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Pharmacognostic Standardization and Evaluation of the Vasodilatory Potential of *Capsicum Annuum* L. var. *Annuum* Fruit

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Abstract
Capsicum annuum L. var. annuum, commonly known as Cayenne pepper, is widely cultivated across tropical regions for its medicinal and nutritional values. Traditionally, its fruits are used to treat conditions like hypertension, cardiovascular shock, fever, and pain. This study seeks to establish the pharmacognostic profile of C. annuum var. annuum fruit and evaluate its vasodilatory effects using a toad heart model. Standard methods were employed for microscopical, physicochemical, and phytochemical analyses. Acute toxicity (LD_{50}) was evaluated in mice, while the vasodilatory activity of the fruit extract was tested on isolated toad heart at concentrations ranging from 6.25 to 100 mg/mL against standard adrenaline and acetylcholine controls. Microscopic evaluation revealed distinct parenchymatous cells, fibers, glandular trichomes, calcium oxalate crystals, oil globules, starch grains, testa of epidermis, and bordered pitted vessels. Chemomicroscopy confirmed the presence of tannins, lignin, carbohydrates, oils, and proteins. Physicochemical analysis yielded a total ash value of 3.85% w/w, water-soluble ash of 1.26%, acid-insoluble ash of 2.56%, moisture content of 3.78%, water-extractive value of 5.77% w/w, and ethanol-extractive value of 4.07% w/w. The toxicological study demonstrated that the LD_{50} in mice is greater than 5000 mg/kg, indicating a high safety profile. The pharmacological assay demonstrated a dose-dependent decrease in heart rate across all extract concentrations. The established organoleptic, microscopic, and physicochemical parameters provide essential diagnostic criteria for the authentication, quality control, and identification of C. annuum var. annuum to prevent adulteration and/or substitution. Furthermore, the dose-dependent cardiac effects could validate the traditional ethnomedicinal use of the plant as a vasodilatory and antihypertensive agent.

Keywords: Antihypertensive, *Capsicum annuum* fruit, Hypertension, Pharmacognostic profile, Vasodilatory effects

INTRODUCTION

Medicinal plants are the nature's gift to human beings to help them pursue a disease-free healthy life (Katkar *et al*., 2010), and remain relevant from ancient times until now, especially in the developing and underdeveloped worlds like Nigeria and parts of Africa, Asia and the Americas. Traditional practices serve as substitutes for orthodox health care services due to the relative safety, accessibility and cost-effectiveness of herbal medications (Afsar *et al*., 2015). *Capsicum*, a genus in the solanaceae family has been part of human diet since 7500 BC, and in

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the sixteenth century, *Capsicum annuum* was widely distributed from the New World to other continents via Spanish and Portuguese traders while the other species are less distributed outside South America (Shruti *et al*., 2014). Those used in cooking are generally varieties of *Capsicum annuum* and *Capsicum frutescens* species, known to contain a wide range of nutritional components and pharmacologically active metabolites (Akhtar *et al*., 2021).

Capsicum annuum L. var. *annuum* belongs to the Solanaceae family, is native to America but now cultivated in different tropical and subtropical parts of the world, including Nigeria, and commonly consumed all over the world as a spice (Pandey *et al*., 2012). It is commonly known as Cayenne pepper or Bird pepper in English, Ata-ijosi in Yoruba, Kananan borkonu in Hausa and Ose-oji in Igbo. Historically, it has been known to possess medicinal properties like anti-inflammatory, analgesic, and stomachic properties (Edeoga *et al*., 2010), as well as use in cardiovascular disorders like hypertension and heart attack, where the powder is given by certain practitioners, orally, for cure. Capsaicinoids are the major chemical entities responsible for the pungency in *C. annuum*, which also acts as a local anesthetic and pain reliever. As a rubefacient, the compound increases blood flow and helps to stimulate circulation in rheumatic and arthritic conditions (Shruti *et al*., 2014). A previous work by Ogunoye and Anthonia (2025), reported the presence of alkaloids, saponins, tannins and flavonoids in *C. annuum*, without specific mention of the variety used in the research. This study was necessitated by the limited scientific evidence on the traditional medicinal uses of *C. annuum* var. *annuum* in hypertension, and other circulatory disorders, in the face of the increasing burden of cardiovascular diseases.

