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ANTIBACTERIAL POTENTIALS OF PLANTS USED IN TRADITIONAL MEDICINE OF RWANDA

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Abstract

In Rwanda, a variety of medicinal plants are being given to patients to treat various bacterial diseases. However, the phytochemistry of these plants is still a big challenge. A total of twenty medicinal plants of Rwanda were investigated for their phytochemical content and antibacterial potentials. The medicinal plant samples were collected, analyzed for phytocompounds' presence, and their antibacterial activities were checked. The plant parts utilized were stems, fruits, and/or leaves, while the solvents utilized were methanol, petroleum, water, and/or hexane. The phytochemicals noticed in Dombeya torrida, Solanum terminale, Rubia cordifolia, Rosmarinus officinalis, Carduus nyassanus, Hypericum revolutum, Senna acutifolia, Acacia sieberiana, Lagenaria sphaerica, Carica papaya, Gynandropsis gynandra, and Artemisia annua were mostly saponins, tannins, phenols, glycosides, resins, and/or alkaloids. However, no phytosubstances were seen in Solanum nigrum L., Zea mays, Persea americana, Clerodendrum sp., Hypoestes triflora, and Acanthus polystachyus. The pathogenic bacteria inhibited by plant parts' extracts were Salmonella typhi B69, S. typhi B71, Staphylococcus aureus ATCC 29213, S. aureus ATCC 43300, Klebsiella oxytoca ATCC 700524, Streptococcus pneumonia ATCC 49619, S. pneumonia ATCC 49313, Streptococcus pyogene ATCC 12344, Shigella Sonei ATCC 25931, Haemophilus influenza ATCC 9007, Escherichia coli ATCC 35218, E. coli ATCC 25922, and Pseudomonas aeruginosa ATCC 27853. These remarkable antibacterial activities can be ascribed to the presence of various phytocompounds. The investigated plants also possessed the curating action of various diseases, in addition to acting as antibacterial agents. Toxicity and in vivo investigations should be carried out before checking the possibility of developing the drugs from the studied plants with high antimicrobial potentials.

Keywords: medicinal plants, antibacterial potentials, extraction solvent, Rwanda, phytochemicals

1. Introduction

The development of plant pharmacopeia in Rwanda dates from the 1980s, with research initiated and conducted by the then-named Rwanda Institute of Sciences and Technology (IRST) through its research center on pharmacology and traditional medicine, Centre Universitaire de Recherche sur la Pharmacopée et la Médecine Traditionelle (CURPHAMETRA), which at that time produced eucalyptus-honey cough syrup and other medicines that were even prescribed by conventional clinics. This initiative was supported by the cottage steam distillation units operated by well-trained community groups in the Southern Province. Following the environmental degradation that Rwanda experienced in the 1990s, some species may have been severely reduced or even exterminated. Rwanda needs to undertake an exhaustive census of plant species to inform conservation efforts [1, 2].
In Rwanda, the utilization of medicinal plants dates from centuries back. However, the knowledge remained oral and was maintained by practitioners who passed it to their descendants. Nowadays, this transfer of indigenous knowledge is threatened by urban migration, in which rural youth represent the majority. Committed to the protection of their knowledge (the main source of their livelihood), aging practitioners are dying without leaving a cultural legacy. These practitioners' right to benefit from the development of medicines from their traditional pharmacopeia may be a key consideration for the study of medicinal plants in Rwanda [1].

To promote access to health services for all, the Government of Rwanda put in place the community health insurance scheme which allows low-income families to get access to medical care through community health social workers, who after preliminary screening may refer them to assigned health centers. Though supported by a large force of community health workers, the patient-to-doctor/ nurse ratio remains very high. Health centers and health posts are overwhelmed by the many patients. This situation is believed to motivate many community members to seek services from traditional healers, especially for those illnesses that are known to be curable using local medicinal plants. Wealthier patients seek services provided by private clinics, but low-income households cannot afford such clinics' consultation fees or prescriptions, and turn instead to indigenous plants known for their medicinal properties. Few investigation studies have screened Rwandan plants for phytochemicals and checked their antibacterial activities [1-7]. The objective of the present research was therefore to screen twenty medicinal plants widely used by traditional healers in Rwanda for their antibacterial potentials.

