

COMPARISON OF ANTIMICROBIAL AND WOUND HEALING PROPERTIES OF *Albizia chevalieri* AND *Commiphora kerstingii* IN RABBIT

¹Olusanmi, F.T., ²Adeyanju, J.B., ³Fadason, S.T., ³Awasum, C.A., ⁴Ambali, S.F., ³Abidoye, E.O., ³Abdulrahman, M., ³Baba, A.A. and ⁵Daodu, O.B.

¹ Veterinary Teaching Hospital, University of Ilorin, Kwara State, Nigeria

² Department of Veterinary Surgery and Radiology, Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria

³Department of Veterinary Surgery and Radiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

⁴ Department of Veterinary Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria

⁵ Department of Veterinary Microbiology, Faculty of Veterinary Medicine, University of Ilorin, Kwara State, Nigeria

Corresponding author: olusanmifoluke@gmail.com; +2347032180266

ABSTRACT

Wound treatment and wound healing have often been made difficult and complicated by the presence of infective microbial particles. The aim of this study was to investigate the wound healing and antimicrobial activities of methanol leaf extracts of the plants *Albizia chevalieri* and *Commiphora kerstingii*. Extraction of the dried pounded plants was done using methanol as solvent in Soxhlet apparatus (Quick fit, England). Preliminary phytochemical screening of the plant extracts were carried out using standard methods. Twelve rabbits of both sexes were divided into four groups (A, B, C, and D) each consisting of three rabbits. Bilateral full thickness excision wounds measuring 2cm × 1cm were surgically induced on the dorsum (lumbar region) of each rabbit. Rabbits in group A were treated with the vehicle petroleum jelly (Unilever PLC) (Negative control), while those in group B were treated with 2% w/w penicillin ointment (positive control). Rabbits in groups C and D were treated with the extracts of *A. chevalieri* (1g/10g petroleum jelly (AC)) and *C. kerstingii* extract (1g/10g petroleum jelly (CK)) respectively. The wounds were treated every 48 hours for three weeks and evaluated for exudation in terms of rate and nature, wound contraction and epithelization. The antimicrobial activities of the methanol leaf extracts of the plants were determined against *S. aureus* (gram – positive organism) and *E. coli* (gram- negative organism) using agar gel diffusion method. The extracts of *A. chevalieri* and *C. kerstingii* contain the following metabolites: flavonoids, tannins, alkaloids, saponins, cardiac glycosides, steroids, triterpenes and carbohydrates. The results showed a consistent decline in bacterial colony count in all the groups irrespective of the treatment formulations used. Exudation decreased drastically with treatment in Groups C and D, while animals in groups A and B showed moderate production of exudate up till the 7th day of treatment which gradually declined between the 9th and 13th day. Wounds of animals in group C showed faster rate of wound contraction, decreased epithelization period and increased healthy granulation tissue formation. This was followed by wounds of animals in group B, wounds of animals in group D and lastly wounds of animals in Group A. No antimicrobial effect was shown by wounds of Group A against any of the tested microorganisms. The 2% w/w penicillin ointment showed remarkable activity against the Gram – positive *S. aureus* (28 mm) and Gram – negative *E. coli* (26 mm). *A. chevalieri* extract exhibited tremendous activity

against the Gram - positive *S. aureus* (30 mm) but no effect against Gram – negative *E. coli*, while *C. kerstingii* extract showed remarkable activity against the Gram – negative *E. coli* (24 mm) but no effect against Gram – positive *S.aureus*. The result of this study showed that methanol leaf extract of the plant *A. chevalieri* was more effective, followed by methanol leaf extract of *C. kerstingii* and the influence on wound healing was to a large extent comparable to 2 % w/w penicillin ointment with no adverse reactions.

Keywords: *Albizia chevalieri*, *Commiphora kerstingii*, Plant extract, wound, healing, Bacteria colony forming unit

INTRODUCTION

Wound is defined as the loss or break in cellular and anatomic or functional continuity of living tissue (Kokane *et al.*, 2009). Wounds commonly occur in animals (Hassan, 2002) with resultant economic impact (Velmar *et al.*, 2009). In animal, wound can result from a variety of causes such as road traffic accidents, falls, horn gore injuries, gun shots, assaults by man following trespass, and surgery amongst others (Milne, 2008).

Wound healing is an intricate process in which the skin (an organ or tissue) repairs itself after injury (Nguyen *et al.*, 2009). Although the body has some mechanism for self-repair when injured (Levine, 2009), the wound management practice is always aimed to facilitate healing in the shortest possible time, with minimal pain, discomfort and scarring to the patient and must occur in a physiological environment conducive to tissue repair and regeneration (Thakur *et al.*, 2011). In fact, a flexible and fine scar with high tensile strength is desired at the site of wound closure (Wyncoll and Beale, 2001).