Pharmacognostic study plays a pivotal role in drug discovery and development. It aims to identify, characterise, and standardise natural products for their potential therapeutic benefits. By understanding the morphological, microscopic, chemical, and biological properties of medicinal plants, pharmacognostic studies contribute to these quality control, authentication and standardization of herbal medicines, as well as scientific evidences of therapeutic claims (Thukral *et al*., 2014). Pharmacognostic studies also provide data for plant identification following standardization parameters to prevent adulterations and help in authentication of the plants and ensure reproducible quality of herbal products which will lead to safety and efficacy of natural products (Kunle *et al*., 2012). Pharmacognostic evaluation here, is also necessitated by the fact that there are many varieties of *Capsicum annuum,* including: var. *abbreviatum*, var. *annuum*, var. *accuminatum*, var. *grossum*, and var. *glabriusculum* (Zhigila *et al*., 2014). This study focused on the Cayenne pepper, the variety used for medicinal purpose (*Capsicum annuum* L. var. *annuum*).

Vasodilation is the widening of blood vessels as a result of the relaxation of the blood vessel's muscular walls. Vasodilation is a mechanism to enhance blood flow to areas of the body that are lacking oxygen and/or nutrients. The vasodilation causes a decrease in systemic vascular resistance (SVR), and heart rate (beats per minute), and an increase in blood flow, resulting in a reduction of blood pressure (Ramanlal *et al*., 2023).

Therefore, this study focused on establishing the pharmacognostic parameters of the fruit of *Capsicum annuum* L. var. *annuum*, as well as determining the vasodilatory effect, based on the observed effect of the aqueous ethanol crude extract of the fruit on the heart rate (blood pressure), using the isolated toad heart, as such information is lacking.

MATERIALS AND METHODS

Plant Collection and Preparation

The plant sample was collected from Jengre village in Bassa Local Government Area (LGA) of Plateau state with the assistance of a practicing herbalist, and was identified and authenticated by a taxonomist, Mr. J.J Azila of the College of Forestry. Afterwards the herbarium specimen of the plant, *Capsicum annum* var. *annuum* was prepared according to the standard procedure, and deposited at the herbarium of the Department of Pharmacognosy and Traditional Medicine, University of Jos, Plateau State, Nigeria, with the specimen number, UJ/PCG/HSP/16S01. The obtained fresh fruits were collected, air dried at ambient temperature, pulverized using a blender into fine powder, and then stored in a well-sealed container until when needed for use. The fruit powder (60 g) was extracted by maceration for 48 hours using 70% aqueous ethanol, filtered, and concentrated to dryness using a rotatory evaporator, and then stored in a suitable container in the refrigerator.

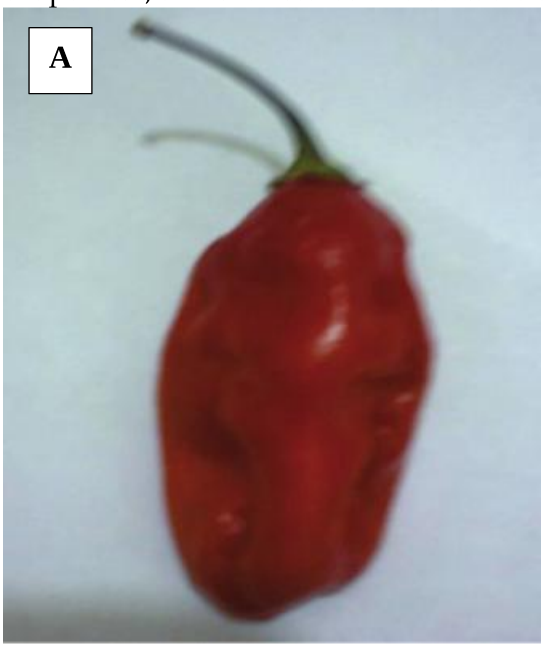

Plate 1: Pictures of *Capsicum annuum* ar. *Annuum*; A, Fruit (Zhigila *et al*., 2014), B, Plant

Organoleptic/Macroscopic Evaluations

Examinations of the colour, odour, taste, size and texture of the fruits were carried out according to the methods described by Evans (2009).

Microscopic Evaluations

Microscopic evaluation of the fruit powder was carried out based on standard procedures described by WHO (1998), and important diagnostic characters were observed, photomicrographs taken and labeled appropriately. Also, chemomicroscopic evaluation for the presence/distribution of substances such as tannins, lignin, proteins, oil, starch and calcium oxalate crystals were done, in triplicates, according to the method specified in Evans (2009).

Phytochemical Screening

The preliminary phytochemical tests for the presence of various secondary metabolites including, alkaloids, saponins, tannins, steroids, anthraquinones, cardiac glycosides, and flavonoids, were done using standard procedures (Sofowora, 2008; Evans, 2009; Amita and Shalini, 2014).

