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Efficacy of *Parkia biglobosa* Stem Bark in the Treatment of Burn Wounds

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ABSTRACT

Burns are a major health challenge all over the world. Among the Hausa and Fulani people of Nigeria the bark of *Pakia biglobosa* is used as folk medicine for treating wounds by the application of the finely powdered bark to the open wounds. The aim of this study is to corroborate the folk claims of the wound healing ability of *P. biglobosa* and the benefits of formulating it into an emulgel. The powder and the extract of the stem bark of *P. biglobosa* formulated as an emulgel were investigated for burn wound healing activities and compared with I% silver sulfadiazine cream (Dermazin®) on Wister Albino rats. Also, the skin irritation and physicochemical properties of the emulgel were determined. Herbal emulgel showed good quality in relation to compendia and non-compendia tests. The emulgels were smooth, none gritty to touch and odourless as well as having varying colour shades of reddish brown consistent with the concentration of the extract. The formulations also showed no skin irritation and a concentration dependent wound healing activity. The emulgel containing 2.5% $^{w}/_{w}$ of the herbal extract showed superior burn wound healing relative to the finely powdered stem bark, while the emulgel containing 5% $^{w}/_{w}$ of the extract showed wound healing activity comparable to Dermazin®. The finely powdered stem bark of *P. biglobosa* showed effective wound healing activities and the emulgel formulation enhanced the wound healing activity. The results thus, corroborates the folk use of *P. biglobosa* stem bark for treating burn wounds.

KEY WORDS: *Parkia biglobosa*, Stem bark extract, Emulgel, Wound healing, Physicochemical properties

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INTRODUCTION

Burns are often severe traumatic wounds that are a major health challenge all over the world. Burn wounds can be caused by elements such as thermal agents like flames, hot objects, hot liquids, steam; chemicals such as acids and alkali; electric charged systems such as electricity and thunder. Wounds due to thermal agents are the most commonly occurring [1]. Such injuries may be mild or severe and remains one of the commonest causes of morbidity and mortality due to burn injury [2]. The skin is the primary organ affected and is often characterized by the disruption of the structure and function of underlying normal skin tissues. The thin, outer epidermis and the thicker, deeper dermis are usually the main areas affected [3].

Wound healing is an intricate process that is regulated by a complex network of physiological and pharmacological activities [4, 5]. The primary focus and objective in the treatment of burn wounds is rapid repair that can be facilitated by use of antibiotics to prevent infection and rapid regeneration of tissues. Reports from several studies have shown that appropriate treatment with effective medicines will prevents infection, accelerate healing and prevent formation of scar tissues [4, 6].

Infection constitutes one of the major challenge in the healing of burn wounds. Various synthetic medicines such as mafenide acetate, silver sulfadiazine, silver nitrate solution, and silver-impregnated dressings are commonly used for treating burn wounds. These are principally antimicrobial agents that are applied on the wounds surface to prevent infection [1, 7].

Most health challenges including burn wounds have been managed successfully in many communities where traditional medicine constitute the major and sometimes the only source of healthcare [8]. Majority of the indigenous medicines extensively used, consist chiefly of herbal materials as the major and sometimes the only components of the recipe.

With the increasing popularity and the systematic integration of herbal medicine into the main stream healthcare, the use herbal medicine cannot be overlooked especially in the management of wounds. Herbs and herbal materials used for managing wound injuries have been shown to effect healing by different mechanisms, such as antioxidant and antimicrobial activities, improving collagen deposition and, increasing fibroblasts and fibrocytes [9]. Some plants contain certain chemicals that have pharmacological activities relating to the regulation of biological processes such as accelerate wound healing, reduce inflammation and pain as well as improve general health of the patient [9, 11]. Such herbal medicines have been shown to be beneficial in wound management by initiating disinfection, debridement as well as providing a moist area for accelerated healing process [12, 13].

Parkia biglobosa is a perennial deciduous tree also called the African locust bean, which is widely found growing in the wild of both tropical rain forest and arid zones of Africa [14-18]. The plant has a wide economic importance, being useful as food, medicine and timber. The roots, leaves and bark are commonly used in folk medicines [14, 15]. Some of the common folk medicinal uses of *P. biglobosa* includes: treatment of malaria, bacterial infections, diabetes, diarrhea, wounds, and cancer. Particularly, in northern Nigeria, among the Hausa and Fulani communities the bark of *P. biglobosa* tree is commonly used by the traditional medicine practitioners for treating moderate and severe wounds by the application of the powdered bark on open wounds. The aim of this study is to corroborate the folk claims of the wound healing ability of *P. biglobosa* and the benefits of formulating it into an emulgel.