Studies on complex dynamics of tissue repair have identified several nutritional cofactors that can impact the speed of wound healing such as vitamins A, C and E, zinc, arginine, glutamine and glucosamine (Porto da Rocha *et al.*, 2002). Botanical extracts from *Aloe vera*, *Centella asiatica*, and the enzyme Bromelain from pineapple have also been shown to improve healing time and wound outcome (Douglas and Miller, 2003; Subramanian *et al.*, 2006;

Kannabiran *et al.*, 2009). Eclectic therapies including topical application of honey and sugar have also been tried in the past with varying outcome (Molan, 2002; Montejo *et al.*, 2003).

Commiphora kerstingii ENGL (*C.kerstingii*) (Myrrh tree) belong to the family Burseraceae and a group of plants commonly called Myrrh (Hanus *et al.*, 2005). It is a tree of about 10 m high grown in the savanna regions including Togo, Nigeria, and the Central African Republic. It has been found to possess antioxidant properties. It has been reported that their exogenous antioxidants are safer compared to synthetic antioxidants (Grice, 1986; Sokmen *et al.*, 2004). The plant is considered to possess useful agents for the prevention of cardiovascular diseases and several kinds of cancer (Duthie and Brown, 1994). Also, the plant has also been shown to have active component against bacteria such as *Bacillus subtilis* and *Escherichia coli*, and opportunistic fungi *Candida albicans* (Kubmarawa *et al.*, 2007). In addition, studies using the stem bark showed it possesses trypanocidal effects (Mikail, 2009).

Albizia is a large genus of trees, of the pea family Fabaceae and subfamily Mimosoideae native to the warm regions of the world. It is a tree of the acacia type native to tropical and subtropical regions of the world including Nigeria and Niger Republic. Approximately 150 species of *Albizia* exist as trees and shrubs, and are grown as ornamentals (Saidu *et al.*, 2007)

but *Albizia chevalieri* (Silk tree) is well known. It is also used in folk medicine for the treatment of diabetes mellitus, rheumatism, stomach ache, cough, diarrhoea, tuberculosis, wounds and arrow poison as well as an anthelmintic (Kokila *et al.*, 2013).

The screening of herbal extracts has been of great interest to scientists for the discovery of new effective drugs (Kosger *et al.*, 2009). A number of reports concerning the antimicrobial and wound healing activities of various plants have appeared in literature, but the vast majority, are yet to be explored (Thakur *et al.*, 2011). The search for the most suitable medicinal plants for wound healing therefore becomes imperative as there is paucity of information regarding the wound healing activities of these plants. This study is therefore geared towards this, with the hope that findings from this study may add to the arsenal of botanicals used in wound management.

MATERIALS AND METHODS

Plant material and extraction process

Branches of plants were collected from Samaru, Zaria in Kaduna State, Nigeria and were taken to the Herbarium, Department of Biological Sciences, Ahmadu Bello University, Zaria for identification. Voucher specimen numbers 900247 and 900228 were assigned to *Albizia chevalieri* Harms (Silk Tree) and *Commiphora kerstingii* (Myrrh Tree) respectively.

The leaves were air dried and weighed at interval until a constant weight was obtained and the dried leaves of each plant were pounded separately. The fine powders were weighed accurately using an electronic digital weighing balance (Metler, England). Six-hundred grams of each powdered plant were extracted in a Soxhlet Apparatus (Quick fit, England) using 6L of methanol as solvent. The extracts obtained were

concentrated to semi-solid mass under reduced pressure in a rotary evaporator (Buchi, Germany) at 40°C. The semi-solid extracts were then dried in a beaker on a water-bath (Baths McDonald Scientific International, England). Percentage yield of the extract were then calculated. The extracts were stored separately in air-tight containers until needed. Emulsions were made for each plant using petroleum jelly (Unilever) as vehicle.

Phytochemical screening

The extracts of both plants were tested qualitatively for different phytochemicals including carbohydrate, triterpenes, unsaturated sterols, cardiac glycoside, saponin glycosides, tannins, flavonoids, alkaloids and free anthracene derivative, using various standard chemical tests (Trease and Evans, 1996).

Antibacterial activity

Preliminary antibacterial activity of methanolic leave extracts of *Albizia chevalieri* and *Commiphora kerstingii* were first carried out using agar gel diffusion test (Jones *et al.*, 1989). Mueller Hinton Agar (MHA) was prepared based on manufacturer's instruction. McFarland standard of 0.5 of overnight broth cultures of *Staphylococcus aureus* and *Escherichia coli* were prepared and used to flood the MHA in duplicate. The plates were left for 2 minutes; the excess broth was tipped off and left again for the agar to dry at room temperature. With the aid of sterile cork borer, seven (7) wells were bored into each agar and a drop of molten MHN agar was then dispensed in each well to form the base and ensure adequate diffusion. Subsequently, 5 wells were filled with 1ml of varying concentrations of plant extracts (0.625, 1.25, 2.5, 5 and 10% w/w) while the remaining 2 wells were filled with 2% Penicillin ointment (positive control) and Petroleum jelly (negative controls). The

plate was left for 1 hour before incubation at 37°C for 24 hours. The zones of inhibition were recorded.

