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# Bioactivities of extracts and isolated compounds of *Vachellia leucophloea* (Roxb.) Maslin, Seigler & Ebinger

Saravanan Vivekanandarajah Sathasivampillai[1,2*], Pholtan Rajamanoharan[3]

[*1] *KnowledgeLink Group, Inc., Waltham, MA 02451, USA*
[2] *Boigai Institute, Batticaloa 30000, Sri Lanka*
[3] *Provincial Herbal Garden Management Center, Trincomalee 31000, Sri Lanka*

*Corresponding author : vivekanandarajahs@yahoo.co.uk
Orcid No: https://orcid.org/0000-0002-5938-0509

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**Abstract:** *Vachellia leucophloea* (Roxb.) Maslin, Seigler & Ebinger is a tree that fits into the *Fabaceae* family. *V. leucophloea* has been applied to heal including bronchitis, diabetes, high cholesterol, leprosy, and snakebite. Phytochemicals including betulinic acid-3-O-β-d-maltoside; $\Delta^7$-avenasterol; leucophleol; leucophleoxol; and leucoxol; have been isolated from bark, root, and leaf of this plant species. This systematic review article purposes to evaluate, outline, and document the bioactivities associated with available researches involving *V. leucophloea*. PubMed, Semantic Scholar, Scopus, ScienceDirect, and Web of Science electronic records were employed to find the applicable available works from 1900 to June 2021. So far, *in vivo* and *in vitro* scientific evidence is presently existing for several bioactivities. To date, antidiabetic, antidiarrheal, antihyperlipidemic, antipyretic, wound healing, antibacterial, antidementia, antifungal, antiinflammatory, antioxidant, antiplatelet, and bronchorelaxant activities have been scientifically demonstrated for different parts of this plant species. Only an antidiabetic compound {(-)-Fisetinidol-(4α,8)-[(-)-fisetinidol-(4α,6)]-(+)-catechin} has been isolated from this plant species. Further *in vitro, in vivo,* and clinical studies of various traditional medicinal uses of *V. leucophloea* should be investigated as well as the bioactive compounds should be identified.

**Keywords:** *Vachellia leucophloea, Acacia leucophloea, Fabaceae,* bioactivity, antioxidant activity



## 1. Introduction

*Vachellia leucophloea* (Roxb.) Maslin, Seigler & Ebinger [synonyms: *Acacia leucophloea* (Roxb.) Willd. and *Mimosa leucophloea* Roxb.; Accepted Infraspecifics: *Vachellia leucophloea* var. *leucophloea* and *Vachellia leucophloea* var. *microcephala* (Kurz) Maslin, Seigler & Ebinger] is a tree that fits into the *Fabaceae* family. It is called வெள்வேல் (Velvel) in Tamil / Siddha Medicine; Arimanja, Arimedaka, Godhaa-skandha, Raamaka, Arimeda, Irimeda, and Vitakhadir in Ayurveda; Kath Safed, Guyaa Babuul, and Vilaayati Babuul in Unani; and Distiller's acacia in English. *V. leucophloea* is native to Asia (Sri Lanka, India, Vietnam, Bangladesh, Myanmar, Thailand, Indonesia, and Pakistan) and has been introduced into Africa (Mauritius and Tanzania) and South America (Trinidad-Tobago). This plant species is used to make chemical products, fiber, food (human and animal), drink (human and animal), medicine, and used for wood (Global Biodiversity Information Facility 2021; Kew Science 2021; Khare 2007). This plant species has been applied to heal including bleedings, bronchitis, constipation, cough, dental cavity, diabetes, diarrhea, dysentery, fevers, gingivitis, high cholesterol, indigestion, leprosy, nausea, snakebite, sore throat, and wounds (Bhadoria and Gupta 1981; Khare 2007; Sathasivampillai et al. 2017, 2018, 2016, 2015; Suriyamoorthy et al. 2012). Phytochemicals including betulinic acid-3-O-β-d-maltoside; linoleic acid; oleic acid; γ-tocopherol; β-tocopherol; β-sitosterol; $\Delta^7$-avenasterol; myricetin; quercetin; leucophleol; leucophleoxol; leucoxol; catechin; O-methyl epicatechin; gallic acid; leuco-fisetinidin; ferulic acid; and syringic acid have been isolated from bark, root, and leaf of *V. leucophloea* (Del Carmen Apreda Rojas et al. 2001; Mishra and Srivastava 1985; Saxena and Srivastava 1986; Sulaiman et al. 2016; Valsakumari and Sulochana 1991; Zia-Ul-Haq et al. 2013).

