

## Antibacterial activity of medicinal plants of Northern Peru – can traditional applications provide leads for modern science?

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Bacterial infections and inflammation are among the ailments treated by traditional healers. The World Health Organization has expressed high interest in traditional medicine, and it is important to demonstrate scientifically that remedies employed in folk medicine are indeed therapeutically active. In this communication, antibacterial assays for 165 plant species conducted under simple laboratory conditions in a private clinic in Trujillo, Peru has been reported. The aim of the study was to scientifically test whether plants used in traditional medicine for the treatment of infections showed antibacterial activity. Extracts of samples of 148 species traditionally used as antibacterial were screened for activity against *Staphylococcus aureus* and *Escherichia coli* using an agar-diffusion method. In addition, 17 closely related species that were also part of the local pharmacopoeia, but only used for other purposes, were included for comparison. Sixteen species tested as traditional water extract and 96 species extracted in ethanol showed activity against at least one of the bacteria. The study confirms that simple laboratory methods are very well suited to assess the efficacy of traditionally used medicinal plants to inhibit bacterial growth. A comparison to the traditional uses also indicated that local knowledge can give important leads for the development of new treatments. Further tests, especially with regard to toxicity, are needed to verify the safety of the traditional preparations.

**Keywords:** Antibacterial activity, Medicinal plants, Peru, Ethnomedicine, Traditional medicine

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In recent years, there is an increasing preference for the use of Traditional Medicine<sup>1,2</sup>. In some developing Latin American and Asian countries, more than half of the population is using traditional medicine in primary healthcare<sup>3</sup>. In most of these cases, the use of traditional medicine is the most affordable and accessible route for the cure of disease. In developed countries, there has been an increasing use of traditional and alternative medicine, even though Western medicine is readily available. For thousands of years, plants have been used in the practice of Peruvian traditional medicine or *curanderismo*. Specifically, Northern-coastal Peru has been noted for being at the core of the *health axis* of the old Central Andean culture area because of the diverse collection of medicinal plants that thrive in the northern regions<sup>4</sup>. As a result, some national governments have sought to integrate traditional medicine as a vital component of healthcare and treatment. Rich in fauna

and plant diversity, Peru is becoming known as a location in which extensive ethnobotanical research is conducted, in an effort to preserve the unique properties of plants and to gain a deeper scientific understanding of how these plants can cure certain ailments<sup>5</sup>. One area of concentration is the study of the bacterial properties of certain plants, with certain plants being tested for antibacterial properties using bio-assays<sup>6</sup>. Most testing and studies have taken place in Northeastern Peru, most notably in the Callejon de Huaylas. However, few studies have been done in places like Trujillo or Chiclayo, to examine the bacterial properties of plants there. Defining the most serious bacterial infections in Northern Peru might help decipher whether or not many plants have antibacterial properties<sup>2,7,8</sup>.

### Methodology

Originally, 512 medicinal plants were collected in the Peruvian departments Lambayeque and La Libertad in the field, in markets of the coastal cities

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Trujillo and Chiclayo and around the homes and in gardens of traditional healers (*curanderos*) of the region. Fieldwork was conducted during 2001-2008 and vouchers of all specimens were deposited at the Herbario Truxillensis (HUT, Universidad Nacional de Trujillo), and Herbario Antenor Orrego (HAO, Universidad Privada Antenor Orrego Trujillo). Recognizing Peru's rights under the CBD, especially with regard to the conservation of genetic resources in the framework of a study treating medicinal plants, the identification of the plant material was conducted entirely in Peru. No plant material was exported in any form whatsoever. The specimens were registered under the collection series RBU/PL, ISA, GER, JULS, EHCHL, VFCHL, TRUBH, and TRUVANERICA, depending on the year of fieldwork and collection location<sup>9</sup>. Plant species were identified using floras and reference material in the herbaria HUT and HAO<sup>10-14</sup>. Ethnobotanical data was collected from plant vendors in local markets and by accompanying local healers (*curanderos*) to the markets and into the field when they harvested. In addition, plants were also collected in the field and taken to the homes of *curanderos* to discuss the plants' healing properties, applications, harvesting methodology, and origins<sup>15</sup>. At the homes of *curanderos*, preparation of remedies and healing rituals were observed. Plant uses were discussed in detail with informants, after seeking Prior Informed Consent from each respondent. One hundred and forty eight species showed uses related to a possible antibacterial activity (Table 1). The selected plants encompassed the most often mentioned species used traditionally against infections as well as plants used against gastro-intestinal problems because it was assumed that these plants would most likely show activity against the bacterial strains tested.

Plant material dried at 37°C for three days was powdered. The plant material was submerged in ethanol for seven days. To produce a traditional water extract for comparison, the plant material was boiled and then left submerged for one day. After maceration, the alcohol extracts were filtered and the solvent was evaporated. The resulting residue was used for bioassays. The water extracts were filtered and evaporated. The dried extracts were re-suspended in distilled water. The antibacterial activity of the plants was determined by using an agar diffusion method. Bacterial samples obtained from patients treated at the clinic where testing was conducted were

used for the assays. This approach has the additional benefit that plant material can be directly tested against bacterial strains prevalent in the local population. *Staphylococcus aureus* (Gram-positive) was isolated from a Laryngitis sample. Two lines of the Gram-negative species *Escherichia coli* were isolated from urinary tract infection samples. The bacteria were incubated on nutrient agar until clean lines could be cultivated. The identification of the bacteria was done<sup>16,17</sup>. The isolates were kept in culture to allow reproduction of the results or further detailed analysis of the strains used.

The antibacterial activity of the crude plant extracts was determined using an agar-diffusion method and bacterial strains were produced. Bacterial cultures were grown on 5% sheep red blood agar (SBA) and then inoculated onto Mueller-Hinton Agar (PML) for testing. Following the initial incubation, organisms were suspended in distilled water and their concentration equilibrated. Using a sterile cotton swab, each sample was transferred onto Mueller-Hinton Agar. Six mm lank paper disks were then saturated with each plant extract, dried, and applied to the agar surface. Disks with Amikacin and distilled water were applied as controls. Amikacin was used because it was the only antibiotic available with efficacy against both *Escherichia coli* and *Staphylococcus aureus*. Disks with distilled water (for water assays) and disks first saturated with Ethanol and then dried (for ethanol assays) were used as negative controls. Plates were incubated overnight at 37°C; after 24 hrs, zones of inhibition appearing around disks were measured and recorded. At least three repetitions were run for each assay. The Amikacin control showed an inhibition zone of at least 7mm after 24 hrs exposition in all assays tested. Plant species showing at least the same activity were considered antibacterially active.