Experimental design

Twelve rabbits were randomly assigned into four groups consisting of 3 rabbits (Group A= Petroleum Jelly only- negative control, Group B= Penicillin ointment only- positive control, Group C= *Albizia chevalieri* methanolic leave extract- test, Group D= *Commiphora kerstingii* methanolic leave-test). The concentration of penicillin ointment used was 2% (w/w) while 10% (w/w) of plant extracts in petroleum jelly were used for the experiment as described by Cooper (1987).

The animals were liberally shaved from the first thoracic vertebrae to the first sacral bone, and laterally to the flanks 10cm on either side of the vertebrae. The shaved surfaces were then scrubbed with soap and 0.5% chlorhexidine solution was applied using gauze.

The rabbits were placed under general anaesthesia using atropine sulphate (0.05 mg/kg) and chlorpromazine (4mg/kg) intramuscularly (IM). This was then followed by ketamine hydrochloride (55mg/kg) IM. The rabbits were then placed on sternal recumbency and draped to expose the surgical sites.

With the aid of radiographic film template, bilateral full thickness excision wounds measuring $2 \times 1\text{cm}^2$ were made on the dorsum (Lumbar region) of each rabbit as described by Morton and Malone, 1972. The wounds were left exposed for 48 hours to allow for contamination as described by Abidoye (2006).

Prior to daily group treatment, wound swabs were obtained using sterile swab sticks and immediately placed in 5ml of normal saline with the aim of determining the bacterial colony forming unit (CFU) using spread

plate method. The wound treatment involved the use of sterile moisten swabs to clean the wounds, followed by group's treatment using various preparations (extract and controls). Then, sterile non-adherent gauze pads were placed on the wounds which were then dressed occlusive and held in place by adhesive tape. This treatment was repeated at every alternate day until complete epithelization was achieved.

Wound contraction was assessed by tracing round the wound area with sterile thread which was then measured using ruler in centimeter.

The epithelization period was estimated by noting the number of days required for eschar to fall away leaving no raw wound behind (Patil *et al.*, 2015). The rate of exudation was assessed as: None (-) = 0, Slight (+) = 1, Moderate (++) = 2 and High (+++) = 3.

RESULT

Phytochemical analysis

The preliminary phytochemical screening of the methanol leaf extracts of *C. kerstingii* and *A. chevalieri* revealed the presence of carbohydrate, steroids, triterpenes, cardiac glycosides, saponins, tannins, flavonoids and alkaloids (Table 1).

Bacterial susceptibility to plant extracts

The in vitro study showed that penicillin ointment (PO) and methanolic leaf extracts of *A. chevalieri* (AC) and *C. kerstingii* (CK) inhibited bacterial growth on MHA (Table 2). Penicillin ointment (positive control) produced zone of inhibition for the two bacteria while 10% *A. chevalieri* leaf extract showed 30 mm diameter of zone of inhibition for *Staphylococcus aureus*, but none for *Escherichia coli*. However, *C. kerstingii* leaf extract had 24mm diameter zone of inhibition around *E. coli* at 10% concentration but none for *Staphylococcus*

aureus. The petroleum jelly had no zone of inhibition for the two bacteria (Table 2).

Wound exudation and contraction

All the treated wound showed a decline in exudation over time, however, Groups C (*A. chevalieri*) and D (*C. kerstingii*) methanol extracts treated wounds had the lowest exudate production at days 3, 5 and 7 (Chart 1) and were the first groups to have the least recorded exudate production at day 5 post-treatment. By days 9, 11 and 13, all the groups had the same exudation score. Methanol leaf extracts of *A. chevalieri* and *C. kerstingii* showed considerable reduction in epithelization

Also, at day 17, Group C had the highest wound contraction rate (smallest wound circumference) of 95.17% (0.33 ± 0.03) followed by Group B 94.16 % (0.40 ± 0.03), Group D 91.24% (0.60 ± 0.00) and Group A 89.98% (0.70 ± 0.10) (Table 3).

Bacterial colony count

In all treated and control groups, there was a steady decline in the bacterial colony count as healing progressed (Chart 3). Although the decrease was considerably greater in Group B-D methanol extract treated wounds compared to Group A (petroleum jelly) treated wounds.

DISCUSSION

Methanol extract of the leaves of the plant *Albizia chevalieri* competed favourably well with the standard 2% w/w penicillin ointment and showed enhanced healing compared to the other treatment formulations in this study. This can only be explained by the report of Kannabiran et al (2009) that plant extracts generally are more active against Gram-positive bacteria than Gram-negative bacteria. Thus, it will be expected that wound treated with *Albizia chevalieri* methanolic leave extract will remove or impede the growth of

opportunistic *Staphylococcus aureus* which are normal flora of the skin.

