Antimicrobial activities of some selected medicinal plants used in the treatment of skin and wound Infection in Bauchi town

Abstract

Aims: This study aimed to capture the medicinal plants used locally to treat skin and wound infection, and to investigate the antimicrobial activity of ethanol, ethyl acetate, and aqueous extracts from four different plant species against bacterial and fungal pathogens causing skin and wound infections.

Study design:This was a cross-sectional analytical study conducted in Bauchi town from January to April 2024 at the Department of Medical Microbiology, Abubakar Tafawa Balewa University.

Methodology: A semi-structured questionnaire was used to gather information on the use of medicinal plants in treating skin and wound diseases. Twelve leaves extracts from *A indica, M.hirtus, C. procera,* and *C. africana* were screened for their antimicrobial activity against four bacterial and one fungal pathogen; *S. aureus, P. mirabilis, P. aeruginosa,k.pneumonia,*~~and~~ *E. coli* and *T. rubrum*using Agar Disc Diffusion Assay. Minimum Inhibitory Concentrations (MIC) were performed using micro broth dilution assay.

Results: A total of94 respondents used 28 medicinal plants for skin and wound disease management, including leaf paste, infusion, root powder, dried powdered leaves, and oral decoction.The most common plants used were *A. indica, M. hirtus, C. procera, and C. africana,* used to treat Eczema, ringworm, skin rashes, and burnt wounds. All of the plant extracts were effective in inhibiting bacterial and fungal growth at variable concentrations, with *M. hirtus* being the most effective. *M. hirtus* showed the greatest zone of inhibition (ZOI > 20 mm) against *S. aureus* and *T. rubrum*, followed by *C. procera*, which had moderate activity on the test isolates with a mean ZOI > 11 mm. *A. indica and C. africana* exhibited mild to poor action on the majority of the isolates. For each plant extract, the MIC values differed according to the bacterial species. *M. hirtus* had the lowest MIC against S. *aureus at* 0.325 mg/mL, as did *C. procera* against *K. pneumoniae*.

Conclusion: The study discovered that many medicinal plants had promising antibacterial activities against the tested isolates, but more research is required to identify and purify active components for safe use

Key words: Antimicrobial activity, skin, wounds, medicinal plant, Bauchi.

UNDER PEER REVIEW

Introduction

Plants that have therapeutic qualities or have positive pharmacological effects on the human or animal body are referred to as medicinal plants [55]. Medicinal herbs are utilized extensively in traditional societies worldwide and are gaining popularity as natural supplements or substitutes for modern chemicals. More over half of all pharmaceuticals used in clinical settings worldwide are made from natural products or their derivatives, with higher plants accounting for at least 25% of the total [62].Over the ages, medicinal plants have developed into vital components of African civilization, and they are now widely acknowledged as symbols of the continent's rich scientific and cultural legacy [17], and are believe to be the cornerstone of traditional African medicine and other treatments drawn from many global civilizations for a variety of ailments. Almost 80% of people on earth, primarily in developing countries like Africa, still only use traditional or herbal medicine to cure illnesses [39].

The skin plays a vital role in protecting the body from the external environment. Damage to skin integrity caused by incisions, burns, scalds, and human lesions (diabetic foot, venous ulcers, pressure sores, etc.) is considered a wound [59]. Wound healing is a complicated process, and the effective management of wounds is a major challenge [34]. Natural herbal remedies have now become fundamental for the management of skin disorders and the treatment of skin infections due to the side effects of modern medicine and lower price for herbal products[5],[9. The use of medicinal plants for treating various ailments has been a common practice for centuries. In the case of skin and wound infections, Medicinal plants may safely treat skin and wound infections and promote healing [42].

There is a renewed interest in the creation of plant-derived pharmaceuticals. These plant-derived compounds can be found in a variety of plant parts, including roots, leaves, shoots, and bark. Many plants are used as crude extracts, infusions, or plasters for treating common illnesses with little scientific evidence of benefit [57]. Nigeria has various medicinal herbs, and collaborative investigation has demonstrated their usefulness. Plants with antibacterial properties include guava (*Psidium guajava*), ginger (*Zingiber officinale*), neem (*A indica*), and moringa. Studies on Nigerian plants have revealed that they include alkaloids, polyphenols, terpenes, glycosides, and other compounds with potential therapeutic applications [60]. Herbal medications are used to cure diseases by all segments of the population in Bauchi State. Traditional practitioners sell the

herbs in open locations, stores, and at markets. Others drive around with the herbs in their trucks and advertise through loud speakers [1].

Despite the widespread acceptance of the use of plants for treatment by the people of Bauchi state, and the wide availability of medicinal plants, there is still a need to discover, document, and establish vast pharmacopeias to use as medicinal plant guidelines. It is also critical to comprehend local ethnobotanical knowledge and its possible impact on healthcare. The use of medicinal plants in Bauchi town is often based on traditional knowledge and experience, and has been passed down through generations. However, it is important to note that the effectiveness and safety of these remedies may vary, and some may interact with modern medications or have side effects. Therefore, for Safety and efficacy scientific investigation such as *in-vitro* tests can provide initial evidence for the safety and efficacy of plant extracts, informing decisions leading to the development of new antimicrobial agents. *In-vitro* testsmay also, provide a controlled environment, minimizing variables and allowing for accurate results

This study therefore, seeks to address the need for thorough recording of traditional medicinal plants in the treatment of skin and wound infection in the study area and to evaluate the *in-vitro*antimicrobial activity of the selected plants used traditionally.

UNDER PEER REVIEW

Materials and Methods

Study Area

The study was conducted in Bauchi town, the capital of Bauchi state. The state is one of Nigeria's northeastern states, spanning two distinct vegetation zones: Sudan savannah and Sahel savannah. Bauchi state covers 549,260 km² and accounts for 5.3% of Nigeria's total land mass. It is located between latitudes 9° 3' and 12° 3' north of the equator. Longitudinally, the state is located between 8° 50' and 11° east of the Greenwich Meridian [27]. Bauchi State's estimated population in 2015 was 6,275,523 based on the 2006 census, when the population was 4,653,066 and the growth rate was 3.6% [38].

