

# A Comparative Study on Wound Healing Using Coconut Water and Cassava Leaf Extract

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**Abstract**— The increasing occurrence of persistent skin wounds worldwide has emerged as a significant public health concern, placing substantial social and financial burdens on individuals, their families and the healthcare systems. Chronic wounds such as ulcers, burns and injuries, pose particular challenges due to their need for prolonged treatment, frequent dressing changes and repeated medical visits, all of which escalate healthcare costs and negatively impact patients' quality of life. Although conventional wound care has advanced through innovations in biomaterials and dressing technologies that create optimal healing conditions, the high expense and limited availability of these modern solutions especially in underserved regions, underscore the importance of exploring more accessible and affordable alternatives. Natural remedies, especially those derived from medicinal plants, have gained attention for their low cost, widespread availability and therapeutic compounds that support tissue regeneration. This study assessed the wound healing potential of coconut water and cassava (*Manihot esculenta*) leaf extract using an animal model. Eighteen (18) healthy Wistar rats were randomly assigned to three groups, including a control group. Standard excision wounds were induced and each group received its respective treatment. Thereafter, wound contraction and closure rates were monitored over a defined period. The findings revealed that rats treated with coconut water and cassava leaf extract experienced a statistically significant acceleration in wound healing compared to the untreated control group ( $P < 0.05$ ). These results indicate that both natural substances exhibit beneficial wound healing effects and may serve as viable complementary or alternative options for wound care, particularly in settings with limited healthcare resources.

**Keywords**— 'Coconut water', 'cassava leaf', 'wound healing'.

## I. INTRODUCTION

Both acute and chronic wounds continue to pose significant public health challenges, especially in low- and middle-income regions where advanced wound care materials are often inaccessible. This has led to growing interest in cost effective plant-based remedies capable of influencing the key stages of healing, namely; hemostasis, inflammation, tissue growth and remodeling<sup>1,2</sup>.

The healing of skin wounds is a crucial biological process that involves the cooperation of various types of cells and their byproducts. Initiatives to heal the damage caused by a local injury start quite early during the inflammatory phase<sup>3</sup>. Ultimately, these efforts lead to repair, which involves replacing specialized structures through collagen deposition, as well as regeneration which refers to the process of cell growth and subsequent differentiation involving preexisting tissue cells and/or stem cells. These mechanisms do not mutually exclude themselves, that is, after a skin lesion, in the same tissue, regeneration and repair can occur, depending on the cell strains compromised by the injury<sup>4</sup>.

Coconut is the fruit of coconut palm (*Cocos nucifera*), also known as coconut, coconut palm, adivana or Indian palm and belongs to the *Arecaceae* family. It is a palm tree native to the eastern tropical regions, grown in Asia, America and Africa<sup>5</sup>. Coconut water has been used successfully in various parts of the world for oral rehydration, treatment of childhood diarrhea, gastro-enteritis and cholera<sup>5</sup>. It also contains organic and inorganic compounds that play a vital role in helping the antioxidant system of the human body<sup>7</sup>. Coconut water, the clean and nutrient dense liquid found inside *Cocos nucifera*, is

rich in electrolytes, amino acids, sugars and plant hormones like cytokinins which are believed to support cell growth and extracellular matrix formation essential for wound healing<sup>6, 8, 9</sup>. Coconut Water effectively prevents liver damage caused by Ischemia/reperfusion and mitigates injury to distant organs by reducing inflammation and oxidative stress in in vivo pretreatment<sup>10</sup>.

