

Medicinal uses, chemical constituents and biological activities of *Rumex abyssinicus*: A Comprehensive review

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Abstract: *Rumex abyssinicus* is a valuable medicinal plant species that is native to tropical Africa. Traditionally, *R. abyssinicus* is used to treat different disease such as, liver diseases, hepatitis, malaria, scabies, blood pressure, jaundice, wound and pneumonia. The purpose of the current study was to review the literature on the ethnomedicinal uses, chemical constituents and biological activities of *R. abyssinicus* in an attempt to create information for future studies aimed towards exploring the therapeutic ability of the species. A scientific search engines, namely Google Scholar, PubMed, Scopus, Science Direct and Web of knowledge for the search terms: *Rumex abyssinicus*, ethnomedicinal studies, phytochemical investigations, and pharmacological activities were undertaken. The search strategy included all articles with descriptors that were available until December 30, 2021. Only published works in English have been used on this study. The data was collected using textual descriptions of the studies, tabulation, grouping, and figures. The principal phytochemicals of *R. abyssinicus* are anthraquinones, flavonoids, terpenoids and phenolic compounds. The *in vitro* and *in vivo* studies on the crude extracts and compounds of *R. abyssinicus* showed antibacterial, antioxidant, anticancer, anti-inflammatory, antifungal, wound healing, anti-alzheimer's and hepatoprotective activities of it. *R. abyssinicus* afforded drug leads such as helminthosporin (**4**) with anti-alzheimer and physicon (**3**) with antifungal and antioxidant activity. *R. abyssinicus* have traditionally been used to cure a variety of diseases. Pharmacological actions of phytochemicals were shown to be promising. Despite this, further studies on crude extracts and promising compounds are needed to find new drug candidates.

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1. INTRODUCTION

Rumex abyssinicus is a flowering plant (genus: *Rumex*, family: *Polygonaceae*) native to tropical Africa. Often used in traditional African medicine for the treatment of hepatitis, asthma, stomachache, anthrax, hypertension, pneumonia, cancer and Diabetes Mellitus (Gorsi & Miraj, 2002; Mishra *et al.*, 2018). It is a perennial plant with a thick, fleshy rhizome that develops up to three meters tall. The plant grows in a variety of soils, from mild loam to clay loam, but

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favors sufficiently heavy soils that retain moisture. It can grow in any soil pH condition, including acid, neutral, and alkaline soils, and in semi-shade or no-shade areas. The plant's leaves is usually sagittate, and the inflorescence and lots of branches. The plant is propagated by means of seeds (Awas, 2007). It is medicinal and meals additive plant. The shoots and leaves are safe to eat, and the tuber can be used as a tea to help with meal insecurity (Duguma, 2020; Hassen, 2021). The rhizomes have been used to refine butter, giving it a deep yellow color, while the roots are utilized for therapy (Mekonnen *et al.*, 2010). In Ethiopia, *R. abyssinicus* (makmeko in Amharic) is widely distributed species with wide spectrum of ethnomedicinal uses such as hepatitis, hypertension, tuberculosis, jaundice and high blood pressure (Tsegay *et al.*, 2019; Tuasha *et al.*, 2018). Given the species' established ethnomedicinal use, *R. abyssinicus* has the potential to promote a vital task in community primary healthcare across its natural distribution. As a result, the goal of this review was to get an in-depth assessment of existing data and literature on *R. abyssinicus*' medicinal benefits, chemical constituents, and biological activities in order to compile a database of records that could be used in future studies aimed at determining the species' therapeutic potential.

Figure 1. Leave and steam parts of *R. abyssinicus* (Workneh, 2017).



2. METHODOLOGY OF THE REVIEW

A scientific search engines, namely Google Scholar, PubMed, Scopus, Science Direct and Web of knowledge for the search terms: *Rumex abyssinicus* and synonyms of the species, ethnomedicinal studies, phytochemical investigations, and pharmacological activities were undertaken. The search strategy included all articles with descriptors that were available until December 30, 2021. Only published works in English have been used on this study. The data was collected using textual descriptions of the studies, tabulation, grouping, and figures. The worldwide plant name index (<https://www.ipni.org>) and the Kew Botanical Garden plant name database (<https://www.kew.org>) were used to check species names and its synonyms.