Evaluation of Physicochemical Properties

All physicochemical parameters, including moisture content (loss on drying), total ash value, acid-insoluble ash value, water-soluble ash value, alcohol soluble extractive value, and water-soluble extractive value, were determined following the standard methods described in the B. P. (1993).

Vasodilatory Study of *Capsicum annuum* Var. *Annuum* Fruit

Acute Toxicity Study

Acute toxicity of the ethanol extract was carried out using 12 mice of both sexes weighing 24.6g to 30.3g to determine the median lethal dose (LD_{50}). In the initial phase, mice were divided into 3 group of 3 mice each and were treated with 10, 100 and 1000 mg/kg of the extracts per body weight intraperitoneally. They were observed for 24 hours for any signs of toxicity, including death within 72 hours. Another two groups of three mice were administered with normal saline and 20 % Dimethyl Sulfoxide (DMSO) to serve as control and observed also for clinical signs. In the final phase, 3 mice were divided into 3 groups of one mouse each and treated with 1600, 2900, and 5000 mg/kg for the ethanol extract. The LD50 was calculated from the results of the final phase as square root of the product of the lowest lethal dose and the highest non-lethal dose (Median Lethal Dose (LD50) = V (minimum dose of death x maximum dose of survival) (Lorke, 1983).

Toad Isolated Heart Test

This was set up following the Langendorff method as applied by Stampfl *et al.* (2011), using a medium sized frog, *ex vivo*. Thoracic cavity is widened by stretching all the four limbs on the sides. The heart is now gently freed from the pericardium and a few drops of warm frog's Ringer solution are poured over it. One branch of the truncus arteriosus is tied firmly with the help of a thread while the other branch is cut open for the perfusion fluid to come out. Heart is then lifted up to locate sinus venosus, and a ligature is passed beneath and a venous cannula is inserted into it. It is kept in position by tying a ligature around it. The venous cannula is connected to the perfusion bottle containing frog's ringer solution, kept warm at 37 ^{o}C and pH of 7.4, with air bubbling for oxygen supply, using rubber tube. The circulation of the frog's Ringer solution inside the heart is from sinus venosus to right auricle ventricle arch of aorta out of the cut end of the aorta (First of all the fluid goes from the reservoir to the venous cannula and then sinus venosus). The rate of perfusion is kept 30-40 drops/min. The perfusion pressure is adjusted by altering the height of the reservoir above the level of the heart. Now a pin hook is passed through the apex of the ventricle and the pin is attached to universal lever to write on smoked drum**.** Various doses of the crude aqueous ethanol extract (6.25 mg/mL, 12.5 mg/mL, 25 mg/mL, 50 mg/mL, 100 mg/mL) prepared in distill water, as well as standard acetylcholine and adrenaline (Controls) were injected in a dose of 1 mL with the help of tuberculin syringe in the rubber tube near the venous cannula and the effect recorded till the heart becomes normal again. At least 5 minutes gap was allowed between administrations of each dose of the drug. Heart Rate was counted by counting the number of times lever comes down per minute, and the force of contraction was determined by the height of the tracing (amplitude). Down going lever indicates systole, while up going lever indicates diastole.

Data Analysis

Data were recorded as mean ± standard error of mean (SEM). The statistical significance of differences was determined by one-way ANOVA using the IBM SPSS statistical tool (version 20). Tukey's test was used for post hoc analysis, and differences of $p \leq 0.05$ were considered statistically significant.

RESULTS

Macroscopic/Organoleptic Characters

The macroscopic examination of the fruit of *C. annuum* var *annuum* showed that the fruits are many-seeded berries which are short and elongated, yellow to red when ripe and green when unripe with a smooth shiny surface, as well as being up to 1.2 to 2.3 cm in length and up to 0.4 to 0.6 cm in width, with characteristic odour and pungent taste (Table 1).

Table 1: Macroscopic Characters of the Fruit of *Capsicum annuum* Var. *Annuum*

Character	Observation
Shape	Short and elongated
Size	1.2-2.3 cm length, 0.4-0.6 cm in width
Stalk	Long Stalk 2-3cm
Colour	Yellow-Red (Ripe), Green (Unripe)
Surface texture	Smooth and Shiny
Odour	Characteristic smell
Taste	Pungent

Microscopic Characters

The microscopic and chemomicroscopic evaluations of the fruit powder revealed the presence of Parenchymatous cells, fibres, glandular trichomes, oil globule, testa of epidermis, and pitted vessel, and calcium oxalate crystals. Some photomicrographs of the features are represented in Plate 2. The chemomicroscopic evaluation of the fruit showed the presence of tannins, lignified cell walls on most structures, particularly the parenchymatous cells. Proteins, carbohydrates, calcium oxalate crystals and oil globules were also seen (Table 2), and some of the photomicrographs represented in Plate 3.

