Wound Healing and Anti-Ulcerogenic Activity of *Gardenia angustifolia* Extract in Rats

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**Abstract**

*Gardenia angustifolia* is widely utilized in many parts of Nigeria to manage a wide range of ailments. As part of effort to elucidate its pharmacological activities and hence medicinal potential, wound healing and anti-ulcerogenic properties of the extract was evaluated using experimentally created wound and ulcers in albino rats. Wound healing properties was evaluated using excision wound model, while anti-ulcer activity was studied using ethanol induced ulcer model. Five groups of rats were experimentally wounded at the back area. An area of uniform wound of 7×7 mm using millimeter ruler was excised. The animal groups were topicaly treated with *Gardenia angustifolia* gel, wound dressed with leaf, fruit and root gel significantly healed earlier than those treated with paraffin base and povidone iodine (standard). In anti-ulcer studies, rats were orally administered with different doses of the root extract (100, 250 and 500 mg/kg body weight) and positive control group (Omeprazole, 8 mg/kg body weight) for five days. After induction of ulcer using 5 ml/kg body weight of ethanol, the stomach of the rats was opened, gastric volume and ulcer area were measured. The results indicated that *Gardenia angustifolia* root extract could prevent ulceration in rats in a dose dependent manner. The acute toxicity study revealed that the plant could be toxic at higher doses. Blood glucose reduction was dose and time dependent. From this study it is evident that *G. angustifolia* possess anti-ulcer properties and also wound dressed with the root, leaf and fruit gels significantly enhanced the acceleration of wound healing in rats.

**Keywords:** *Gardenia angustifolia*; Anti-ulcer; Wound healing; Albino rats; Omeprazole; Toxicity

**Introduction**

Wound is a breach in the normal tissue continuum, resulting in a variety of cellular and molecular sequelae. The basic principles of optimal wound healing which include minimizing tissue damage, debridging nonviable tissue, maximizing tissue perfusion and oxygenation, proper nutrition and moist wound healing environment have been recognized for many years [1].

A number of drugs ranging from simple non-expensive analgesics to complex and expensive chemotherapeutic agents administered in the management of wound affect healing either positively or negatively [2]. Aspirin, indomethacin, cytotoxic agents and immunosuppressant have been proved experimentally to affect healing negatively [3]. Wound is defined as the disruption of the cellular and anatomic discontinuity of a tissue and may be produced by chemical, physical, thermal, microbial or immunological insult to the tissue. Wound cause discomfort and are more prone to infection and other troublesome complications [4].

Peptic ulcer is a conglomerate of heterogeneous disorders, which manifests itself as a break in the lining of the gastrointestinal mucosa bathed by acid and or pepsin [5]. Mucosal injury may occur when noxious factors “overwhelm” an intact mucosal defense or when the mucosal defense is somehow in paired [6]. Although a number of anti-ulcer drugs such as H₂ receptors antagonists, proton pump inhibitors and cytoprotectants are available for ulceration all these drugs have side effects and limitations. Herbal medicine deals with plants and plant extracts in treating diseases. These medicines are considered safer because of the natural ingredients with no side effects [7]. These natural agents induce healing and regeneration of the tissue by multiple mechanisms, however, there is need for scientific validation, standardization and safety evaluation of plants of traditional medicine before they could be recommended for wound and ulcer treatment [8].

*Gardenia angustifolia* (*G. angustifolia*) is found in the tropical and subtropical regions of Africa and Southern Asia. Different parts of *G. angustifolia* are used in the management of many diseases traditionally including abdominal irritation, abortion abscesses, chicken pox, mental disorder, erectile dysfunction, cough, diabetes, etc. Inspite of being one of the well-known medicinal plants used in Nigerian traditional medicine, studies pertaining to the pharmacological properties of *G. angustifolia* are very rare. There is no scientific evidence available for wound healing and anti-ulcer activity of *G. angustifolia*; therefore, the present research was undertaken.

**Materials and Methods**

**Plant material**

The plant sample was collected from Abocho in Dekina Local Government Area of Kogi State, Nigeria during rainy season when the plant thrives well and produces fruits. Dirt was removed from the plant sample by rinsing properly in clean water. The sample was air-dried for three weeks and pulverized into powder form using mechanical hand blender and sieved.

**Preparation of extract**

Portions of the samples-600 g of the powdered root, 300 g of the leaf and 60 g of the powdered fruit were weighed out and soaked in containers containing 1200 ml, 800 ml and 200 ml of methanol respectively. The extracts were allowed to stand for 8 weeks and filtered. The filtered solutions were further heated until the remaining residue was removed. The extract was then allowed to cool and filtered and concentrated using a vacuum distillation apparatus. The concentrated extracts were dried using a rotary evaporator at 40°C. The crude extracts were weighed and the yields were calculated in percentage. Each sample was further dried under vacuum and homogenized using a blender and sieved.