## Results and discussion

One hundred and sixty nine plant species were tested for antibacterial activity against *Escherichia coli* (Gram negative) and *Staphylococcus aureus* (Gram positive) (Table 1). The results of the antibacterial assays are presented (Table 2). Out of 169 plant species, 104 species (63%) showed some antibacterial activity. A total of 84 species (50.9%) showed antibacterial activity against *Staphylococcus aureus*; 74 were species where activity had been suspected based on traditional knowledge, while the remaining 10 species were closely related but were

Table 1— Traditional uses of plants selected for antibacterial bioassays

Plant name	Vernacular name	Plant parts used	Uses
<i>Alternanthera brasiliana</i> (L.) Kuntze	<i>Hierba del Oso, Moradilla de Cerro</i>	Whole plant, fresh or dried	Bronchitis, asthma
<i>Alternanthera porrigens</i> (Jacquin) Kuntze	<i>Sanguinaria, Moradilla, Lancetilla</i>	Whole plant, fresh or dried	Cleansing womb after childbirth
<i>Amaranthus hybridus</i> L.	<i>Yuyo</i>	Fresh leaves and stems	Inflammation (general)
<i>Iresine diffusa</i> H.B.K. ex Willd.	<i>Paja Blanca, Sangrinaria</i>	Fresh whole plant	Liver, kidneys, inflammation of the ovaries
<i>Iresine herbstii</i> Lindley	<i>Colores, Timoras, Zangurache</i>	Fresh leaves	Liver, kidneys, cancer of the blood, intoxication, inflammation of the stomach, inflammation
<i>Eustephia coccinea</i> Cav.	<i>Tumapara, Para Para Pomanpara, Puma Para,</i>	Bark, fresh or dried	Inflammation of the stomach, inflammation, haemorrhages, inflammation of uterus, ulcers, cysts, cancerous wounds, wounds
<i>Mauria heterophylla</i> H.B.K.	<i>Shimir, Tres Hojas, Trinidad, Chacur, Ahimir, Feregreco</i>	Fresh leaves	Skin irritation, vaginal cleansing, inflammation, liver, kidneys, wounds, inflammation of uterus, cleansing, ulcers, inflammation of the ovaries, cysts, fibroids
<i>Schinus molle</i> L.	<i>Molle, Moy</i>	Fresh flowers, leaves, stem, bark, latex	Bronchitis, cough, cold, chills, inflammation of the body, cancer, tuberculosis, vaginal infection
<i>Foeniculum vulgare</i> P. Miller	<i>Hinojo, Anis Criollo</i>	Fresh whole plant, seeds	Colic, gases, after birth, stomachache, diarrhoea
<i>Niphogeton dissecta</i> (Benth.) Macbr.	<i>Hornamo Toro, Orma Motora</i>	Fresh leaves, dried stems	wounds (cancerous), wounds from sorcery
<i>Petroselinum crispum</i> (Miller) A.W. Hill	<i>Perejil</i>	Fresh whole plant	Infections
<i>Nerium oleander</i> L.	<i>Laurel, Laurel Rosa</i>	Fresh flowers, leaves, stem	Cleaning wounds, itching, sarna, rashes, skin mark, herpes
Araliaceae			
<i>Oreopanax eriocephalus</i> Harms	<i>Maque Maque, Mano de León</i>	Fresh leaves, flowers	Inflammation
<i>Acanthoxanthium spinosum</i> (L.) Furreau	<i>Juan Alonso, Espina de Perro, Corona de Cristo</i>	Whole plant fresh or dried	Inflammation, bronchitis
<i>Ambrosia peruviana</i> Willd.	<i>Altamisa, Marco, Manzanilla del Muerto, Ajenjo, Llatama Malera</i>	Fresh leaves, stem	Liver, bronchitis, colds, burns, fungus, after birth to reduce inflammation
<i>Arctium lappa</i> L.	<i>Lampazo</i>	Dried seeds	Urinary problems, skin, liver, intestine, tumors
<i>Baccharis ciliaris</i> (Retz.) Koeler	<i>Pata de Gallina</i>	Whole plant fresh or dried	Protection
<i>Baccharis genistelloides</i> (Lam.) Pers.	<i>Simba Simba, Carceja, Karqueja, Cadillo</i>	Fresh whole plant	Kidneys, internal Inflammation, liver
<i>Baccharis glutinosa</i> Persoon	<i>Chilco Macho</i>	Fresh leaves	Diabetes
<i>Baccharis latifolia</i> (R. & P.) Pers.	<i>Chilca Chica, Chilca Grande</i>	Leaves and stems	Bone pain, arthritis, rheumatism
<i>Baccharis salicifolia</i> (R. & P.) Pers.	<i>Hierba de la Plata, Chilco Hembra</i>	Fresh whole plant	Rashes, pimples
<i>Chuquiraga spinosa</i> sp. huamanpinta C. Ezcurra	<i>Chuquiragua, Huamanpinta</i>	Dried leaves	Inflammation, kidneys, bladder, prostate inflammation
<i>Chuquiragua weberbaueri</i> Tovar	<i>Amaro Amaro</i>	Whole plant fresh or dried	Cough, bronchitis, asthma, liver
<i>Clibadium</i> cf. <i>sylvestre</i> (Aubl.) Baill.	<i>Flor de Novia</i>	Flowers, leaves, stem	Cold
<i>Cronquistianthus lavandulifolius</i> DC.	<i>Clavelillo, Espino de Hoja, Pulmonaria</i>	Flowers, leaves, stem	Cough, bronchitis, cold, pulmonary disease

Table 1— Traditional uses of plants selected for antibacterial bioassays —*Contd*

