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Solanum anguivi (gnangnan) as a functional food: A natural approach to hypertension management in rats

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Abstract

Hypertension poses a significant challenge to global health, particularly in regions with limited access to conventional treatments. *Solanum anguivi*, locally known as gnangnan, is a neglected wild edible plant that has been used in traditional Ivorian medicine. This study investigated the antihypertensive effects of freeze-dried *Solanum anguivi* fruit powder in Wistar rats with fructose- and salt-induced hypertension. The rats were divided into four groups: a healthy control group; a hypertensive control group; a group of hypertensive rats treated with 200 mg/kg of *Solanum anguivi* powder; and a group of hypertensive rats treated with nifedipine. Phytochemical analyses revealed high levels of polyphenols, flavonoids and tannins, as well as significant antioxidant and anti-inflammatory activities. Treatment with *Solanum anguivi* significantly reduced both systolic and diastolic blood pressure, with comparable effects to those of nifedipine. No signs of renal or hepatic toxicity were observed. A notable increase in platelet count and stable body mass suggest good tolerance. Histological analyses confirmed the absence of organ damage. These findings highlight the potential of *Solanum anguivi* powder as a functional food or adjunctive phytotherapeutic agent for managing hypertension.

Keywords: *Solanum anguivi*; Functional food; Hypertension; Antyoxydant; Anti-inflammatory

1. Introduction

According to the World Health Organization (WHO) in 2019, hypertension, also known as high blood pressure, is defined as a condition in which the pressure in the blood vessels remains persistently high due to the force exerted by the blood on the artery walls. Hypertension is diagnosed when the systolic blood pressure is higher than 140 mmHg or the diastolic pressure is higher than 90 mmHg [1]. This metabolic disorder is a major health problem. Arterial hypertension is characterised as a 'silent killer' due to the lack of obvious symptoms, which is associated with serious complications such as cardiovascular disease, stroke, renal failure and hypertensive retinopathy [2]. Despite the effectiveness of conventional treatments such as diuretics, angiotensin-converting enzyme (ACE) inhibitors, beta-blockers and angiotensin II receptor antagonists. These are often associated with undesirable side effects such as visual impairment, muscle weakness, anaemia etc., and remain expensive for many developing countries [3, 4]. This prompted the WHO to identify this as a public health issue at the 66th United Nations General Assembly in 2011, and to recommend that

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African countries develop regional strategies for traditional medicine to conduct studies on medicinal plants and promote their optimal integration into health systems. In this context, the WHO recommends the consumption of fruits and vegetables, which are not only cheap but also an important source of bioactive compounds such as prebiotics, vitamins, minerals, antioxidants and anti-inflammatory agents [5]. These compounds act in particular by improving endothelial function, reducing oxidative stress and regulating angiotensin II activity. Fruit and vegetable consumption promotes a healthy gut microbiota. According to [6], they are recognised as functional foods or 'alicaments'. Several studies have linked frequent fruit and vegetable consumption to a reduced risk of hypertension [7, 8]. The data show an 11% reduction in the risk of hypertension in people who eat a lot of fruit and vegetables. Côte d'Ivoire, which has a wide variety of fruits and vegetables, should seize this opportunity to make the most of them. One of the fruits commonly used for food is the fruit of *Solanum anguivi*, locally known as gnangnan. Gnangnan is a neglected wild edible vegetable that grows naturally in local ecosystems. This fruit-vegetable is characterised by spherical berries arranged in clusters, ranging from green to orange-red and averaging 7 mm in diameter [9]. Gnangnan is valued for its bitter aftertaste, nutritional value and therapeutic properties. In fact, it is rich in phenolic compounds (quinones, flavonoids and coumarins) and vitamin C, which can combat stress [9]. In addition, the fruit and leaves are used in phytotherapy to treat malaria, hypertension and diabetes [9]. Despite research confirming its medicinal benefits, the post-harvest perishability of this product due to microbial attack limits its long-term preservation. For this reason, this fruit-vegetable is usually boiled or steamed before being sun-dried for preservation [9]. However, technological processes involving heat can alter the bioactive molecules present in the food. Therefore, new alternatives are being sought to preserve foods in their fresh powder form using the freeze-drying technique to better preserve their taste, nutritional and therapeutic qualities. What's more, there is no research to support the consumption of functional foods based on these plant seeds. The freeze-dried powder of fresh gnangnan fruit was therefore considered as an alternative to post-harvest consumption in order to benefit from the health effects associated with the plant's bioactive compounds. Therefore, this work investigates the antihypertensive effects of fresh gnangnan fruit powder from the Ivory Coast on rat models.