**Gardenia angustifolia** (*G. angustifolia*) is locally called Ikaga by the Igalas people of Kogi State, Nigeria. *G. angustifolia* (*Rubiaceae*) is locally grown and grown from nursery in Kogi State, Nigeria.
respectively for 72 hours. The mixtures were then filtered under vacuum pressure and the filtrates were concentrated by evaporation using water bath at 60°C.

Animals

The animals selected for this study were albino rats of both sexes with average weight range between 130–220 g. They were obtained from Mr. Friday Titus Emmanuel who breeds them and housed in the departmental animal house during the experimental period in a standard environmental conditions. They were allowed free access to standard laboratory diet and drinking water without any form of restriction. This study was carried out in conformity with national and international laws and guidelines for care and use of laboratory animals in biomedical research; especially as promulgated and approved by United States Institute of Health (1985).

Ointment preparation for topical application

Methanol-free extract of G. angustifolia leaf, root and fruit gels were used for the preparation of the ointment for topical application [9]. A 50% (w/w) of extract ointment of G. angustifolia (leaf, root and fruit) were formulated using soft white paraffin base [10].

Excision wound model

Animals were anaesthetized with 0.3 ml of lindocane adrexl (local anesthetic) to prevent any movement of animals for at least two hours after administration and animals were left without being restrained [11].

The back of the animals were shaved and sterilized with 70% ethanol before 7x7 mm excision wound was created by a surgical blade from a predetermined shaved area on the back of each animal [12]. The experimental groups were topically applied with the extracts twice daily for consecutive 16 days. The group treated with povidone iodine drug served as a reference-standard. A progressive decrease in the wound area was periodically monitored. The wound contractions or closures were measured by a tracing paper on the wounded margin and calculated as percentage reduction in wounded area. The actual value was converted into percentage value taking the size of the wound at the time of wounding as 100%. The animals were divided into five groups of four animals per group.

Group 1: Control (wound treated with paraffin base).
Group 2: Standard (wound treated with povidone iodine).
Group 3: Wound treated with G. angustifolia root extract ointment.
Group 4: Wound treated with G. angustifolia leaf extract ointment.
Group 5: Wound treated with G. angustifolia fruit extract ointment.

Measurement of wound closure was taken the 4, 6, 8, 10 and 16th day post wound creation.

Acute toxicity

Seven groups (n=7) of albino rats of both sex were used in the acute toxicity of the root extract of G. angustifolia. Animals from all groups were fasted overnight and a safe dose of extract was determined through the acute oral toxicity test in rats at different doses up to 6000 mg/kg−1 was prepared by dissolving the extract in phosphate buffer saline (PBS). The extract was then administered (P.O.) with single dose (100, 200, 500, 1000, 2000, 5000 and 6000 mg/kg−1) of the extract. The animals were observed for behavioral changes, any sign of toxicity and mortality up to 48 hrs and their blood glucose level were measured after 12 and 24 hrs. Blood glucose measurement: The blood glucose level was determined according to the method described by [13].

Anti-ulcer activity study

Five groups (n=4) of albino rats were used to evaluate the anti-ulcerogenic activity of G. angustifolia methanol extract. Phosphate buffer saline (PBS), G. angustifolia methanol extract, Omeprazole and ethanol were administered to the group of animals per orally (P.O.). Group 1 received PBS (10 ml/kg−1) for 4 days and on the 5th day received absolute ethanol (5 ml/kg−1) and served as ulcer control. Group 2 was administered Omeprazole (8 ml/kg−1) for 5 days and served as positive control. Group 3, 4 and 5 were respectively administered with 100, 250 and 500 ml/kg−1 of G. angustifolia methanol extract for 5 days. All groups were fasted for 24 hrs and again administered with the extract or drug at the respective dose. After 30 minutes of this treatment, animals of group 2-5 were administered with 5 ml/kg−1 ethanol to induce ulcer. After 15 minutes of ethanol administration, all the animals were sacrificed using anaesthetic ether. Gastric volume was measured by pylorus ligation approach [14].