2. Materials and methods

2.1 Reagents and bacterial species

Organic solvents, viz methanol, hexane, petroleum ether, and various culture media such as nutrient agar, Mueller Hinton agar, and blood agar, were bought from HiMedia, India. The pathogenic bacteria considered were E. coli ATCC 25922, S. typhi B69, E. coli ATCC 35218, S. typhi B71, H. influenza ATCC 9007, S. aureus ATCC 29213, S. Sonei ATCC 25931, S. aureus ATCC 43300, S. pyogene ATCC 12344, K. oxytoca ATCC 700524, S. pneumonia ATCC 49313, S. pneumonia ATCC 49619, and P. aeruginosa ATCC 27853. All the bacteria were available in the Microbiology lab of INES Ruhengeri.

2.2. Plant samples' collection and plant part extracts' preparation

All plant parts/plants were collected in different areas of Rwanda and the collection team included two taxonomists for plants' identification. The plant materials utilized were stems, fruits, and leaves. After harvest, the fresh plant materials were brought directly to the chemistry laboratory. The phytopowder preparation included washing with tap water followed by distilled water, drying at room temperature for 3 weeks, and grinding into a fine powder utilizing a mill machine (DE-200 g Electronica powder grinder). The sterile airtight containers were utilized to store the resulting powders until further use. For phytosubstances' extraction, the powdered sample was subjected to double extraction with different solvents in the 1:10 ratio. The mixture was continuously agitated at 60 rpm for 5 days (Orbital shaker / OS-340C). The suspension, resulting from plant parts' maceration, was filtered, and the hydro-distillation procedure was followed to get the crude plant/plant part extract. The utilized solvents were evaporated with a rotary vacuum evaporator (R-11) at 120 rpm and 45 °C for water bath. The sterilized labeled tubes were utilized to stock the resulting extracts at 4 °C, for antimicrobial investigations [5].

2.3 Identification of various active phytocompounds

Flavonoids, resins, saponins, tannins, glycosides, phenols, and alkaloids were detected utilizing the procedure proposed by Harborne [8], Raaman [9], and Chuku et al. [10].

2.4 Bacterial inoculum preparation and antibacterial potentials of medicinal plant extracts of Rwanda

The pathogenic bacteria were sub-cultured on their selective media before the antibacterial studies [2]. Then, they were made in each underside labeled Petri plate. They were filled with diluted extracts and these experiments were conducted in triplicate. The solvent was also utilized in the same condition and was considered as a negative control. An overnight incubation at 37 °C was considered for all the Petri plates. After the incubation time, the zones of inhibition in millimeters were recorded. The antibacterial experiments were interpreted according to the Kirby-Bauer technique [11]. All the antibacterial experiments were done in triplicate.

3. Results and discussion

3.1 Identification of various active phytocompounds from Rwandese medicinal plant parts

To extract phytosubstances of interest, it is very crucial to choose a mixture of solvents to be utilized [7]. In the present investigation, both polar and non-polar solvents were considered to maximally extract phytocompounds. Indeed, methanol and water were utilized as polar solvents, whereas hexane and petroleum ether were utilized as non-polar solvents. Similarly, methanol, water, petroleum ether, and/or hexane were also utilized to extract phytosubstances from fruits, leaves, and stems of the Rwandese plants [2-7]. Thus, a mixture of non-polar and polar solvents is advised to optimally extract phytochemicals [12, 13].

New drugs are being manufactured from medicinal plants worldwide owing to their less toxicity and side effects [1, 14]. Qualitative screening showed a wide range of phytochemical compounds in extracts of plant parts (Table 1). Indeed, alkaloids and resins were seen in Aloe vera. Likewise, various phytosubstances such as phenolic compounds, flavonoids, and

alkaloids were noticed with ethanol as an extraction solvent [15]. Artemisia annua was found to contain tannins, phenols, glycosides, and resins in both stem and leaves. However, alkaloids were present in the stem only. Mohammed et al. [16] reported various phytocompounds like phenolics, flavonoids, and artemisinin when n-hexane was utilized in the extraction process. Resins, tannins, alkaloids, and phenolic substances were present in both the stem and leaves of Gynandropsis gynandra, with saponins in the leaves only. In contrast, cyanogenetic glycosides, reducing sugars, and steroids were present in the methanolic and hexane extracts of the stem and leaves of G. gynandra [17]. However, alkaloids were also present in this investigation.