This systematic review article purposes to evaluate, outline, and document the bioactivities associated with available researches involving *V. leucophloea*. This article will be

advantageous for the scholars who are concerned to perform forthcoming bioactivities and phytochemical linked researches employing this plant species.

## 2. Materials and Methods

PubMed, Semantic Scholar, Scopus, ScienceDirect, and Web of Science electronic records were employed to find the applicable available works from 1900 to June 2021. "*Vachellia leucophloea*", "*Acacia leucophloea"*, "*Mimosa leucophloea*", "*Vachellia leucophloea* var. *leucophloea",* and "*Vachellia leucophloea* var. *microcephala"* were applied as exploration terms, and only bioactivities interrelated to available works were taken into account in this research article.

## 3. Results and discussion

### 3.1. Reported bioactivities of various parts of *V. leucophloea*

Table 1 presents the Level of scientific evidence, bioactivity, part used, extract / fraction / compound, assay / model, dose / concentration, and reference of available bioactivities linked studies of *V. leucophloea*. So far, *in vivo* and *in vitro* scientific evidence is presently existing for several bioactivities. Though, more *in vitro* scientific evidence is available at the moment. To date, antidiabetic, antidiarrheal, antihyperlipidemic, antipyretic, wound healing, antibacterial, antidementia, antifungal, antiinflammatory, antioxidant, antiplatelet, and bronchorelaxant activities have been scientifically demonstrated for different parts of this plant species (Bobade 2020; Doss et al. 2012; Gupta et al. 2011, 2012; Imram et al. 2014; Imran et al. 2011, 2012; Jhade et al. 2012; Koppula and Koppula 2012; Madhavi et al. 2014; Shahid and Firdous 2012; Sowndhararajan et al. 2016; Sulaiman et al. 2013; Suriyamoorthy et al. 2012; Zia-Ul-Haq et al. 2013). Among these reported bioactivities, antibacterial and antioxidant activities have the most number of published works. Antidiabetic, antidiarrheal, antihyperlipidemic, antipyretic, and wound healing activities have only *in vivo* evidence, whereas, antibacterial, antidementia, antifungal, antiinflammatory, antioxidant, antiplatelet, and bronchorelaxant activities have only *in vitro* evidence. None of the reported bioactivity has both *in vitro* and *in vivo* evidence. Plant parts bark, flower, leaf, and root of *V. leucophloea* have been used to study various bioactivities. Anyway, bark has been used in the majority of the investigations. Thus far, only an antidiabetic compound {(-)-Fisetinidol-(4α,8)-[(-)-fisetinidol-(4α,6) ]-(+)-catechin} has been isolated from this plant species (Ahmed et al. 2014). At the moment, traditional medicinal uses to treat such as bronchitis, diabetes, diarrhea, fevers, wounds, and high cholesterol have scientific evidence (Imram et al. 2014; Imran et al. 2011; Madhavi et al. 2014; Suriyamoorthy et al. 2012). On the other hand, other traditional medicinal treatments for constipation, dysentery, leprosy, nausea, and snakebite, have no scientific evidence at the moment. Only noteworthy reported investigations which used the lowest concentration / dose used are deliberated in detail under.

### 3.2. Reported *in vivo* bioactivities

#### 3.2.1. Antidiabetic activity

Ethanol extract prepared using bark was orally administered to Streptozotocin-Nicotinamide-induced diabetic rats at 200 mg/kg for 14 days. The results showed that there was a significant reduction in elevated blood glucose concentrations. Glibenclamide at a dose of 10 mg/kg was used as a standard drug in this study (Madhavi et al. 2014).

#### 3.2.2. Antidiarrheal activity

In a study conducted by Imran et al. (2011), 100 mg/kg bark methanol (80%) extract was orally administered to castor oil-induced diarrheal mice. After one hour, it was observed that there was a protective property against diarrhea. Loperamide (10 mg/kg) was used aa a standard medication in this investigation (Imran et al. 2011).

#### 3.2.3. Antihyperlipidemic activity

Bark ethanol extract (400 mg/kg) was orally administered to Streptozotocin-nicotinamide-induced diabetic rats for 14 days. It was noticed that there was a reduction in the increased triglycerides, total cholesterol, low-density lipoprotein cholesterol, and Very-low-density lipoprotein cholesterol levels. Glibenclamide at a dose of 10 mg/kg was used as a standard drug in this study (Madhavi et al. 2014).