Each animal’s stomach was opened along the greater curvature and examined macroscopically for gastric erosions under a dissecting microscope (20x). The length and width (mm) of ulcer on the gastric mucosa were measured by plane glass square (10x10mm). The ulcer area (UA) was calculated. The percentage of protection (P%) availed the animals through various treatments which are calculated using the formula:

\[ P% = \left( \frac{UA \text{ Ulcer Control} - UA \text{ Treatment}}{UA \text{ Ulcer Control}} \right) \times 100 \]

Chemicals and reference drugs

All chemicals and reagents used in this investigation were of analytical grade and were obtained from BDH, Poole, England. Omeprazole and povidone iodine (reference drugs) were obtained from Kuzak Pharmacy in Anyigba, Kogi State, Nigeria. Omeprazole is an anti-ulcer drug which blocks the enzymes in the wall of the stomach from producing acid, the main culprit in peptic ulcer. By blocking the enzymes, the production of stomach acid is decreased, thus allowing the ulcer to heal [15].

Statistical analysis

All data were expressed as mean ± SEM. Statistical comparisons were performed using ANOVA. The level of significance was set at P<0.01.

Results

Wound healing

The topical application of G. angustifolia ointments increased the percentage of wound closure and this indicates rapid epithelization and collagenation. The administration of the extracts (root, leaf and fruit) accelerated the progression of wound healing. The root extract appears more potent than the leaf and fruit ointments (Table 1).

Acute toxicity evaluation

The result is as presented in table 2. Single dose (100, 200, 500, 1000, 2000, 5000 and 6000 mg/kg−1) of G. angustifolia root methanol extract administered to albino rats elicited some behavioural characteristics in them. There were some physical signs of toxicity when doses up 500
The root extract showed the highest healing activity. Wound healing is a complex and dynamic process of restoring cellular structures and tissue layers in damaged tissues as closely as possible to its normal state. Wound contracture is a process that occurs throughout the healing process, commencing in the fibroblastic stage whereby the area of the wound undergoes shrinkage. In maturation phase, the final phase of wound healing the wound undergoes contraction resulting in a smaller amount of apparent scar tissue.

Granulation tissue formed in the final part of the proliferative phase is primarily composed of fibroblasts, collagen, edema, and new small blood vessel [16]. In this study, it may be inferred that *G. angustifolia* ointments have the potential to satisfy all requirements of an ideal dressing material in that it provides an environment at the surface of the wound in which healing took place at the maximum rate consistent with the formation of granulation tissue with an acceptable cosmetic appearance and also provides a rationale for the use of *G. angustifolia* preparations in traditional system of medicine to promote wound healing.

Furthermore, it can be concluded that *G. angustifolia* extract has a beneficial effect as antiseptic and as an injury healing promoter. This effect may be explained by several mechanisms such as coating the wound, forming complexes with proteins of microorganism cell wall, chelating free radicals and reactive oxygen species, stimulating the contraction of the wound and increasing the formation of new capillaries and fibroblasts. Moreover, the extract did not produce any adverse effect on the wound surface and because of this it is possible to recommend its use in the treatment of skin wounds or ulcers.

Methanol extract of the root of *G. angustifolia* up to 5000 mg/kg did not cause any mortality in rats. All the doses below 5000 mg/kg did not produce any gross apparent effect on general motor activity; there was no convulsion, salivation, diarrhea and paralysis. Though there were mild signs of CNS depression at higher doses as well as sedation, respiration changes and slight tremor but all these signs faded as the time of exposure increased thus at 48 hrs after administration, the animals were near normal and well again (Table 2). Any substance that is not toxic at 5000 mg/kg is considered relatively safe [17].

### Table 1: Effect of *G. angustifolia* extracts on wound closure.

| Group/Treatment | Percentage Wound Contraction |
|-----------------|------------------------------|
|                 | 4 | 6 | 8 | 10 | 16 |
| 1. Paraffin base| 14.1 ± 0.35<sup>a</sup> | 21.26 ± 0.05<sup>a</sup> | 39.00 ± 6.97<sup>a</sup> | 49.50 ± 7.67<sup>a</sup> | 60.49 ± 6.77<sup>a</sup> |
| 2. Povidone iodine| 17.69 ± 7.27<sup>a</sup> | 28.22 ± 0.42<sup>a</sup> | 42.68 ± 11.37<sup>a</sup> | 53.49 ± 7.09<sup>a</sup> | 71.24 ± 0.36<sup>a</sup> |
| 3. Root extract | 21.24 ± 7.50<sup>bc</sup> | 30.73 ± 7.76<sup>bc</sup> | 48.53 ± 7.48<sup>bc</sup> | 64.38 ± 8.19<sup>bc</sup> | 87.36 ± 3.46<sup>bc</sup> |
| 4. Leaf extract | 17.50 ± 7.85<sup>bc</sup> | 28.39 ± 0.37<sup>bc</sup> | 46.07 ± 6.91<sup>bc</sup> | 60.46 ± 7.12<sup>bc</sup> | 81.81 ± 7.12<sup>bc</sup> |
| 5. Fruit extract | 21.07 ± 6.65<sup>bc</sup> | 24.75 ± 6.98<sup>bc</sup> | 45.93 ± 7.11<sup>bc</sup> | 49.49 ± 8.34<sup>bc</sup> | 67.25 ± 6.74<sup>bc</sup> |