Plant name	Vernacular name	Plant parts used	Uses
<i>Cynara cardunculus</i> L.	<i>Alcachofa</i>	Stems and Leaves	Liver, blood purification
<i>Eupatorium gayanum</i> Wedd.	<i>Asma Chilca, Asma (Chica)</i>	Fresh leaves	Cough, bronchitis
<i>Flaveria bidentis</i> (L.) Kuntze	<i>Mata Gusano</i>	Flowers, leaves, stem	Cough, bronchitis
<i>Matricaria frigidum</i> (HBK) Kunth	<i>Manzanilla</i>	Whole plant fresh or dried	Inflammation of wounds, vagina, colic, stomachache, bronchitis, injuries, wounds
<i>Matricaria recutita</i> L.	<i>Manzanillon, Manzanilla Blanca, Amarga, Manzanilla Manzanilla</i>	Fresh whole plant	Infection of wounds, vaginal cleansing, blood purification, infection of wounds
<i>Monactis flaverioides</i> H.B.K.	<i>Hierba del Susto, Malva, Mocura</i>	Fresh stem and leaves	Prostate, vaginal cleansing
<i>Oritrophium peruvianum</i> (Lam.) Cuatrec.	<i>Huamanripa, China Linda, Wiña Wiña, Vira Vira, Hierba del Lucero</i>	Whole plant	Bronchitis, pneumonia
<i>Paranephelium uniflorum</i> Poepp. & Endl.	<i>Pacha Rosa, Carapa de Chanco</i>	Whole plant fresh or dried	Inflammation of the ovaries, uterus, inflammation (internal female parts), stones
<i>Perezia multiflora</i> (H. & B.) Lessing	<i>Corzonera, Escorcionera, Escorzonera</i>	Whole plant fresh or dried	Cough, bronchitis
<i>Perezia pungens</i> (H.B.K.) Cas.	<i>Lengua de Vaca</i>	Fresh leaves	Infection of wounds, prevents, peeling of skin after sunburn
<i>Schkuhria pinnata</i> (Lam.) Kuntze	<i>Canchalagua, Canchalagua (Chica)</i>	Fresh whole plant	Blood cleansing, liver, blood purification, inflammation of the urinary tract
<i>Senecio canescens</i> (H.B.K.) Cuatrecasas	<i>Vira Vira, Oreja de Conejo</i>	Fresh whole plant	Bronchitis, cough
<i>Senecio chinogeton</i> Wedd.	<i>Hornamo Leon Amarillo</i>	Leaves, stem	Inflammation (general)
<i>Senecio hysandinus</i> Cuatr.	<i>Ornamo Blanco</i>	Fresh whole plant	Fragrance
<i>Senecio pseudotites</i> Grieseb.	<i>Arnica</i>	Fresh leaves and stem	Inflammation, rheumatism, high fever
<i>Smallanthus sonchifolius</i> (Poepp. & Endl) H. Rob.	<i>Hojas de Yacon, Llacon</i>	Dried leaves	Kidney, inflammation of the prostate
<i>Tagetes elliptica</i> Sm.	<i>Culantrillo Serrano</i>	Whole plant	Cold, bronchitis, congestion
<i>Tagetes erecta</i> L.	<i>Flores del Muerto, Claveles Chino</i>	Fresh flowers, leaves	Colic of the stomach, cough, inflammation
<i>Taraxacum officinale</i> Wiggers	<i>Diente de Leon, Amargon</i>	Fresh whole plant	Liver, stomach, inflammation, ovaries
<i>Tesaria integrifolia</i> R. & P.	<i>Pajaro Bobo</i>	Fresh flowers, leaves	Liver, kidneys, gallbladder, inflammation, fever
<i>Berberis buceronis</i> J.F. Macbride	<i>Palo Amarillo</i>	Dried wood bark	Liver, hepatitis
<i>Alnus acuminata</i> H.B.K.	<i>Aliso Blanco (Liso), Aliso Colorado (Arrugado)</i>	Fresh bark	Sealing wounds, rashes, skin irritations, cold, colic of the stomach, colic of the intestine
<i>Crescentia cujete</i> L.	<i>Higueron</i>	Fresh latex from leaf	Healing of belly button after birth
<i>Cydista aequinoctialis</i> (L.) Miers	<i>Bejuco Amarillo</i>	Fresh flowers, leaves, stem	Internal inflammation
<i>Bixa orellana</i> L.	<i>Achote</i>	Seeds, leaves fresh or dried	Inflammation of kidney, prostate, bronchitis, haemorrhages, pulmonary systems, urinary infections
<i>Borrigo officinalis</i> L.	<i>Borraja</i>	Whole plant fresh or dried	Bronchitis, lungs, cough, cold, blood problems,
<i>Cordia alliodora</i> (R. & P.) Oken	<i>Ajos Giro Ajo Sacha</i>	Bark and Stems, dried	Bronchitis

Table 1— Traditional uses of plants selected for antibacterial bioassays— *Contd*