2. Materials and methods

2.1. Preparation of gnangnan fruits powders

The gnangnan fruits were purchased at the Adjamé market (Abidjan, Ivory Coast). Once at the UPR Biotechnologies Laboratory, a sample of fruits was transferred to the National Floristic Center of the Félix Houphouët-Boigny University of Abidjan for identification using the Analytical Flora. The fruits were destemmed and then washed with distilled water.

The seeds were freeze-dried at -55 °C under a pressure of 1 Pa for 72 hours using a freeze dryer (Biobase, China). The fruits were then ground into a powder using a grinder (Moulinex, France). The obtained powders were preserved for further analysis.

2.2. Identification of phytochemical compounds in fresh and cooked gnangnan seed powders

Phenolic compounds were measured after extraction with methanol according to the method described in [10]. A quantity of 1 g of dried powdered material was immersed in 10 ml of 70% (w/v) methanol and centrifuged at 1000 rpm for 10 minutes. An aliquot (1 ml) of the supernatant was oxidised with 1 ml of Folin-Ciocalteu reagent and then neutralised with 1 ml of 20 % (w/v) sodium carbonate. The reaction mixture was incubated for 30 min at room temperature and the absorbance was recorded at 745 nm using a spectrophotometer (PG Instruments, England). A standard series derived from a stock solution of gallic acid (1 mg/ml) was used to quantify the polyphenol content of the sample under identical conditions to the test. This method provided a reliable determination of phenolic compounds known for their antioxidant properties and potential health benefits. Subsequent analyses were performed to compare the polyphenol levels in different samples.

Flavonoids were measured by the method described in [11] after extraction with methanol. 0.5 mL methanolic extract, 0.5 mL methanol, 0.5 mL $AlCl_3$ (10%, w/v), 0.5 mL potassium acetate (1 M) and 2 mL distilled water were combined. The solution was incubated for 30 min at room temperature. Absorbance was quantified using a spectrophotometer at 415 nm relative to a blank. A stock solution of quercetin at 0.1 mg/ml was used to establish a calibration range.

The anti-inflammatory activity of water-soluble gnangnan extracts was evaluated using the protein denaturation inhibition technique [12]. The reaction mixture (0.5 ml) contained 0.45 ml of 5% bovine serum albumin (SAB) and 0.05 ml of broths containing different amounts of diclofenac sodium as standard drug. Six values ranging from 31.25 to 1000 µg/ml were evaluated. The pH was adjusted to 6.3 using 1 N hydrochloric acid. Samples were incubated at 37°C for 20

minutes and then heated to 57°C for 3 minutes. After cooling, 2.5 ml of phosphate buffer (pH = 6.3) was added to each test tube. Absorbance was measured using a spectrophotometer at 614 nm (Jasco V-630, Germany). Distilled water was used instead of broth for the control tubes. The product control tube lacked ASB. The percentage inhibition of protein denaturation was determined as follows:

$$\% \text{ Inhibition} = 100- [(\text{D.O of sample - D.O of control /D. O of control})] \times 10$$

For antioxidant activity [13], l g of sample was prepared in 20 ml of 70% methanol. To a volume of 2 ml of methanolic extract at different concentrations, 1 ml of freshly prepared DPPH (0.3 mM) was added. The negative control was prepared in the same conditions. After incubation in the dark for 30 min, the absorbances were read at 517 nm using a spectrophotometer against a blank for each concentration containing 50 µl of each concentration of extract and 1.95 ml of methanol. The results are expressed as the percentage of anti-free radical activity or free radical inhibition (I %) according to the following formula:

The quantification of tannins was carried out according to the protocol described by [14]. The principle of the experiment was to show that tannins react with vanillin in the presence of sulphuric acid to form a yellow complex. The intensity of this complex was directly related to the concentration of tannins in the medium. Tannins were measured by adding 1 mL of methanolic extract to a test tube. After adding 5 mL of reagent containing vanillin (at a concentration of 0.1% in 70% sulphuric acid), the tube was left in the dark for 30 minutes and the optical density (OD) was measured at 500 nm against a blank. The concentration of tannins in the samples was measured using a series of standards prepared from a stock solution of catechol (2 mg/ml) under conditions identical to those used in the experiment.