3. ETHNOMEDICINAL USES

Throughout the species' distributional area, the leaves, fruits, roots, rhizomes, and stem are said to have numerous traditional medicinal characteristics and treat a variety of human and animal ailments (Table 1). In Ethiopia the root decoction of *R. abyssinicus* macerated with water and taken orally as remedy of liver diseases (Gabriel & Guji, 2014). In Uganda, chewing *R. abyssinicus* leaves is used to treat gynecological morbidity and allergies (Gumisiriza *et al.*, 2021; Kamatenesi-Mugisha *et al.*, 2007). The majority of the *R. abyssinicus* remedies are used as mono therapies indicated in (Table 1). However, multi therapies/ a mixture of dry leaf of *R. abyssinicus* with leaf of *Zehneria scabra* is pounded, powdered, mixed with milk and boiled, then drunk when it is cooled for malaria remedy (Omara, 2020).

Table 1. Ethnomedicinal uses and preparation methods of different parts of *R. abyssinicus*

Disease Treated	Parts Used	Method of Preparation	Country Practiced	Ref.
Hepatitis	Root, Aerial parts	The roots are crushed, powdered, and mixed with bat meat that has been dried and powdered, then eaten once or twice. The fluid is ingested after chewing the roots.	Ethiopia	(Limenih <i>et al.</i> , 2015; Novotna <i>et al.</i> , 2020; Suleman & Alemu, 2012; Tegen <i>et al.</i> , 2021)
Liver disease,	Root	Orally, the root is mashed, macerated with water, and consumed or Powdered and drunk 1 tea cup with coffee/tea	Ethiopia	(Etana, 2010; Gabriel & Guji, 2014)
Gonorrhea	Root	Pounding the fresh roots, boiling, adding butter and drinking one water glass daily until cured.	Ethiopia	(Eshete <i>et al.</i> , 2016)
TB	Root	steeping the fresh/dried root in boiled water and drunk a cup of the resulting decoction	Ethiopia	(Gidey <i>et al.</i> , 2015)
Bone Tuberculosis	Root	The paste is softened with cow butter	Ethiopia	(Moravec <i>et al.</i> , 2014)
Scabies	Leaves	Fresh leaves are pulverized and blended and applied to the injured area	Ethiopia	(Megersa, 2010)
Malaria	Leaves	The dry leaves of <i>R. abyssinicus</i> and <i>Z. scabra</i> are powdered, combined with milk, and boiled, then cooled or consumed orally as a decoction	Ethiopia, Kenya	(Eskedar, 2011; Omara, 2020)
Gynecological morbidity	Leaves/ Steams	Chewing, Squeezing and boiling	Uganda	(Kamatenesi-Mugisha <i>et al.</i> , 2007)
Allergy	Leaves	Chewing	Uganda	(Gumisiriza <i>et al.</i> , 2021)
Heamaturia	Roots	Pounding	Ethiopia	(Dinbiso <i>et al.</i> , 2020)
Eye infections	Leaves	Eye drops/ boiled	Kenya	(Odongo <i>et al.</i> , 2018)
Hypertension	Leaves	The dried leaves is boiled in water and the liquid is consumed	Ethiopia	(Tsegay <i>et al.</i> , 2019)
Ascariasis	Root	Pulverized the root, mixed it with a small amount of water, and drank the solution	Ethiopia	(Dalle, 2019; Getu, 2017; Khan <i>et al.</i> , 2018)
Fungal and bacterial infection	Leaves/ Steams	Chewing, pounding and Smearing	Uganda	(Kamatenesi-Mugisha <i>et al.</i> , 2008)
Breast cancer	Rhizome	Concoction taken oral	Ethiopia	(Bussa & Belayneh, 2019)
Amoeba	Root	Fresh root crush, mix with tea/milk and drink	Ethiopia	(Regassa, 2013; Sina & Degu, 2015)
Gonorrhea	Root	Infusion/ decoction	Ethiopia, Rwanda	(Silva <i>et al.</i> , 2020; Teka <i>et al.</i> , 2020)
Liver complaint, Kidney problem	Root	Infusion/ decoction	Ethiopia	(Teka <i>et al.</i> , 2020)
Syphilis	Leaves	pound and mixed with water and drunk, 150mL 3x daily	Uganda	(Gumisiriza <i>et al.</i> , 2019)