Fruits and leaves of Lagenaria sphaerica were analyzed, and resins, tannins, saponins, and phenolic substances were noticed in both fruits and leaves. However, alkaloids were seen in the extract from fruits. Prajapati et al. [18] reported saponins, sterols, flavonoids, and terpenoids. Tannins, phenols, alkaloids, resins, and saponins were observed in the extract of Carica papaya. Similarly, these phytocompounds were observed in Tragia brevipes by Migabo et al. [2]. Dwivedi et al. [19] reported saponins, flavonoids, tannins, and alkaloids, but in C. papaya flowers. The phytochemical contents of the leaves of Zahneria scabra had tannins and saponins only. Similar phytocompounds were also reported by Tadesse et al. [20] in the methanolic extract. The absence of steroids and alkaloids was noticed in these two investigations. Methanol extract from the leaves of Acacia sieberiana harbored tannins, resins, alkaloids, and saponins. In contrast, various phenolic compounds such as Gallic acid, Syringic acid, and Rutin were observed by Alain et al. [21].

The extract of Senna acutifolia leaves had tannins, phenols, glycosides, flavonoids, and resins. Likewise, the extracts of Mystroxylon aethiopicum and Psidium guajava were found to have similar phytosubstances [7]. Alshehri et al. [22] also extracted alkaloids, flavonoids, saponins, terpenoids, and tannins from the same Senna plant. For the methanol extract of Hypericum revolutum, saponins, tannins, and resins were seen in both leaves and stems, whereas phenols and alkaloids were present in leaves only. In contrast for Ocimum suave, saponins were present only in the stem, but tannins, phenol substances, flavonoids, alkaloids, and steroids were available in both leaves and stems [4]. The phenolic and flavonoid compounds were also reported by Sengera et al. [23]. Saponins, tannins, glycosides, phenols, and resins were noticed in the Carduus nyassanus. Simugomwa et al. [7] reported the same phytocompounds from Mystroxylon aethiopicum and Psidium guajava leaf extracts.

Stem and leaves of Rosmarinus officinalis contained tannins, phenols, glycosides, flavonoids, resins, alkaloids, and saponins in both plant parts. Likewise, Migabo et al. [2] noticed all 6 phytosubstances in the leaves and stem of Tragia brevipes. Various phytosubstances, such as camphor, bornylacetate, α-pinene, and eucalyptol were extracted from plant oil by Saleh et al. [24]. Rubia cordifolia had phenols, saponins, and resins in the methanolic extracts. Similarly, the root extract with methanol harbors terpenes, alkaloids, flavonoids, phenols, and tannins [25]. Alkaloids, saponins, and resins were noticed in the stem of Solanum terminale. Stem and leaves from Dombeya torrida had alkaloids, tannins, and phenols in stem extracts; saponins, resins, and tannins in the methanolic leaf extracts. The same phytosubstances in these plant parts were also observed in the stems and leaves of Lantana camara [6]. Ndwiga et al. [26]

extracted important phytosterols like β-sitosterol, stigmasterol, y-friedelin, taraxerol, and friedelan-3β-ol. Thus, to extract phytosubstances acting as antibacterial agents, any part of the plant might be utilized [5, 13].

In this study, the plants of Acanthus polystachyus, Hypoestes triflora, Clerodendrum sp., Persea americana, Zea mays, and Solanum nigrum L. showed the absence of the tested active phytocompounds as shown in Table 1. This difference in phytometabolites might be due to geographic location, plant age, ecological factors, plant part utilized, stage of growth, and genetic aspects [1, 6, 7].