Plant name	Vernacular name	Plant parts used	Uses
<i>Cordia lutea</i> Lam.	<i>Overo, Flor de Overo, Overal</i>	Flowers, fresh or dried	Liver, bladder, hepatitis, inflammation of the kidneys, prostate inflammation.
<i>Capsella bursa-pastoris</i> (L.) Medic.	<i>Hierba del Pastor, Bolsa de Pastor</i>	Whole plant, fresh or dried	Kidneys, prostate, inflammation, liver, gallbladder, stomach and urinary tract infection
<i>Rorippa nasturtium-aquaticum</i> (L.) Hayek	<i>Berros</i>	Whole plant except root, fresh or dried	Liver, urine retention, bronchitis, kidney ailments, inflammation of the liver and kidney
<i>Puya hamata</i> L.B. Sm.	<i>Hierba del Carnero, Hierba de Borrego</i>	Hairy part of the Seeds, dried	Tumors, infections
<i>Bursera graveolens</i> (H.B.K.) Triana & Planchon	<i>Palo Santo, Palo de Santo</i>	Small Stems, Bark and Wood, dried	Cough, flu, bronchitis, cold
<i>Capparis crotonoides</i> H.B.K.	<i>Simuro, Bichayo, Simulo</i>	Fresh flowers Fresh leaves	Bronchitis Cold
<i>Sambucus nigra</i> L.	<i>Cinta de novia</i>	Stems, fresh	To tie a person
<i>Sambucus peruviana</i> H.B.K.	<i>Sauco, Saucotillo</i>	Leaves, flowers, stem, fresh/dried Fresh leaves	Kidneys, cough, concussions, prostate, fever, bronchitis, yellow fever, cold Fever, yellow fever, gastritis, inflammation of the kidneys,
<i>Chenopodium ambrosioides</i> L.	<i>Paico</i>	Fresh leaves and stem	Worms, cough
<i>Hedyosmum racemosum</i> (R. & P.) G. Don.	<i>Masamoche, Asancito, Asarcito, Choleta</i>	Dried bark	Bronchitis, cold, cough
Clusiaceae			
<i>Hypericum silenoides</i> Jus.	<i>Cintaura</i>	Fresh whole plant	Diarrhoea, dysentery
<i>Ipomoea pauciflora</i> M. Martens & Galeotti	<i>Huanarpo</i>	Fresh whole plant	Chills, colds
<i>Dioscorea tambillensis</i> Kunth	<i>Papa Semitona</i>	Fresh tuber	Inflammation of the kidneys, ovaries, liver
<i>Dioscorea trifida</i> L.f.	<i>Papa Madre, Papa Pacta</i>	Fresh tuber	Inflammation, renal and uterus disease, internal inflammation, cancer of uterus, inflammation of ovaries and kidneys, vaginal discharge, cysts, wounds
<i>Equisetum bogotense</i> (H.B.K.) Kunth	<i>Cola de Caballo, Cola de Caballo (Hembra)</i>	Dried stem	Inflammation of the kidneys, wounds, ailments of stomach, urinary tract, kidney stones
<i>Bejaria aestuans</i> L.	<i>Pullunrosa, Cadillo, Payama, Hierba de la Postema, Purenrosa, Hierba de la Postema, Hierba del buen querer</i>	Flowers, leaves, stem, fresh or dried	Diabetes, liver, prostate, blood related illnesses, inflammation of kidneys uterus, liver, bladder, cysts, ovaries, womb, uterus, inflammation
<i>Gaultheria erecta</i> Vent.	<i>Mullaca Mistura, Mullaca, Mullaca Real</i>	Whole plant, fresh or dried	Bronchitis
<i>Gaultheria reticulata</i> H.B.K.	<i>Toromaique, Maique, Maque Candela, Gavilan Maique</i>	Whole plant, fresh	Cold, bronchitis, wounds, cysts, ulcers, sores
<i>Erythroxylon coca</i> Lam.	<i>Coca</i>	Dried leaves	Cold, cough, inflammation of throat
<i>Acalypha mandonii</i> Muell.-Arg.	<i>Chilca Dulce</i>	Whole plant, fresh or dried	Liver inflammation, clean blood from toxins
<i>Alchornea castaneifolia</i> (Willd.) Juss.	<i>Chilca Dulce</i>	Leaves, dried	Liver inflammation, clean blood from toxins
<i>Phyllanthus niuriri</i> L.	<i>Chanca Piedra</i>	Whole plant, fresh or dried	Bladder stones, liver and gall bladder inflammation, clean blood from toxins, liver, kidneys
<i>Phyllanthus urinaria</i> L.	<i>Chanca Piedra</i>	Whole plant, fresh or dried	Bladder stones, liver and gall bladder inflammation, clean blood from toxins, liver, kidneys

Table 1— Traditional uses of plants selected for antibacterial bioassays— *Contd*