Phytochemical screening for sterols and terpenoids was carried out using the method described by [15]. To test for steroids, 2 ml of acetic anhydride was combined with 0.5 mL of ethanolic extract from each sample, together with 2 ml of H2SO4. the colour changed from purple to blue or green, indicating the presence of steroids. The Salkowski test for terpenoids involved mixing 5 ml of each extract with 2 ml of chloroform, followed by the careful addition of 3 ml of concentrated H2SO4 to form a distinct layer. A reddish brown colour at the interface indicates the presence of terpenoids [15].

2.3. Effect of *Solanum anguivi* seeds powder on body weight and blood pressure in rats

Animal experiments were performed in accordance with European Union guidelines (2007/526/EC) and with the approval of the National Ethics Committee for Life Sciences and Health. Rats were housed in Plexiglas cages in the vivarium of the Normal Superior School of Abidjan under standard environmental conditions, with a temperature of 25°C and a 12 h light/dark cycle [16]. The effect of the aqueous solution of fresh *Solanum anguivi* seed powder on the body mass of treated and control rats was monitored at three-day intervals using an electronic balance (*Biobase*). A group of 16 healthy male Wistar rats weighing between 150 and 200 g was selected for blood pressure analysis. The animals were not given any medication during the acclimatisation period. The rats were continuously monitored for any signs of abnormal behaviour, such as signs of illness or mortality. After two weeks, the rats were randomly divided into four batches. The first batch consisted of control rats that had not been subjected to any induction, while batches 2 to 4 were given fructose diluted in 50% water for 2 weeks, followed by 15% saline for the same period. During the study period, the body weight and blood pressure of each batch were assessed twice a week until the hypertension was fully established after 4 weeks of treatment. During this period, the animals were not subjected to any pharmacological treatment before being randomly assigned to study the effect of *Solanum anguivi* aqueous seed extract on fructose- and NaCl-induced hypertension. The treatment was administered orally by gavage once a day for 28 days (4 weeks). Animal weights were measured at three-day intervals after administration of four separate treatments in batches. Batch 1 consisted of normal rats that had not been subjected to hypertension induction, thus forming the negative control group. Batch 2 consisted of untreated diseased rats given distilled water. Batch 3 consisted of sick rats administered an aqueous solution of *Solanum anguivi* powder at a dose of 200 mg/kg bw per day. Batch 4 consisted of diseased rats treated with a reference drug, Nifedipine®, a calcium channel blocker used as a positive control.

2.4. Determination of haematological and biochemical parameters in rats

For biochemical and haematological analyses, blood samples were collected by caudal puncture after a 12-hour fast under anaesthesia with ethyl ether (Gifrer ®; France) in dry Vacutainer ® tubes [17]. These samples were used to measure blood glucose levels on a weekly basis in all groups. Haematological examination was performed using an automated haematological analyser (Biobase, Chine). Whole blood from *Solanum anguivi* treated animals was collected in tubes containing an anticoagulant (EDTA). The following variables were measured: red blood cell (RBC) count, white blood cell (WBC) count, haemoglobin (Hb) level, haematocrit (HCT), mean corpuscular haemoglobin concentration (MCHC) and platelet count. Biochemical analysis was performed on serum collected after centrifugation of the blood at

1480 rpm for 10 minutes. Serum was analysed using a Hycel Lisa 300 to measure the following biochemical parameters: aspartate aminotransferase (ASAT), alanine aminotransferase (ALAT), lactate dehydrogenase (LDH), urea, creatinine, alkaline phosphatase (ALP), total cholesterol, triglycerides, low-density lipoprotein (LDL) and high-density lipoprotein (HDL).

