be due to duration of salt administration in the study. Also sample size might also plays a role.

CONCLUSION

Salt loading significantly raised plasma sodium concentration with subsequent elevation in blood pressure and heart rate. Besides excessive salt consumption also promoted abnormally high total and LDL cholesterol levels and decreased HDL concentrations/. However, concomitant administration of Gongronema latifolium, these adverse effects were significantly ameliorated. This might be due to its ameliorative effects on plasma sodium and cholesterol concentrations. These findings suggest that the plant might have potential to lower blood pressure primarily in a hypertensive condition.

LIMITATION OF THE STUDY

Possibly small sample size that was used in the study. Larger sample size might shed more light on our findings.

CONFLICT OF INTEREST

The authors have no o conflict of interest.

ACKNOWLEDGEMENT

Prof. Oloyo A.K.is acknowledged for his assistance on the use of Physiology laboratory for the analyses in this study.

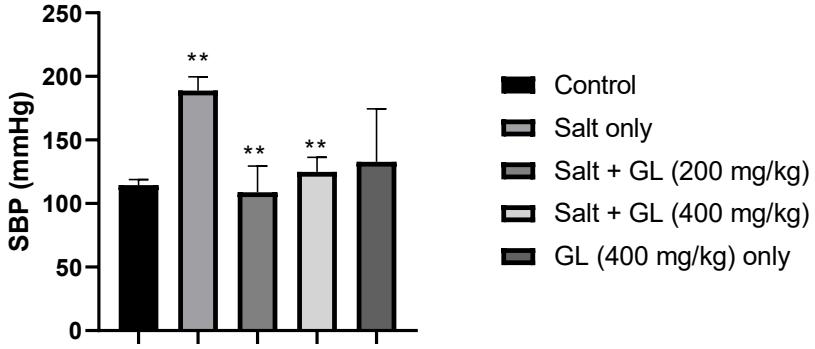

Figure 1: Effect of aqueous axtract of *Gongronema latifolium* on systolic blood pressure responses to salt loading in male Wistar rats

KEY: **p < 0.01; GL = Gongronema latifolium; SBP = Systolic blood pressure

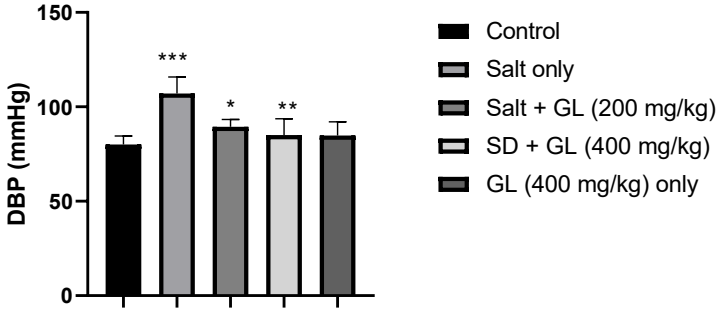

Figure 2: Effect of aqueous axtract of *Gongronema latifolium* on diastolic blood pressure responses to salt loading in male Wistar rats

KEY: *p < 0.05; **p < 0.01; ***p < 0.001; GL = *Gongronema latifolium;* DBP = Diastolic blood pressure

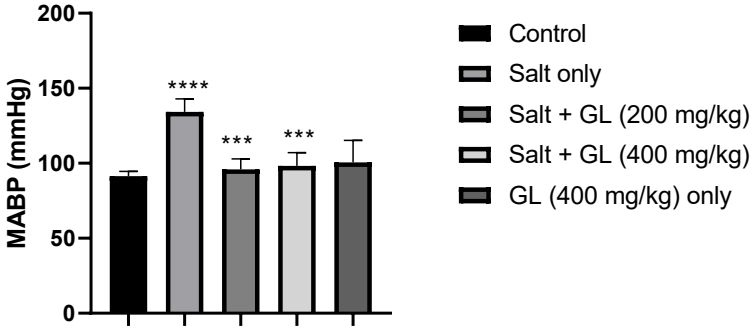

Figure 3: Effect of aqueous axtract of *Gongronema latifolium* on mean arterial blood pressure responses to salt loading in male Wistar rats