Plant name	Vernacular name	Plant parts used	Uses
<i>Acacia macracantha</i> H. & B. ex Willd.	<i>Faique, Espino, Huarango</i>	Bark, dried	Wounds
<i>Caesalpinia paipai</i> R. & P.	<i>Pay Pay</i>	Fruits, fresh or dried	Killing lice, wounds
<i>Caesalpinia spinosa</i> (Molina) Kuntze	<i>Tara, Talla, Chanchalagua</i>	Seeds pods, fresh or dried	Pharyngitis, throat and skin infection, animal bites, inflammation of tonsils, wounds, boils, Inflammation of ovaries, uterus and vagina
<i>Desmodium molliculum</i> (H.B.K.) DC.	<i>Pie de Perro, Pata de Perro, Pata-Perro, Chancas de Comida, Muña, Manayupa</i>	Whole plant, fresh or dried	Inflammation of the kidneys, ovaries and womb, diarrhoea, stomachache, kidneys, gastritis, wounds cleansing, scars
<i>Dolichos lablab</i> L.	<i>Frijol chileno</i>	Fresh fruits	Fever, inflammation of intestine, protects lungs
<i>Leucaena leucocephala</i> (Lam.) De Wit	<i>Arabisca, Huaba Bruja</i>	Fresh bark, flowers and stem	Antiseptic, clean wounds
<i>Melilotus alba</i> Medikus	<i>Alfalfilla</i>	Seeds, dried	Fever, tuberculosis, cold, respiratory infections
<i>Myroxylon balsamum</i> (L.) Harms.	<i>Quina Quina, Kina Kina</i>	Seeds, dried	Bronchitis, cough
<i>Otholobium glandulosum</i> (L.) Grimes	<i>Culein, Culen</i>	Stems, fresh or dried	Diarrhoea, cold of the stomach
<i>Prosopis pallida</i> (H. & B. ex Willd.) H.B.K.	<i>Algarrobo</i>	Dried seeds Leaves, stem Fresh resin	Cough and bronchitis Stomachache Cold, critical wounds
<i>Spartium junceum</i> L.	<i>Retama</i>	Flowers, root Whole plant	Hepatitis, liver Sinusitis, blood purification
<i>Trifolium repens</i> L.	<i>Trebol, Trebol de agua</i>	Flowers, leaves, stem, fresh or dried	Inflammation of the urinary tract, and kidneys, stomach, ulcer, kidneys, blood
<i>Coutoubea ramosa</i> Aublet	<i>Genciana</i>	Fresh fruits	Wounds, scars, rashes, cold sores
<i>Gentianella bicolor</i> (Wedd.) J. Pringle	<i>Corpus Way, Corposhuar, Hornamo Leon</i>	Whole plant, fresh or dried	Arthritis, diabetes, bone pain, cholesterol, gastritis, liver, blood, rheumatism
<i>Gentianella bruneotricha</i> (Gilg.) J.S. Pringle.	<i>Anga Macha</i>	Whole plant, fresh	Infection of the uterus after giving birth
<i>Gentianella crassicaulis</i> J.S. Pringle	<i>Violeta Genciana</i>	Whole plant, fresh or dried	Gastritis, diabetes, dizziness
<i>Geranium ayavacense</i> Willd ex H.B.K.	<i>Puli Punchi, Pasuchaca, Pachuchaca, Miscamisca</i>	Whole plant, fresh or dried	Inflammation of kidney, liver, urinary tract, inflammation of all kinds
<i>Geranium sesiliflorum</i> Cavanilles	<i>Puli Punchi, Pasuchaca, Pachuchaca, Miscamisca</i>	Whole plant, fresh or dried	Inflammation, kidneys, liver, urinary tract, inflammation of all kinds
<i>Pelargonium odoratissimum</i> (L.) L'Herit.	<i>Malva de Oro, Malva de Olor, Malva Olorosa</i>	Whole plant, fresh or dried	Blood, inflammation of ovaries and womb
<i>Juglans neotropica</i> Diels	<i>Nogal</i>	Leaves, fresh	Wounds cleansing, cough, bronchitis
<i>Krameria lappacea</i> (Dombey) Berdet & B. Simpson	<i>Ratania, Raima</i>	Leaves and Root, fresh	Inflammation of kidneys, ovaries, intestine, bladder
<i>Lepechinia meyenii</i> (Walpers) Epling	<i>Salvia, Salvia Real</i>	Whole plant, fresh or dried	Bronchitis, wounds
<i>Marrubium vulgare</i> L.	<i>Cordon de Muerto, Chanca de Comida</i>	Whole plant, fresh or dried	Inflammation of the body
<i>Mentha x piperita</i> L.	<i>Poleo</i>	Whole plant, fresh or dried	Colic, stomach pain
<i>Mentha spicata</i> L.	<i>Hierba Buena, Hierba Buena Silvestre, Menta</i>	Fresh whole plant	Parasites, colic, stomachache, gastritis, indigestion, tapeworms, intestinal worms, gases
<i>Salvia cuspidata</i> R. & P.	<i>Fright/Susto, Daño</i>	Whole plant, fresh or dried	Cough, cold
<i>Salvia discolor</i> H.B.K.	<i>Palmeras, Llatama</i>	Stems, fresh	Cough, preventing infections related to birth
<i>Salvia rosmarinifolia</i> Hort. ex G. Don.	<i>Romero del Campo, Romero Serrano</i>	Whole plant, fresh	Inflammation, sinusitis

Table 1— Traditional uses of plants selected for antibacterial bioassays— *Contd*

Plant name	Vernacular name	Plant parts used	Uses
<i>Salvia sagittata</i> R. & P.	<i>Salvia Negra</i>	Root/stem fresh or dried	Cough
<i>Stachys lanata</i> Jacq.	<i>Veronica (Macho)</i>	Whole plant	Bronchitis
<i>Satureja pulchella</i> (H.B.K.) Briquet	<i>Panizara</i>	Leaves, fresh/dried	Bronchitis, liver disease, infection (internal)
<i>Thymus vulgaris</i> L.	<i>Tomillo</i>	Leaves, stem, flowers	Cough, colic, liver, gases, indigestion, bladder
<i>Persea americana</i> Mill.	<i>Palta</i>	Fresh seeds Fresh flowers	Cough Diarrhoea, kidney stones
<i>Gustavia augusta</i> L.	<i>Chope</i>	Fresh leaves	Allergies, rashes, pimples
<i>Linum sativum</i> L.	<i>Linaza</i>	Seeds, dried	Inflammation of kidneys, liver, prostate, gallbladder and kidney stone
<i>Buddleja utilis</i> Kraenzl.	<i>Flor Blanca</i>	Flowers, fresh or dried	Inflammation of womb, ovarian cysts, inflammation of uterus
<i>Cuphea strigulosa</i> H.B.K.	<i>Lancetilla, Gacetilla, Sanguinaria, Gansetilla, Hierba del Toro</i>	Fresh leaves and Stem	Fever, blood purification, intestinal infections, liver, discharges, colic, gases, diarrhoea, inflammation of stomach and kidney
<i>Malesherbia ardens</i> Macbr.	<i>Veronica</i>	Whole plant, fresh or dried	Cold, cough, bronchitis
<i>Alcea rosea</i> (L.) Cavanilles	<i>Malva Blanca, Malva Morada</i>	Whole plant except stem	Inflammation, cough
<i>Peumus boldus</i> Molina	<i>Boldo</i>	Dried leaves	Inflammation of liver and kidney
<i>Eugenia obtusifolia</i> Cambes.	<i>Unquia Real, Rumilanchi</i>	Leaves, stem, fresh or dried	Inflammation (general)
<i>Eucalyptus citriodora</i> Hooker	<i>Citrodora</i>	Whole plant, fresh or dried	Diabetes
<i>Eucalyptus globulus</i> Labill.	<i>Alcanfor, Serrano, Eucalipto Eucalipto</i>	Leaves, fresh or dried	Bronchitis, respiration, cold, cough, sinusitis, congestion
<i>Myrcianthes discolor</i> (H.B.K.) Vaughn	<i>Lanche, Mirto</i>	Fresh whole plant	Inflammation
<i>Psidium guajava</i> L.	<i>Hoja de Guanábana, Graviola</i>	Leaves and Stem, fresh or dried	Cancer, liver sickness
<i>Syzygium jambos</i> (L.) Alston	<i>Poma Rosa</i>	Fruits and Leaves, fresh	Diarrhoea
<i>Heisteria acuminata</i> (H. & B.) Engler	<i>Chuchuasi, Chuchuhuasi</i>	Bark, fresh or dried	Cold, cough
<i>Ximenea americana</i> L.	<i>Limoncillo</i>	Whole plant, fresh or dried	Stomach ailments
<i>Stelis</i> sp	<i>Huaima-Huaima, Cucharilla</i>	Dried root	Inflammation of ovaries and uterus
<i>Passiflora caerulea</i> L.	<i>Pasionara</i>	Flowers,stem, leaves and	Nerves, insomnia, anxiety
<i>Passiflora ligularis</i> Jus.	<i>Hoja de Granadilla, Granadilla</i>	Leaves,shoots Fruit peel	Inflammation of kidneys, liver Diarrhoea
<i>Passiflora quardrangularis</i> L.	<i>Hojas de Tumbo</i>	Fresh leaves	Liver, stomachache
<i>Gallesia integrifolia</i> (Spreng.) Harms.	<i>Palo de Ajo</i>	Dried stem	Bronchitis
<i>Phytolacca bogotensis</i> H.B.K.	<i>Laylambo, Ilambo</i>	Flowers, Leaves stem	Malaria, dengue, yellow fever
<i>Piper aduncum</i> L.	<i>Yerba del Soldado, Tilonga, Matico, Mogo-Mogo</i>	Leaves, fresh or dried	Cold, fungus, cough, wounds, bronchitis, chills, tuberculosisInfection, inflammation
<i>Plantago linearis</i> H.B.K.	<i>Llantén Serrano, Llantén de la Costa, Llantén</i>	Fresh whole plant, fresh root	Inflammation of wounds, kidneys, and bladder, cough, bronchitis, liver, wounds
<i>Plantago sericea</i> R. & P. var. <i>lanuginosa</i> Grieseb.	<i>Pajilla Blanca</i>	Whole plant, fresh or dried	Vaginal discharge