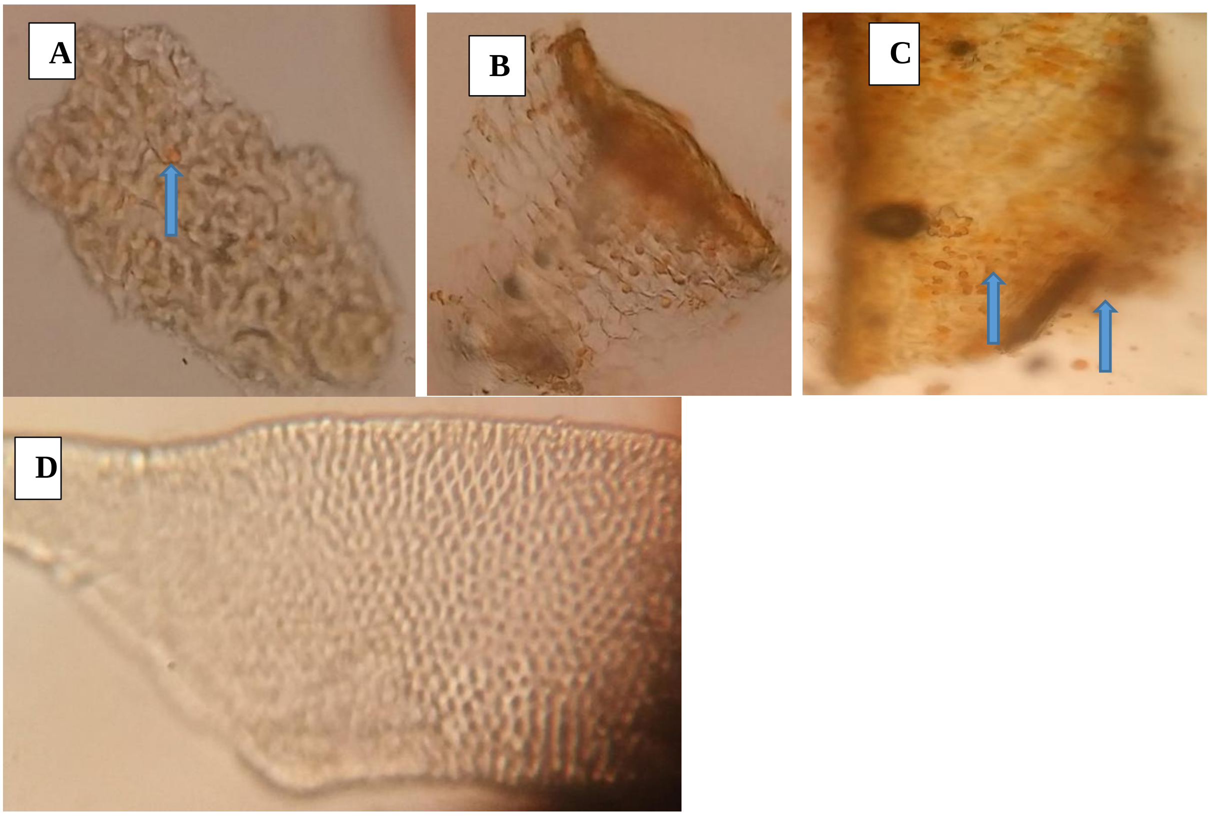

Plate 2: Photomicrographs of some microscopical characters of *C. annuum* var. *annuum* fruit; A, an oil globule within the matrix of sclereids, B, fragment of seed testa with cuticularised epidermis, accompanying parenchyma cells and oil globules, C,fragment s of glandular trichome and bundle of fibres with surrounding parenchyma cells, D, bordered pitted vessel (x40)

Table 2: Chemomicroscopical Microscopical Characters of *C. annuum* Var. *Annuum* Fruit

Metabolites	Observation	Inference
Protein	Yellow-red mass formed	Protein present
Lignin	Pink stain on parenchymatous cells and vascular bundle	Lignification
Starch	Spherical granules stained blue-black around the vessels	Starch present
Tannins	Greenish-blue colouration on most structures particularly the parenchymatous cells.	Tannins present
Oils	Numerous orange-stained globules	Oil present
Calcium oxalate	Crystalline structures scattered on fibres	Calcium present