Ethnobotanical Survey

An extensive survey was conducted between January and April of 2024, involving individuals possessing valuable knowledge of local plant uses, herb sellers and alternative medicine practitioners. The questionnaire covered essential demographic information; age, gender and place of residence,the local name of the plant used andrelated ailments,Assumed Pharmacological Importance=(Times New Roman 11???), and~~Method of~~administrationmode. Participants (personal comment=I wonder why don't you use the Fischer's formula to calculate the size of the surveyed participants?)included both male and female aged 18 to 65, with or without formal education.The plants were recognized using their native names and verified by a botanist using a guide by [20] for their botanical names.

UNDER PEER REVIEW

Plant collection and Identification

Fresh leaves offour plants that were frequently mentioned in the survey were collected after the interview from different parts of Bauchi town. The plants were*Azadirachta indica* (Neem), *Mitracarpus hirtus* (Tropical Girdle pod), *Calotropis procera* (Rooster tree)and *Commiphora africana* (African Myrrh). The plants were identified by a botanist in the department of Biological sciences, Abubakar Tafawa Balewa University. The voucher specimens (ATBU herbarium 2571, 2572, 2573 & 2574) were prepared anddeposited at the departmental herbarium.

Sample Preparation

Collected plant materials were air dried and= police????pulverized to a fine powder using an electric blender.Powder of selected plant (400 g) were macerated in 1.5 liter of ethanol, Ethyl acetate and distilled water, this was carried-out in a water bath at 40 °C for 4 h to allow liquid adsorption before transferring to an incubator shaker at 40°C for another 24 h. The extract was filtered through a nylon filter and subsequently centrifuged at 3500 rpm (KUBOTA 5100, Japan) for 5 min. The supernatant was filtered under vacuum through a filter paper (Whatman 125 mm GF/C, England). The concentrated extracts were transferred into glass Petri dishes and freeze dried for 3 days [22].

Bacterial Strains

Five Bacterial and one fungal isolates repeatedly isolated from patients presenting with skin and wound infection attending Bauchi State Specialist Hospital and Abubakar Tafawa balewa University Teaching Hospital were obtained and further confirmed via standard microbiological techniques. The confirmed organisms were *S.??? aureus, P. mirabilis, P. aeruginosa, k???. pneumoniea, E. coli, and Trichphytonrubrum.*It is preferable to write the scientific names in full but not using abbreviations (please, correct everywhere in the manuscript)

Sample preparation and Agar Disc Diffusion Assay

The microbial growth inhibition potential of the plant extracts was determined by using the agar disc diffusion method. Varying concentrations of the crude extracts (400mg/mL, 200mg/mL, 100mg/mL 50mg/mL,) were prepared by weighing 0.40g, 0.20g, 0.10g 0.05g,0.025 and 0.0125g respectively using an electric metler balance with model No. H30 and then each dissolved in 1mL of diluents called dimethyl sulphoxide (DMSO) under aseptic condition. The sterilized discs were then put into the bottles each containing discs so that each would absorb equal volume [16]. Cultures of different bacterial isolates were grown in nutrient media, SabouraudDextrose Agar (Oxoid) was employed in growing fungal isolates. All cultures were cultivated in a shaking incubator at 37°C for 24h overnight prior to use. Bacterial and fungal cultures were adjusted to 0.5 McFarland's standard 1.5×10^8 CFU/mL of each organism used in experiments, and were swabbed evenly onto plates containing Mueller Hinton agar and SaboroudDextrose Agar respectively. The filter paper discs impregnated with the above concentrations of extracts were placed on the surface of the inoculated plates with the aid of sterilized pair of forceps.An amount of 100 μL DMSO/discwasserved as negative control;ciprofloxacin (5µg) and clotrimazole (10μg) (Source: Oxoid) were placed at the center of the plates to serve as positive controls for bacteria and fungi respectively. A pre – diffusion time of 30 seconds was allowed for the extracts to

UNDER PEER REVIEW

diffuse from the discs into the agar medium before incubation. The plates were inverted and incubated at 37°C for 24 hours. The degree of sensitivity of the organisms to the extracts was determined by measuring diameter of visible zones of inhibition to the nearest millimeter with respect to each isolate and extract concentration [64].

Minimum Inhibitory Concentration (MIC) Assay

The stock concentration of extracts 10 mg/mL was added in to Mueller Hinton broth (MHB; Merck, Germany) and sabouraud for *T .rubrum* and serially diluted two fold in 96 well microtitre plate (Nunc; 300µL total volume per well)to a final volume of 100µL until 0.325mg/mL. Bacterial and fungal suspension (100µL) were adjusted to 0.5 McFarland standards, and added to test solutions or antibiotics controls to a final volume of 200µL well. The negative control comprises only Mueller Hinton broth (MHB; Merck, Germany) and test organism. All tests were performed in triplicate. The MIC was recorded as the lowest concentration that produced no visible growth after 24h incubation at 37ºC (NA; Merck, Germany) [40].

Data Analysis

Data analysis was done immediately after the completion of data collection. Data was entered manually from the questionnaires into an excel sheet.The Microsoft Excel=is not used for analysis, it is a big calculator software was used to ~~analyzethedatato~~generate frequencies, percentages and averages.

UNDER PEER REVIEW

Results

3.1 Ethnobotanical Survey

An ethnobotanical survey conducted in Bauchi town revealed a total of twenty-eight (28) plants species belonging sixteen (16) families used in the treatment of skin and wound infections. Respondents from various parts of the town disclosed the types of plants they utilizedon a particular skin or wound ailments. Participants surveyed included both Male 67 (71.2%) and female 27(28.1%) across the ages of 18 to over 50 years old. The vast majority of the surveyed participants fall under the category of herbalist; this is followed by alternative medicine practitioners and then others having varied occupations. The investigation was conducted throughout Bauchi town as such; the study interviewees were from almost all the districts visited (Table1). The study subjects disclosed that, the ways in which the mentioned plants are being used in treatment include; (Table 2). It was compiled from the survey conducted, that the most frequent plant used in the management of skin and wound infection were*Azadirachta indica, Mitracarpus hirtus, Calotropis procera* and *Commiphora africa,* and wereused to treat eczema, ringworm, skin rashes, burnt wounds etc.