KEY: ***P < 0.001; GL = *Gongronema latifolium;* MABP = Mean arterial blood pressure

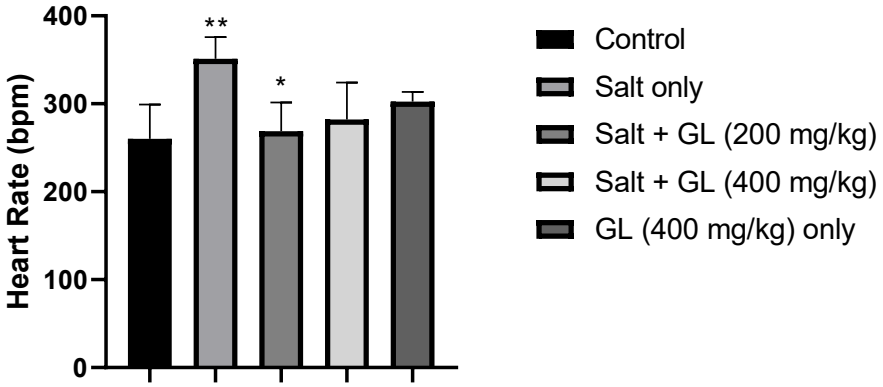

Figure 4: Effect of aqueous axtract of *Gongronema latifolium* on Heart Rate responses to salt loading in male Wistar rats

KEY: *p < 0.05; **p < 0.01

Table 1: Effects of *Gongrolema latiforium* on Biochemical Parameter Responses to Salt Loading

Biochemical Parameters measured	Control	Salt only	Salt + GL (200 mg/kg)	Salt + GL (400 mg/kg)	GL (400 mg/kg) Only
Sodium (mmol/L)	135.10 ± 0.84	151.20 ± 0.86***	141.50 ± 3.36*	137.10 ± 2.45**	138.70 ± 1.37
Potassium (Mmol/L)	1.90 ± 0.04	1.65 ± 0.15	2.02 ± 0.05	2.22 ± 0.19	1.99 ± 0.48
AST (U/L)	69.76 ± 6.15	87.37 ± 1.12	67.69 ± 7.12	69.99 ± 9.43	66.80 ± 3.76
ALT (U/L)	69.26 ± 2.63	72.09 ± 2.69	65.72 ± 4.80	67.83 ± 4.59	61.44 ± 11.20
Total Cholesterol (Mmmol/L)	4.65 ± 0.11	6.11 ± 0.14*	4.71 ± 0.45	4.75 ± 0.28	4.62 ± 0.46
LDL (Mmol/L)	1.40 ± 0.18	2.26 ± 0.13**	1.62 ± 0.10	1.37 ± 0.20**	1.26 ± 1.17
HDL (Mmol/L)	1.63 ± 0.05	0.99 ±0.15**	1.39 ± 0.07	1.48 ± 0.11*	1.55 ± 0.12
Triglyceride (Mmol/l)	2.02 ± 0.03	2.70 ± 0.36	1.65 ± 0.25*	1.68 ± 0.19*	1.99 ± 0.20

*p < 0.05; ***p < 0.001; **p < 0.01,

KEY: GL= *Gongronema latifolium;* AST = Aspartate aminotransferase: ALT = Alanine amino-transferase: LDL = Low density lipoprotein**;** HDL = High density lipoprotein

REFERENCES

Aba PE, Udechukwu IR. (2018). Comparative hypoglycaemic and phytochemical profile of 12 common leafy culinary consumed in Nsukka Southeaster Nigeria. J. Basic Clin. Physiol. Pharmacol., 29 (4) : 313 – 320.

Abera AWA, Hirigo AT, Alemayehu R, Ambachew S. (2024). Dyslipidemia and associated factors among adult cardiac patients: a hospital-based comparative cross-sectional study. Eur J Med Res., 29(1):237. doi: 10.1186/s40001-024-01802.