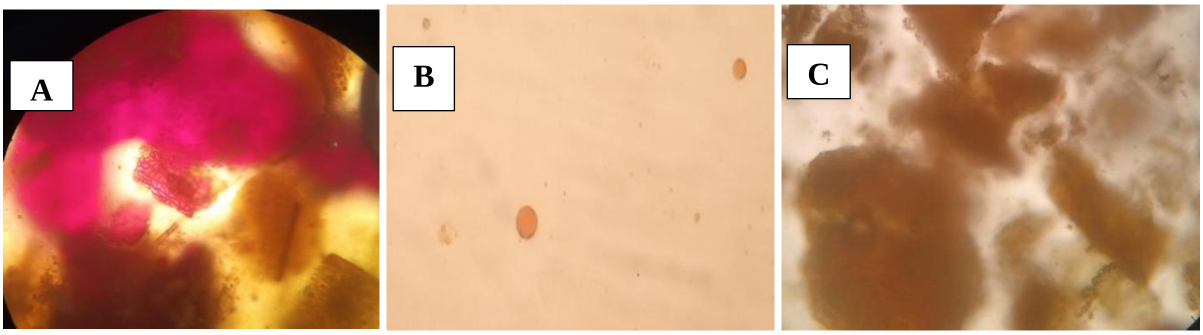

Plate 3: Photomicrographs of the chemomicroscopical characters of *C. annuum* var. *annuum* fruit; A, pink stained lignified structures, including parenchyma, and fibres, B, scattered orange-stained oil globules, C, yellow-red stained structures, including vessels indicating proteins (x40)

Phytochemical Constituents

The phytochemicals screening of the fruit revealed the presence of alkaloids, carbohydrates, cardiac glycosides, tannins, and steroids, as in Table 3.

Table 3: Phytochemical Constituents of the Fruit of *Capsicum annuum* Var. *Annuum*

Metabolite	Result
Carbohydrates	+
Tannins	+
Anthraquinones	-
Saponins	-
Cardiac glycoside	+
Steroid	+
Alkaloids	+
Flavonoids	+

Key: + = Present, - = Absent

Physicochemical Properties

The results of the evaluations of the physicochemical properties of the *C. annuum* var. *annuum* fruit as shown in Table 4, include those of moisture content, total ash value, acid insoluble ash value, water-soluble ash value, alcohol extractive value, and water extractive value.

Table 4: Physicochemical Parameters of *C. annuum* Var. *Annuum* Fruit

Parameter	Composition (%)
Moisture content	3.78 ± 0.11
Alcohol extractive value	4.07 ± 0.08
Water extractive value	5.77 ± 0.04
Total ash value	3.85 ± 0.12
Acid insoluble ash value	2.56 ± 0.05
Water soluble ash value	1.26 ± 0.02

Values are expressed as mean ± standard error of mean (SEM), n = 3

Acute Toxicity (LD_{50})

The results as presented in Table 5 revealed that the LD_{50} is greater than 5000 mg/kg. This implies that the 70% aqueous ethanol extract of the *C. annuum* var. *annuum* fruit is safe, since there were no mortality and morbidity even at a high dose of 5000 mg/kg in mice, *in vivo*.

Table 5: Median Lethal Dose of the Aqueous Ethanol Extract of *Capsicum annuum* Var. *Annuum* Fruit in Mice

Phase	Doses of Aq. Ethanol Extract (mg/kg)	Number of deaths over number of lives
I	10	0/3
	100	0/3
	1000	0/3
II	1600	0/1
	2900	0/1
	5000	0/1

Vasodilatory Effect of *Capsicum annuum* Var. *Annuum* Fruit

The effects of various concentrations of aqueous ethanol extract of *C. annuum* var. *annuum* fruit on the heart rate of the toad were determined as presented in Table 6. The results show significant ($p \leq 0.05$) decreases in heart rate, which results from vasodilatory actions, for all the doses (6.25 mg/mL, 12.5 mg/mL, 25 mg/mL, 50 mg/mL, and 100 mg/mL) when compared to the control. The 100 mg/mL exhibited the highest decrease in heart rate, which shows that the effect is dose dependent. The effects can also be clearly seen, graphically, as expressed in Figure 1.