Table 1— Traditional uses of plants selected for antibacterial bioassays— *Contd*

Plant name	Vernacular name	Plant parts used	Uses
<i>Cenchrus echinatus</i> L.	<i>Abrojo, Cadillo</i>	Fresh whole plant	Inflammation, skin, intestine, liver disease, tumors, gallbladder and urinary disease
<i>Cymbopogon citratus</i> (DC.) Stapf.	<i>Cedron, Hierba Luisa, Maria Luisa</i>	Leaves, roots stem	Cold, cough, flu, cancer
<i>Cynodon dactylon</i> (L.) Persoon	<i>Gramma Dulce</i>	Dried stem	Cysts of ovary and uterus, inflammation of kidney, fibroids
<i>Hordeum vulgare</i> L.	<i>Cebada</i>	Dried seed	Inflammation of kidneys
<i>Triticum sativum</i> L.	<i>Trigo</i>	Dried seed	Vaginal infection and discharge
<i>Polygonum hydropiperoides</i> Michx	<i>Pica Pica</i>	Fresh leaves	Infections
<i>Polypodium crassifolium</i> L.	<i>Lengua de Ciervo, Calagualla</i>	Fresh stem	Inflammation of kidney, prostate, bladder, inflammation of liver and kidneys, ulcer
<i>Laccopetalum giganteum</i> (Wedd.) Ulbrich	<i>Huamanripa, Pacra, Flor de Guarmarya</i>	Leaves, fresh or dried	Cough, bronchitis, flu, cold
<i>Thalictrum decipiens</i> Boivin	<i>Chontilla (Chica)</i>	Dried whole plant	Fever, papera in children, mumps
<i>Cydonia oblonga</i> Miller	<i>Membrillo</i>	Fresh fruit pulp	Vomiting, nausea
<i>Prunus serotina</i> Ehrhart subsp. <i>capuli</i> (Cav.) McVough	<i>Capuli</i>	Fresh whole plant	Wounds of skin
<i>Rubus robustus</i> C. Presl.	<i>Zarzamora, Zarza Parrilla, Mora, Cushai</i>	Flowers, leaves, fresh or dried	Cough, bronchitis, kidney stones, inflammation of kidney and uterus
<i>Cinchona officinalis</i> L.	<i>Cascarilla, Quinuagiro</i>	Flowers, leaves Dried bark	Cough Cold
<i>Uncaria tomentosa</i> (Willdenow ex Roemer & Schultes) DC.	<i>Uña de Gato, Una de Gato de la Selva</i>	Leaves, stem, fresh or dried	Bronchitis, AIDS, allergies, cancer, ulcers, prostate, bladder, wounds (internal), kidney Inflammation
<i>Citrus sinensis</i> (L.) Osbeck	<i>Naranja</i>	Fresh fruit peel	Stomachache
<i>Caprania peruviana</i> Bentham	<i>Flor Arenilla, Te de Indio</i>	Whole plant, fresh or dried	Urine retention, inflammation of urinary tract and kidney
<i>Escobedia grandiflora</i> (L.f.) Kuntze	<i>Azafran</i>	Flowers, dried	Bronchitis, pneumonia, chills (general)
<i>Galvesia fruticosa</i> J. Gmelin	<i>Curil, Macacha</i>	Flowers, leaves, stem	Cold, bronchitis
<i>Cestrum auriculatum</i> L'Herit	<i>Hierba Santa, Agrasejo</i>	Leaves, fresh or dried	Wounds fever typhoid, cough, bronchitis, colic of stomach, liver
<i>Cestrum strigilatum</i> R. & P.	<i>Santa María</i>	Flowers, leaves, stem	Control and regulate menstrual cycle
<i>Lycopersicon hirsutum</i> Dunal	<i>Ambulluco de Muerto</i>	Whole plant, fresh or dried	Fear of death/Susto de muerte
<i>Lycopersicon peruvianum</i> (L.) Mill.	<i>Tomate de Monte</i>	Fresh whole plant	Inflammation (internal), urinary infection
<i>Solanum americanum</i> Mill.	<i>Hierba Mora, Hierba del Susto, Paja del Espanto</i>	Fresh whole plant	Sinusitis, flu, cold, fever, cold sores, mouth blisters, herpes
<i>Solanum melongena</i> L.	<i>Berenjena</i>	Fresh whole fruit	Burn fat, Lose weight
<i>Solanum tuberosum</i> L.	<i>Chuno de Papa</i>	Dried tuber	After childbirth complications, bronchitis, respiratory problems
<i>Theobroma cacao</i> L.	<i>Cacao</i>	Dried fruit peel	Inflammation of the kidneys
<i>Tropaeolum Minus</i> L.	<i>Mastuerzo</i>	Whole plant	Inflammation of the stomach
<i>Pilea microphylla</i> (L.) Lieberman	<i>Contra Hierba</i>	Fresh whole plant	Bladder stone, Inflammation of kidney and prostate, cysts
<i>Urtica magellanica</i> A. Jussieu ex Poiret	<i>Ortiga, Ortiga de Obeja, Ortiga Negra</i>	Whole plant, fresh or dried	Blood purification, inflammation
<i>Urtica urens</i> L.	<i>Ortiga</i>	Fresh stem, leaves	Vaginal cleansing