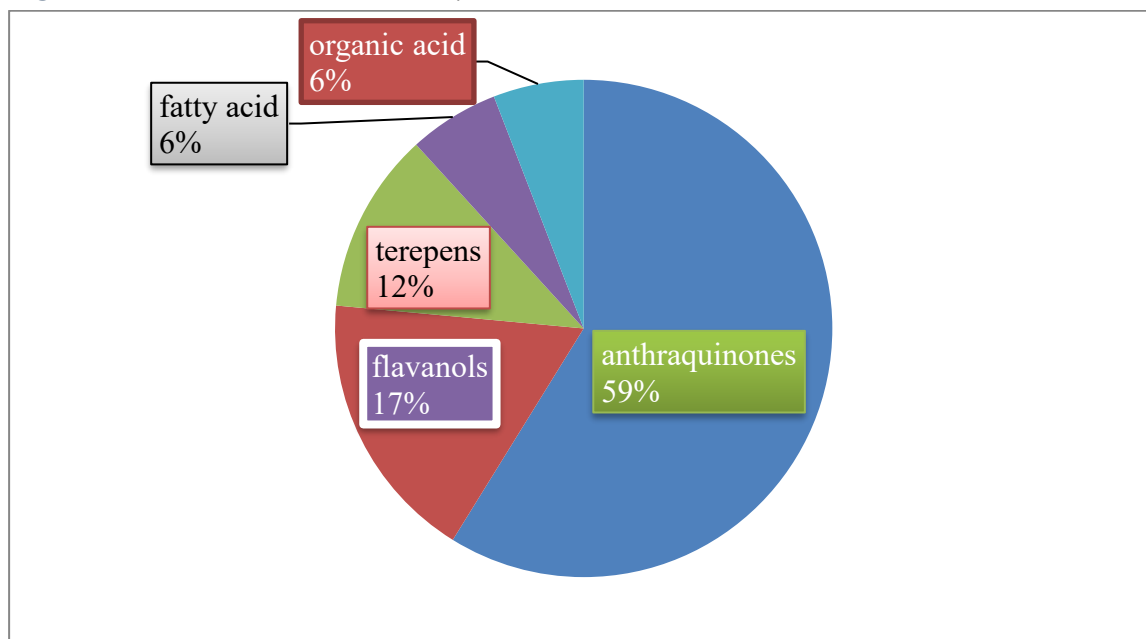
Table 1. Continued

Jaundice	Root	Fresh roots are pulverized, boiled, and given orally in a cup	Ethiopia	(Tuasha <i>et al.</i> , 2018)
Pneumonia	Stem	Crushed/ chewed	Kenya	(Kamau <i>et al.</i> , 2016)
Diabetes Mellitus	Aerial Parts	The aerial parts are decocted after being crushed	Ethiopia	(Suleman & Alemu, 2012)
Skin infection	Leaves	Pulverized and mashed leaves are applied to the affected area after being soaked in water	Ethiopia	(Birhanu <i>et al.</i> , 2015)
Anthrax	Root	For five days, dry roots are crushed, boiled in water, and drunk with honey	Ethiopia	(Birhan <i>et al.</i> , 2017)
Expel delayed embryo in the uterus	Root	After powdering the dry root and mixing it with water, drink it	Ethiopia	(Chekole, 2017)
Headache	Leave/Root	Adding to tea	Ethiopia	(Teklay <i>et al.</i> , 2013)
Goiter	Root	Dry roots chewed and swallowed	Ethiopia	(Sina & Degu, 2015)
Snake bite	Root	Pulverize the root and mix it with honey before chewing and swallowing	Ethiopia	(Assefa <i>et al.</i> , 2019)
Scabies	Whole plant	Pounded whole plant, mixed with water, and used to wash the animal	Ethiopia	(Kefalew <i>et al.</i> , 2015)
Blackleg	Root	Dry root pound and drunk to the cattle with ATELLA (By product of local alcohol, Tella)	Ethiopia	(Kefalew <i>et al.</i> , 2015)
Tooth diseases	Root	Chewing / hold with teeth	Ethiopia	(Gebru <i>et al.</i> , 2021)
Vomiting	Root	Drink as herbal tea	Ethiopia	(Gebru <i>et al.</i> , 2021)
Diuretic, carminative	Leaves	-	Pakistan	(Muhammad <i>et al.</i> , 2021)
Gastrointestinal disorders	Root	-	Ethiopia	(Guadie <i>et al.</i> , 2020)

4. CHEMICAL CONSTITUENT

Flavonoids, phenols, anthraquinones, saponins, cardiac glycosides, tannins, steroids, and quinones were detected in the qualitative phytochemical screening of *R. abyssinicus*, which could be linked to the plant's therapeutic effectiveness (Awoke & Gedamu, 2020; Kebede *et al.*, 2021; Workneh, 2021; Workneh, 2017). Previous investigation into the chemical constituents of *R. abyssinicus* have led to the isolation of anthraquinones (**1-10**), flavanols (**11-13**), terpenes (**14-15**), fatty acid (**16**) and organic acid (**17**) (Figure 1). The chemical structures of these compounds are shown in Figures 2 and summarized in (Table 2).