3.3 Antibacterial potentials of medicinal plant extracts of Rwanda

Medicinal plants of Rwanda were reported to possess various active phytochemicals responsible for preventing the growth of human clinical pathogens [2-7]. For instance, alkaloids and resins of Aloe vera were able to kill S. typhi B69, Proteus P126, and E. coli 35218 (Table 1). S. pyogenes, E. coli, P. aeruginosa and S. aureus were also killed by ethanolic extract of the Aloa vera plant [15]. Potential activity against S. aureus 43300, S. aureus 29213, S. pneumonia 49619, E. coli 25922, and P. aeruginosa 27853 was noticed in all stem and leaf extracts of Artemisia annua. Similarly, these bacteria-causing diseases were also killed by the leaf and stem extracts of Lantana camara [6]. Artemisia annua extract, an Ethiopian plant, had the curative effect against E. coli ATCC 25922, K. pneumoniae 1053, S. aureus 25923, and S. enteritidis 13076. This was attributed to the apoptosis facilitation of host cells and/or inflammatory response suppression. This can also be ascribed to the occurrence of sesquiterpene substances (like artemisinin) that may break down bacterial structures necessary for protein synthesis [16].

The methanolic extract of Gynandropsis gynandra possessed an important activity activity against S. pyogenes 12344, S. typhi B71, S. typhi B69, E. coli 25922, and S. pneumonia 49619 in all extracts. However, no activity with Proteus P126. In the same line, the methanolic and hexane extracts from stems and leaves were very active against human pathogenic bacteria, viz. Escherichia coli, Bacillus cereus, Streptococcus faecalis, B. subtilis, Pseudomonas aeruginosa and Staphylococcus aureus [17]. Carica papaya leaves had a potential activity against S. sonnei 29531, E. coli 25922, S. typhi B71, S. typhi B69, and E. coli 35218. Similarly, the C. papaya flowers were active against B. subtilis and E. coli, when methanol was utilized as an extraction solvent [19]. Senna acutifolia had a potential activity against E. coli 25922, Proteus P126, S. typhi B71, S. typhi B69, and E. coli 35218 in both methanol and petroleum ether extracts. The extract of Tragia brevipes was able to kill S. aureus 29213, P. aeruginosa 27853, P. mirabilis 126, K. oxytoca 700524, S. pyogene 12344, and S. pneumonia 49619, in addition to the above five pathogenic bacteria [2].

Potential activity against S. typhi B71 and S. typhi B69 was observed for the extract of Carduus nyassanus leaves. However, no influence against E. coli 25922, Proteus P126, and E. coli 35218. Similarly, the leaf extract of Mystroxylon aethiopicum has no effect against E. coli (as well as S. pneumonia) [7]. The leaf and stem extracts from Rosmarinus officinalis with methanol, water, and petroleum ether as extracting solvents were able to kill P. aeruginosa

27853, E. coli 25922, S. pneumonia 49619, S. aureus 43300 and S. aureus 29213. Similarly, extracts of the same 3 solvents were able to kill S. sonnei, E. coli, S. aureus, S. typhi, S. pneumoniae and H. influenza with Kalanchoe integra extracts [3]. Rosmarinus officinalis oil also killed E. coli, and S. aureus [24]. Rubiaceae plant known as Rubia cordifolia was able to prevent the bacterial growth of S. typhi B71, S. typhi B69, S. aureus 43300, S. aureus 29213, and Proteus sp. However, the same methanolic extract was inactive against E. coli 25922, K. oxytoca 700324, and E. coli 35218. Alkaloids, saponins, and resins from the extract of Solanum terminale Stem were responsible for the potential antibacterial activity noticed against E. coli 25922 and E. coli 35218. However, no activity was detected against activity against S. typhi B71, S. typhi B69, and S. sonnei 25931.

The methanol, water, and/or petroleum ether extracts from Hypoestes triflora, Clerodendrum sp., Persea americana, and /or Zea mays were found to be inactive against various tested bacteria. These are S. typhi B71, S. typhi B69, Proteus P126, E. coli 35218, E. coli 25922, S. sonnei 29531, S. aureus 43300, S. aureus 29213, S. pyogenes 12344, S. pneumonia 49619, and/or K. oxytoca 700324 (Table 1). This absence of antibacterial activity can be ascribed to the lack of active phytocompounds. Although no major phytochemical constituents were detected in Acanthus polystachyus and Solanum nigrum, they were able to inhibit completely S. aureus 43300 in the presence of methanol stem/leaf extracts. The methanolic extract of the 2nd plant had also potential activity against S. aureus 29213. The solvents utilized might be not appropriate in extracting plant phytosubstances or few phytochemicals are there in these plants or the extraction method utilized is not appropriate.