The result of the *in vitro* antibacterial test showed that petroleum Jelly (vehicle and negative control) exhibited no antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*. This shows that it possesses no antimicrobial effects. However, 2% w/w Penicillin ointment (positive control) exhibited significant activity against *S. aureus* and *E. coli*. The methanol extract of the leaves of *A. chevalieri* exhibited significant activity against *S. aureus*, but has no activity against *Escherichia coli*. However, the methanol extract of the leaves of *C. kerstingii* showed activity against *E. coli* only. This is contrary to what was reported by Musa (2008) on the stem bark of these plants which exhibited significant activity against both *S. aureus* and *E. coli*. This study underpins the need to collect the appropriate plant part for evaluation, since different parts of the same plant have different properties and also show different activities (Nwinyi *et al.*, 2004).

Given that wounds can generate pain, it is important that the dressing applied does not increase pain, and if possible, it should lessen the pain (Gupta and Jain, 2010). The rabbits did not exhibit any adverse reaction to the plant extracts showing that their application caused no irritation or pain. This may be attributed to the presence of bioactive constituents such as flavonoids in the extracts, which are known to protect against allergies and inflammation (Maduka *et al.*, 2014). This also agrees with the work of Mackay and Miller (2003) and Venkatesh et al (2003) which showed that compared to traditional herbal medicines, synthetic drugs are more liable to cause problems such as allergies, pain and drug resistance.

The phytochemical constituents of plants have been shown to be responsible for their therapeutic actions (Damintoti *et al.*, 2005).

The preliminary phytochemical screening of the methanol leaf extract of *A. chevalieri* and *C. kerstingii* revealed the presence of flavonoids, tannins, alkaloids, saponins, steroids, triterpenes, cardiac glycosides and carbohydrate. Synergistic effect of secondary metabolites found in plant crude extracts has been continuously demonstrated (Serafin *et al.*, 2007). Tannins, flavonoids, saponins, and triterpenes promote wound healing due to their astringent and antimicrobial properties, which seems to be responsible for wound contraction and increased rate of epithelization (Getie *et al.*, 2002; Chaudhari and Mengi, 2006; Deshmukh *et al.*, 2009; Vinothapooshan and Sundhar, 2010; Murti *et al.*, 2011). Also, alkaloids has been reported to possess antibacterial properties (Njoku and Akumefula, 2007) while carbohydrates provide essential nutrient that promote wound healing (Ndukwe *et al.*, 2005). Agents that demonstrate significant antioxidant activities such as the extracts of *A. chevalieri* and *C. kerstingii* may therefore, preserve viable tissue and facilitate wound healing (Yeoh, 2000). Scavenging of reactive oxygen species, super oxide and hydroxyl radicals by these phytochemicals (Acharya, 2004) decrease the risk of oxidative damage to the tissues contributing to rapid and efficient wound healing.

Methanol leaf extracts of *A. chevalieri* and *C. kerstingii* showed considerable reduction in epithelization period and wound contraction time, which can be due to several effects, direct or indirect (Saha *et al.*, 1997). Direct effect can be the stimulation of release of factors contributing to wound healing by enhancement of localised cell proliferation in the wound area and rapid collagen deposition (Shourie and Karla, 2013). Indirect effects can be the anti-inflammatory property of extract and the antimicrobial activity particularly against

potential wound microbes like *S. aureus* and *E. coli*. The eradication of colonizing organisms and inhibition of microbial contamination creates a suitable environment for the healing process (O'meara *et al.*, 2001). The antibacterial activities of the extracts might have contributed remarkably to faster wound healing rate as evident by the experimentally treated groups. These properties can be attributed to the phytochemicals identified in the extracts such as carbohydrates, alkaloids, flavonoids, tannins, saponins, cardiac glycosides, sterols and triterpenes. All of which are known to have some therapeutic properties like anti-microbial, anti-inflammatory or pro-wound healing activity which makes the plants medicinally valuable (Francois *et al.*, 2010).

The present study revealed that methanol leaf extracts of the plants *A. chevalieri* and *C. kerstingii* have remarkable antibacterial and wound healing activities and can compete favourably well with conventional topical wound healing medicaments in the treatment of wounds as claimed in folklores and traditional information (Mann *et al.*, 2003; Sofowora, 2006; Kokila, *et al.*, 2013).

CONCLUSION

This study showed that the plants *A. chevalieri* and *C. kerstingii* contain bioactive substances (secondary metabolites) such as flavonoids, alkaloids, saponins, tannins, triterpenes, steroids which could be responsible for their wound healing and antimicrobial effects. The plant *A. chevalieri* showed great activity against *S. aureus* while the plant *C. kerstingii* showed great activity against *Escherichia coli*. Also, the two plants extracts are safe for topical wound management with no gross evidence of adverse reactions or pain in rabbits. Since these plants are indigenous and readily accessible, they can compete favorably well

with conventional topical wound management medicaments if properly harnessed and can serve as alternative to the conventional topical drugs used in management of acute (traumatic) wounds. It is recommended that further studies should be done to validate the pathopharmacological activities of these plant extract to ensure their use in routine wound management.