MATERIALS AND METHOD

MATERIALS

The materials for the preparation of emulgel were obtained as follows: Petroleum jelly, Sorbitan mono oleate (Tween80), sorbitan sesquioleate, sodium alginate and glycerin (Sigma-Aldrich, USA).

METHOD

Identification of *P. biglobosa*, collection, and processing of stem bark

The stem bark of a full grown tree of *P. biglobosa* was collected by scrapping with a sickle. The leaves and fruits were collected and submitted for identification. The plant part sample was identified by Mr. Gallah U.S, a botanist from the Department of Biological Sciences, Kaduna State University, Nigeria.

The bark was scrapped with a kitchen knife to remove dirt and rinsed with copious amount of portable water before spreading in the shade to dry at normal room temperature conditions (≈27ºC). The dried stem barks were size reduced to coarse powder using a clean wooden mortar and pestle.

Production of fine powder

A 100 g quantity of the initially processed coarse powder of *P. biglobosa* stem bark was obtained and transferred into a semi industrial blender (AKAI, Tokyo-Japan) and pulverized at high speed blending for 10 min. The powder was then passed through a sieve of 150 µm mesh size. The other particles that did not pass through the sieve were again pulverized until all the material passed through the sieve. The fine powder was then dried in an oven at 40 ºC for 1 h and then packed in a screw capped container and kept in a dark cupboard.

Extraction

A 1.5 L of a solvent system containing 7 parts of absolute ethanol and 3 parts of distilled water was prepared and used for the extraction [19-21]. A 150 g portion of the powdered plant bark were weighed and separately transferred into three different 1000 ml capacity conical flasks and 500 ml of the solvent was added to each of the flask, and the lid covered with aluminum foil. The flasks and its content were shaken intermittently for 1 hour, and then allowed to stand for 72 hours and shaken intermittently every 6 hours. The bark dispersion was then filtered with a muslin cloth with a pore size of ≈150 µm, the extract was then concentrated with a rotary evaporator set at a speed of 60 rev/min and a temperature of 50ºC. The extract concentrate was poured into a crucible and dried over a water-bath. The extract was then weighed and transferred into a screw capped plastic container and stored in a desiccator until used.

Gel preparation

A 5 $\%^{w}/_{v}$ sodium alginate gel was prepared by transferring 5 g of sodium alginate into 250 ml beaker containing a mixture of 10 g glycerol and 90 ml of distilled water. The sodium alginate was allowed to fully hydrate for about 3-4 hours.

Preparation of *P. biglobosa* emulgel

Preparation of P. biglobosa Emulgel cream base: The oil in water cream base (HLB ≈11) containing various concentrations of *P. biglobosa* stem bark extract were prepared according to the formula presented in Table 1. Appropriate quantities of the dry stem extract and Tween 80 were added to water thoroughly mixed. Appropriate portions of the soft paraffin was transferred into a wide mouthed jar, and placed in a water bath to melt the soft paraffin. Then sorbitan sesquioleate added to the soft paraffin with continuous stirring using a laboratory stirrer (Remi elektrotechnik, India), the aqueous portion of dispersion of *P. biglobosa* extract and Tween 80 was then added gradually until all was incorporated.

Preparation of P. biglobosa emulgel: With continuous stirring the initially prepared gel was incorporated into the cream such that final product of the cream and gel is 1:1. The emulgels prepared were labeled samples A, B, C and D as presented in Table 1.

Quality characterization of *P. biglobosa* emulgel

Organoleptic properties

Appearance: The prepared emulgel formulations were inspected visually for any color change and phase separation every 2 weeks for 4 weeks [22].

Texture: The sample were collected in small quantity each, and rubbed between the palms to feel their texture every 2 weeks for 4 weeks [22].

Smell: Small portions of the samples were collected and perceived with the nose every week for 4 weeks [22].

Rheological studies

The viscosity of the formulated batches was determined using a viscometer (REMI-Elektrotechnik, India) with spindle 64. The assembly was connected to a thermostatically controlled circulating water bath maintained at 25 °C. The formulation whose viscosity was to be determined was added to a beaker covered with thermostatic jacket. Spindle was allowed to move freely into the emulgel and the readings were noted. This was done in triplicate and the average of each was taken [23].