Furthermore, even if various extracts of Lagenaria sphaerica, Zahneria scabra, Acacia sieberiana, Hypericum revolutum, and Dombeya torrida had various phytochemicals, they were unable to inhibit Proteus P126, S. typhi B71, E. coli 25922, S. typhi B69, E. coli 35218, S. pyogenes 12344, S. pneumonia 49619, E. coli 35218, and/or S. sonnei 29531. This can be solved by choosing an appropriate method and /or solvent to extract phytosubstances in a significant amount. This explanation appears to be true because, in Ethiopia, Goji et al. [27] reported the inhibition of P. aeruginosa and S. pyogenes, but no curative effect against S. aureus and E. coli. The discrepancies noticed in terms of the degree of pathogenic bacteria' inhibition can be ascribed to the metabolites' variation observed in these Rwandese medicinal plants. Other reasons leading to pathogenic bacterial death include gene expression modification [28], protein synthesis prevention [29], or growth inhibition by tannins/phenols [30].

3.5 Traditional medicinal uses in Rwanda

African plants including Rwandan plants were reported by many researchers to possess various phytosubstances, and thus may act as antioxidant, antibacterial, antifungal, and antiviral agents [31]. Acanthus polystachyus and Hypoestes triflora are used by the Rwandan population to treat skin ulcers, gastritis, and liver intoxication, respectively. For instance, Aloe vera is used to cure various diseases. These are typhoid fever, gastritis, skin cancer, sunburns, minor cuts, skin softening, good digestion, lower blood pressure, proper circulation of lymphatic and blood, and proper functioning of the liver, colon, kidney, small intestines, and gall bladder. Nejatzadeh-Barandozi [15] also reported that A. vera is utilized to cure diabetes, cardiovascular

diseases, neurodegeneration, and cancer. This was ascribed to the A. vera phytosubstances that may lower fasting blood glucose, LDL-C, and total cholesterol.

Asteraceae plant, called Artemisia annua, is used to treat insomnia, stress, epilepsy, depression, psychoneurosis, headache, fever, inflammation, infections, and malaria. The same curative effects against the common cold, malaria, hemorrhoids, wounds of domestic animals, and asthma were also reported by Mohammed et al. [16]. Gynandropsis gynandra is utilized to treat headaches, stomachache, conjunctivitis, severe thread-worm infection arthritis, and oral candidiasis. It also facilitates childbirth in pregnant women and acts as an enzyme inhibitor with antioxidant activities. Ajaiyeoba [17] found the plant extract acting as nasal congestion, Vitamin C, headaches, food additive, earache, disinfectants, bronchitis, eye wash, and anthelmintic agents. The extract of Carica papaya is used to cure ulcers and gonorrhea. It also assists in digestion and acts as an antioxidant, bactericidal, fungicidal, and bacteriostatic agent. In India, C. papaya flowers are utilized to combat skin infections, malaria, inflammation, and dengue [19]. Lagenaria sphaerica is utilized to treat gonorrhea, infection of the umbilical cord, and swelling caused by blood disorders. Similar curative effects by the same species were reported by Prajapati et al. [18]. Indeed, the plant is utilized to treat rheumatism, jaundice, insomnia, diabetes, as a diuretic agent, ulcers, skin diseases, piles, cardiac failure, colitis, hypertension, and insanity.

Zahneria scabra is used to treat body swelling, wound healing, pharyngitis, syphilis, gastritis, and plague in Rwanda. However, in Ethiopia, it is utilized to treat various ailments such as diarrhea, alopecia, skin rashes, wounds, burns, and eczema [20]. The leaves of Acacia sieberiana are utilized to treat dropsy, urethral problems, decoction, stomachache, earache, otitis, and skin ulcers. However, when root extracts are utilized, the impotence (sexual dysfunction) is cured. Alain et al. [21] reported the antioxidant, antidiabetic, and antimicrobial actions of the various Acacia species, in Benin. Constipation, loss of appetite, gastritis, tonic, eczema, and skin diseases are treated by the extract of Senna acutifolia in Rwanda. A laxative action to remove waste from the intestine was also reported [22]. In Rwanda, Hypericum revolutum is used to cure malaria, tuberculosis, stomachache, dysuria, and urinary incontinence. In African traditional medicine, it is also utilized to combat wounds, diarrhea, nervous disorders, and rheumatism [23].