Cassava, *Manihot esculenta* is a perennial woody shrub belonging to *Euphorbiaceae* family. Additionally, it is grown in tropical and subtropical areas of the world, as well as being native to South America. It is one of the most significant industrial food crops worldwide<sup>11</sup>. Its leaves contain substantial amounts of proteins, minerals and bioactive compounds such as phenolics and flavonoids, which exhibit antioxidant and anti-inflammatory activities that may help reduce oxidative stress and modulate inflammation during wound healing<sup>12, 13</sup>. Hence, its usage in the treatment of a variety of illnesses<sup>13, 14</sup>. Although coconut water and cassava leaf extracts are widely used in traditional medicine, direct comparative studies on their effectiveness as topical or supportive wound healing agents remain scarce. Preclinical studies indicate potential benefits such as estrogen-like and anti-inflammatory effects of young coconut juice in animal skin models and the antioxidant and antibacterial properties of cassava leaves. However, clinical evidence in humans is still limited and inconsistent with reviews highlighting the absence of strong clinical trials assessing coconut-based products in wound care<sup>16, 17</sup>.

Therefore, a controlled comparative study could clarify relative efficacy, mechanisms (oxidative stress and

inflammatory markers) and safety considerations (e.g., cyanogenic glycosides in cassava leaves)<sup>13</sup>.

Skin wound healing occurs through four interconnected stages: hemostasis (in which a clot forms), inflammation (characterized by immune cell recruitment and mediator release), proliferation (involving fibroblast activation, granulation tissue development, angiogenesis, and re-epithelialization) and remodeling (where collagen reorganizes and tensile strength is restored)<sup>17, 18, 19, 20</sup>. When inflammation and oxidative stress are poorly regulated, the transition between these stages is disrupted, underscoring the potential value of antioxidant and anti-inflammatory interventions in wound management<sup>18</sup>.

Coconut water contains a potassium rich electrolyte profile along with peptides, amino acids, vitamins, sugars and phytohormones such as cytokinins. These constituents have demonstrated antioxidant and anti-inflammatory effects in both in vitro and in vivo models, though most studies lie outside the context of wound healing<sup>7, 21, 22</sup>. Notably, cytokinins regulate cell cycle activity and tissue regeneration, providing a potential mechanistic basis for their role in promoting the proliferative stage of wound repair<sup>23, 24</sup>.

Direct evidence for the role of coconut water in wound healing remains sparse. In an animal study using ovariectomized rats, young coconut juice was shown to accelerate skin repair, likely through estrogen-like mechanisms involving upregulation of ER- $\alpha$  and ER- $\beta$ , suggesting hormonal modulation of healing processes<sup>15</sup>. However, the antimicrobial effects of tender coconut water appear inconsistent; for example, one study reported no activity against *Streptococcus mutans*, indicating that any wound healing benefits are unlikely due to broad antibacterial properties alone<sup>23</sup>. Additionally, an evidence summary on topical coconut products—mostly oils rather than water—highlighted the absence of robust human clinical trials, emphasizing the need for more rigorous research<sup>16</sup>.

Safety considerations are critical when using cassava leaves as they may contain cyanogenic glycosides such as linamarin and lotaustralin, therefore, proper processing is essential to reduce toxicity which is particularly important for both topical and oral applications and for standardizing extract preparation in research<sup>13</sup>. Direct comparisons of coconut water and cassava leaf extracts for wound healing are largely lacking in peer reviewed clinical literature. Some reports from grey literature and small animal studies indicate potential wound healing effects of cassava leaves and estrogenic or anti-inflammatory effects of young coconut juice, though these studies vary in experimental models, endpoints and preparation methods<sup>15</sup>. Systematic reviews acknowledge the phytochemical plausibility of these interventions but note the heterogeneous study quality and limited clinical translation, particularly for standardized topical formulations<sup>14, 16</sup>. This evidence gap supports the rationale for a controlled comparative study that: (1) standardizes cassava leaf extracts (including processing to reduce cyanogens and quantification of total phenolics and flavonoids) and coconut water (considering fresh versus processed forms, osmolality and cytokinin content); (2) assesses objective wound-healing

outcomes such as closure rate, re-epithelialization, and tensile strength, alongside mechanistic biomarkers including TNF- $\alpha$ , IL-1 $\beta$ , IL-10, TGF- $\beta$ 1, VEGF and oxidative stress markers like MDA, SOD, CAT, and GPx; and (3) incorporates microbiological evaluation and safety monitoring<sup>14, 18, 20, 24</sup>.