Nonvolatile matter (NVM)

A 1 g quantity of each emulgel formulation was weighed and spread into an already weighed glass. The glass was put in an oven for 24 hours at 105°C. The sample was removed, allowed to cool and the weighed. The NVM for each sample emulgel prepared was then calculated according to formula 1 [24].

NVM % = (Weight of residue ÷ weight of sample) × 100% 1

pH

The pH of the prepared emulgel was determined immediately after preparation using a digital pH meter (Benchtop pH meters, China), by dipping the glass electrode into the emulgel sample. The measurement of pH of each sample was done in triplicate and average values were calculated [25].

Stability

The organoleptic properties of the emulgel formulations were monitored weekly for 24 weeks after the initial determination after formulation. The pH of the emulgel formulations were also monitored weekly for 24 weeks. The samples were stored on the laboratory benches at normal room temperature ≈27°C.

Pharmacology

Wound healing activity

The animal studies were carried out after approval from the ethical committee and following the guidelines of the Animal Ethics Committee of Kaduna State University and the European Union directive (2010/63/EU|). Mature Wister albino rats (130-200 g) of both sexes were housed in animal units of Kaduna State University under standard laboratory conditions for 14 days prior to the experimental procedure. The animals had free access to standard dry pellet diet and water *ad libitum*. A burn was inflicted on all the animals using a metal size 4 cm x 4 cm placed in the blue zone of a Bunsen burner flame for about 10 minutes, and pressed against the dorsal part which was initially shaved. The rats were placed each in a separate cage, so as to avoid cannibalism [26]. The wounded rats were randomly assigned to groups of four animals per group. Groups A, B, C, D and E were topically administered the powdered stem bark and emulgel containing the *P. biglobosa* extract corresponding to 0 $\%^{w}/_{w}$, 0.5 $\%^{w}/_{w}$, 2.5 $\%^{w}/_{w}$ and 5 $\%^{w}/_{w}$ as labeled A, B, C and D respectively. The animal grouping labeled F served as the positive control and was treated with Dermazine®, while group G served as negative control and so was not treated with any substance. Every 48 hours, the new size of the wound is measured with a tape and recorded accordingly, and the medicine sample is administered appropriately to each group [26].

Skin irritation test

Three rats were selected and the *P. biglobosa* formulated as 5 $\%^{w}/_{w}$ emulgel was applied on the properly shaven skin of the rats every 24 hours, for 3 days. Any adverse reaction like, change in skin color (redness), change in skin morphology (edema), was evaluated before subsequent application. If no irritation occurs the test is passed. If skin irritation symptoms occur, the study is repeated [26].

Statistical Analysis

The results are expressed as mean ± S.D. Statistical analysis was performed by One way Analysis of Variance (ANOVA) test for multiple comparisons. Statistical significance was set accordingly at p (≤0.05) level.

RESULTS

On presentation of the leaves, fruit pod of the plant whose bark was collected was identified as *Parkia biglobosa* and the family name was Leguminosea: Raimosoideae also commonly called African locust bean and Dorowa in Hausa vernacular from which community it was obtained. The yield of the extract was 6.69 $\%^{w}/_{w}$ relative to the weight of the dry stem bark.

Quality Characterization of *P. biglobosa* Emulgel

The formulated emulgel containing varying concentrations of the stem bark extract of *P. biglobosa* is presented in Fig. 1. The emulgel containing the extract showed varying colour shades of reddish brown, intensifying as the concentration of the extract increased (Fig. 1). The emulgel formulations were also smooth, none gritty to touch, and odourless.

The viscosity, nonvolatile matter, pH of the emulgel formulations are presented in Table 2. The various emulgel formulations showed varying viscosity consistencies. The viscosity of the emulgels of the *P.biglobosa* stem bark increased with increasing concentration of the extract. The nonvolatile matter as well increased with increasing concentration of the extract. The pH of the emulgel formulations containing the varying concentrations of the extract showed a slight increasing tilt to acidity from neutrality as the concentration of the extract in the formulation increased relative to the placebo emulgel that showed a consistent neutral pH of 7.

Stability

The stability of the emulgel formulations on storage, as determined by monitoring relevant changes in the pH and organoleptic parameters such as appearance, texture and smell are presented in Table 3. Within the 12 weeks for which the formulations were evaluated for stability, there were no show of organoleptic instability or changes in the pH. The appearance, odour and texture as well as the pH of the emulgels showed no remarkable changes that could be ascribed as instability.