Values are expressed as mean ± S.E. The mean values with the same superscript (ab) in the same column are significantly different (P<0.01). Values in the same column with (a) superscript are not significant (P<0.01) when compared with the reference standard.

### Table 2: Changes in the animal’s behavior after administration of *G. angustifolia* methanol root extracts.

| Dosage (mg/kg) | Time (hr) | 100 | 200 | 500 | 1000 | 2000 | 5000 | 6000 |
|---------------|----------|-----|-----|-----|------|------|------|------|
|               | 2 4 6 8 12 24 | 2 4 6 8 12 24 | 2 4 6 8 12 24 | 2 4 6 8 12 24 | 2 4 6 8 12 24 | 2 4 6 8 12 24 | 2 4 6 8 12 24 |
| Gross activity | Respiration | - | - | - | - | - | - | - |
|               | Writhing | - | - | - | - | - | - | - |
|               | Tremors | - | - | - | - | - | - | - |
|               | Convulsion | - | - | - | - | - | - | - |
|               | Salivation | - | - | - | - | - | - | - |
|               | Diarrhea | - | - | - | - | - | - | - |
|               | Mortality | - | - | - | - | - | - | - |
|               | Hind limb paralysis | - | - | - | - | - | - | - |
|               | Sedation | - | - | - | - | - | - | - |
|               | Skin irritation | - | - | - | - | - | - | - |
|               | Eye irritation | - | - | - | - | - | - | - |
|               | CNS depression | - | - | - | - | - | - | - |

+: Indicates that changes were observed; -: Indicates that there was no change; D: Indicates death.
Ethanol-induced gastric mucosal lesions, predominant in the ethanol, reduction of the secretion of bicarbonate and depletion of gastric wall mucus [22].

**Conclusion**

In conclusion, our results suggest that *G. angustifolia* methanol extract ointment possess wound healing activity and gastro-protective effect against acute ethanol-induced ulcer models in rats. In this regard, we suggest that natural gastro-protective agent in *G. angustifolia* may be effective as plant gastro-protector and thus may have some obvious therapeutic implications. This plant could be toxic at higher doses. Further work is needed in the area of biosafety, phytoconstituents and mechanisms of action of *G. angustifolia* in wound healing action.

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**Table 3: Effect of *G. angustifolia* on blood glucose level in rats.**

| Treatment | Dose (mg/kg) | Gastric Volume (ML) | Ulcer Area (mm²) | Protection (%) |
|-----------|--------------|---------------------|-----------------|----------------|
| Ulcer control | 0 | 2.98 ± 0.22* | 753.33 ± 3.42* | 0.00 |
| Drug control (Omeprazole) | 8 | 1.46 ± 0.12* | 171.33 ± 8.62* | 76.15 |
| Treatment 1 (G. angustifolia) | 100 | 1.63 ± 0.03* | 370.33 ± 24.68* | 47.59 |
| Treatment 2 (G. angustifolia) | 250 | 1.67 ± 0.10* | 297.66 ± 23.16* | 58.65 |
| Treatment 3 (G. angustifolia) | 500 | 1.55 ± 0.62* | 191.67 ± 14.84* | 71.37 |

Values are expressed as mean ± S.E. Values in a column followed by different letters are significantly different (P<0.01). Values in a column with an asterisk (*) are significantly different from ulcer control (P<0.01).

**Table 4: Anti-ulcerogenic effect of *G. angustifolia* root methanol extract.**

| Treatment | Dose (mg/kg) | Gastric Volume (ML) | Ulcer Area (mm²) | Protection (%) |
|-----------|--------------|---------------------|-----------------|----------------|
| Ulcer control | 0 | 2.98 ± 0.22* | 753.33 ± 3.42* | 0.00 |
| Drug control (Omeprazole) | 8 | 1.46 ± 0.12* | 171.33 ± 8.62* | 76.15 |
| Treatment 1 (G. angustifolia) | 100 | 1.63 ± 0.03* | 370.33 ± 24.68* | 47.59 |
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