2.5. Histopathological analysis of rat livers, kidneys and hearts

The histological method was used to prepare thin sections of organs such as the liver, heart and kidneys. This method involves several main consecutive steps. The organs were immersed in a 10% formalin solution and fixed for 48 hours at room temperature. The aim of organ fixation is to preserve the cells in a state similar to life. Fixation stiffens the organ, ensures the stability of the various tissue structures and protects the cells from bacterial attack, deformation and shrinkage. The fragments of each organ were placed separately in labelled blocks and then dehydrated by passing through successive alcohol baths of increasing concentration (80°C for 1 hour, 90°C for 2 hours and two baths at 100°C for 2 hours each). After dehydration, the cassettes containing the organ fragments were immersed successively in three toluene baths for 2 hours each. This procedure removed all traces of ethanol and prepared the organs for impregnation. Impregnation was carried out using two successive baths of paraffin in an oven (Memmert, Germany) maintained between 58 and 60°C. The cassettes were immersed in the first bath for 2 hours and then in the second bath for 3 hours. The organs were immersed in paraffin at room temperature in moulds and then sectioned using a LEICA model microtome (RM2125 TRS). After sectioning, the blocks were placed on ice. The blocks were then fixed to the back of the cassettes and clamped onto the microtome for efficient sectioning. The sections were 5 micrometres thick. This makes it possible to obtain paraffin strips containing organ sections. The resulting strips were immersed in a water bath at a temperature of 40°C before being fixed to the slides. Slides containing paraffin strips were placed in an oven (Memmert, Germany) at a temperature of 58-60°C for 30 minutes and then deparaffinised in three successive toluene baths, each bath lasting 15 minutes. Rehydration was carried out in three successive alcohol baths of decreasing concentration (100°, 90° and 80°) for 5 minutes each. The sections were then rinsed in distilled water. After rinsing in distilled water, the specimens were stained in a modified Harris hematoxylin solution (2-3 min), followed by rinsing in running water and immersion in a 3% yellow alcoholic eosin solution (3-5 min). After staining, the sections were dehydrated in three successive alcohol baths of increasing concentration (75°, 95°, 100°) for 5 minutes each. The stained slides were protected to facilitate microscopic observation and to ensure that they were preserved without risk of damage. For this purpose, the slides were covered with coverslips using EUKITT adhesive. The samples were examined using a tri-ocular electron microscope (Olympus CX31, Philippines) equipped with a camera (AmScope, model MD130) connected to a computer (HP EliteBook Folio 1040, China) [17].

2.6. Statistical analysis

Data were expressed as mean ± standard error of the mean. Data were subjected to one-way analysis of variance (ANOVA). Subsequent analysis was performed using the Tukey test with GraphPad Prism 8.0.2. A p-value less than 0.05 was considered statistically significant.

3. Results

3.1. Effect of *Solanum anguivi* on blood pressure

Systolic and diastolic blood pressure were measured throughout the experiment (see Table 2). In the negative control group, values remained stable throughout the experiment, with systolic pressure around 115 mmHg and diastolic pressure around 75 to 80 mmHg. Inducing hypertension with fructose and salt resulted in a significant increase in blood pressure in the positive control group, with systolic pressure reaching 150.67 mmHg and diastolic pressure reaching 98.36 mmHg by the fourth week. Baseline treatment with nifedipine resulted in a significant fall in pressure, with final systolic pressure at 128.67 mmHg and diastolic pressure at 89.09 mmHg. Furthermore, rats treated with 200 mg/kg of *Solanum anguivi* exhibited a notable hypotensive effect, comparable to nifedipine, with reductions in systolic pressure from 143.67 mmHg to 127.67 mmHg and diastolic pressure from 93 mmHg to 89.64 mmHg.

Table 1 Evolution of blood pressure in rats treated with *Solanum anguivi* powder

Blood pressure (mmHg)	Before induction		After induction		2 weeks treatment of hypertensive rat		4 weeks treatment of hypertensive rat	
	Systole	Diastole	Systole	Diastole	Systole	Diastole	Systole	Diastole
Negative control	107.5±4.82^{a}	80.5±8.51^{ab}	114.66±5.11^{ab}	73± 14.6^{a}	118.33±6.22^{ab}	82.711±5.56^{ab}	115±9.33^{ab}	74.67±15.33^{ab}
Positive control	105.5±9.24^{a}	60.12±6.68^{a}	146± 8.67^{b}	105.67±11.56^{bc}	144.33±9.78^{b}	91.82±11.56^{b}	150.67±7.11^{b}	98.36±17.78^{bc}
Reference	95.25±5.97^{a}	66.12±2.22^{a}	152.33± 6.44^{c}	107.33± 12.22^{bc}	137.33±9.78^{bc}	105.62±35.56^{bc}	128.67±3.78^{b}	89.09±3.11^{b}
Solanum anguivi	95.87±5.05^{a}	59±3.83a	143.67± 2.22^{bc}	93±20.67^{bc}	141.33±7.56^{bc}	85.78±10.22^{b}	127.67±9.56^{b}	89.64±10.89^{b}

Values represent means and standard deviations of triplicate measurements. Values with the same superscript in a column are significantly different at P ≤0.05

3.2. Variation in body mass

Table 1 shows the body mass results before and after induction, and at two and four weeks after treatment. In the negative control group, body mass increased moderately throughout the experiment. Body mass increased from 171.58 g to 212 g over four weeks. Rats in the positive control group, which were fed a fructose and salt diet but not treated, showed a continuous and significant increase in body weight, from 166.82 g to 229.68 g. The batch treated with the reference drug nifedipine showed an initial increase in body mass, followed by a slight decrease, reaching 151.9 g after four weeks. Rats treated with 200 mg/kg CP of *Solanum anguivi* powder showed a steady increase in body weight from 151.24 g to 209.64 g, which was comparable to that observed in the negative control group.