## II. MATERIALS AND METHOD

The study utilized cassava leaf extract, coconut water, 18 Wistar rats, animal cages, standard finisher feed (Top Feed, Nigeria), cotton wool, organ bottles, hematoxylin and eosin (H&E) stain, distilled water, an animal weighing balance, a microscope and a microtome.

Eighteen Wistar rats weighing 110–260 g was obtained and housed in cages for a two-week acclimatization period. During this time, the rats had unrestricted access to feed and water and the cages were cleaned weekly. Cassava leaf extract and coconut water were prepared as aqueous solutions prior to use and dermal toxicity was evaluated using sighting and limit tests.

The rats were randomly assigned into three groups of six rats each (n = 6), following the Morton and Malone (1972) model:

Group 1: Control (distilled water)

Group 2: Cassava leaf extract

Group 3: Coconut water

Under anesthesia, the rats were positioned on a dissecting table at the Bayelsa Medical University Animal House. A square excisional wound (1 cm<sup>2</sup>, 2 mm depth) was created on the dorsal surface of each rat. The test groups received daily topical application of cassava leaf extract or coconut water, while the control group was treated with distilled water.

Wound healing was monitored for 21 days, evaluating parameters such as epithelialization period, wound contraction rate and wound closure time. At the end of the study, healed skin samples from all groups were collected for histopathological examination using H&E staining.

## III. RESULTS

TABLE 1: Mean Area Of Wound Contraction In Different Days

DAYS	Control	Cassava leaf extract	Coconut water	p-value	Inference
2	0.23±0.03	0.17±0.01 <sup>b</sup>	0.29±0.01 <sup>b</sup>	0.002	Significant
4	0.16±0.02 <sup>b</sup>	0.36±0.02 <sup>a</sup>	0.26±0.01 <sup>a,b</sup>	0.000	Significant
6	0.12±0.01 <sup>b</sup>	0.35±0.01 <sup>a,b</sup>	0.21±0.02 <sup>a,b</sup>	0.000	Significant
8	0.10±0.02 <sup>b</sup>	0.34±0.01 <sup>a</sup>	0.11±0.01	0.000	Significant
10	0.07±0.01 <sup>b</sup>	0.32±0.02 <sup>a,b</sup>	0.07±0.01	0.000	Significant
12	0.05±0.01 <sup>b</sup>	0.26±0.01 <sup>a,b</sup>	0.04±0.01	0.000	Significant
14	0.04±0.01	0.22±0.01 <sup>a,b</sup>	0.03±0.01	0.000	Significant
16	0.02±0.01	0.21±0.01 <sup>a,b</sup>	0.02±0.00	0.000	Significant
18	0.01±0.00	0.13±0.01 <sup>a,b</sup>	0.01±0.00	0.000	Significant
20	0.00±0.00	0.01±0.00	0.01±0.00	0.000	Significant

Values are in Mean ± SEM.

Superscript ‘a’ and ‘b’, indicate significant difference (p<0.05) compared to Control and Providine iodine groups respectively. P: statistical level of significance was determined by one-way Analysis of Variance (ANOVA) followed by Tukey post-hoc test.