UNDER PEER REVIEW

Table 1: Demographic information of the study participants (n=94)

Variables	Category	Number	Percentage (%)
Age (years)	18-30	17	18.0
	31-50	32	34.1
	50 and above	45	47.8
Gender	Male	67	71.2
	Female	27	28.7
Place of residence	Makama	22	23.4
	Majidadi	15	15.9
	Birshi/Miri	21	22.3
	Turwun	25	26.5
	Durum	7	7.4
	Zungur	4	4.2
Occupation	Alternative Medicine practitioners	15	15.9
	Herbalist	27	28.7
	Others	52	55.3

Table 2: Ethnobotanical survey of Medicinal plants

Botanical name	Local name	English name	Plant part	Pharmacolgical Importance	~~Method of~~Administration mode
Bombax brevicuspe	Kurya	Silk-cotton	Leaves	Bruises	Topically applied as Ointments
Zanthoxylum zanthoxyloides	Fasa-kwairi	Prickly ash	Bark and root	Cuts, Abrasions	Decoctions and ointments
Brachiaria distichophylla	Gariji	Brachiaria	Leaves	Wound	Leaves powder applied topically
Cassia occidentalis	Bauzanfari	Coffee senna	Seed/leaves	Ringworm	Infusions applied topically
Cymbopogan citrus	Kififi	Lemon grass	Leaves	Athletes foot, eczema, wound	Topically applied as Ointments
Parkia bigbolosa	Dorawa	Locust bean	Bark	Skin and wound	Powder applied topically
Entada africana	Tawatsa	Monkey ladder	Leaves	Wound	Powder Applied topically
Solanum rigrum	Gautar kaddi	African Nightshade	Fruit	Skin eruptions	Leaf paste applied topically
Curcuma longa	Kurkur	Tumeric	Root	Eczema	Root paste and powder
Azadirachta indica	Dogon yaro	Neem	Root, leaves, oil	Eczema, ringworm	Decoctions taken orally, leaf paste or oil is applied to infected area
Mitracarpus hirtus,	Gogamasu	Tropical girdle pod	Leaves	Ringworm, eczema	Leaves powder or paste is Applied topically.
Calotropis procera	Tunfafiya	Rooster tree	Leaves	Skin	Leaf paste applied topically
Commiphora Africana	Dashi	African myrrh	Leaves	Burnt wound	Leaves powder applied topically
Ageratum conyzoides	Gangarde	Billy goat weed	Whole plant	Wound	Applied topically
Tamarindus indica	Tsamiya	Tamarind	Leaves	Burnt wound	Burnt leaves powder applied to infected area.
Centauriea perrottetii	Tarzargade	Artemisia	Whole plant	Skin infection	Decoctions taken orally
Ziziphus spina-christi	Kurna	Christ´ thorn	Leaves	Skin	Ointments
Acacia nilotica	Bagaruwa	Acasia seed	Bark, branches and Pods	sores, rashes, boils, and scabies	Infusions applied topically, powder sprinkled in infected area
Psiduim guajava	Gwaiba	Guava	Leaves	Skin burns	Infusions taken orally, leaf paste applied topically
Prosopis Africana	Kirya	Iron wood tree	Leaves	Sores, bruises	Infusions applied topically
Terminalia avicennioides	Baushe	Black Afzelia	Leaves	Laceration Wound, sores	Powder applied topically
Aloe barbadensis miller	Alobera	Aleo vera	Gel	Burns, eczema	Gel applied topically
Vernonia amygdalina	Shuwaka	Bitter leaf	Leaves	Ringworm, eczema	Leaf paste applied topically
Bowellia dalzielii	Árárráɓíí	Bowellia	Bark	Sores, wounds and burns	Infusions taken orally, powder applied topically
Lawsonia inermis	Lalle	Henna	Leaves	Athletes foot and wound	Leaf paste applied topically
Zizipus abyssinica	Magarya	Large jujebe	Leaves/bark	Rashes	Powder applied topically
Cajanus cajans	Waken turawa	Pigeon pea	Leaves	Skin infections	Leaf paste
Combretum aculeatum	Farar geza	Red buswillow	Leaves	Skin infections	Decoctions taken orally

UNDER PEER REVIEW

Table 3.The list of plant family and number of the species

Family	Species	Percentages (%)
Asteraceae	*Ageratum conyzoides, Vernonia amygdalina, Centauriea perrottetii*	10.7
Bombacaceae	*Bombax brevicuspe*	3.5
Poaceae	*Brachiaria distichophylla,Cymbopogan citrus*	7.1
Solamaceae,	*Solanum rigrum*	3.5
Maliaceae	*Azadirachta indica*	3.3
Rutaceae	*Zanthoxylum zanthoxyloides*	3.5
Asphodalaceae	*Aloe barbadensis miller*	3.5
Myrtaceae	*Psiduim guajava*	3.5
Lythraceae	*Lawsonia inermis*	3.5
Rhamnaceae	*Ziziphus spina-christ, Zizipus abyssinica*	7.1
Combreteceae	*Combretum aculeatum, Terminalia avicennioides*	7.1
Burseraceae	*Commiphora Africana,Bowellia dalzielii*	7.1
Fabaceae	*Cajanus cajans, Prosopis Africana, Acacia nilotica Parkia biglobosa, Entada Africana, Termarindus indica, Cassia occidentalis*	25.0
Rubiaceae	*Mitracarpus hirtus,*	3.5
Apocynaceae	*Calotropis procera*	3.5
Zingiberaceae	*Curcuma longa*	3.5

UNDER PEER REVIEW

3.2 Antimicrobial activities andMinimum Inhibitory Concentration of the plants extracts

The study evaluated the antimicrobial activity of plants extracts against various bacterial and fungal pathogens. The greatest zone of inhibition (ZOI) was recorded from the ethanol extracts of *Mitracarpus hirtus* against *S. aureus* and *tricophyton rubrum* with ZOI >20mm.*Azadirachta indica* showed significant activity against *S. aureusand P.aeruginosa*with ZOI>16mm, while *Calotropis procera* show notable activity against *k. pneumoniea, S. aureus, p. mirabilis and P.aeruginosa*with ZOI>16mm. *Commiphora africana* showed moderate activity*S. aureus, P. mirabilis* with ZOI>16mm.The result of Minimum inhibitory concentration performed showed that the growths of the bacterial isolates were inhibited at concentration ranging from 0.326mg/ml to 5mg/ml.The aqueous extract of *Calotropis procera* had the lowest activity against S. aureus, with a MIC value of 0.325mg/mL, while the ethanol extract of *Mitracarpus hirtus* had the lowest activity, with a MIC value of 0.625mg/mL (Table 6).