Table 2 Weight variation during treatment of hypertensive rats

Test	Before induction	After induction	2 weeks treatment of hypertensive rat	4 weeks treatment of hypertensive rat
	Weight (g)			
Batch 1 Negative control	171.58±13.55^{a}	219.21±14.79b^{c}	215.78±8.39^{bc}	212.13±7.19^{b}
Batch 2 Positive control	166.82±5.89^{a}	207.14±10.12^{b}	213.29±13.66^{bc}	229.68±18.41^{c}
Batch 3 Reference	135.90±24.78^{a}	166.51±19.15^{b}	180.33±15.46^{bc}	151.9±15.92^{ab}
Batch 4 *Solanum anguivi*	151.24±25.58^{a}	180.17±19.55^{ab}	185.64±14.91^{bc}	209.64±14.39^{c}

Values represent means and standard deviations of triplicate measurements. Values with the same superscript in a column are significantly different at P ≤0.05

3.3. Evaluation of haematological and biochemical parameters

3.3.1. Complete Blood Count (CBC)

The results of the CBC after four weeks of treatment are presented in Table 3. Most haematological parameters, including white blood cells (WBCs), lymphocytes (LYMs), monocytes (MIDs) and granulocytes (GRNs), showed no significant differences between groups. However, a marked increase in platelets (PLT) was observed in the *Solanum anguivi* group (488.3), which was significantly higher than in the other groups. Haemoglobin concentration (HGB) and haematocrit (HCT) remained high in this group, comparable to the reference group.

Table 3 Complete Blood Count

Parameters	Negatif control	Positif control	Reference	*Solanum anguivi*
WBC 10^9/L	14.85±3.97^a	13.9±3.34^a	16.46±0.4^a	14.93±3.64^a
LYM 10^9/L	8.23±0.16^a	9.18±2.54^a	11.45±0.74^a	11.08±2.11^a
MID 10^9/L	3.37±2.02^a	2.61±0.71^a	2.88±0.19^a	2.26±0.77^a
GR 10^9/L	3.25±2.1^a	2.11±0.24^a	2.13±0.59^a	1.59±0.76^a
RBC 10^{12}/L	9.74±2.33^a	7.09±2.93^a	8.71±0.96^a	8.82±1.58^a
HGB g/L	173±55.4^b	126±74.8^a	165±33.3^b	163±47.4^b
HCT %	56.37±16.35^a	42.85±21.72^a	53.03±5.59^a	54.97±12.02^a
MCV fL	57.3±3.8^a	64.88±5.35^b	60.9±0.7^{ab}	62±2.83^{ab}
MCH pg	17.47±1.81^a	18±2.59^a	18.87±1.7^a	18.27±1.91^a
MCHC g/L	304.67±11.93^b	281.5±16.44^a	310±29.14^b	294.67±16.97^{ab}
RDW- CV %	14.43±2.64^a	12.95±2.35^a	12.93±0.55^a	14.43±0.57^a
RDW- SD fL	37.97±6.66^a	37.3±6.16^a	39.3±0.7^a	41.03±3.04^a
PLT 10^9/L	296.3±25.9^a	364.8±21.44^c	345±25.61^b	488.3±20.1^d
MPV fL	8.3±0.36^a	8.8±0.46^a	8.63±0.12^a	8.63±0.14^a
PCT %	0.21±0.06^a	0.27±0.05^a	0.23±0.07^a	0.25±0.06^a
PDW %	13.87±0.93^a	15.98±1.2^b	15.6±0.7^b	15.8±0.57^b
P-LCR %	29.6±3.8^a	22.63±4.24^a	25.2±5.27^a	24.1±1.13^a
P-LCC 10^9/L	79.67±33.23^b	65.75±10.97^{ab}	64.67±13.32^{ab}	56.67±15.2^a