TABLE 2: Mean Percentage Of Wound Contraction In Different Days

DAYS	Control	Cassava leaf extract	Coconut water	p-value	Inference
2	-13.67±13.78	14.33±3.97 <sup>b</sup>	-43.83±4.39 <sup>b</sup>	0.002	Significant
4	13.00±12.61 <sup>b</sup>	-77.88±8.21 <sup>a</sup>	-15.80±14.98 <sup>b</sup>	0.000	Significant
6	31.33±12.96 <sup>b</sup>	-76.67±5.38 <sup>a</sup>	-4.47±10.03 <sup>b</sup>	0.000	Significant
8	20.60±16.56	-68.08±6.07 <sup>a</sup>	44.83±4.34	0.002	Significant
10	67.50±5.57 <sup>b</sup>	10.71±27.78	67.50±3.70	0.000	Significant
12	87.17±2.34 <sup>b</sup>	-33.29±7.69 <sup>a</sup>	79.83±3.34	0.000	Significant
14	80.83±2.87 <sup>b</sup>	-10.87±3.94 <sup>a</sup>	84.83±3.43	0.000	Significant
16	88.83±2.48	2.17±3.25	89.83±2.23	0.429	Not significant
18	95.17±1.11	34.17±4.62 <sup>a</sup> <sup>b</sup>	94.67±1.31	0.000	Significant
20	98.17±0.48 <sup>b</sup>	95.00±0.52	97.67±0.56	0.000	Significant

Values are in Mean ± SEM. Superscript ‘a’ and ‘b’, indicate significant difference (p<0.05) compared to Control and Providine iodine groups respectively. P: statistical level of significance was determined by one-way Analysis of Variance (ANOVA) followed by Tukey post-hoc test.

TABLE 3: Mean epithelization and wound closure time in Days

GROUPS	Epithelization time
Control	16.00±1.15
Cassava Leaf	15.33±1.76
Coconut Water	16.00±2.00
P-value	0.516
Inference	Significant

Values are in Mean ± SEM. Superscript ‘x’, indicate significant difference (p<0.05) compared to Control and Providine iodine groups respectively. P: statistical level of significance was determined by one-way Analysis of Variance (ANOVA) followed by Tukey post-hoc test.

TABLE 4: Mean Wound Closure Time in Days

GROUPS	Wound closure time
Control	18.67±0.67
Cassava Leaf	17.83±0.54
Coconut Water	19.33±0.42 <sup>b</sup>
P-value	0.394
Inference	Significant

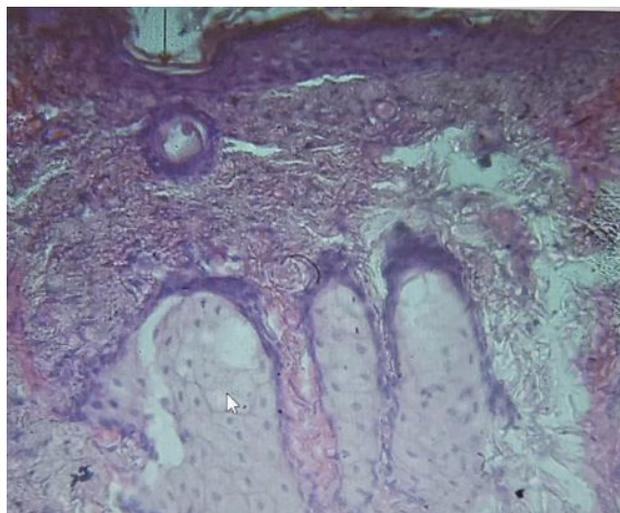


Fig. 1: Wound Treated with Cassava Leave Extract

Photomicrograph (H&E X400) of skin showing a stage 3 wound healing (arrow) in the epidermis; there is epithelialization of the stratum corneum with an associated discrete inflammation.

Diagnostic Lesion: Moderate Epithelialization.

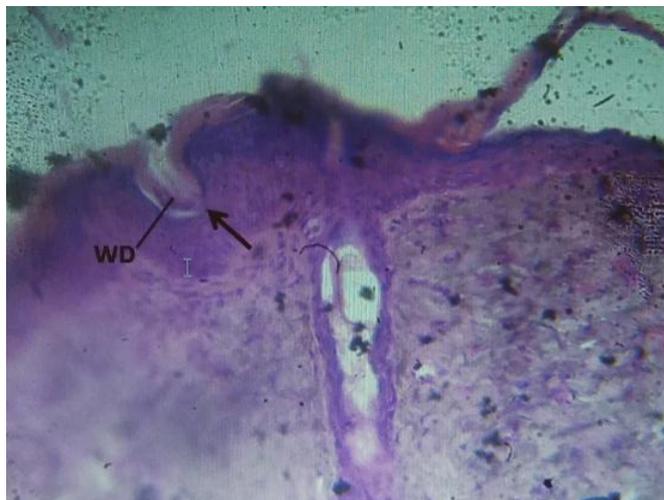


Fig. 2: Normal Wound Untreated

Photomicrograph (H&E X400) of skin showing a wound in the epidermis with wound debris (WD). The stratum corneum is severed (arrow).