Agwaramgbo A, Ilodigwe EE, Ajaghaku DL, Onuorah MU, Mbagwu SI. (2014). Evaluation of antioxidant, immunomodulatory activities, and safety of ethanol extract and fractions of *Gongronema latifolium* Fruit. Int Sch Res Notices, doi: 10.1155/2014/695272.

Amrelia M. (2022). Nutritive and medicinal value of *Gongronema latifolium Benth.* (*Aselepiadaceae*). JNPD., 1: 2 – 14..

Bachheti RK, Worku LA, Gonfa YH, Zebeaman M, Deepti, Pandey DP, Bachheti A. (2022). Prevention and treatment of cardiovascular diseases with plant phytochemicals: A review. Evid Based Complement Alternat Med., doi: 10.1155/2022/5741198.

Beshel JA, Palacios J, Beshel FN, Nku CO, Owu DU, Nwokocha M, Bórquez J, Simirgiotis MJ, Nwokocha CR. (2019). Blood pressure-reducing activity of *Gongronema latifolium Benth*. (*Apocynaceae)* and the identification of its main phytochemicals by UHPLC Q-Orbitrap mass spectrometry. J Basic Clin Physiol Pharmacol., 31(1). doi: 10.1515/jbcpp-2018-0178.

Bjune K, Halvorsen PS, Wangensteen H, Leren TP, Bogsrud MP, Strøm TB. (2024). Flavonoids regulate LDLR through different mechanisms tied to their specific structures. J Lipid Res,. 65(5):100539. doi: 10.1016/j.jlr.2024.100539.

Cieniak C, Walshe-Roussel B, Liu R, Muhammad A, Saleem A, Haddad PS, Cuerrier A, Foster BC, Arnason JT.(2015). Phytochemical Comparison of the Water and Ethanol Leaf Extracts of the Cree medicinal plant, *Sarracenia purpurea L*. (*Sarraceniaceae*). J Pharm Pharm Sci;18(4):484-93. doi: 10.18433/j35w27.

Cho YK and Jung OH. (2021). HDL-C and cardiovascular risk: You don't need to worry about excremely high HDL-C levels; J lipid Atheroscler., 10.1.57.57

Eleyinmi AF. (2007). Chemical composition and antibacterial activity of *Gongronema latifolium*. J Zhejiang Univ Sci B., 8(5):352-358.

Feigin VL, Brainin M, Norrving B, Martins SO, Pandian J, Lindsay P, F Grupper M, Rautalin I (2025).. World Stroke Organization: Global Stroke Fact Sheet 2025. Int J Stroke, 20(2):132-144

Flora GD and Nayak MK. (2019). A Brief Review of Cardiovascular Diseases, Associated Risk Factors and Current Treatment Regimes. Curr Pharm Des., 25(38):4063-4084.

Friedewald WT, Levy RI, Fredrickson DS. (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem., 18:499-502.

Gabriel EI, Uneojo OV, Chukwudi E.(2014). Evaluation of methanol extract of Gongronema latifolium leaves singly and in combination with glibenclamide for anti-hyperglycemic effects in alloxan-

induced hyperglycemic rats. J Intercult Ethnopharmacol., 3(3):119-22

.Gan W. (2026).Impact of Sample Size and Its Estimation in Medical Research, AJPM Focus;5 (3):100451, https://doi.org/10.1016/j.focus.2025.100451.

Goldstein J.L., Brown M.S. The LDL receptor. (2009). ArteriosclerThromb. Vasc. Biol. 2009;29:431–438.

Grijalva-Guiza RE, Grijalva-Montano TL, Cuautle M., Quiroga-González E., Hernández LR., Ortega Aguilar A., *et al*. (2023). Analysis of beneficial effects of flavonoids in patients with atherosclerosis risk on blood pressure or cholesterol during random controlled trials: a systematic review and meta-analysis. Sci. Pharm., 91:55.

Grillo A, Salvi L, Coruzzi P, Salvi P, Parati G. (2019). Sodium Intake and Hypertension. Nutrients., 11(9):1970. doi: 10.3390/nu11091970.