Table 6: Effect of *C. annuum* Var. *Annuum* Fruit Extract on Toad Heart Rate

Drug/Extract	Concentration (mg/mL)	Heart Rate (Beats/Minute)
BL	0	90
EC1	6.25	84
EC2	12.5	78
EC3	25	60
EC4	50	54*
EC5	100	42*
ACH	1×10^{-5}	30
ADR	0.1	54

*$p \leq 0.05$ compared to the blank (Distilled water); EC= Extract concentration, ACH= Acetylcholine, ADR=Adrenaline, BL=Blank

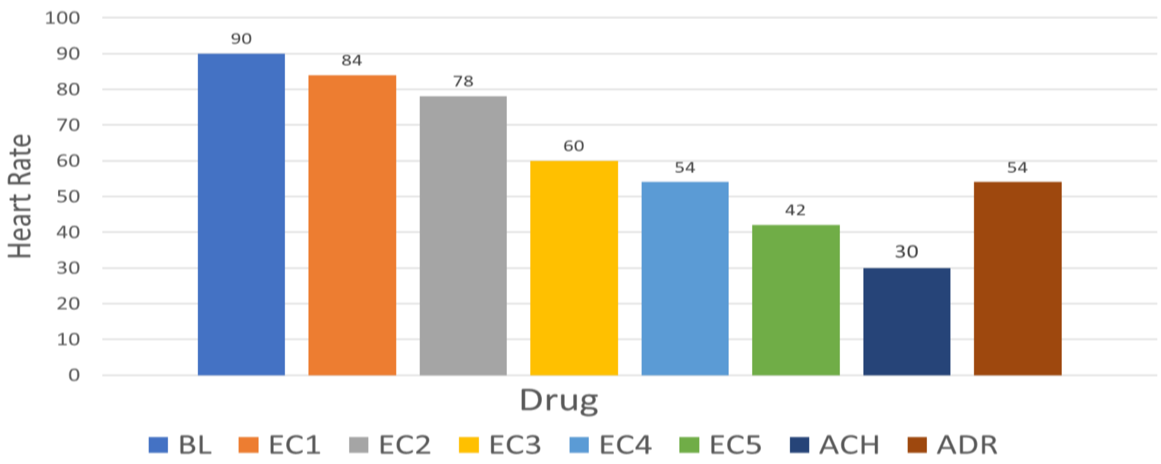

Figure 1: Toad Heart Rate Against Various Doses of the Aqueous Ethanol Extract of *C. annuum* Var. *Annuum* Fruit

Key: EC= Extract concentration, ACH= Acetylcholine, ADR=Adrenaline, BL=Blank

DISCUSSION

The macroscopic study shows that the size of the fruit falls within the range for the general *C. annuum* species of 1 – 25 cm reported by Swamy (2023), while the average length (7.10 cm), and the width (1.99 cm) reported for the *C. annuum* var. *annuum* fruits found in Ilorin, Kwara State, by Zhigila *et al*. (2014) shows this one from Jos, Plateau State to be smaller. Also, the Pakistani variety has been reported by Shaheen *et al*. (2018) to be longer (7.0 to 10.0 cm) and sometimes narrower (4.0 to 4.5 cm) than this variety, while the colour and taste were similar. This could be attributable to genetic variations due to varying soil and climatic conditions. Among Nigerian varieties, it is only longer than var. *abbreviatum*, but shorter than var. *accuminatum*, var. *grossum*, and var *glabriusculum*, only a little wider than var. *glabriusculum* (Zhigila *et al*., 2014). These should help in the identification of *C. annuum* var. *annuum* from among many other species and varieties. The availability of the fruit, also in other states, gives credence to the traditional uses for food and medicine around Nigeria, as in Asia and other nations.

With respect to the microscopic evaluation results here, the only earlier report seen on the microscopic characters of *C. annuum* var. *annuum* (a Nigerian variety) is by Zhigila *et al*., (2014), on the epidermal cells being 235.74 µm in size, polygonal in shape, and having straight or curved walls. The additional data from this work would enhance the monograph of the Nigerian fruit variety. There seems to be some similarities with the Pakistani varieties based on the report by Shaheen *et al*. (2018), which shows the presence of fibres, sclereids of endocarp, epidermis cells, elongated sclereids, calcium oxalates and glandular trichome, endosperm cells, parenchyma of mesocarp with oil glands, group of vessels, annular vessel, mesocarp cells, epidermis of testa, oil globules, yellow fragment of epicarp, epicarp with cuticular striation and epicarp with stomata, as well as proteins.

In comparison to the phytoconstituents revealed in this study as shown in Table 3, Ogunoye and Anthonia (2025) have also reported the presence of alkaloids, tannins, saponins, and flavonoids, without mentioning cardiac glycosides and steroids, in an unspecified variety of *C. annuum* obtained from various open markets in Benin city, Edo State, Nigeria. Shaheen *et al*. (2018) have also reported the presence of alkaloids, carbohydrates, flavonoids, saponins, cardiac glycosides and tannins in the Pakistani variety of *C. annuum*. The slight qualitative and/or quantitative variations in the constituents could still be attributable to soil and climatic differences. The presence of these phytochemicals, known to be bioactive, justifies the use of the fruit for medicine. Cardiac glycosides are so named for their effect on the heart, and an alkaloid, capsaicin, known to occur in some *Capsicum* species has been indicated to have relaxant properties on vascular muscles (Carter, 2008). Therefore, the alkaloidal content here may be very crucial.