Plants belonging to Lamiaceae family are used to treat various conditions. For instance, Carduus nyassanus is utilized to cure bacterial infections and liver diseases. Clerodendrum sp. is utilized to treat ulcers, asthma, shingles, and spleen in children, in cephalalgia, rheumatism, asthma, malaria, febrifuge, and other inflammatory diseases. The plant leaves also act as antidiabetic and antihypertensive agents. Rosmarinus officinalis treats various diseases. Some of them are dysmenorrhea, stomachache, epilepsy, rheumatic pain, spasms, colds, rheumatism, pain of muscles and joints, respiratory, skin, genitourinary and reproductive system diseases. Similar curative action in treating these diseases was seen in Saudi Arabia [24]. The leaves of Persea americana may be considered for the treatment of diarrhea, dysentery, toothache, intestinal parasites and Panaris, rheumatism, high blood pressure, and asthma. They may act as antibacterial, antioxidant, antihypertensive, hypolipidemic, larvicidal, and fungicidal agents.

Zea mays is utilized to cure bacillary/amoebic dysentery, improve blood pressure, support liver functioning and bile production, and act as potential antioxidant and analgesic agents. Treatment of syphilis, liver fluke, wounds, skin disorders, cancer, and vermifuge can be done with the leaves of Rubia cordifolia. In India and China, the plant is known to be utilized for spotting, amenorrhea, hematemesis, traumatic bleeding, and epistaxis treatment [25]. Leaves of Solanum nigrum L. can be utilized to cure bacterial infections, indigestion, stomachache, wing worms, pain, inflammation, skin ulcer, fever, and cough, and can be used as a diuretic agent. Another Solanaceae plant known as Solanum terminale is used to treat stomachache, inflammation, tonsillitis, typhoid fever, wing worms, and pneumonia when its stem is taken into consideration. Treatment of cancer, amoebic dysentery, and wood healing can be done by Dombeya torrida. These studied plants can be considered in African ethnopharmacology for these treatments of the highlighted diseases. This curative action was ascribed to the phytochemicals' presence [5].

Table 1. Rwandese medicinal plants investigated in the present study and their antibacterial and traditional potentials

Botanical name	**Family**	**Local name**	**English name**	**Parts used for medicinal purposes**	**Solvent utilized**	**Major phytochemical constituents**	**Antibacterial potentials of plant part extracts**	**Traditional medicinal uses in Rwanda**
Acanthus polystachyus	Acanthaceae	Igitovu	*Prickly acanthus*	Stem and leaves	Methanol and petroleum ether	Not detected	Potential activity against *S. aureus* 43300 in the presence of methanol stem/leaf extracts; no activity noticed with stem /leaf extracts against *S. pyogenes* 12344 and *P. aeruginosa* 27853	Treatments for skin ulcer
Hypoestes triflora	Acanthaceae	Magaru	-	Leaves	Methanol	Not detected	No activity against *S. typhi* B71, *S. typhi*	Treatment of gastritis and liver intoxication

							B69, *Proteus* P126, *E. coli* 35218, and *E. coli* 25922	
Aloe vera	Asphodelaceae	Igikakarubamba	Medicinal aloe	Leaves	Methanol	Alkaloids and resins	Potential activity against *S. typhi* B69, *Proteus* P126, and *E. coli* 35218	Treatment of typhoid fever, gastritis, skin cancer, sunburns, minor cuts, skin softening, good digestion, lower blood pressure, proper circulation of lymphatic and blood, and proper functioning of the liver, colon, kidney, small intestines, and gall bladder
Artemisia annua	Asteraceae	Aritemiziya	Wormwood or sweet sagewort	Stem and leaves	Methanol, water, and petroleum ether	Tannins, phenols, glycosides, and resins are present in both stems and leaves. Alkaloids in stem extract only	Potential activity against *S. aureus* 43300, *S. aureus* 29213, *S. pneumonia* 49619, *E. coli* 25922, and *P. aeruginosa* 27853 in all extracts	Treatment of insomnia, stress, epilepsy, depression, psychoneurosis, headache, fever, inflammation, infections and malaria
Gynandropsis gynandra	Capparaceae	Isogi	*African spider flower*	Stem and leaves	Methanol	Tannins, phenols, alkaloids, and resins are present	Potential activity against *S. pyogenes* 12344, *S.*	Treatment of headaches, stomach-ache, conjunctiviti