Table 4: Antimicrobial Activity of the extracts of *Azadirachta indica* and*Calotropis procera*

S/N	Extracts	Organisms	Diameter of Zones of Inhibition for different extracts (mm)					
			Positive Control	200mg/ml	100mg/ml	50mg/ml	25mg/ml	DMSO
1.	*Azadirachta indica*							
		S. aureus	++++	++	++	++	+	-
	Ethanol extract	*P. mirabilis*	+++	-	-	-	-	-
		P. aeruginosa	++++	-	-	-	-	-
		k. pneumoniea	++++	-	-	-	-	-
		E. coli	++++	-	-	-	-	-
	Ethyl acetate extract	*S. aureus*	++++	+++	+++	++	++	-
		P. mirabilis	++++	+	-	-	-	-
		P. aeruginosa	+++	-	-	-	-	-
		k. pneumoniea	++++	++	+	-	-	-
		E. coli	++++	++	++	+	+	-
	Aqueous extract	*S. aureus*	++++	++	+	+	+	-
		P. mirabilis	++++	-	-	-	-	-
		P. aeruginosa	++++	+++	+	-	-	-
		k. pneumoniea	++++	+	+	+	-	-
		E. coli	++++	++	++	+	-	-
2.	*Calotropis procera*							
		S. aureus	++++	++	++	+	+	-
	Ethanol extract	*P. mirabilis*	++++	++	++	++	+	-
		P. aeruginosa	+++	++	++	++	+	
		k. pneumoniea	++++	++	++	+	+	-
		E. coli	++++	++	++	+	+	-
	Ethyl acetate extract	*S. aureus*	++++	+++	++	++	-	-
		P. mirabilis	++++	+++	++	++	+	-
		P. aeruginosa	++++	+++	+++	++	+	-
		k. pneumoniea	++++	+++	++	++	+	-
		E. coli	++++	++	++	+	+	-
	Aqueous extract	*S. aureus*	+++	++	+	+	-	-
		P. mirabilis	+++	++	+	+	+	-
		P. aeruginosa	++++	+++	+	+	-	-
		k. pneumoniea	++++	+++	++	++	-	-
		E. coli	+++	++	++	+	-	-

UNDER PEER REVIEW

Table 5:Antimicrobial Activity of the extracts of *Commiphora Africana* and *Mitracarpus hirtus*

S/N	Extracts	Organisms	Diameter of Zones of Inhibition for different extracts (mm)					
			Positive Control	400mg/ml	200mg/ml	100mg/ml	50mg/ml	DMSO
3.	*Commiphora Africana*							
	Ethanol extract	*S. aureus*	++++	++	+	+	-	-
		P. mirabilis	+++	-	-	-	-	-
		P. aeruginosa	+++	-	-	-	-	-
		E. coli	+++	-	-	-	-	-
		Trichophyton spp	++	+	+	-	-	-
	Ethyl Acetate extract	*S. aureus*	++++	+++	++	++	+	-
		P. mirabilis	++++	+++	++	++	-	-
		P. aeruginosa	+++	++	++	+	+	-
		E. coli	+++	+	+	-	-	-
		Trichophyton spp	++	++	++	+	+	
	Aqueous extract	*S. aureus*	++++	+	-	-	-	-
		P. mirabilis	++++	-	-	-	-	-
		P. aeruginosa	++	-	-	-	-	-
		E. coli	++++	++	++	-	-	-
		Trichophyton spp	++	-	-	-	-	-
2.	*Mitracarpus hirtus*							
	Ethanol extract	*S. aureus*	++++	++++	+++	++	++	-
		P. mirabilis	++++	+++	++	++	+	-
		P. aeruginosa	+++	+++	++	+	+	-
		E. coli	++++	+++	++	++	+	-
		Trichophyton spp	++	++++	++	++	+	-
B	Ethyl acetate extract	*S. aureus*	+++	++	+	-	-	-
		P. mirabilis	++++	++	+	+	-	-
		P. aeruginosa	+++	+	+	-	-	-
		E. coli	++++	+++	++	++	++	-
		Trichophyton spp	+++	+++	++	++	+	-
	Aqueous extract	*S. aureus*	++++	++	+	-	-	-
		P. mirabilis	++++	+	+	-	-	-
		P. aeruginosa	+++	+	-	-	-	-
		E. coli	+++	++	+	+	+	-
		Trichophyton spp	++	-	-	-	-	

UNDER PEER REVIEW

Keys:(-) inactive

(+) Inhibition diameter between 7–10mm

(++) Inhibition diameter between 11 – 15mm

(+++) Inhibition diameter between 16 – 20mm

(++++) Inhibition diameter higher than 20mm

Table 6Minimum Inhibitory Concentration

Organisms	*Azadirachta indica* mg/mL			*Mitracarpus hirtus* ~~MIC~~ mg/mL			*Calotropis procera* ~~MIC~~ mg/mL			*Commiphora africana*~~MIC~~ mg/mL		
	Ethanol	Ethyl acetate	Aqueous	Ethanol	Ethyl acetate	Aqueous	Ethanol	Ethyl acetate	Aqueous	Ethanol	Ethyl acetate	Aqueous
S. aureus	1.25	0.625	1.25	0.325	2.5	2.5	1.25	1.25	1.25	1.25	0.625	2.5
E. coli	2.5	2.5	5	1.25	0.625	1.25	1.25	0.625	1.25	2.5	2.5	1.25
P. mirabilis	5	5	2.5	1.25	1.25	2.5	0.625	0.625	0.625	2.5	1.25	5
P. aeruginosa	5	2.5	5	1.25	2.5	5	0.625	0.625	1.25	5	1.25	5
k. pneumoniea	5	2.5	5	-	-	-	1.25	0.625	0.325	-	-	-
Trichophyton spp	-	-	-	1.25	0.625	5	-	-	-	1.25	0.625	5

Discussion

UNDER PEER REVIEW

This study has strived to assess the knowledge and practice of indigenous people of Bauchi town on medicinal plants used traditionally to treat skin and wound infections. Bauchi town, located in Northeastern part of Nigeria, has a tropical savanna climate and a flat to gently sloping topography, which significantly influences the use of medicinal plants in treating skin and wound infections [61]. High temperatures and low humidity during the dry season (November to April) lead to dry skin conditions, increased risk of wound infections, and prolonged healing times[31].The wet season (May to October) brings heavy rainfall that can harbor bacteria virus and fungi, leading to skin infection or even exacerbate skin conditions such as leptospirosis which can cause skin lesions and rashes [8]. The ethnobotanical survey carried-out in Bauchi town (Table 2), disclosed that quiet a number of inhabitants utilized medicinal plants. In the survey, systematic random sampling was used in the selection of participants, and a total of ninety-four respondents interviewed all provided useful information on the medicinal plants utilized to treat skin and wound infection. The surveyed participants comprise of both male and female, however, male gender make up two-third f the respondents. This may not be unconnected with the fact that Male had more knowledge of using traditional medicines, and are found in the occupation of alternative medicines than females as reported by[21], [32] & [45].