The determination of physicochemical parameters is important in the determination of adulterants and improper handling of crude drugs. Moisture content is the amount of water/moisture present in a crude drug. Drugs with high moisture content are liable to deteriorate, especially in warm climates leading to the activation of enzymatic activities, proliferation of certain microorganisms (Evans, 2009). The plant has a moisture content of 3.78%, which is below the maximum acceptable limit of 14%, indicating relative safety from microbial growth. Ash values are useful in the determination of quality and purity of crude drugs, particularly in powdered forms. The total ash is used as a criterion to judge the identity and purity of drugs. The total ash for this study was found to be 3.85%w/w, falling below the maximum acceptable range of 14%. This implies that the plant is of good quality, with high amount of organic matter. The water-soluble ash value was 1.26%, indicative of little physiological ash, while acid insoluble ash value was 2.56%, representing much more non-physiological ash (foreign matter like sand). These show a high degree of purity of the sample used, enhancing the reliability of evaluation results, in general (WHO, 2011; Shaheen *et al*., 2018). The amount of the active constituents in a given quantity of plant material is determined by the extractive values. The composition of these phytoconstituents depends upon the nature of the drug and the solvent used. In addition, it gives an indication whether the drug is exhausted or not (Tatiya *et al*., 2012; Bruce *et al*., 2019). The result of this study showed that the water extractive value was 5.77% w/w compared to that of ethanol which was 4.074% w/w. This explains that water had better extractive ability, with more constituents, compared to ethanol. These results provide useful data for standardisation of the fruit of *Capsicum annuum* var. *annuum* in order to ascertain its quality parameters.

The determination of the LD_{50} as shown in Table 5 indicates that the fruit is practically non-toxic and safe to use, based on the toxicity classification which states that substance with LD_{50} of 5000 mg/kg to 15000 mg/kg body weight are practically non-toxic (Loomis and Hayes, 1996). Lagu and Kayanja (2013) have reported the safety of *C. annuum* seeds from South Western Uganda, which further confirms the safety of the fruit that contains the seeds. This justifies the wide use of the fruit as a food spice and medicine, and can safely be used in animal experiments.

The implication of the dose dependent decrease in the toad heart rate as indicated in the results in Table 6, and represented in Figure 1 is that the fruit has significant vasodilatory activity. The vasodilation causes a decrease in systemic vascular resistance (SVR), and heart rate (beats per minute), and an increase in blood flow, resulting in a reduction of blood pressure (Ramanlal *et al*., 2023). Thus, this explains the basis for the effective traditional uses of *C. annuum* var. *annuum* fruit in cases of cardiovascular shock and hypertension, which can be further corroborated by the report of Carter (2008).

CONCLUSION AND RECOMMENDATIONS

More pharmacognostic data have been established and will be useful for the correct identification of the plant, thereby preventing adulteration and substitution. It has also been scientifically confirmed that *Capsicum annuum* var. *annuum* fruit is safe and effective as a vasodilatory agent. This outcome supports the traditional use of the fruit in the treatment of cardiovascular shock and hypertension. It is therefore recommended that formulations of standardized herbal preparations should be experimented, as well as further isolation and testing of the constituents of the fruit specifically responsible for vasodilatory activities, for possible new drug discovery.

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References

Afsar, T., Khan, M. R., Razak, S., Ullah, S., and Mirza, B. (2015). Antipyretic, anti-inflammatory and analgesic activity of Acacia hydaspica R. Parker and its phytochemical analysis. *BMC complementary and alternative medicine*, *15*, 136. https://doi.org/10.1186/s12906-015- 0658-8

Akhtar, A., Asghar, W., and Khalid, N. (2021). Phytochemical constituents and biological properties of domesticated capsicum species: a review. Bioactive Compounds in Health and Disease,4(9),201. https://doi.org/10.31989/bchd.v4i9.837

Amita, P. and Shalini, T. (2014). Concept of Standardization, Extraction and Pre-phtyochemical Screening Strategies for Herbal Drugs. *Journal of Pharmacognosy and Phytochemistry*, 2(5): 115-119.

British Pharmacopoeia (1993). Herbal Drugs. Her Majesty's Stationary Office, London. UK.