REFERENCES

- ABIDOYE, O. E. (2006). Wound healing properties of *Aspilia africana* and *Chromolaena odorata* extract on experimental canine wounds. M.Sc. Thesis, Ahmadu Bello University, Zaria.
- ACHARYA, D. (2004). Medicinal plants for curing common ailments in India. *Positive Health*, 102:28-30.
- CHAUDHARI, M. and MENGI, S. (2006). Evaluation of phytoconstituents of *Terminalia arjuna* for wound healing activity in rats. *Phytotherapy Research*, 20:799-805.
- Cooper, R. (1987). Gunn's Dispensing for Pharmaceutical Students. 12th edition. CBS Publishers and Distributors, New Delhi, PP. 199 – 200.
- DAMINTOTI, K., ALY, S., ANTONELLA, C., SAYDOU, U., CARLA, M., JACQUES, S., VITTORIE, C. and ALFRED, S.T. (2005). Antibacterial activity of alkaloid from *Sida acuta*. *African Journal of Biotechnology*, 4(12):145-147.
- DESHMUKH, P. T., FERNANDES, J., AKARTE, A. and EMMANUEL, T. (2009). Wound healing activity of *Calotropis gigantea* root bark in rats. *Journal of Ethnopharmacology*, 125:178-181.
- DOUGLAS, J. M. and MILLER, A. L. (2003). Nutritional support for wound healing. *Alternative Medicine Review*, 8(4):359-377.
- DUTHIE, G. G. and BROWN, K. M. (1994). Reducing the risk of cardiovascular diseases. Functional Foods: Designer Foods. In: Goldberg, I. (Ed) *Pharmaceutical Foods Nutraceuticals*, Chapman and Hall, London, England, PP. 19-38.
- FRANCOIS, M. N., AMADOU, D. and RACHID, S. (2010). Chemical composition and biological activities of *Ficus capensis* leaves extract. *Journal of Natural Products*, 3:146 – 160.
- GETIE, M., GEBRE, M. T., REITZ, R. and NEUBERTH, R. H. (2002). Evaluation of the release profiles of flavonoids from topical formulation of the crude extract of leaves of *Dodonaea viscosa* (sapiaceae). *Pharmazie*, 57:320-322.
- GRICE, H. C. (1986). Safety evaluation of butylated hydroxytoluene (BHT) in liver, lung and gastrointestinal tract. *Food Chemical Toxicology*, 24:1127 – 1130.
- GUPTA, N. and JAIN, U. K. (2010). Prominent wound healing properties of indigenous medicines. *Journal of Natural Pharmaceuticals*, 1(1):2-13.
- HANUS, L. O., RESANKA, J., DEMBITSKY, V. M. and MOUSSAIEFF, A. (2005). Myrrh – *Commiphora* chemistry. *Biomedical Papers*, 149:3 – 28.
- HASSAN, A. Z. (2002). Trial of varieties of topical mix on canine wounds. A Ph.D. Dissertation. Ahmadu Bello University, Zaria.