#### 3.2.4. Antipyretic activity

Antipyretic activity of methanol extract of bark (100 mg/kg) was studied in yeast-induced pyrexia mice. After 30 minutes, it was observed that the increased temperature of 38.24 °C was reduced to 37.97 °C. Paracetamol at a dose of 10 mg/kg was used as a standard drug in this study (Gupta et al. 2012).

#### 3.2.5. Wound healing activity

Suriyamoorthy et al. (2012) investigated applied an ointment containing 2% of bark ethanol extract to excision and incision wounds in rats. It was detected that the wounds were contracted and there was a significant wound healing effect. Betadine ointment was employed as a standard medication in this investigation (Suriyamoorthy et al. 2012).

### 3.2. Reported *in vitro* bioactivities

#### 3.2.1. Antibacterial activity

Leaf methanol extract at 25 mg/ml concentration revealed the antibacterial activity in the *Escherichia coli* assay. Ciprofloxacin was used as a positive control at 0.31 µg/ml concentration in this study (Gupta et al. 2011).

#### 3.2.2. Antidementia activity

Sulaiman et al. (2013) researched the antidementia activity of ethanol (50%) extract in acetylcholinesterase inhibitory assay. Results exhibited that 1 mg/ml was an effective concentration in this research. Anyway, the authors did not state the plant part and the positive control used in this research (Sulaiman et al. 2013).

**Table 1** Reported bioactivities of *V. leucophloea*

| Level of scientific evidence | Bioactivity | Part used | Extract / compound | Assay / model | Dose / concentration | Reference |
|---|---|---|---|---|---|---|
| *In vivo* | Antidiabetic | Bark | Ethanol | Streptozotocin-Nicotinamide-induced diabetic | 200 mg/kg | (Madhavi et al. 2014) |
| *In vivo* | Antidiarrheal | Bark | Methanol (80%) | Castor oil-induced diarrheal | 100 mg/kg | (Imran et al. 2011) |
| *In vivo* | Antihyperlipidemic | Bark | Ethanol | Streptozotocin-nicotinamide-induced diabetic | 400 mg/kg | (Madhavi et al. 2014) |
| *In vivo* | Antipyretic | Bark | Methanol | Yeast-induced pyrexia | 100 mg/kg | (Gupta et al. 2012) |
| *In vivo* | Wound healing | Bark | Ethanol | Excision wound, Incision wound | 2% | (Suriyamoorthy et al. 2012) |
| *In vitro* | Antibacterial | Bark | Aqueous, Methanol | *Bacillus subtilis, Escherichia coli, Klebseilla pneumonia, Proteus vulgaris, Pseudomonas florescence* | NS | (Koppula and Koppula 2012) |
| *In vitro* | Antibacterial | Flower | Methanol | *Bacillus subtilis* | 8 mg | (Shahid and Firdous 2012) |
| *In vitro* | Antibacterial | Flower | Methanol | *Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhi, Staphylococcus aureus* | 9 mg | (Shahid and Firdous 2012) |
| *In vitro* | Antibacterial | Leaf | Aqueous | *Staphylococcus aureus, Streptococcus agalactiae* | 100 mg/ml | (Doss et al. 2012) |
| *In vitro* | Antibacterial | Leaf | Methanol | *Cutibacterium acnes, Escherichia coli, Salmonella typhi, Staphylococcus aureus* | NS | (Bobade 2020) |
| *In vitro* | Antibacterial | Leaf | Methanol | *Staphylococcus aureus* | 100 mg/ml | (Doss et al. 2012) |
| *In vitro* | Antibacterial | Leaf | Methanol | *Streptococcus agalactiae* | 200 mg/ml | |
| *In vitro* | Antibacterial | Leaf | Methanol | *Bacillus Subtilis, Pseudomonas aeruginosa* | 75 mg/ml | (Gupta et al. 2011) |
| *In vitro* | Antibacterial | Leaf | Methanol | *Escherichia coli* | 25 mg/ml | |
| *In vitro* | Antibacterial | Leaf | Methanol | *Staphylococcus aureus* | 50 mg/ml | |
| *In vitro* | Antibacterial | Pod | Methanol | *Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi, Staphylococcus aureus* | 7 mg | (Shahid and Firdous 2012) |
| *In vitro* | Antibacterial | Pod | Methanol | *Proteus mirabilis* | 6 mg | |
| *In vitro* | Antibacterial | Root | Methanol | *Bacillus subtilis, Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhi, Staphylococcus aureus* | 13 mg | |
| *In vitro* | Antibacterial | Seed | Methanol | *Bacillus subtilis* | 5 mg | |