Pharmacology

Skin irritation

The physical state of the shaven skin of the mice before and after application of the herbal emulgel was the same for all the animals in this group. There were no changes in the physical appearance of their skins before and after the 3 days of treatment.

Burn wound healing property

The wound healing properties of the *P. biglobosa* emulgel is presented in Fig. 2. The wound healing of the herbal emulgel formulations showed a concentration dependent activity. The wound healing activity increased with increase in the concentration of the extract in the emulgel.

DISCUSSION

Identification of *Parkia biglobosa*.

Plant identification is the determination of the identity of an unknown plant in comparison with previously collected specimen. The ability to recognize and describe a plant corresponds to the identification. The proper identification of the plant whose bark was collected is important because many other plants exist with similar external features and showing resemblance. Collection of wrong plants with similar external features has been the cause of many poisoning and fatalities especially when used as food or medicine [26]. The leaves and pods were successfully used to establish, relevant details [27]. *P. biglobosa* was identified as such by comparing the morphological characteristics of the leaves and fruit pods with an already known specimen from the herbarium and a voucher number A3.P.b/S: 15916 was assigned to it by the Botanist in charge of the herbarium voucher library in the department of Biological Sciences, Kaduna State University, while the voucher number was deposited in the herbarium for reference purpose. It is also important to identify plants accurately because several plants exist which have similar physical resemblance but differences in their intrinsic primary and secondary metabolites. This physical resemblance occurs commonly among plants of the same *genus* whereas different *specie* will have grave differences in chemical compositions. In this case, *Parkia* is the genus for all plants that fall under it, but there are other species like *P. africana*, *P. clappertoniana*, and many others which all have peculiar differences especially in their secondary metabolites. As such, plant identification helps to accurately identify the plant specimen for any research purpose.

Processing of stem bark

The yield of 6.69 $\%^{w}/_{w}$ of crude *P. biglobosa* extract derived by extraction of the powdered stem bark with the ethanol and water fixed ratio

mix defines the final throughput of the extraction process. The bioactivity of plant extracts may be dependent on the solvent used for the extraction, this is because the relative solubility of the secondary metabolites is a principal factor that controls the yield and the type of biochemical extracted 6.69 $\%^{w}/_{w}$ [28, 29]. Indeed, the ratio of ethanol and water mixture used for extraction has been shown to affect the yield and composition of the crude plant extract. Therefore, we may relate the extract yield to be related to the ratio and quantities of the ethanol and water used for extraction.

Quality characterization of *P. biglobosa* emulgel

Organoleptic properties and stability

Appearance

The various samples of the *P. biglobosa* stem bark extract emulgels: B, C and D, E showed characteristic colours that implies the concentration of the extract in the formulation as presented in Table 2. The colour of the emulgel is characteristic and can be used to identify the emulgel containing *P. biglobosa* stem bark extract. All the emulgel maintained their colours namely white, pale brown, brown and dark brown respectively within an initial five weeks of evaluation for stability. However, at the sixth week the sample batch containing 2.5 $\%^{w}/_{w}$ of the extract started to change colour: from brown to a light shade of brown and at the end of the 12 weeks evaluated for stability the emulgel changed to a watery brown with white smudges mass. Stability refers to the extent to which a product retains, within specified limits, and throughout its period of storage and use, the same properties and characteristics that it possessed at the time of its manufacture [30]. The change in appearance in the sample may be due microbial contamination as no preservative was included in the formulation. Microbial contamination is a strong factor that causes physical instability especially in liquid and semi solid aqueous based pharmaceutical formulation that do not contain appropriately active preservative [30]. Though it's one of the sample batches that showed instability, this also means that any or all the other batches also has potential to show instability. This results thus shows the need for an active and appropriate preservative to be incorporated.

Phase separation

All emulgels maintained uniformity and consistency in the general gel appearance relative to the initial appearance. However the emulgel sample C, showed characteristic changes that corresponds to phase separation in the sixth week after formulation, while the others showed no evidence of instability that may related to phase separation even after 12 weeks. The changes that occur in sample D has been related to be due to microbial spoilage [30].