- JONES, R. N., GAVAN, T. L., THORNSBERRY, C., FUCH, P. C., GERLACH, E. H., KNAPP, J. S., MURRAY, P. and WASHINGTON, J. A. (1989). Standardization of disk diffusion and agar dilution susceptibility tests for *Neisseria gonorrhea*: Interpretive and quality control guidelines for ceftriaxone. *Journal of Clinical Microbiology*, 27:2758-2766
- KANNABIRAN, K., MOHANKUMAR, T. and GUNASEKER, V. (2009). Evaluation of antimicrobial activity of saponin isolated from *Solanum xanthocarpum* and *Centella asiatica*. *International Journal of Natural and Engineering Sciences*, 3(1):25-28.
- KOKANE, D. D., MORE, R. Y., KALE, M. B., NEHETE, M. N., MEHENDALE, P. C. and GADGOLI, C. H. (2009). Evaluation of wound healing activity of root of *Mimosapudica*. *Journal of Ethnopharmacology*, 124:311- 315.
- KOKILA, K., SUBRAMANIAN, D. P. and SUJATHA, V. (2013). Phytopharmacological properties of *Albizia* species: A Review. *International Journal of Pharmacy and Pharmaceutical Sciences*, 5(3).
- KOSGER, H. H., OZTURK, M., SOKMEN, A., BULUT, E. and AY, S. (2009). Wound healing effects of *Arnebiadensi* flora root extracts on rat palatal mucosa. *European Journal of Dentistry*, 3(2):96-99.
- Kubmarawa, D., Ajoku, G. A., Enwerem, N. M. and Okorie, D. A. (2007). Preliminary phytochemical and antimicrobial screening of 50 medicinal plants from Nigeria. *African Journal of Biotechnology*, 6: 1690-1696.
- KUMAR, M. S., KIRUBANANDAN, S., SRIPRIYA, R. and SEHGAL, P. K. (2008). *Triphala* promotes healing of infected full – thickness dermal wound. *Journal of Surgical Research*, 144:94 – 101.
- LEVINE, M. (2009). Bioelectrical mechanism in regeneration: Unique aspects and future perspectives. *Seminar in cell and Development Biology*, 20:543-556.
- MACKAY, D. J. and MILLER, A. L. (2003). Nutritional support for wound healing. *Alternative Medicine Review*, 8(4):359-377.
- MADUKA, H. C. C., OKPOGBA, A. N., UGWU, C. E., DIKE, C. C., OGUECHE, P. N., ONWUZURIKE, D. EFFECTS T. and IBE, D. C. (2014). Phytochemical, anti-oxidant and microbial inhibitory of *Spondias mombin* leaf and stem bark extracts. *Journal of Pharmacy and Biological Sciences*, 9(2):14-17.
- MANN, A., GBATE, M. and UMAR, N. A. (2003). *Medicinal and Economic Plants of Nupeland*. Jube Evans Books and Publications, Bida, Nigeria, P. 276.
- MIKAIL, H. G. (2009). In-vitro trypanocidal effect of methanolic extract of *Sclerocarya birrea*, *Commiphora kerstingii* and *Khaya senegalensis*. *African Journal of Biotechnology*, 8(10), PP.2047-2049.
- MILNE, C. T. (2008). Wound and skin care centre, American association of Nurses. Assessed at www.peacehealth.org/klbase/cam/hm on 10 - 7 - 2015.
- MOLAN, P. C. (2002). Re – introducing honey in the management of wounds and ulcers: theory and practice.

- Ostomy and Wound Management*, 48(11):28-40.
- MONTEJO, J. C., ZARAZAGA, A. and LOPEZ-MARTINEZ, I. (2003). Immunonutrition in the intensive care unit. A systematic review and consensus statement. *Clinical Nutrition*, 22:221-223.
- MURTI, K., LAMBOLE, V., PANCHAL, M., SHAH, M. and GAJERA, V. (2011). Evaluation of wound healing activity of polyherbal formulations in rats. *Research Journal of Pharmacognosy and Phytochemistry*, 3:112-115.
- MUSA, A. A. (2008). Antioxidant and Antibacterial Activity of *Commiphora kerstingii* ENGL. Stem bark extract. *Research Journal of Phytochemistry*, 2:106-111.
- NDUKWE, K. C., OKEKE, I. N., LAMIKARRA, A., ADESINA, S. K. and ABODERIN, O. (2005). Antibacterial activity of aqueous extracts of selected chewing sticks. *Journal of Contemporary Dental practice*, 6(3):86 – 94.
- NGUYEN, D. T., ORGILL, D. P. and MURPHY, G. F. (2009). The pathophysiologic basis for wound healing and cutaneous regeneration. *Biomaterials for treating skin loss*. CRC press (US) and Woodhead Publishing (UK/Europe), Boca Raton/Cambridge. pp. 25-57.
- NJOKU, P. C. and AKUMEFULA, M. I. (2007). Phytochemical and nutrient evaluation of *Spondias mombin* leaves. *Pakistanian Journal of Nutrition*, 6(6): 613 – 615.
- NWINYI, F. C., BINDAH, L., AJOKU, G. A., ANIAGU, S. O., ENWEREM, N. M., ORISADIPE, A. and KUBMARAWA, K. S. (2004). Evaluation of the aqueous extract of *Boswellia dalzielii* stem bark for antimicrobial activities gastrointestinal effect. *African Journal of Biotechnology*, 3(5):284-288.
- O'MEARA, S. M., CULLUM, N. A., MAJID, M. and SHELDON, T. A. (2001). Systematic review of antimicrobial agents used for chronic wounds. *British Journal of Surgery*, 88(1):4-21.
- PATIL, N., VAISHNAV, L. R., THANUSUBRAMANIAN, H., HOLLA, N. S., MONOHAR, D. H. and BAIRY, K. L. (2005). Formulation and evaluation of the hydroalcoholic extract of *Caesalpinia pulcherrima* stem bark on wound healing model in wistar rats. *International Journal of Advanced Research*, 3(3):648-654.
- PORTO DA ROCHA, R., LUCIO, D. P. and SOUZA, T. L. (2002). Effects of a vitamin pool (Vitamins A, E, and C) on tissue necrosis process: experimental study on rats. *Aesthetic Plastic Surgery*, 26:197-202.
- SAHA, K., MUKHERJE, P. K., DAS, J., POT, M. and SAHA, B. P. (1997). Wound healing activity of *Leucas lavandulafolia*. *Research Journal of Ethnopharmacology*, 64:57 – 60.
- SAIDU, Y., LAWAL, M., ISEZUO, S. A., SHEHU, R. A., SAHABI, D. M. and BILBIS, L. S. (2007). Partial purification and elucidation of mechanism of hypoglycaemic agent of aqueous leaf extract of *Albizia chevalieri* Harms (Leguminosae). *Journal of Pharmacology and Toxicology*, 2(6): 513- 523.