The age group 50 and above constituted a greater percentage of the study subject. Knowledge on traditional medicines is passed down from generation to generationswith older people learning more from their parents and grandparents more than the younger individuals. Likewise, older people may feel a strong sense of responsibility to preserve cultural traditions and knowledge. This is in consistent with the findings of [28], [19] & [30] that reported older people possessing more knowledge on traditional medicines. However, is in contrast with the findings of [3],[12]& [4], who reported younger people aged 18-35 years use herbal medicines to treat and prevent skin illness more frequently than older groups. This study indicates that majority of the respondents are herbalist, followed by Alternative medicines practitioners and then peoples from other professions. Bauchi town is known for its rich cultural heritage and diverse population and this may constitute to the widespread use of medicinal plants across different demographics. Furthermore, some individuals may be unaware of modern treatment options or prefer traditional methods due to cultural beliefs. In addition, medicinal plants are often readily available and affordable, making them a more accessible option for people from different socioeconomic background.

In terms of the medicinal plants utilize to treat skin and wound infection, a total of twenty-eight (28) plants belonging to sixteen (16) families were mentioned.One-fourth of the depicted plants in this study belonged to the family Fabaceae. Fabaceae, also known as the legume family, plays a significant role in treating skin and wound infections. Several species within this family have been traditionally used in folk medicine for their antimicrobial, anti-inflammatory, and wound-healing properties [13]. Fabaceae species like *Acacia nilotica, Albizia lebbeck*, and *Dalbergia sissoo* have shown significant antibacterial activity against various bacterial strains, making them effective in treating bacterial skin infections [51]. Legumes like *Vicia faba, Pisum sativum*, and *Cicer arietinum* have been traditionally used to treat wounds, cuts, and abrasions. They promote collagen synthesis, improve tissue strength, and enhance the healing process [56].The leaves (67.8%) recorded the most typically used plant portion, followed by the bark (17.8%) and root (10.7).The most common way of using medicinal plants involves the use of leaf paste, whereby fresh leaves are harvested, rinsed with clean water, and then turned into paste with the aid of a mortar and pestle prior to application to the affected skin part. It also involves the preparation of infusions and decoctions by steeping herbs in cold water to make teas or boiling them to make concentrated liquid from the plants. These infusions and decoctions are applied topically or taken

orally. The use of root, bark, leaves, or whole powder and then sprinkled onto wounds are some of the cited ways medicinal plants treat skin and wound infections in Bauchi town.

In-vitro tests provide a preliminary screening of plant extracts for antimicrobial activity, helping to identify potential candidates for further research [58]. The results of the *in-vitro* antimicrobial activity of the plants extracts against bacterial and fungal pathogens; *S. aureus, P. mirabilis, P. aeruginosa, k. pneumoniea, E. coli, and Trichophytonspp????*, displayed varying effects of the extracts against the isolates (Table 3). *Azadirachta indica* showed significant activity on *S. aureus* with Zone of Inhibition (ZOI) > than 16mm, it produces moderate activity on *P. aeruginosa and k. pneumoniea* and *E. coli* with ZOI extending slightly above 10mm and displayed least activity on *P. mirabilis* with the only one recorded ZOI of >10mm. *Calotropisprocera* showed notable activity against the tested isolates with ZOI ranging from 11 – 20mm at various concentrations. In addition to this, aqueous extract of *Calotropisprocera*produces highest activity on *k. pneumoniea* with ZOI >20mm. *Commiphora Africana* displayed moderate activity on the test isolates, highest ZOI of >16mm was recorded on *S. aureus* and *P. mirabilis.*The ethanol extract of *Mitracarpus hirtus* exhibited the highest activity against *S. aureus and Trichophyton rubrum*, with ZOI value >20mm at 400mg/mL. Moreover, the plants exhibited moderate activity on the other isolates with ZOI >11mm.

The MIC assay was used to determine the efficiency of the extracts in inhibiting the growth of the tested bacteria. Plant extracts with great activity against a certain organism usually produce low MIC value, whereas extracts with low activity yield high MIC value [33].The Ethyl acetate extract of *Azadirachta indica* recorded the lowest activity against *S. aureus* with MIC value of 0.625mg/mL, while the ethanol extract of *Mitracarpus hirtus* showed the lowest activity against S. aureus, with an MIC value 0.325mg/mL. The Aqueous extract of *Calotropis procera* showed notable activity against *k. pneumoniea*, with an MIC value of 0.325mg/mL. The ethyl acetate extract of *Commiphora africana* displayed significant activity against *S. aureus and* an MIC value of 0.625mg/mL. Against fungal isolates, the Ethyl acetate extract of *Mitracarpus hirtus* and *Commiphora africana* showed significant activity against *T. rubrum*, with an MIC value of 0.625mg/mL, more so, the ethanol extracts of showed notable against the fungal isolates with MIC value of 1.25mg/mL.

Our findings are in agreements with other studies conducted globally on the above chosen medicinal plants for their*in-vitro* antimicrobial activities.*Azadirachta indica* showed moderate

UNDER PEER REVIEW

activity on *S. aureus* and *P. aeruginosa* (12mm) at the same concentration of 400mg/mL [2].The aqueous extract of *Mitracarpus*specie showed a minimum inhibitory concentration (MIC) of 0.01 mg/mL against *S. aureus* and *E.coli*[47]. Amini et al. [7] reported *S. aureus* and *T. rubrum* to be susceptible to the extracts of *C???. procera* with ZOI of 16 – 18mm, and 19.60±0.2mm ZOI was recorded against *P. aeruginosa* as documented by [23].*In-vitro* antimicrobial activity of *C. Africana* has been reported by Omer et al. [37] and Idris et al. [24] and has shown notable activity against*S. aureus, P. aeruginosa* and *T. rubrum* with ZOI >20mm.