Figure 1. Structure classes from *R. abyssinicus*.



4.1. Anthraquinones

Anthraquinones are a significant class of compounds with numerous applications. Anthraquinone-containing plants, such as rhubarb and aloe, have been known and utilized in folk medicine for over 4000 years (Monks *et al.*, 1992). Biologically active anthraquinone derivatives have also been identified in bacteria, fungi and insects (Malik & Müller, 2016). Both natural and synthetic anthraquinones are widely used in textile dyeing, paints, imaging devices, foods, cosmetics, and pharmaceuticals (Malik *et al.*, 2015). So far, 10 anthraquinones (**1-10**) have been isolated and identified from various parts of this plant, including the rhizome, root tuber, and whole plant (Augustin *et al.*, 2020; Fassil *et al.*, 1985; Kengne *et al.*, 2021; Munavu *et al.*, 1984; Shifa *et al.*, 2021; Tala *et al.*, 2018). Out of ten, six anthraquinones have been investigated its pharmacological activities (Augustin *et al.*, 2020; Kengne *et al.*, 2021).

4.2. Flavanols

Flavanols are distinguished sub-group of flavonoids by the absence of a double bond between C-2 and C-3 and the absence of a carbonyl group on the C ring (C-4), as well as the presence of hydroxyl group(s) on C-3 or C-4. Flavanols have previously been found in cereals, legumes, fruits, vegetables, forages, hops, beers, red wine, tea, cocoa, grapes, and apples, among other foods (Manach *et al.*, 2004). Three flavanols (**11-13**) have been isolated and identified from this plant's root parts so far (Tala *et al.*, 2018).

4.3. Terpenes

Terpenes have the chemical formula $(C_5H_8)_n$, which is defined by the unit isoprene. From the whole part and root of *R. abyssinicus* two compounds (**14** and **15**) were isolated (Fufa *et al.*,

2016; Kengne *et al.*, 2021). The compounds' pharmacological activities have not been investigated.