Han F, Li W, Duan N, Hu X, Yao N, Yu G, Qu J. (2025). Relationship between salt intake and cardiovascular disease. J Clin Hypertens (Greenwich)., 27(6):e7007 doi: 10.1111/jch.70078.

Harrison, DG., Coffman, TM., and Wilcox, CS. (2021). Pathophysiology of Hypertension: The Mosaic Theory and Beyond. Circ.Res.,128(7). https://www.ahajournals.org/doi/pdf/10.1161/CIRCRESAHA.121.318082

JohnKennedy N. and Adamma, E. (2011). The protective role of *Gongronema latifolium* in acetaminophen induced hepatic toxicity in Wistar rats. *APJTB.,* 1: 151-154.

Johnkennedy N, Augustine UU, Doris NE, Ekpere Kelechi NF, (2026), Mechanisms and therapeutic potential of *Gongronema latifolium* in Sickle Cell Disease. Clinical Endocrinology and Metabolism, 5(1); Doi:10.31579/2834-8761/102

Kazi, RNA. (2025). Silent Effects of High Salt: Risks Beyond Hypertension and Body's Adaptation to High Salt. Biomedicines, 13, 746. https://doi.org/10.3390/biomedicines13030746

Kjeldsen SE.(2018). Hypertension and cardiovascular risk: General aspects,Pharmacol. Res., 129: 95-99.

Kovesdy CP. (2022). Epidemiology of chronic kidney disease: an update 2022. Kidney Int Suppl., 12(1):7-11.

Kuwabara M, Hisatome I, Roncal-Jimenez CA, Niwa K, Andres-Hernando A, Jensen T, Bjornstad P, Milagres T, Cicerchi C, Song Z, Garcia G, Sánchez-Lozada LG, Ohno M, Lanaspa MA, Johnson RJ. (2017). Increased serum sodium and serum osmolarity are independent risk factors for developing chronic kidney disease; 5 Year cohort study. PLoS One. 12(1):e0169137. doi: 10.1371/journal.pone.0169137

Liao G., Liu W., Dai Y., Shi X., Liu Y., Li D., *et al* (2023). Beneficial effects of flavonoids on animal models of atherosclerosis: a systematic review and meta-analysis. iScience.;27;26(11):108337. doi: 10.1016/j.isci.2023.108337.

Linton MRF, Yancey PG, Davies SS, *et al*. (2024). The Role of lipids and lipoproteins in Atherosclerosis.. In: Feingold KR, Adler RA, Ahmed SF, *et al*., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK343489

Maaliki D, Shaito AA, Pintus G, El-Yazbi A, Eid AH. (2019). Flavonoids in hypertension: a brief review of the underlying mechanisms. Curr OpinPharmacol., 45:57-65

Magder, S. (2018). The meaning of blood pressure. Crit Care, **22**: 257 https://doi.org/10.1186/s13054-018-2171-1.

Micek A, Godos J, Del Rio D, Galvano F, Grosso G. (2021). Dietary flavonoids and cardiovascular disease: a comprehensive dose-response meta-analysis. Mol. Nutr. Food Res., 65 doi: 10.1002/mnfr.202001019

Mei L, Qin J, Liu X, Yu M. (2025). Association between serum osmolality and chronic kidney disease prevalence: Evidence from NHANES 1999-2018. Sci Rep., 15(1):24295. doi: 10.1038/s41598-025-08624-9.

Mensah GA. (2016). Hypertension and target organ damage: Don't believe everything you think! Ethn Dis., ;26(3):275-8. doi: 10.18865/ed.26.3.275.

Mensah GA.(2016). Hypertension and Target Organ Damage: Don't Believe Everything You Think! Ethn Dis. 2016 Jul 21;26(3):275-8. un;27(6):e70078. doi: 10.1111/jch.70078.

Nehme M, Uppal A, Zimmerman O, Lamour J, Mechoullam S, Guessous I. (2025). Twenty years population-based trends in prevalence, awareness, treatment, and control of hypertension in Geneva, Switzerland. Prev Med Rep., 53:103055. doi: 10.1016/j.pmedr.2025.103055.