- SERAFIN, C., NART, V., MALHEIROS, A., CRUZ, A. B., MONACHE, F. D., GETTE, M. A., ZACCHINOS, S. and CECHINEL, V. (2007). Evaluation of the antimicrobial effects of *Plinia glomerata* (Myrtaceae). *Brazilian Journal of Pharmacognosy*, 17(4):578-582.
- SHOURIE, A. and KARLA, K. (2013). Analysis of phytochemical constituents and pharmacological properties of *Abrus precatorius* L. *International Journal of Pharmacy and Biological Sciences*, 4(1): 91-101.
- SOKMEN, A., SOKMEN, M., DAFERARA, D., POLLISSON, M. and CANDAN, F. (2004). The in-Vitro, antioxidant and antimicrobial activities of essential oil and menthol extracts of (*Achillea biebersteini*). *Phytotherapy Research*, 18:451-456.
- SUBRAMANIAN, S., KUMAR, D. S. and ARULSELVAN, P. (2006). Wound healing potential of *Aloe vera* leaf gel studied in experimental rabbits. *Asian Journal of Biochemistry*, 1: 178-185
- THAKUR, P., JAIN, N., PATHAK, R. and SANDHU, S. S. (2011). Practices in wound healing studies of plants. *Evidence Based Complementary and Alternative Medicine*, 2011: 1 – 17.
- TREASE, G. E. and EVANS, W. C. (1996). *Pharmacognosy*. 11th ed Bailliere Tindall, London England, PP.45-50.
- VELNAR, T., BAILEY, T. and SMRKOLJ, V. (2009). The Wound Healing Process: an Overview of the Cellular and Molecular Mechanisms. In: *The Journal of International Medical Research*:37(5):1528-1542. Retrieved from mr.sagepub.com July 13, 2015.
- VENKATESH, S., REDDY, G. O., REDDY, B. M., RAMESH, M. and APPA RAO, A. V. N. (2003). Antihyperglycemic activity of *Caralluma altenuate*. *Fitoterapia*, 74:274-279.
- VINOTHAPOOSHAN, G. and SUNDHAR, K. (2010). Wound healing effect of various extracts of *Adhatoda vasica*. *International Journal of Pharmacy and Biological Sciences*, 1:530-536.
- WYN COLL, D. and BEALE, R. (2001). Immunologically enhanced enteral nutrition: current status. *Current Opinion Critical Care*, 7:128-132.
- YEOH, S. (2000). The influence of iron and free radicals on chronic leg ulceration. *Primary Intention*, 8: 47-55.

Table 1: Phytochemical Components of the Methanol Extracts of the leaves of *Albizia chevalieri* and *Commiphora kerstingii*

Metabolites	<i>Albizia chevalieri</i>	<i>Commiphora kerstingii</i>
Carbohydrates	+	+
Steroids	+	+
Triterpenes	+	+
Cardiac glycosides	+	+
Saponins	+	+
Tannins	+	+
Flavonoids	+	+
Alkaloids	+	+
Anthraquinone	-	-

KEY: + = Presence of metabolite; - = Absence of metabolite

TABLE 2: *In vitro* Antibacterial Activities of *Albizia chevalieri* and *Commiphora kerstingii*

Bacteria	^a <i>Albizia chevalieri</i> (% w/w)						^a <i>Commiphora kerstingii</i> (% w/w)						PO(%)	PJ (%)
	10	5	2.5	1.25	0.625	10	5	2.5	1.25	0.625	2			
<i>Staphylococcus aureus</i>	30	25	10	10	10	10	10	10	10	10	10	28	10	
<i>Escherichia coli</i>	10	10	10	10	10	10	24	20	10	10	10	26	10	

Legend: PO- Penicillin ointment PJ- Petroleum Jelly 10mm is the diameter of the hole bored into the agar

Diameter of zone
of inhibition
(mm)