The presence of numerous bioactive chemical components in the extracts may explain the active plants' antibacterial properties. According to Savoia[48], plant extracts may contain Efflux Pump inhibitors in their composition. According to Shankar et al. [52], suppressing normal cell communication through quorum sensing (QS) is a promising way of action for plant-based bioactive compounds against MDR=what does it mean??? infections.Studies have reported the antimicrobial effects of the above investigated medicinal plants; *M. hirtus* extracts have shown significant antibacterial and antifungal activity against various microorganisms, including *S. aureus, E. coli, and C.??? albicans*, which are common causes of skin and wound infections [18]. The plant's extracts have been reported to enhance wound contraction, increase collagen synthesis, and promote tissue regeneration, leading to faster wound closure and improved skin integrity [25].*C. procera* contains compounds like calotropin, calactin, and uscharin, which have been shown to exhibit antibacterial, antifungal, and antiviral activities against various microorganisms, making it effective against skin and wound infections [44]. *C. africana* contains compounds like furanoeudesma-1,3-diene, which have been shown to exhibit antibacterial and antifungal activities against various microorganisms, making it effective against skin and wound infections [14]. Active compounds from *A. indica* such as nimbidin and nimbin helped to inhibit the growth of bacteria like *S. aureus and S. pyogenes,* as well as fungi like *C. albicans*[46],and has long been known to have therapeutic effects [9].

Understanding the role of these microorganisms in skin and wound infections is crucial for proper diagnosis, treatment, and prevention [49]. The microorganism investigated in this research has been identified as some of the troublesome agents of skin and wound infection. For instances, *T. rubrum* is a fungus that causes superficial skin infections, particularly: athlete's foot (*Tinea pedis*), jock itch (*Tinea cruris*), ringworm (*Tinea corporis*), infects the keratinized layers of the skin, nails, and hair leading to inflammation, itching, and scaling [10]. *S. aureus* is a

UNDER PEER REVIEW

common cause of skin and wound infections, including abscesses, cellulitis, and impetigo can produce toxins that damage skin tissue and impede wound healing [15]. *E. coli* is typically found in the gastrointestinal tract, but can cause skin and wound infections, especially in people with compromised immune systems can lead to cellulitis, abscesses, and wound necrosis [36]. *P. aeruginosa* is frequently found in chronic wounds, such as diabetic foot ulcers and burn wounds produces biofilms that make it resistant to antibiotics and impede wound healing [43]. In addition, *Proteus mirabilis* is a gram-negative bacterium commonly found in the gastrointestinal tract but can cause a range of infections, including Urinary tract infections (UTIs), Wound, Burn and Surgical site infections [35]. These microorganisms can cause skin and wound infections through various mechanisms, including: direct invasion of skin tissue [49], Production of toxins and enzymes that damage skin and impede wound healing [26], biofilm formation, which protects them from antibiotics [63], and the host's immune system and colonization of wounds, leading to chronic infection and delayed healing [65].

Conclusion

The study showed the utilization of medicinal plants in the management of skin and wound infection in Bauchi town. This mayaffirms, using scientific fundamental experiments(personal comment =because we can't extrapolate *in-vitro* test results to *in-vivo* application/realities),the use of medicinal plants in treating various illnesses which is a deeply rooted cultural practice that dates back centuries in the study area. Preliminary *in-vitro* antimicrobial activity demonstrates the potential of *A. indica*, *M.hirtus,C. procera* and *C. africana* as a natural antimicrobial agent, which could be used to develop new treatments for various infections and diseases. While Ethnobtanicalsurvey had revealed so many medicinal plants to have been traditionally used to treat skin and wound infections, the effectiveness and safety should be further evaluated through scientific studies to ensure efficacy and safety for modern medical use.

Ethical considerationpolice ???

Approval to conduct this study was granted by Bauchi state Ministry of Health. The Ethical clearance has a health research ethical review committee approval number NERC/040/11/19B/2021/0105. Prior participation, all participants were informed about the aims and objectives of the study, their freedom of participation, and the anonymity of their participation. Only those individuals that gave informed consent to partake in the study were recruited. The data obtained was handled with the utmost confidentiality.

UNDER PEER REVIEW

References

[1] Adamu HM, Abayeh OJ, Agho MO, Abdullahi AL, Uba A, Dukku HU, Wufem BM. An ethnobotanical survey of Bauchi State herbal plants and their antimicrobial activity. J Ethnopharmacoal2005 May 13;99(1):1-4.

[2] Adamu MB, Moshood AY, Adamu SU, Uba A. In vitro Antibacterial Activity of crude extracts of leaf, bark and root of Azadirachta indica on some selected medically important Bacteria. Greener J Biol Sci. (2020). 10(1): 8-15.

[3] Abbasi AM, Khan MA, Ahmad M, Zafar M, Jahan S, Sultana S. Ethnopharmacological application of medicinal plants to cure skin diseases and in folk cosmetics among the tribal communities of North-West Frontier Province, Pakistan. J Ethnopharmacoal, 2010 Mar 24;128(2):322-35..

[4] Agize M, Asfaw Z, Nemomissa S, Gebre T. Ethnobotany of traditional medicinal plants and associated indigenous knowledge in Dawuro Zone of Southwestern Ethiopia. J. Ethnobiol. Ethnomed. 2022 Jun 21;18(1):48..

[5] Alamgeer, Sharif A, Asif H, Younis W, Riaz H, Bukhari IA, Assiri AM. Indigenous medicinal plants of Pakistan used to treat skin diseases: a review. Chinese medicine. 2018 Dec;13:1-26.

[6] Al-Kahfaji MH. Human Skin Infection: A Review Study. **Biomed. chem. Sci.police ???**2022 Oct 1;1(4):254-8.

[7] Amini MH, Ashraf K, Salim F, Lim SM, Ramasamy K, Manshoor N, Sultan S, Ahmad W. Important insights from the antimicrobial activity of Calotropis procera. Arab J Chem. 2021 Jul 1;14(7):103181..

[8] Andersen LK. The impact of climate change on skin and skin-related disease. Environment and skin. 2018:17-26.

[9]Bappah AM, Qossim M, Dambam ZN, Usman AS, Awalu U. Antibacterial Activity of Alkaloid, Flavonoids and Lipids from Crude Extracts of Azadirachta indica on Some Selected Medically Important Bacteria. J Biochem, Microbiol and Biotechnol. 2022 Dec 31;10(2):20-4.