Values represent means and standard deviations of triplicate measurements. Values with the same superscript in a line are significantly different at P ≤0.05

3.3.2. Biochemical parameters

The renal parameters (urea and creatinine) showed no significant differences between the groups, indicating that Solanum anguivi has no apparent renal toxicity. With regard to liver parameters, a slight increase in transaminases (ASAT and ALAT) and creatine kinase MB (CK-MB) was observed in the *Solanum anguivi* group, although not to the levels of the nifedipine-treated group. In terms of lipid parameters, the Solanum anguivi group showed a slight increase in triglycerides (0.81 g/L) and a decrease in total cholesterol (0.45 g/L) and HDL (28.04 mg/Dl) compared with the other groups. This drop in HDL deserves particular attention in the overall interpretation of the metabolic effect of the treatment.

Table 4 Biochemical analysis

Parameter balance		Negatif control	Positif control	Reference	*Solanum anguivi*
Renal	Urea (g/L)	0.3±0^a	0.26±0.05^a	0.39±0.02^a	0.52±0.38^a
	Crea (mg/L)	0.48±0.03^a	0.55±0.15^a	0.51±0.02^a	0.49±0.03^a
Liver	Asat (UI/L)	189.45±31.89^a	159.9±5.6^b	258.3±24.7^d	217.67±39.64^c
	Alat (UI/L)	26.25±1.63^{ab}	17.95±9.27^a	35.7±2.01^b	23.3±8.19^{ab}
	Ckmb (UI/L)	2509±46.39^a	2543±56.29^b	3191±30.4^d	2699.7±30.4^c
	Bil (µmol/L)	1.51±0.445^a	1.78±0.49^a	1.14±0.06^a	1.337±0.59^a
	Tryg	0.74±0.32^a	0.67±0.2^a	0.7±0.17^a	0.81±0.32^a

Lipid (g/L)	Cho	0.62±0.04[a]	0.64±0.11[ab]	0.81±0.02[b]	0.46±0.15[a]
	HDL	36.11±7.43[ab]	43.07±7.8[b]	58.6±2.14[c]	28.04±8.81[a]

Values represent means and standard deviations of triplicate measurements. Values with the same superscript in a line are significantly different at P ≤0.05

3.4. Analysis of nutritional parameters

The biochemical composition of *Solanum anguivi* was analysed and revealed a high content of total polyphenols (138.53 mg/mL), flavonoids (25.35 mg/mL), anthocyanins (16.25 mg/mL) and tannins (916.7 mg/mL). This is associated with high antioxidant (83.77%) and anti-inflammatory (71.35%) activity.

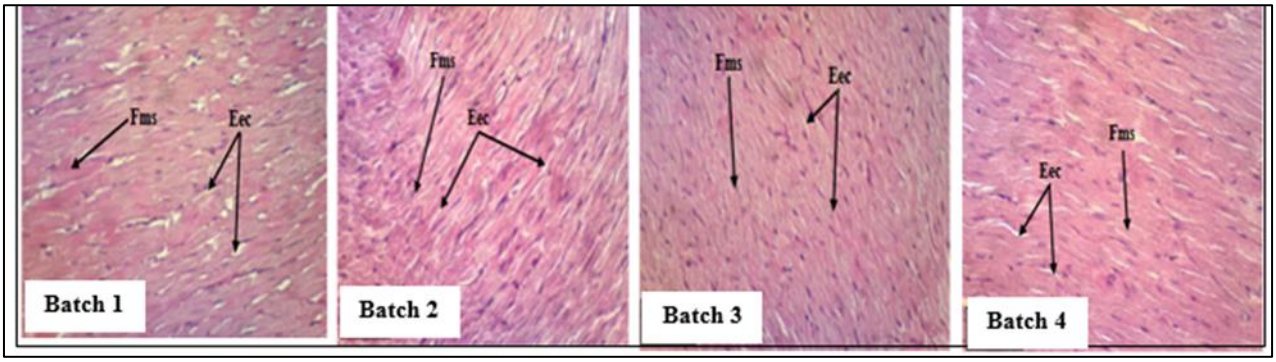
Table 5 Biochemical characteristics of *Solanum anguivi*

Nutritional properties	***Solanum anguivi***
Dry matter %	19.15±0.09
Polyphenols mg/mL	138.53±20.80
Flavonoids mg/mL	25.35±0.30
Anthocyan mg/mL	16.25±1.92
Tanins mg/mL	916.70±2.53
Antioxydant activity%	83.77 ± 10.29
Anti-inflammatory activity %	71.35 ± 4.36
Sterol	++
Terpens	++

Values represent means and standard deviations of triplicate measurements.