Diagnostic Lesion: Non-epithelial Skin Wound.

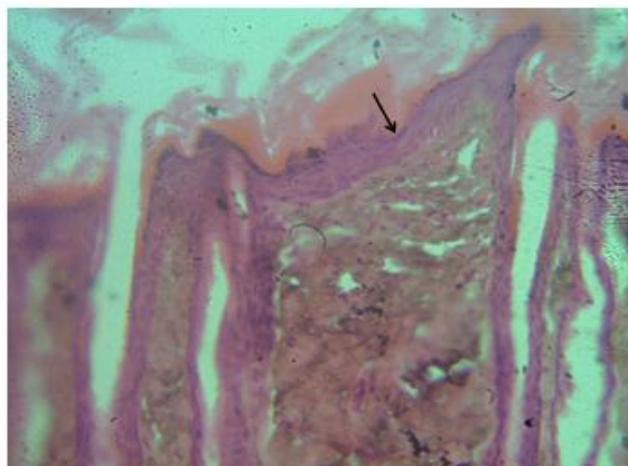


Fig. 3: Wound Treated with Coconut Water

Photomicrograph (H&E X400) of skin showing a stage 3 wound healing (arrow) in the epidermis; there is epithelialization of the stratum corneum with an associated edematous scab.

Diagnostic Lesion: Moderate Epithelialization

#### IV. DISCUSSION

This study aimed to evaluate and compare the wound healing efficacy of coconut water and cassava leaf extract in Wistar rats. Both extracts were assessed for their impact on

wound contraction, percentage wound contraction, epithelisation time, and wound closure time.

The weight data of rats treated with cassava leaf extract indicated an overall increase compared to the control group, suggesting good systemic health and possible nutritional benefits from the extract. Coconut water treated rats also showed consistent weight gain but to a lesser extent compared to cassava leaf extract.

Analysis of wound contraction area and percentage wound contraction showed statistically significant differences ( $p < 0.05$ ) across treatment groups from day 2 through day 20. Cassava leaf extract demonstrated a more rapid wound contraction compared to coconut water, particularly between days 4 and 10, where contraction values for cassava were higher than coconut water. However, by day 16 and beyond, both extracts showed near complete contraction, with no significant difference between them by day 16 ( $p = 0.429$ ).

The epithelization time was shortest in the cassava leaf group ( $15.33 \pm 1.76$  days), while coconut water and the control groups had longer durations ( $16.00 \pm 2.00$  days). Though these differences were not statistically significant ( $p = 0.516$ ), they suggest a trend towards faster healing with cassava extract. Similarly, the wound closure time was shorter in the cassava group ( $17.83 \pm 0.54$  days) than coconut water ( $19.33 \pm 0.42$  days), though not statistically significant ( $p = 0.394$ ).

These findings support the wound healing potential of both natural agents, particularly cassava leaf extract, which may offer enhanced contraction and earlier wound closure. Coconut water, with its antimicrobial and hydrating properties, also showed comparable efficacy over the entire period.

## V. CONCLUSION

Cassava leaf extract and coconut water both demonstrated effective wound healing properties in Wistar rats. Cassava leaf extract showed slightly superior outcomes in terms of earlier wound contraction and closure. Both agents may serve as viable, affordable alternatives to conventional therapies in wound management, particularly in resource limited settings. Further studies including histological analysis and mechanistic exploration are recommended.

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CONFLICT OF INTEREST

No conflict of interest.

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