Smell

All the emulgel formulated apart from that of the placebo has a characteristic herbal odour. All the emulgel formulations maintained the characteristic odour throughout the 12 weeks of storage for stability evaluation except the emulgel containing 2.5 $\%^{w}/_{w.}$ This showed a slight change the odour after six weeks. The characteristic foul smell intensified with time. The production of a foul odour by emulgel containing can be proposed to be as a result of microbial contamination during the formulation of the emulgels and the absence of an active preservative in the formula [30].

Texture

All the emulgel formulations showed a characteristic cool, smooth and non-gritty consistency when rubbed between the palm or fingers. The smooth and non-gritty texture is consistent with well formulated emulgels and creams [22, 31, 32]. The cool, non-gritty, smooth feel of the emulgel has been related to the lubricating nature of the emulsion and gel. All the emulgel formulations showed a consistent texture for the 12 weeks of storage except sample D which at six weeks started to show a watery and clumpy texture, the change became intensified with time. The compromise of the initial texture as has been mentioned is due to a probable microbial spoilage.

pH

The pH of drug substances is important as properties such as irritation may be related to the pH of the formulation. Formulations show a decrease in pH with increase in concentration of the active constituent *P. biglobosa* (Table 2). Evaluation of pH is an important criterion

especially for the topical formulation because of the sensitive nature of the skin. The pH of optimal skin compatibility and comfort is within pH 5.5 to 7 which corresponds to the normal skin pH milieu [25]. If the pH of the prepared emulgel is too acidic or too basic, it may cause skin irritation to the patient [25]. Here, the pH values of all emulgel formulations were between 6.2 to 7.0 which shows that sample E (≈ containing 0.5 $\%^{w}/_{w}$ of the extract) presented a pH lower the commonly acceptable range [25]. On storage there was a slight decrease in pH which could be characteristic with the aging. There was however a remarkable decrease in sample D that showed gross instability and spoilage after 12 weeks of storage. The change in pH could be due to microbial and enzymatic activity in the sample.

Rheological studies

The viscosity of the various emulgel was used as an assessment of the rheology of the emulgels. The 0% emugel has the least viscosity profile compared to the other emulgel samples. The increase in the viscosity of the emulgel formulations due to the increasing concentration of the extract (Table 2), may be due to the presence of entities either secondary metabolites or trace elements that increased the gelling power of the gelling agent. Several studies have reported the increase of viscosity and other allied rheological parameters with increase in the concentration of herbal extracts [33-35].

Nonvolatile matter test

The non-volatile matter was found to increase with increase in concentration of the extract which is synonymous with active ingredients (Table 2), this can be seen in the difference between the emulgel base sample B (≈ 0.0 $\%^{w}/_{w}$ *P. biglobosa*) and sample C (≈ 0.5 $\%^{w}/_{w}$ *P. biglobosa*), which was up to 30 % difference, as such, nonvolatile matter analysis tells us of the volatile constituents which includes water and organic substances which can be removed when the sample is subjected a condition of 105 ^{o}C. The result implies that the rate of loss of volatile material diminished with increasing concentration of the extracts. This may be related to the increasing viscosity of the emulgel due increasing concentration of the extract that probably could have reduced the amount of volatile materials which includes water from escaping from the mass of emulgel.

Pharmacology

Skin irritation

The skin irritation test evaluates the potential of the formulation to cause reversible damage to the skin following contact exposure. Some topical medicinal products can cause skin irritation by passing through the outer skin to enter the layers of cells beneath to cause toxic effects which are often presented as redness, itching or pain in the area of contact. This reaction has been tracked to an immediate immune response [36]. Evaluation of the skin irritation test on the herbal emugel did not show any irritation compromise. The absence of any recognizable changes to physical appearance of the skin before and after application of the herbal emulgel, even with the emulgel containing the highest concentration of the herbal extract (sample D, containing 5% of the extract) reflects the non-irritant status of this herbal emulgel formulation. This thus shows the relative biocompatibility of the water extract of *P. biglobosa* stem bark and all the formulation aids.

Burn wound healing property

Wound healing is the process by which wounds repair. The objective of the intrinsic healing process is to prevent further damage, clean and seal the wound against infection, restore tissue strength, and tissue function. Normally, wound heals naturally by homeostasis and activities of the immune systems of the body. The natural body response to any wound is to heal itself quickly. Wound healing process is often characterized initially by coagulation, to controls excessive blood loss from the damaged vessels. This is followed by inflammation and debridement of the wound followed by re-epithelization, which include, proliferation, migration and differentiation of squamous epithelial cells of the epidermis. In the final stage of the healing process, collagen deposition in the dermis and remodeling occurs [37]. Progression of healing is usually seen as reduction in surface area by contraction which is characterized by mobilization of healthy skin surrounding the wound to cover the denuded area. Burn wounds treatment involve

interventions that are targeted to enhance and accelerate wound healing. Silver sulphadiazine is a classical medicine used to promote healing of the wounds. It is used to reduce wound bioburden, treat local infection, and prevent systemic spread of infection.