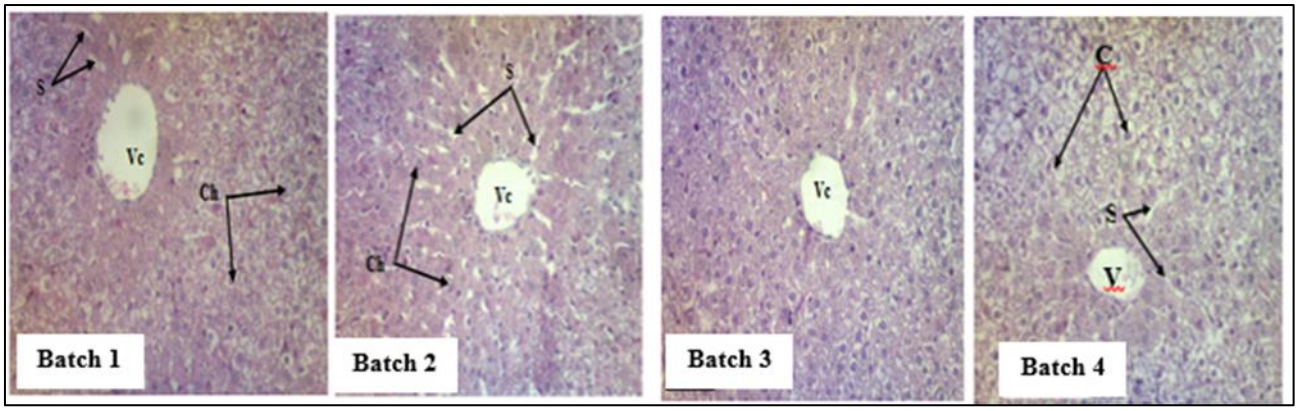
3.5. Histological evaluation of the effects of *Solanum anguivi* on the kidneys, heart and liver in rats

Histological examination of the kidneys, heart and liver after treatment with *Solanum anguivi* revealed no significant morphological changes compared with control rats. No major structural changes were noted (Figure 1,2, 3).



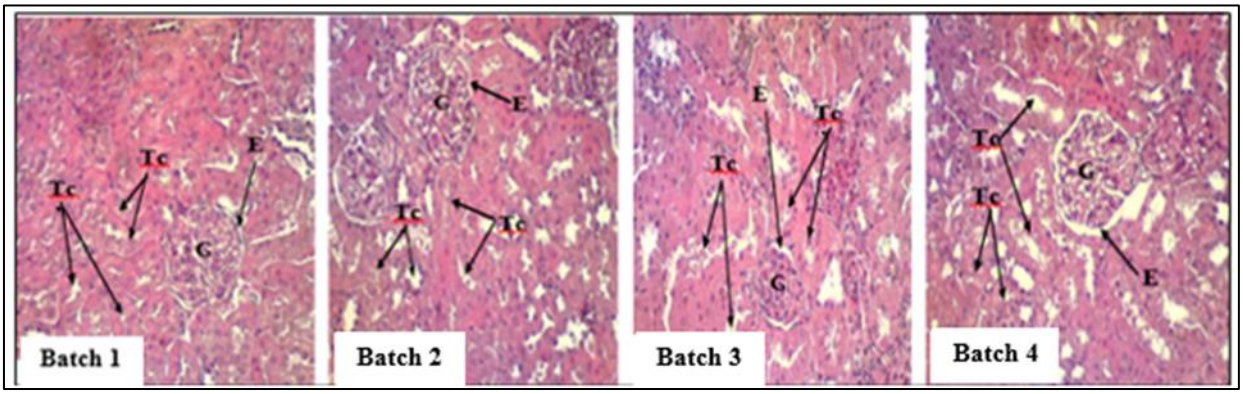
Staining: Haematoxylin-eosin; Magnification: X100 Fms: Striated muscle fibre; Eec: Extra-cellular space; Batch 1: Negative control; Batch 2 : Positive control; Batch 3: Reference; Batch 4 : Solanum anguivi

Figure 1 Histological section of hearts from control and treated Wistar rats



Staining: Haematoxylin-eosin; Magnification: X100 Vc: Centrilobular vein; Ch: Haptic cells; S: Sinusoid; Batch 1: Negative control; Batch 2 : Positive control; Batch 3: Reference; Batch 4 : *Solanum anguivi*