						in both stems and leaves. Saponins in leaf extract only	*typhi* B71, *S. typhi* B69, *E. coli* 25922, and *S. pneumoni a* 49619 in all extracts. No activity with *Proteus* P126	s, severe thread-worm infection arthritis, and oral candidiasis; facilitates childbirth in pregnant women; and acts as enzyme inhibitor with antioxidant activities
Carica papaya	Caricaceae	Ipapayi	Papaya	Leaves	Metha nol	Tannins, phenols, alkaloids, resins, and saponins	Potential activity against *S. sonnei* 29531, *E. coli* 25922, *S. typhi* B71, *S. typhi* B69, and *E. coli* 35218	Treatment of ulcers, Gonorrhea; assists in digestion; and acts as antioxidant, bactericidal, fungicidal, and bacteriostati c agents
Lagenaria sphaerica	Cucurbitac eae	Umutanga	Wild melon	Fruits and leaves	Metha nol	Tannins, phenols, saponins, and resins are present in both fruits and leaves. Alkaloids in fruit extract only	No activity with *Proteus* P126, *S. typhi* B71, *E. coli* 25922, *S. typhi* B69, and *E. coli* 35218 in both fruit and leaf extracts	Treatment of gonorrhea, infection of the umbilical cord, and swelling caused by a blood disorder
Zahneria scabra	Cucurbitac eae	Umushishiro	*Wild cucumbe r*	Leaves	Metha nol and petrole um ether	Tannins and saponins	No activity with *Proteus* P126, *S. typhi* B71, *S. typhi* B69, *E. coli* 25922, *S. pyogenes* 12344, *S.*	Treatment of body swelling, wound healing, pharyngitis, syphilis, gastritis and plague

							pneumoniae 49619 and *E. coli* 35218 in both solvent extracts	
Acacia sieberiana	Fabaceae	Umunyinya	*Paperbark acacia*	Leaves	Methanol	Tannins, resins, alkaloids, and saponins	No activity with *S. sonnei* 29531. Potential activity with *S. typhi* B71, *E. coli* 25922, *S. typhi* B69, and *E. coli* 35218	Treatment of dropsy, urethral problems, decoction, stomach-ache, earache, otitis, skin ulcer, and impotence (sexual dysfunction), especially when root extracts are utilized
Senna acutifolia	Fabaceae	Umuyoka	Senna	Leaves	Methanol and petroleum ether	Tannins, phenols, glycosides, flavonoids and resins	Potential activity against *E. coli* 25922, *Proteus* P126, *S. typhi* B71, *S. typhi* B69, and *E. coli* 35218 in both solvent extracts	Treatment of constipation, loss of appetite, gastritis, tonic, eczema and skin diseases
Hypericum revolutum	Hypericaceae	Umushungur u	forest primrose or curry bush	Leaves and stem	Methanol	Saponins, tannins, and resins in both leaves and stem; phenols and alkaloids present in leaves only	No activity with *S. pyogenes* 12344, *E. coli* 25922, and *S. pneumoniae* 49619 in all extracts.	Treatment of malaria, tuberculosis, stomachache, dysuria and urinary incontinence
Carduus nyassanus	Lamiaceae	Ikigwarara /	-	Leaves	Methanol	Tannins, phenols, glycosides,	Potential activity against *S.*	Treatment of bacterial infections