*Contd* —



Table 1— Traditional uses of plants selected for antibacterial bioassays— *Contd*

Plant name	Vernacular name	Plant parts used	Uses
<i>Clerodendron</i> sp.	<i>Brochamelia</i>	Flowers	Bronchitis, whooping cough
<i>Lippia integrifolia</i> (Grieseb.) Hieron	<i>Poleo del Inca</i>	Fresh leaves and stem	Cold, Colic, Inflammation of the kidneys, Bronchitis
<i>Verbena littoralis</i> H.B.K.	<i>Verbena, Berbena</i>	Whole plant, fresh or dried	Fever, fungus, inflammation, wounds, colic, cold
<i>Tribulus terrestris</i> L.	<i>Abrojo, Cadillo</i>	Whole plant, fresh	gallbladder disease, tumors, liver and urinary disease, inflammation of skin, intestine

Underlined = antibacterial activity

Table 2— Plants active against at least one of the bacteria tested

Plant name	Activity of water extract against <i>E.</i> <i>coli</i> *	Activity of ethanol extract against <i>E.</i> <i>coli</i> *	Activity of water extract against <i>S. E.</i> <i>aureus</i> *	Activity of ethanol extract against <i>S. aureus</i> *	Positive control
<i>Acacia macracantha</i> H.&B.ex Willd.				15mm	***
<i>Acalypha mandoni</i> Müll.-Arg.				11 mm	***
<i>Alchornea castaneifolia</i> (Willd.) Juss.			17mm	16mm	***
<i>Alnus acuminata</i> H.B.K.				14mm	***
<i>Amaranthus hybridus</i> L.				11 mm	***
<i>Ambrosia peruviana</i> Willd.		17 mm		12 mm	***
<i>Arctium lappa</i> L.				15 mm	***
<i>Baccharis ciliaris</i> (Retz.) Koeler				8mm	***
<i>Baccharis latifolia</i> Pers.				12 mm	***
<i>Baccharis salicifolia</i> (Ruiz. & Pav.) Pers.				10 mm	***
<i>Bejaria aestuans</i> L.				15mm	***
<i>Berberis buceronis</i> J.F. Macbr.				21 mm	***
<i>Bixa orellana</i> L.			22 mm	11mm	***
<i>Caesalpinia paipai</i> R. & P.				17mm	***
<i>Caesalpinia spinosa</i> (Molina) Kuntze		10mm		24mm	***
<i>Caprania peruviana</i> Bentham				11mm	***
<i>Cestrum strigilatum</i> Ruiz. & Pav.		13 mm	12 mm	19 mm	***
<i>Chuquiragua spinosa</i> ssp. <i>huamanpinta</i> C. Ezcurra			13mm		***
<i>Citrus sinensis</i> Osbeck				16 mm	***
<i>Clerodendron</i> sp				8mm	***
<i>Coutoubea ramosa</i> Aublet				12mm	***
<i>Crescentia cujete</i> L.		9 mm			***
<i>Cuphea strigulosa</i> H.B.K.				12mm	***
<i>Cydista aequinoctialis</i> Miers		7 mm		21 mm	***
<i>Cydonia oblonga</i> Miller				11mm	***
<i>Cynara cardunculus</i> .L.				14 mm	***
<i>Desmodium molliculum</i> (H.B.K.) DC.				8mm	***
<i>Dioscorea tambillensis</i> Kunth				9mm	***
<i>Dioscorea trifida</i> L.f.				8mm	***
<i>Escobedia grandiflora</i> (L.f.) Kuntze				22mm	***
<i>Eucalyptus citriodora</i> Hooker				21mm	***
<i>Eucalyptus globulus</i> Labill.				20mm	***
<i>Eugenia obtusifolia</i> Cambes.				15mm	***