[10] Bilovol A, Tkachenko S, Berehova A, Havryliuk O, Manhusheva V. Dermatology. Venereology. Part 3.

[11] Burkhill HM. The useful plants of west tropical Africa, vol. 1. Families AD. Royal Botanical Gardens. Kew, England. 1985:266-7.

[12] Chukwuma EC, Soladoye MO, Feyisola RT. Traditional medicine and the future of medicinal Plants in Nigeria. J Med Plants Stud. 2015;3(4):23-9.

[13] Das S, Sharangi AB, Egbuna C, Jeevanandam J, Ezzat SM, Adetunji CO, Tijjani H, Olisah MC, Patrick-Iwuanyanwu KC, Adetunji JB, Ifemeje JC. Health benefits of isoflavones found

exclusively of plants of the fabaceae family. Functional Foods and Nutraceuticals: Bioactive Components, Formulations and Innovations. 2020:473-508..

[14] Dekebo A, Juniedi S, Hu X, Jung C. Ethnobotany, chemistry, and biological activities of some Commiphora species resins. InGums, Resins and Latexes of Plant Origin: Chemistry, Biological Activities and Uses 2021 Nov 21 (pp. 1-27). Cham: Springer International Publishing..

[15] Del Giudice P. Skin infections caused by Staphylococcus aureus. Acta dermato-venereologica. 2020;100(9).

[16] Dhale DA, Markandeya SK. Antimicrobial and phytochemical screening of Plumbago zeylanica Linn.(Plumbaginaceae) leaf. J Exp Sci. 2011 Feb 26;2(3):04-6.

[17] Dzoyem JP, Tshikalange E, Kuete V. Medicinal plants market and industry in Africa. In J Med. Plants. Res. 2013 Jan 1 (pp. 859-890). Elsevier.

[18] Ekalu A. Medicinal uses, phytochemistry, and pharmacological activities of Mitracarpus species (Rubiaceae): A review. Scientific African. 2021 Mar 1;11:e00692.

[19] Giday M, Asfaw Z, Woldu Z. Ethnomedicinal study of plants used by Sheko ethnic group of Ethiopia. J Ethnopharmacoal2010 Oct 28;132(1):75-85.

[20] Gbile ZO. Vernacular names of Nigerian plants (Hausa).

[21] Horowitz S. American Indian health: Integrating traditional native healing practices and western medicine. Altern Complement Med. **police ???** 2012 Feb 1;18(1):24-30.

[22] Ho SH, Huang SW, Chen CY, Hasunuma T, Kondo A, Chang JS. Bioethanol production using carbohydrate-rich microalgae biomass as feedstock. Bioresource technology. 2013 May 1;135:191-8.

[23] Ibrahim D. *Antibacterial activities and phytochemical analysis of selected medicinal plants on selected pathogenic bacteria from patients attending general hospital Minna, Nigeria* (Doctoral dissertation) (2021).

[24] Idris MM, Usman SJ. Antimicrobial activity of leaf extracts of Commiphora africana. Bayero Journal of Pure and Applied Sciences. 2018;11(1):191-4.

[25] Inalegwu B, Jato JA, Ovye A, John A. Comparative wound healing potential of Mitracarpus hirtus ointment and honey in diabetic albino rats by collagen assessment. Asian J Nat Prod Biochem. 2021 Jun 14;19(2).

[26] Jones SG, Edwards R, Thomas DW. Inflammation and wound healing: the role of bacteria in the immuno-regulation of wound healing. Int. J Low. Extrem. Wounds. 2004 Dec;3(4):201-8.

[27] Kafi KM, Shafri HZ, Shariff AB. An analysis of LULC change detection using remotely sensed data; A Case study of Bauchi City. InIOP conference series: Earth environ. Sci. 2014 Jun 23 (Vol. 20, No. 1, p. 012056). IOP Publishing..

[28] Awas T. Plant diversity in Western Ethiopia: ecology, ethnobotany and conservation. 2007.

[29] Kutama AS, Dangora II, Aisha W, Auyo MI, Sharif U, Umma M, Hassan KY. An overview of plant resources and their economic uses in Nigeria. Glob. Adv. Res. J Agric. Sci. 2015;4(2):042-67.

[30] Li S, Odedina S, Agwai I, Ojengbede O, Huo D, Olopade OI. Traditional medicine usage among adult women in Ibadan, Nigeria: a cross-sectional study. BMC complement. Med. Ther. 2020 Dec;20:1-7.

[31] Mitchell A, Hill B. Moisture-associated skin damage: an overview of its diagnosis and management. Br. J Community Nurs. 2020 Mar 1;25(3):S12-8.

[32] Mohammed AY, Kasso M, Demeke A. Knowledge, attitude and practice of community on traditional medicine in Jara Town, Bale Zone South East Ethiopia. Sci J Public Health. 2016;4(3):241.

[33] Mummed B, Abraha A, Feyera T, Nigusse A, Assefa S. In vitro antibacterial activity of selected medicinal plants in the traditional treatment of skin and wound infections in eastern Ethiopia. BioMed Res. Int. 2018;2018(1):1862401.

[34] Monika P, Chandraprabha MN, Rangarajan A, Waiker PV, Chidambara Murthy KN. Challenges in healing wound: role of complementary and alternative medicine. Front. Nutr. 2022 Jan 20;8:791899.

[35] Nayak N, Lenka RK, Padhy RN. Surveillance of multidrug resistant suppurative infection causing bacteria in hospitalized patients in an Indian tertiary care hospital. J Acute Dis. 2014 Jan 1;3(2):148-56.

[36] Nead JA. Bacterial Infections of the Skin and Skin Structures. Introduction to Clinical Infectious Diseases: A Problem-Based Approach. 2019:3-15.

[37] Omer S, Adam S, Mohammed O. Antimicrobial activity of commiphora myrrha against some bacteria and candida albicans Isolated from Gazelles at King. Res. J Med. Plant. 2011;5(1):65-71.

[38] Ori PU, Adebowale A, Umeokonkwo CD, Osigwe U, Balogun MS. Descriptive epidemiology of measles cases in Bauchi State, 2013–2018. BMC Public Health. 2021 Dec;21:1-1.

[39] Okoye TC, Uzor PF, Onyeto CA, Okereke EK. Safe African medicinal plants for clinical studies. InToxicological survey of African medicinal plants 2014 Jan 1 (pp. 535-555). Elsevier.