		Mugabudasunikwa				saponins and resins	*typhi* B71 and *S. typhi* B69. No effect against *E. coli* 25922, *Proteus* P126, and *E. coli* 35218	and liver diseases
Clerodendrum sp.	Lamiaceae	Ikiziranyenzi	Glorybower, bleeding-heart, or bag flower	Leaves	Methanol	Not detected	No activity against *S. typhi* B71, *S. typhi* B69, *E. coli* 25922, *S. sonnei* 29531, *S. aureus* 43300, *S. aureus* 29213, and *E. coli* 35218	Treatment of ulcers, asthma, shingles, spleen in children, rheumatism, asthma, malaria, febrifuge, and other inflammatory diseases; act as an antidiabetic and antihypertensive agent
Rosmarinus officinalis	Lamiaceae	Romari	Rosemary	Stem and leaves	Methanol, water, and petroleum ether	Tannins, phenols, glycosides, flavonoids, resins, alkaloids, and saponins present in both plant parts	Potential activity against *P. aeruginosa* 27853, *S. pneumoniae* 49619, *E. coli* 25922, *S. aureus* 43300, and *S. aureus* 29213 in both stem and leaf extracts	Treatment of dysmenorrhea, stomachache, epilepsy, rheumatic pain, spasms, colds, rheumatism, pain of muscles and joints, respiratory, skin, genitourinary and reproductive system diseases
Persea americana	Lauraceae	Avoka	Avocado	Leaves	Methanol	Not detected	No activity against *S. pyogenes* 12344, *S.*	Treatment of diarrhea, dysentery, toothache, intestinal

							aureus 43300, *E. coli* 35218, *S. pneumoni a* 49619, and *K. oxytoca* 700324	parasites and Panaris, rheumatism, high blood pressure, and asthma; act as antibacterial, antioxidant, antihyperten sive, hypolipidem ic, larvicidal, and fungicidal agents
Zea mays	Poaceae	Ikigori	Maize	Leaves and stem	Metha nol	Not detected	No activity against *E. coli* 35218, *S. sonnei* 25931, and *S. typhi* B69	Treatments of bacillary/am oebic dysentery, improve blood pressure, support liver functioning and bile production, and act as potential antioxidant and analgesic agents
Rubia cordifolia	Rubiaceae	Urukararamb we	Commo n madder	Leaves	Metha nol	Phenols, saponins and resins	Potential activity against *S. typhi* B71, *S. typhi* B69, *S. aureus* 43300, *S. aureus* 29213, and *Proteus* sp. No activity with *E. coli* 25922, *K. oxytoca* 700324, and *E.*	Treatment of syphilis, liver fluke, wounds, skin disorders, cancer, and vermifuge

							coli 35218	
Solanum nigrum L.	Solanaceae	Isogo	Black nightshade	Leaves	Methanol and hexane	Not detected	Potential action against *S. aureus* 43300 and *S. aureus* 29213 in methanolic extract; no activity noticed with *E. coli* 25922, *S. pyogenes* 12344, and *E. coli* 35218	Treatment of bacterial infections, indigestion, stomachache, wing worms, pain, inflammation, skin ulcer, fever, and cough, and as a diuretic agent
Solanum terminale	Solanaceae	Umumanurankuba	-	Stem	Methanol	Alkaloids, saponins and resins	Potential activity against *E. coli* 25922 and *E. coli* 35218; no activity against activity against *S. typhi* B71, *S. typhi* B69, and *S. sonnei* 25931	Treatment of stomachache, inflammation, tonsillitis, typhoid fever, wing worms and pneumonia
Dombeya torrida	Sterculiaceae	Umukore	Dombeya	Stem and leaves	Methanol	Alkaloids, tannins and phenols in stem extracts; saponins, resins and tannins in leaf extracts	No activity against *E. coli* 25922, *E. coli* 35218, *S. typhi* B71, *S. typhi* B69, and *S. sonnei* 25931	Treatment of cancer, amoebic dysentery, and wood healing

5. Conclusion

In the present analysis, twenty Rwandese plants were screened for their antibacterial potential. The presence of various phytosubstances in them confirmed their medicinal values. They can therefore be utilized to cure various illnesses resulting from the investigated pathogenic bacteria. Further investigations are suggested to determine the concentrations of phytochemicals in these plants/plant parts for genuine use in traditional medicine. Side effects and toxicity investigations and their mechanisms of action have also to be conducted before using the studied plants/plant parts as medicines.

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