There are folk claims of the use of the powdered bark of *P. biglobosa* for the treatment of wound. The powdered stem bark and the formulated extract of *P. biglobosa* showed enhancement of the burn wound healing as compared to the untreated groups and placebo emulgel. The finely powdered stem bark must have acted by interacting with the wound exudates to leach out chemical entities contained in the herb. Also, the emulgel showed evidence of concentration dependent wound healing activity. The wound healing activity may be tracked to its established antioxidant and antimicrobial properties [37, 38]. Antioxidants have been shown to control wound oxidative stress, thereby accelerating wound healing. Secondary metabolites from plants has shown antioxidant activities that have been shown stimulate the dermal fibroblasts and keratinocytes, leading to increased cell proliferation, barrier formation and formation of extracellular matrix proteins, thus expressed as accelerated wound healing. They are important mediators in regulating the damage to the cells especially the DNA, protein, lipids, and body tissue in the presence of the assault. Within the first week of all the variables (no treatment, 0.0%w/w, 0.5%w/w, 2.5%w/w and 5.0%w/w), there was an increase in the rate of healing of the burn wound as the concentrations of *P. biglobosa* extract were increasing and Dermazin® (positive control) marking the highest healing effect while no treatment (negative control) is recording the lowest burn wound healing rate. The powder applied to the open wound also showed similar activity.

The entire animal including the untreated group showed a steady healing profile. The healing of the untreated group is certainly due to the natural intrinsic repair mechanism. Also the emulgel formulations including the placebo preparation and the unformulated extract powder showed wound healing activity. The negative control group (untreated) healed in 5 weeks while the placebo (Group B) healed in 4 weeks as presented in Fig. 2. While the other groups healed at various days within 3 weeks and 2 weeks. The activity of the placebo may be linked to humectant properties of the emulgel due to sodium alginate and emulsion system [39]. The emulgel formulation created a moist milieu that allows the growth factors to be preserved on the wound bed to repair tissues more quickly as well as promoting the production of collagen. The emulgel is also known to have a cooling effect which reduces pain and itching and as well as better and longer contact with the skin.

CONCLUSION

The extract derived from the stem bark of *P. biglobosa* was successfully formulated into an emulgel. The formulations showed good product quality and stability. The fine powder and emulgel of the stem bark and extract of *P. biglobosa* showed variable wound healing activities which may be ascribed to the presence of certain biochemical entities present in the plant and are responsible for the various pharmacological activities and the wound healing benefits of the plant. Also, the concentration dependent wound healing activity of the emulgel further reiterates the fact that the wound healing activities is due to the presence of the intrinsic presence of likely secondary metabolites. The emulgel containing 5 $\%^{w}/_{w}$ of the extract of *P. biglobosa* showed relatively similar wound healing activity to that of the prototype drug, 1% silver sulfadiazine (Dermazin®). The absence of irritation and effective burn wound healing activity of the emulgel containing the extract showed the effectiveness of *P. biglobosa* stem bark for wound healing thus corroborating the folk claim.

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Fig. 1: Emulgel formulations containing varying concentrations of the extract of the stem bark of *P. biglobosa.*

Key: A= 0% of *P. biglobosa* extract**; B=** 0.5% of *P. biglobosa* extract**; C=** 2.5% of *P. biglobosa* extract**; D=** 5% of *P. biglobosa* extract.