[40] Oyedemi BO, Oyedemi SO, Chibuzor JV, Ijeh II, Coopoosamy RM, Aiyegoro AO. Pharmacological Evaluation of Selected Medicinal Plants Used in the Management of Oral and Skin Infections in Ebem□Ohafia District, Abia State, Nigeria. Sci. World J. 2018;2018(1):4757458.

[41] Oladosu IA, Balogun SO, Zhi-Qiang LI. Chemical constituents of Allophylus africanus. Chin. J Nat. Med. 2015 Feb 1;13(2):133-41.

[42] Pereira RF, Bartolo PJ. Traditional therapies for skin wound healing. Adv. wound care. 2016 May 1;5(5):208-29.

[43] Rahim K, Saleha S, Basit A, Zhu X, Ahmed I, Huo L, Zhang P, Usman B, Munir S, Franco OL. Pseudomonas aeruginosa as a powerful biofilm producer and positive action of amikacin against isolates from chronic wounds. Jundishapur J Microbiol. 2017 Oct 31;10(10).

[44] Rabelo AC, Noratto G, Borghesi J, Souza Fonseca A, Cantanhede Filho AJ, Costa Carneiro FJ, Abreu-Silva AL, Miglino MA. Calotropis procera (Aiton) Dryand (Apocynaceae): State of the art of its uses and Applications. Curr. Top. Med. Chem. 2023 Sep 1;23(23):2197-213..

[45] Roulette CJ, Njau EF, Quinlan MB, Quinlan RJ, Call DR. Medicinal foods and beverages among Maasai agro-pastoralists in northern Tanzania. J Ethnopharmacoal2018 Apr 24;216:191-202..

[46] Roulette CJ, Njau EF, Quinlan MB, Quinlan RJ, Call DR. Medicinal foods and beverages among Maasai agro-pastoralists in northern Tanzania. J Ethnopharmacoal2018 Apr 24;216:191-202.

[47Samson SO, Edegbo E, Omatola CA. In-vitro assessment of antibacterial activity of crude methanolic and aqueous extracts of Mitracarpus villosus. Afr. J. Microbiol. Res. 2021 Jan 31;15(1):62-8.

[48] Savoia, D. Plant-Derived Antimicrobial Compounds: Alternatives to Antibiotics. *Future Microbiol.* **2012**, *7*, 979–99

[49] Scalise A, Bianchi A, Tartaglione C, Bolletta E, Pierangeli M, Torresetti M, Marazzi M, Di Benedetto GI. Microenvironment and microbiology of skin wounds: the role of bacterial biofilms and related factors. InSeminars in vascular surgery 2015 Sep 1 (Vol. 28, No. 3-4, pp. 151-159). WB Saunders..

[50] Sen T, Samanta SK. Medicinal plants, human health and biodiversity: a broad review. Adv Biochem Eng Biotechnol. 2015;147:59-110. doi: 10.1007/10_2014_273. PMID: 25001990.

[51] Shah SA, Iqbal W, Sheraz M, Javed B, Zehra SS, Abbas HA, Hussain W, Sarwer A, Mashwani ZU. Ethnopharmacological study of medicinal plants in Bajwat wildlife sanctuary, district Sialkot, Punjab Province of Pakistan. Evid□Based Complement Altern. Med. 2021;2021(1):5547987.

[52] Shankar, S.R.; Rangarajan, R.; Sarada, D.V.L.; Kumar, C.S. Evaluation of Antibacterial Activity and Phytochemical Screening of *Wrightia Tinctoria* L. *Pharmacogn. J.* **2010why bold???**, *2*, 19–22.

[53] Suleiman MS, Wasonga VO, Mbau JS, Suleiman A, Elhadi YA. Non-timber forest products and their contribution to households income around Falgore Game Reserve in Kano, Nigeria. Ecological Processes. 2017 Dec;6:1-4.

[54] Song Y, Li R. Superficial fungal infections. InMolecular Medical Microbiology 2024 Jan 1 (pp. 2895-2904). Academic Press.

[55] Süntar I. Importance of ethnopharmacological studies in drug discovery: role of medicinal plants. Phytochemistry Reviews. 2020 Oct;19(5):1199-209.

[56] Tabasum H, Ahmad T. Principles and Short Practice of Cosmetic Care in Unani Medicine. Educreation Publishing; 2018 May 20.

[57Tekwu EM, Pieme AC, Beng VP. Investigations of antimicrobial activity of some Cameroonian medicinal plant extracts against bacteria and yeast with gastrointestinal relevance. J Ethnopharmacoal2012 Jun 26;142(1):265-73.

[58] Vaou N, Stavropoulou E, Voidarou C, Tsigalou C, Bezirtzoglou E. Towards advances in medicinal plant antimicrobial activity: A review study on challenges and future perspectives. Microorganisms. 2021 Sep 27;9(10):2041..

[59] Vitale S, Colanero S, Placidi M, Di Emidio G, Tatone C, Amicarelli F, D'Alessandro AM. Phytochemistry and Biological Activity of Medicinal Plants in Wound Healing: An Overview of Current Research. Molecules. 2022 Jun 1;27(11):3566.

[60] Ugboko HU, Nwinyi OC, Oranusi SU, Fatoki TH, Omonhinmin CA. Antimicrobial importance of medicinal plants in Nigeria. The Sci. World J. 2020;2020(1):7059323.

[61] Udo RK. Geographical regions of Nigeria. Univ of California Press; 2023 Nov 15.

[62] Van Wyk BE, Wink M. Medicinal plants of the world. Cabi; 2018 Oct 31.

[63] Versey Z, da Cruz Nizer WS, Russell E, Zigic S, DeZeeuw KG, Marek JE, Overhage J, Cassol E. Biofilm-innate immune interface: contribution to chronic wound formation. Front. Immunol. 2021 Apr 9;12:648554.

[64] Yagnik D, Serafin V, J. Shah A. Antimicrobial activity of apple cider vinegar against Escherichia coli, Staphylococcus aureus and Candida albicans; downregulating cytokine and microbial protein expression. Scientific reports. 2018 Jan 29;8(1):1732.

[65] Mihai MM, Preda M, Lungu I, Gestal MC, Popa MI, Holban AM. Nanocoatings for chronic wound repair—modulation of microbial colonization and biofilm formation. Int. J Mol. Sci. 2018 Apr 12;19(4):1179.

UNDER PEER REVIEW