Bruce, S. O., Onyegbule, F. A. and Ezugwu, C. O. (2019). Pharmacognostic, physicochemical and phytochemical evaluation of the leaves of *Fadogia cienkowski* Schweinf (Rubiaceae). Journal of Pharmacognosy and Phytotherapy, 11(3): 52-60. DOI: 10.5897/JPP2019.0552

Carter, D. (2008). Cayenne as a Treatment: Effects on Circulatory Disorders and Acute Coronary Artery Adverse Events. *The Journal of Applied Natural Medicine*

Edeoga, H.O., Omosun, G.O., ThankGod, L.I. (2010). Exomorphology of leaf epidermis of some Nigerian Capsicum (Solanaceae). Int. J. Curr. Res. 4, 087-090.

Evans, W.C. (2009). Trease and Evans' Text book of Pharmacognosy. Fourteenth Edition. W.B. Saunders Company Ltd. London. Pp 119-120, 194-227 &343

Hedge, S., Hedge, G. R., Mulgund, G. and Upadhya, V. (2014). Pharmacognostic Evaluation of Leaf and Fruit of Capsicum frutescens (Solanaceae). Pharmacognosy Journal 6(3):14-22. DOI:10.5530/pj.2014.3.3.

Katkar, K. V., Suthar, A. C., and Chauhan, V. S. (2010). The chemistry, pharmacologic, and therapeutic applications of Polyalthia longifolia. *Pharmacognosy Reviews/Bioinformatics Trends/Pharmacognosy Review*, 4(7), 62. https://doi.org/10.4103/0973-7847.65329

Kunle, O. F., Egharevba, H. O. and Ahmadu, P. O. (2012). Standardization of Herbal Medicines- A Review. *International Journal of Biodiversity and Conservation*, 4(3): 101-112.

Lagu C and B. Kayanj FI (2013) Acute Toxicity Profiles of Aqueous and Ethanolic Extracts of Capsicum annum Seeds from South Western Uganda. Insights from Veterinary Medicine. InTech. Available at: http://dx.doi.org/10.5772/53599.

Loomis, T. A. and Hayes, A. W. (1996). Loomi's Essentials of Toxicology, 4th Ed. Academic Press, New York, 210 – 213.

Lorke, D. (1983). A New Approach to Acute toxicity Testing. *Archive of Toxicology*, 273-287.

Ogunoye, O. and Anthonia, C. (2025). Phytochemical and microbial study of pepper (*Capsicum annuum* L.) obtained from three different markets in Benin city, Nigeria. *International Journal of Secondary Metabolite*, 12(4): 868–876. https://doi.org/10.21448/ijsm.1613868.

Pandey SK, Yadav SK, Sing VK. An overview on Capsicum annum L. J Pharm Sci Technology 2012; 4(2):821–828.

Ramanlal, R. and Gupta, V. (2023). Physiology,Vasodilation. Treasure Island (FL), StatPearls Publishing; Available from: https://www.ncbi.nlm.nih.gov/books/NBK557562/

Shaheen, N., Imam, S., Abidi, S., Sultan, R. A., Azhar, I. and Mahmood, Z. A. (2018). Comparative Pharmacognostic Evaluation and Standardization of *Capsicum Annuum* L. (Red Chili). *International Journal of Pharmaceutical Sciences and Research*, 9(7): 2807-2817

Sofowora, A. (2008). Medcinal plant and Traditional Medcine in Africa, Spectrum Books Limited, Ibadan, Nigeria 3rd edition. Pp. 70-74

Stampfl, A., Maier, M., Radykewicz, R., Reitmeir, P., Gottlicher, M. and Niessner, R. (2011). Langendorff Heart: A Model System to Study Cardiovascular Effects of Engineered Nanoparticles. *American Chemical Society Nano*, 5(7): 5345-5353.

Swamy, K.R.M. (2023). Origin, distribution, taxonomy, botanical description, genetic diversity and breeding of capsicum (Capsicum annuum L.). *International Journal of Development Research*, 13 (03): 61956-61977.

Tatiya A, Surana S, Bhavsar S, Patil D, Patil Y (2012). Pharmacognostic and preliminary phytochemical investigation of *Eulophia herbacea* Lindl. Tubers (Orchidaceae). *Asian Pacific Journal of Tropical Diseases*, 2(1):50-55.

World Health Organization (2011). Quality Control Method for Herbal Materials. Pp.9-13
Zhigila, D. A., AbdulRahaman, A. A., Kolawole, O. S. and Oladele, F. A. (2014). Fruit Morphology as Taxonomic Features in Five Varieties of Capsicum annuum L. Solanaceae. *Journal of Botany* Volume 2014, Article ID 540868, 6 pages http://dx.doi.org/10.1155/2014/540868