Nelson RH. (2013). Hyperlipidemia as a risk factor for cardiovascular disease. Prim Care: Clinics Off Pract., 40(1):195–211. doi: 10.1016/j.pop.2012.11.003

Octavio JA, Azpuurua B, Amair P, Pineda T, Bello Z, Esis C, Silva E. Parati G. (2025). Estimation of mean blood pressure by the conventional formula, compared with that obtained with the calculation taking account the duration of ejection time and cardiac cycle. Journal of Hypertension. 43(1)L 84, *DOI:* 10.1097/01.hjh.0001115976.64106.4c

Ojangba T, Boamah S, Miao Y, Guo X, Fen Y, Agboyibor C, Yuan J, Dong W. (2023). Comprehensive effects of lifestyle reform, adherence, and related factors on hypertension control: A review. J Clin Hypertens., 25(6):509-520.

Ojo OA, Osukoya OA, Ekakitie LI, Ajiboye BO, Oyinloye BE, Agboinghale PE, Kappo AP. (2020). *Gongronema latifolium* leaf extract modulates hyperglycaemia, inhibits redox imbalance and inflammation in alloxan-induced diabetic nephropathy. J Diabetes Metab Disord. 19(1):469-481.

Park Chanhyun ,Guijing Wang, Boon Peng Ng, Jing Fang, Jeffrey M. Durthaler, Carma Ayala. (2020).

The uses and expenses of antihypertensive medications among hypertensive adults, Research in Social and Administrative Pharmacy, 16 (2):183-189

Patel P, Ordunez P, DiPette D, Escobar MC, Hassell T, Wyss F, Hennis A, Asma S, Angell S. (2016). Standardized hypertension treatment and prevention network. improved blood pressure control to reduce cardiovascular disease morbidity and mortality: The standardized hypertension treatment and prevention project. J Clin Hypertens., 18(12):1284-1294..

Reule S, Drawz PE. (2012). Heart rate and blood pressure: any possible implications for management of hypertension? CurrHypertens Rep., 14(6):478-784

Rubattu S, Pagliaro B; Pierelli G, Santolamazza C, Di Castro S, Mennuni S, Volpe M. (2015). Pathogenesis of target organ damage in hypertension: Role of mitochondrial oxidative stress. *Int. J. Mol. Sci.*, *16*:823-839.

Shahoud JS, Sanvictores T, Aeddula NR. (2023). Physiology, arterial pressure regulation. [Updated 2023 Aug 28]. In: StatPearls [Internet]. treasure Island (FL): StatPearls Publishing; Available from: https://www.ncbi.nlm.nih.gov/books/NBK538509/

Strazzullo P, Leclercq C.(2014). Sodium. Adv Nutr., 5(2):188-90.

Surma S, Okopień B, Murphy AJ, Banach M. (2025). High salt intake and atherosclerosis progression—Not Only via blood pressure: A narrative review. Nutrients 17*: 3464.* https://doi.org/10.3390/nu17213464

Ugwu CE, Olajide JE, Alumanah EO, Ezeanyika LUS. (2009): Comparative effects of the leaves of *Congronema laatifolium* and *Teifaira occidentalis* incorporated diet on lipid profile of rats. GJPAS., 16 (3): 319 - 324.

Wan Y, Ma D, Shang Q, Xu H. (2024).. Association between dietary flavonoid intake and hypertension among U.S. adults. Front Immunol., 15:1380493. doi: 10.3389/fimmu.2024.1380493

Zhang S, Liu Y, Wang X, Tian Z, Qi D, Li Y, Jiang H.(2020). Antihypertensive activity of oleanolic acid is mediated via downregulation of secretory phospholipase A2 and fatty acid synthase in spontaneously hypertensive rats. Int J Mol Med., 46(6):2019-2034..

Zheng T, Wu Y, Guo K, *Yang, T. (2023*). The process of hypertension induced by high-salt diet. Front. Microbiol, 14. https://doi.org/10.3389/fmicb.2023.1123843