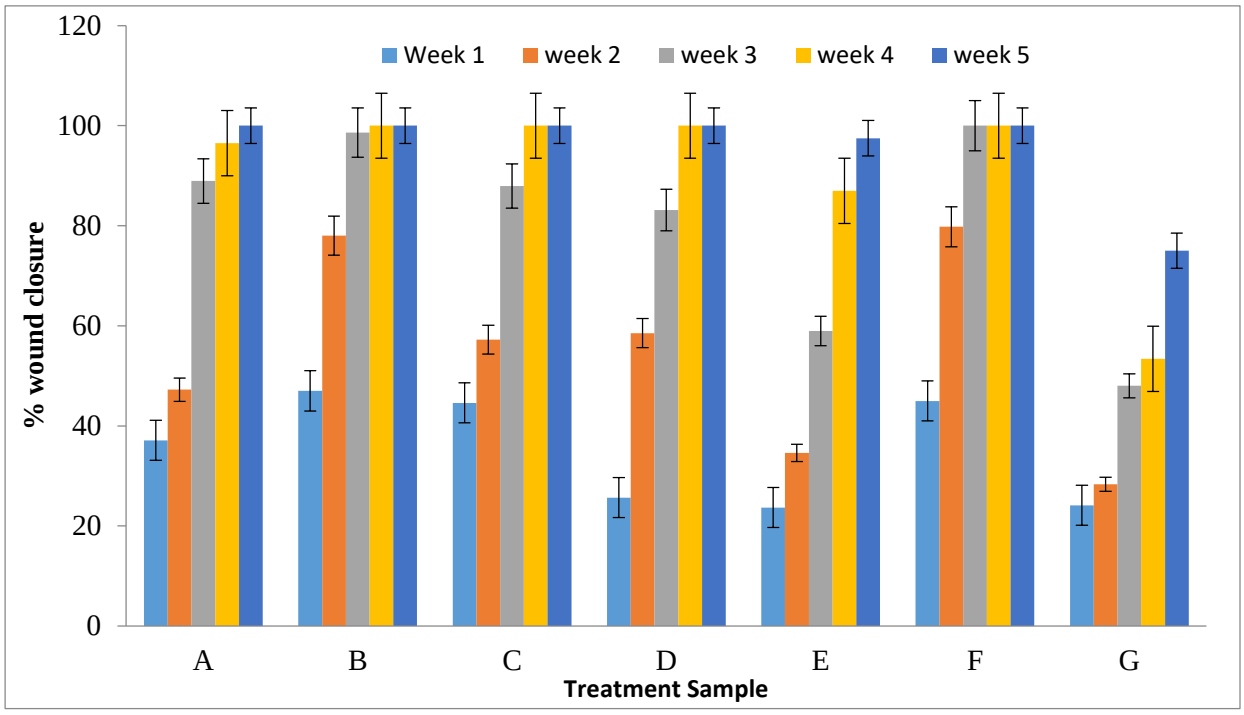

Fig. 2: Wound healing potential of the *Parkia biglobosa* stem bark powder and extract emulgel

Key: A: Fine powder; **B**: 5 %w/w extract; **C**: 2.5 %w/w extract; **D**: 0.5% w/w extract; **E**: 0% w/w extract; **F**: 1% Silver sulphadiazine cream; **G**: Wounded but not treated

Table 1: Formula for preparing an oil in water emulsion base and emulgel of *P. biglobosa* stem bark extract.

Sample	Soft paraffin (g)	Tween 80 (g)	SS (g)	CrS (g)	DW (g)	*P. b* extract (g)	Emulgel (*add to*) (g)	% P. *b* extract in Emulgel
A	12	4.4	1.6	1	82	0	100	0
B	12	4.4	1.6	1	81	1	100	0.5
C	12	4.4	1.6	1	77	5	100	2.5
D	12	4.4	1.6	1	72	10	100	5

SS = Sorbitan sesquioleate, CrS= Chlorocresol, DW = Distilled water, *P. b* extract = *Pakia biglobosa* extract

Table 2: The group profile of the animals in relation to the samples administered.

S/N	Group	Sample applied
1	A	Fine powder
2	B	0.0 % extract emulgel
3	C	0.50 % extract emulgel
4	D	2.50 % extract emulgel
5	E	5.00 % extract emulgel
6	F	1% Silver sulphadiazine ((Demazine®)
7	G	None

Table 3: The effect of concentration of *P. biglobosa* stem bark extract on the viscosity and pH of the emugel formulations.

S/N	*P. biglobosa* extract concentration (% $^{w}/_{w}$)	Viscosity (mPa.s)	Non-volatile matter (%)	pH
A	0.00	978.00 ± 17.20	20.00 ± 1.5	7.00 ±1.48
B	0.50	1200.67 ± 24.57	50.00 ± 1.0	6.76 ±1.51
C	2.50	1292.74 ± 26.08	70.00 ± 1.5	6.58 ±1.58
D	5.00	1840.67 ± 28.77	81.00 ± 2.1	6.26 ±1.60