| Level of scientific evidence | Bioactivity | Part used | Extract / compound | Assay / model | Dose / concentration | Reference |
|---|---|---|---|---|---|---|
| *In vitro* | Antibacterial | Seed | Methanol | *Escherichia coli, Proteus mirabilis, Pseudomonas aeruginosa, Salmonella typhi, Staphylococcus aureus* | 6 mg | |
| *In vitro* | Antidementia | NS | Ethanol (50%) | Acetylcholinestrase inhibitory | 1 mg/ml | (Sulaiman et al. 2013) |
| *In vitro* | Antidiabetic | Bark | (-)-Fisetinidol-(4α,8)-[(-)-fisetinidol-(4α,6)]-(+)-catechin | α-Glucosidase inhibitory | 102.3 µM ($IC_{50}$) | (Ahmed et al. 2014) |
| *In vitro* | Antifungal | Flower | Methanol | *Aspergillus effusus, Aspergilus niger, Aspergilus parasiticus, Saccharomyces cerevisiae* | 12 mg | (Shahid and Firdous 2012) |
| *In vitro* | Antifungal | Flower | Methanol | *Candida albicans* | 11 mg | |
| *In vitro* | Antifungal | Flower | Methanol | *Fusarium solani* | 9 mg | |
| *In vitro* | Antifungal | Pod | Methanol | *Aspergillus effusus, Aspergilus niger, Aspergilus parasiticus, Saccharomyces cerevisiae, Fusarium solani* | 8 mg | |
| *In vitro* | Antifungal | Pod | Methanol | *Candida albicans* | 7 mg | |
| *In vitro* | Antifungal | Root | Methanol | *Aspergillus effusus, Aspergilus niger, Aspergilus parasiticus, Candida albicans, Fusarium solani, Saccharomyces cerevisiae* | 16 mg | |
| *In vitro* | Antifungal | Seed | Methanol | *Aspergillus effusus, Aspergilus niger, Aspergilus parasiticus, Fusarium solani* | 9 mg | |
| *In vitro* | Antifungal | Seed | Methanol | *Candida albicans, Saccharomyces cerevisiae* | 10 mg | |
| *In vitro* | Antiinflammatory | Bark | Acetone | Lipopolysaccharide-stimulated RAW 264.7 macrophage cell | 25 µg/ml | (Sowndhararajan et al. 2016) |
| *In vitro* | Antioxidant | Bark | Methanol (80%) | Ferric reducing antioxidant power | 2234.43 µmol/g | (Imram et al. 2014) |
| *In vitro* | Antioxidant | Bark | Methanol (80%) | Total radical-trapping antioxidant parameter | 90.91 µmol/g | |
| *In vitro* | Antioxidant | Bark | Methanol (80%) | Trolox equivalent antioxidant capacity | 682.95 µmol/g | |
| *In vitro* | Antioxidant | Leaf | Methanol | DPPH free radical scavenging | 1000 µg/ml | (Bobade 2020) |
| *In vitro* | Antioxidant | Leaf | Methanol (80%) | Ferric reducing antioxidant power | 233.17 µmol/g | (Zia-Ul-Haq et al. 2013) |
| *In vitro* | Antioxidant | Leaf | Methanol (80%) | Total radical-trapping antioxidant parameter | 68.39 µmol/g | |
| *In vitro* | Antioxidant | Leaf | Methanol (80%) | Trolox equivalent antioxidant capacity | 543.03 µmol/g | |