Figure 2 Histological section of liver from control and treated Wistar rats



Staining: Haematoxylin-eosin; Magnification: X100 Eu: Urinary space; G: Glomerulus; DcT: Distal convoluted tubules; PcT: Proximal convoluted tubules; Batch 1: Negative control; Batch 2 : Positive control; Batch 3: Reference; Batch 4 : *Solanum anguivi*

Figure 3 Histological section of kidney from control and treated Wistar rats

4. Discussion

The results of this study highlight the therapeutic potential of *Solanum anguivi* powder for treating induced arterial hypertension in rats. The antihypertensive effect, which was significant from the second week of treatment and was maintained until the fourth week, was comparable to that of nifedipine, the reference drug. This efficacy may be attributed to its nutritional and biochemical composition, particularly certain bioactive compounds recognised for their vasodilatory, antioxidant, and diuretic properties [18]. Nutritional analyses revealed high levels of polyphenols (138.53 mg/mL), flavonoids (25.35 mg/mL), anthocyanins (16.25 mg/mL) and tannins (916.7 mg/mL). These are associated with high antioxidant activity (83.77%) and significant anti-inflammatory activity (71.35%). These compounds play a key role in protecting the cardiovascular system by neutralising reactive oxygen species (ROS) and modulating pro-inflammatory mediators [19, 20, 21]. In addition, the significant reductions in systolic and diastolic blood pressure observed in the treated groups suggest that *Solanum anguivi* may improve endothelial function that has been impaired by oxidative stress and chronic inflammation. These result corroborate those of [22]. This protective effect could also be attributed to the presence of sterols and terpenes, which are known to improve lipid profiles and stabilise cell membranes [23]. Furthermore, the stability of body mass in rats treated with *Solanum anguivi*, compared to the control group, could indicate favourable tolerance of the treatment, beneficial effects on energy metabolism, or protection against muscle breakdown associated with inflammation. Conversely, the reduction in body weight observed in animals receiving nifedipine could indicate the undesirable effects of conventional treatment [24]. Haematological analyses showed that *Solanum anguivi* did not cause any significant imbalance in blood cell counts. The significant increase in platelet count may indicate a stimulatory effect on thrombopoiesis, but the clinical significance of this remains to be determined. Haemoglobin, haematocrit and erythrocyte indices remained within normal limits, suggesting an absence of anaemia or haematopoietic oxidative stress [25].

Biochemically, no renal toxicity was detected, with urea and creatinine levels comparable to those of the control group. Although liver enzymes were slightly elevated in the *Solanum anguivi* group, these values were lower than those observed with nifedipine, indicating better hepatic tolerance. The effect of treatment on the lipid profile was mixed. The observed reduction in total cholesterol was accompanied by a fall in HDL, which could reduce the long-term cardiovascular benefit [26]. Overall, these results suggest that the antihypertensive effects of *Solanum anguivi* are due to a combination of factors, including reducing oxidative stress, inhibiting inflammatory pathways and modulating osmotic pressure.

This research reveals new information about the potential antihypertensive properties of *Solanum anguivi*. Having examined the mechanisms by which blood pressure is regulated and the associated biomarkers, we conclude that this African plant shows great promise as a therapeutic agent, despite having received little attention to date. The results of this study contribute to the substantial existing body of evidence that supports the efficacy of traditional medicinal plants in preventing and treating hypertension. They pave the way for further pharmacological research and clinical studies, which will expand our knowledge and help us develop potential therapeutic applications.

5. Conclusion

This study demonstrated the blood pressure-lowering effect of *Solanum anguivi* powder in Wistar rats with fructose- and salt-induced hypertension. Treatment with 200 mg/kg resulted in a significant reduction in blood pressure, comparable to the effect of nifedipine. Treatment with *Solanum anguivi* appears to be well tolerated in hematological and biochemical terms. It does not induce renal toxicity or major disruption of liver function; however, vigilance is required with regard to a fall in HDL. The rise in platelets may indicate a beneficial effect on haematological regulation. Therefore, this plant could represent a functional food or phytotherapeutic candidate for the prevention or complementary treatment of arterial hypertension. These results pave the way for the pharmacological use of this underutilised plant in traditional medicine to combat cardiovascular disease.

Compliance with ethical standards

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Disclosure of conflict of interest

No potential competing interests have been declared.

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