*Contd* —

Table 2—Plants active against at least one of the bacteria tested —*Contd*

Plant name	Activity of water extract against <i>E. coli</i> *	Activity of ethanol extract against <i>E. coli</i> *	Activity of water extract against <i>S. E. aureus</i> *	Activity of ethanol extract against <i>S. aureus</i> *	Positive control
<i>Eustephia coccinea</i> Cav.			8mm	7mm	***
<i>Flaveria bidentis</i> (L.) Kuntze			10mm	9mm	***
<i>Foeniculum vulgare</i> P. Miller				8mm	***
<i>Gallesia integrifolia</i> (Spreng.) Harms				19 mm	***
<i>Gaultheria erecta</i> Vent.				13mm	***
<i>Gentianella bicolor</i> (Wedd.) J. Pringle				18mm	***
<i>Gentianella bruneotricha</i> (Gilg.) J.S. Pringle.			9mm		***
<i>Geranium ayavacense</i> Willd. ex H.B.K.				12mm	***
<i>Geranium sessiliflorum</i> Cavanilles			8mm	18mm	***
<i>Heisteria acuminata</i> (H.&B.) Engler				14mm	***
<i>Hypericum silenoides</i> Juss.				13 mm	***
<i>Ilex guayusa</i> Loes			14mm	14mm	***
<i>Ipomoea pauciflora</i> M. Martens & Galeotti			10 mm	16 mm	***
<i>Iresine herbstii</i> Hook.		10 mm		16 mm	***
<i>Krameria lappacea</i> (Dombey) H.M. Burdet & B.B. Simpson		12 mm		15 mm	***
<i>Laccopetalum giganteum</i> (Wedd.) Ulbrich				9mm	***
<i>Leucaena leucocephala</i> (Lam.) De Wit		7mm			***
<i>Lycopersicon hirsutum</i> Dunal				26 mm	***
<i>Malesherbia ardens</i> J.F. Macbr.				9 mm	***
<i>Mauria heterophylla</i> H.B.K.		14mm		17mm	***
<i>Mentha piperita</i> Stokes				6 mm	***
<i>Mentha spicata</i> L.				12mm	***
<i>Myrcianthes discolor</i> (Kunth.) McVaugh				16 mm	***
<i>Myroxylon balsamum</i> (L.) Harms				12mm	***
<i>Niphogeton dissecta</i> J.F. Macbr.		16 mm		10 mm	***
<i>Oreopanax eriocephalus</i> Harms				8mm	***
<i>Oritrophium peruvianum</i> (Lam.) Cuatrec.				14mm	***
<i>Otholobium glandulosum</i> (L.) Grimes				10mm	***
<i>Passiflora ligularis</i> Jus.			12mm	8mm	***
<i>Pelargonium odoratissimum</i> (L.) L'Herit				8mm	***
<i>Persea americana</i> Mill.				9mm	***
<i>Petroselinum crispum</i> (Miller) A.W. Hill.				15 mm	***
<i>Peumus boldus</i> Molina			13mm	15mm	***
<i>Phyllanthus niuriri</i> L.		9mm		12mm	***
<i>Phyllanthus urinaria</i> L.			15mm	14mm	***
<i>Phytolacca bogotensis</i> H.B.K.			17mm	7mm	***
<i>Pilea microphylla</i> (L.) Lieberman			10mm	8mm	***
<i>Piper aduncum</i> L.		12mm			***
<i>Plantago linearis</i> Kunth.				10 mm	***
<i>Plantago sericea</i> R. & P. var. <i>lanuginosa</i> Grieseb.				19mm	***
<i>Polygonum hydropiperoides</i> Michaux				9mm	***

*Contd* —

Table 2—Plants active against at least one of the bacteria tested —Contd

Plant name	Activity of water extract against <i>E. coli</i> *	Activity of ethanol extract against <i>E. coli</i> *	Activity of water extract against <i>S. E. aureus</i> *	Activity of ethanol extract against <i>S. aureus</i> *	Positive control
<i>Prosopis pallida</i> (Humb. & Bonpl. ex =Willd.) Kunth.				15 mm	***
<i>Prunus serotina</i> Ehrh.				12 mm	***
<i>Psidium guajava</i> L.				7 mm	***
<i>Rorippa nasturtium-aquaticum</i> (L.) Hayek				7mm	***
<i>Rubus robustus</i> C. Presl				10mm	***
<i>Salvia cuspidata</i> Ruiz. & Pav.				18 mm	***
<i>Salvia discolor</i> H.B.K.				13mm	***
<i>Salvia sagittata</i> Ruiz. & Pav.				12 mm	***
<i>Sambucus nigra</i> L.				6 mm	***
<i>Schinus molle</i> L.	12mm			14mm	***
<i>Schkuhria pinnata</i> (Lam.) Kuntze		12mm			***
<i>Senecio canescens</i> (H.B.K.) Cuatrec.				8mm	***
<i>Senecio chionogeton</i> Wedd.		13 mm		18 mm	***
<i>Solanum americanum</i> Mill.				16mm	***
<i>Spartium junceum</i> (L.) Harms				12mm	***
<i>Stachys lanata</i> Jacq.				12 mm	***
<i>Syzygium jambos</i> (L.) Alston				13 mm	***
<i>Tagetes elliptica</i> Sm.				13mm	***
<i>Tagetes erecta</i> L.				20 mm	***
<i>Taraxacum officinale</i> Wiggers				20mm	***
<i>Thalictrum decipiens</i> B. Bovin		12 mm		14 mm	***
<i>Thymus vulgaris</i> L.				16 mm	***
<i>Tropaeolum minus</i> L.				17mm	***
<i>Uncaria tomentosa</i> DC.		8 mm		10 mm	***
<i>Verbena littoralis</i> H.B.K.				12mm	***
<i>Ximenia americana</i> L.		12 mm		10 mm	***

\*\*\* Positive control: at least 7mm inhibition ring against bacteria tested

remaining 10 species were closely related but were not used as antibacterial in traditional medicine. Only four species (2.4%) were solely active against *Escherichia coli*. All of these plant species were used for antibacterial purposes in traditional healing. Finally, sixteen species (9.7%) showed activity against both bacteria; 13 were used for this purpose by traditional healers, and only three were closely related species. Only one species (*Schinus molle*) showed activity against *E. coli* in the water extract, while 15 water extracts were active against *S. aureus*. Of these, two species (*Chuquiragua spinosa* ssp *huamanpinta*, *Gentianella brueneotricha*) were only active as water extract.

Altogether 101 (68.2%) of the plant species used by traditional healers were effective against at least one of the bacterial strains tested. Thirteen (76.5%) of

the 19 closely related species that were not used in a traditional context were found to have experimental antibacterial activity. This indicates that taking traditional uses into account it provides a good lead for the scientific assessment of efficacy. Even the species not used traditionally for this purpose were part of the local pharmacopoeia, although mostly used for preparations that were applied topically, and not just randomly selected. It would be highly interesting to assess whether there is any specific reason (e.g. high toxicity) that would explain why these species are not being used. Especially in taxonomically complicated genera (e.g. *Baccharis*, *Senecio*, *Gentianella*, *Passiflora*, *Solanum*), the closely related species that were not used also did not show any efficacy, indicating selective selection of species for the treatment. Many of the *inactive* species were

employed against bronchitis, inflammations, coughs and colds, which could be caused by an underlying bacterial infection. These species, while not showing any direct antibacterial activity, might prove interesting leads for anti-inflammatory compounds. The study confirms that simple laboratory methods are very well suited to assess the efficacy of traditionally used medicinal plants to inhibit bacterial growth. A comparison to the traditional uses also indicated that local knowledge can give important leads for the development of new treatments. Further tests, especially with regard to toxicity, are needed to verify the safety of the traditional preparations.

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