| Level of scientific evidence | Bioactivity | Part used | Extract / compound | Assay / model | Dose / concentration | Reference |
|---|---|---|---|---|---|---|
| *In vitro* | Antioxidant | NS | Ethanol (50%) | ABTS radical scavenging | 0.36 mmol/l | (Sulaiman et al. 2013) |
| *In vitro* | Antioxidant | NS | Ethanol (50%) | DPPH free radical scavenging | 18.38 µg/ml ($EC_{50}$) | |
| *In vitro* | Antioxidant | NS | Ethanol (50%) | Nitric Oxide quenching capacity | 10 µg | |
| *In vitro* | Antioxidant | Pod | Methanol (80%) | Ferric reducing antioxidant power | 254.42 µmol/g | (Zia-Ul-Haq et al. 2013) |
| *In vitro* | Antioxidant | Pod | Methanol (80%) | Total radical-trapping antioxidant parameter | 76.02 µmol/g | |
| *In vitro* | Antioxidant | Pod | Methanol (80%) | Trolox equivalent antioxidant capacity | 683.23 µmol/g | |
| *In vitro* | Antioxidant | Root | Aqueous, Ethanol, Petroleum ether | Superoxide radical scavenging | 50 µg/ml | (Jhade et al. 2012) |
| *In vitro* | Antioxidant | Seed | Methanol (80%) | Ferric reducing antioxidant power | 178.14 µmol/g | (Zia-Ul-Haq et al. 2013) |
| *In vitro* | Antioxidant | Seed | Methanol (80%) | Total radical-trapping antioxidant parameter | 49.14 µmol/g | |
| *In vitro* | Antioxidant | Seed | Methanol (80%) | Trolox equivalent antioxidant capacity | 529.66 µmol/g | |
| *In vitro* | Antiplatelet | Bark | Methanol | Adenosine 5' diphosphate-induced human platelet | 0.83 mg/ml ($IC_{50}$) | (Imran et al. 2012) |
| *In vitro* | Bronchorelaxant | Bark | Methanol (80%) | Guinea pig ileum | 0.3 mg/ml | (Imran et al. 2011) |
| *In vitro* | Bronchorelaxant | Bark | Methanol (80%) | Isolated rabbit jejunum | 0.1 mg/ml | (Imran et al. 2011) |

Abbreviation:
ABTS: (3-ethylbenzothiazoline-6-sulphonic acid); DPPH: 2,2-diphenyl-1-picrylhydrazyl; $EC_{50}$: Half maximal effective concentration; FRAP: Ferric Reducing Antioxidant Power; $IC_{50}$: Half maximal inhibitory concentration; NS: Not Stated

**3.2.3. Antifungal activity**
Methanol extract of the pod (7 mg) showed the antifungal activity in the *Candida albicans* assay. Both Itraconazole (2 mg) and Amphotericin B (2 mg) were applied as a positive control in this investigation (Shahid and Firdous 2012).

**3.2.4. Antiinflammatory activity**
Acetone was used to prepare the extract of bark and antiinflammatory activity was studied in the lipopolysaccharide-stimulated RAW 264.7 macrophage cell line. Outcomes revealed that 25 µg/ml was the effective concentration in this study (Sowndhararajan et al. 2016).

**3.2.5. Antioxidant activity**
An investigation carried out by Jhade et al. (2012) unveiled that aqueous, ethanol, and petroleum ether extracts of root at 50 µg/ml concentration showed antioxidant activities in superoxide radical scavenging assay. Ascorbic acid was employed as a standard drug in this investigation. However, the authors did not mention the concentration of the standard drug used in this investigation (Jhade et al. 2012).

**3.2.6. Antiplatelet activity**
Bark methanol extract at $IC_{50}$ of 0.83 mg/ml exhibited antiplatelet activity in adenosine 5' diphosphate-induced human platelet assay. Besides, the authors did not mention the name and concentration of the standard drug used in this research (Imran et al. 2012).

### 3.2.7. Bronchorelaxant activity

Imran et al. (2011) revealed the bronchorelaxant activity of bark methanol (80%) extract in isolated rabbit jejunum assay at a concentration of 0.1 mg/ml. Both Nifedipine and Dicyclomine were applied as positive controls in this study. Again, the authors did not state the concentration of the positive control used in this study (Imran et al. 2011).

## 4. Conclusion

*V. leucophloea* has a great number of traditional medicinal uses although, only some of these utilizations have scientific evidence at the moment. Therefore, further *in vitro*, *in vivo*, and clinical studies of various traditional medicinal uses of this plant species should be investigated as well as the bioactive compounds should be identified. The reaction mechanism of the bioactive extracts and bioactive compounds of this plant species also should be further studied in detail. These bioactive compounds might be lead compound candidates in future drug discovery programs. This systematic review article evaluated, outlined, and documented the bioactivities associated with available researches involving *V. leucophloea*.

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**Authors' contributions:** Both authors contributed equally to this work.

## Conflict of interest

The authors declare that there is no conflict of interest.

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