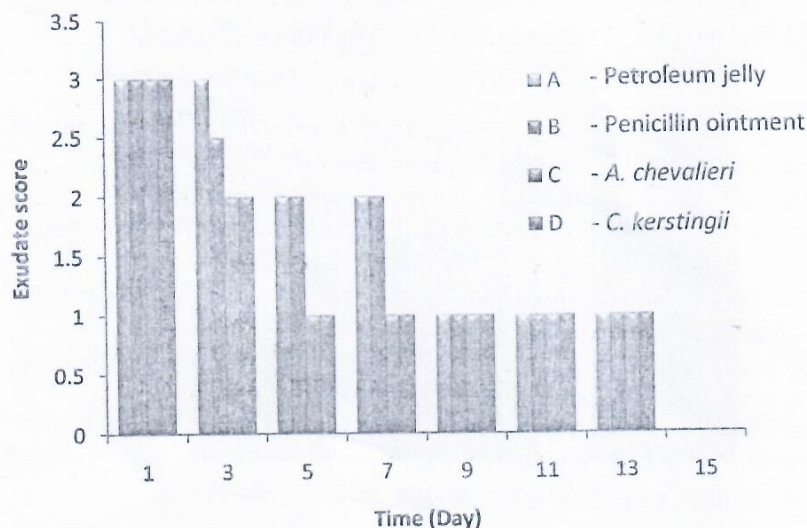


Chart 1: Effect of methanol extracts of *A. chevalieri* and *C. kerstingii* on wound exudate in rabbits.

Table 3: ^aMean $\pm$ Standard Error of mean of Wound Circumference using various treatments formulations

Treatment Days	A	B	C	D
0	6.85 $\pm$ 0.02	6.85 $\pm$ 0.05	6.83 $\pm$ 0.00	6.85 $\pm$ 0.02
3	6.57 $\pm$ 0.04	6.45 $\pm$ 0.05	6.45 $\pm$ 0.02	6.57 $\pm$ 0.00
5	6.28 $\pm$ 0.02	6.05 $\pm$ 0.02	6.08 $\pm$ 0.02	6.30 $\pm$ 0.00
7	5.75 $\pm$ 0.05	5.68 $\pm$ 0.05	5.63 $\pm$ 0.07	6.00 $\pm$ 0.03
9	5.43 $\pm$ 0.04	4.52 $\pm$ 0.29	4.10 $\pm$ 0.07	5.35 $\pm$ 0.28
11	4.08 $\pm$ 0.02	3.22 $\pm$ 0.39	2.52 $\pm$ 0.09	3.70 $\pm$ 0.40
13	2.62 $\pm$ 0.05	1.92 $\pm$ 0.25	1.35 $\pm$ 0.05	3.03 $\pm$ 0.04
15	1.35 $\pm$ 0.08	0.90 $\pm$ 0.10	0.60 $\pm$ 0.03	1.45 $\pm$ 0.05
17	0.70 $\pm$ 0.10	0.40 $\pm$ 0.03	0.33 $\pm$ 0.03	0.60 $\pm$ 0.00
19	0.30 $\pm$ 0.00	0.20 $\pm$ 0.00	0.00 $\pm$ 0.00	0.30 $\pm$ 0.00

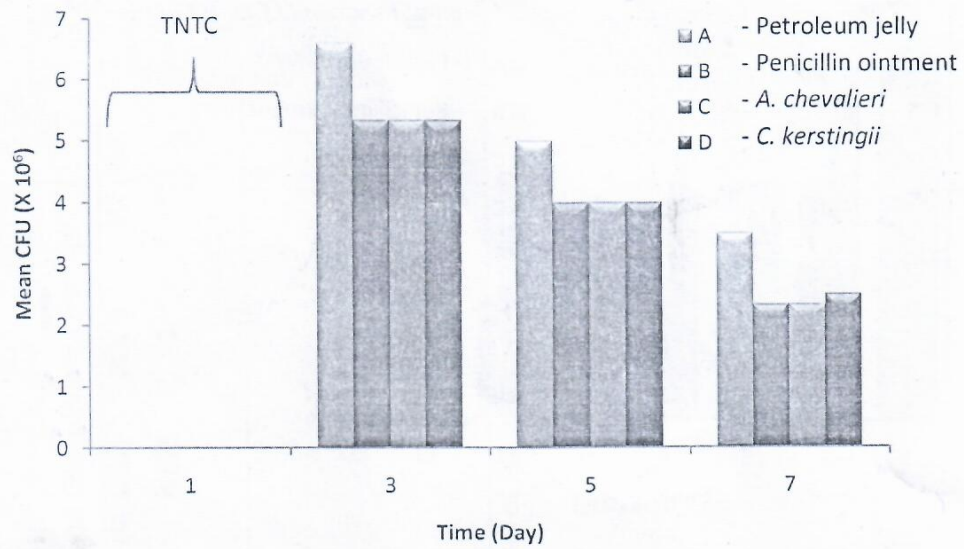
Legend:

A- Petroleum Jelly

B- Penicillin Ointment

C-*Albizia chevalieri* D-*Commiphora kerstingii*

^aThe initial wound circumference was 6 cm



Legend: TNTC- Too numerous to count bacterial load

Chart 3: Effect of the methanol extracts of *A. chevalieri* and *C. kerstingii* on bacterial colony count on surgically induced wound in rabbits