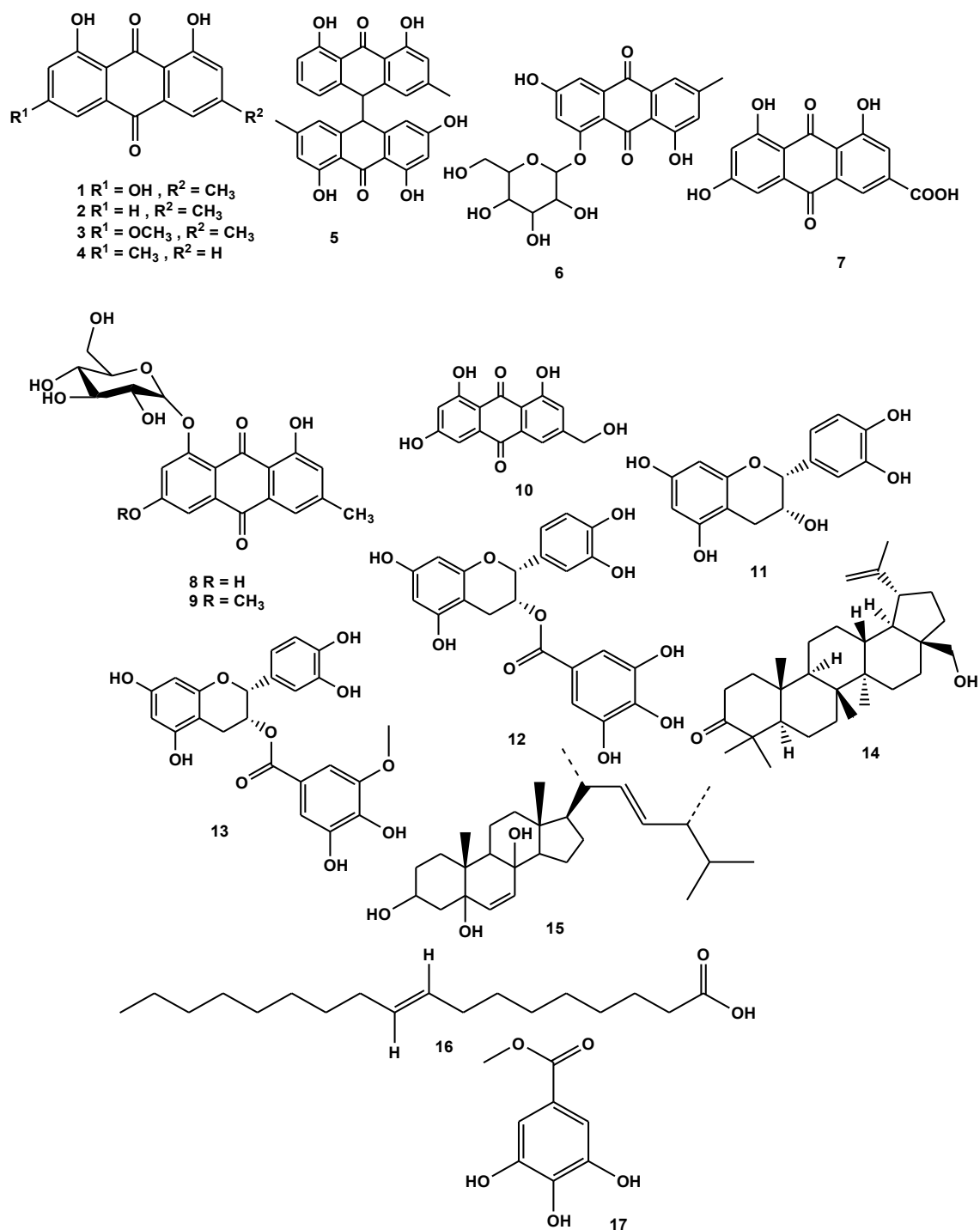
4.4. Organic and Fatty acids

Organic and fatty acid are another important component of *R. abyssinicus*. The compound (16 and 17) was isolated in the roots of the plant (Fufa *et al.*, 2016; Tala *et al.*, 2018). The compounds' pharmacological activities have not been investigated.

Table 2. Compounds isolated and identified from *R. abyssinicus*

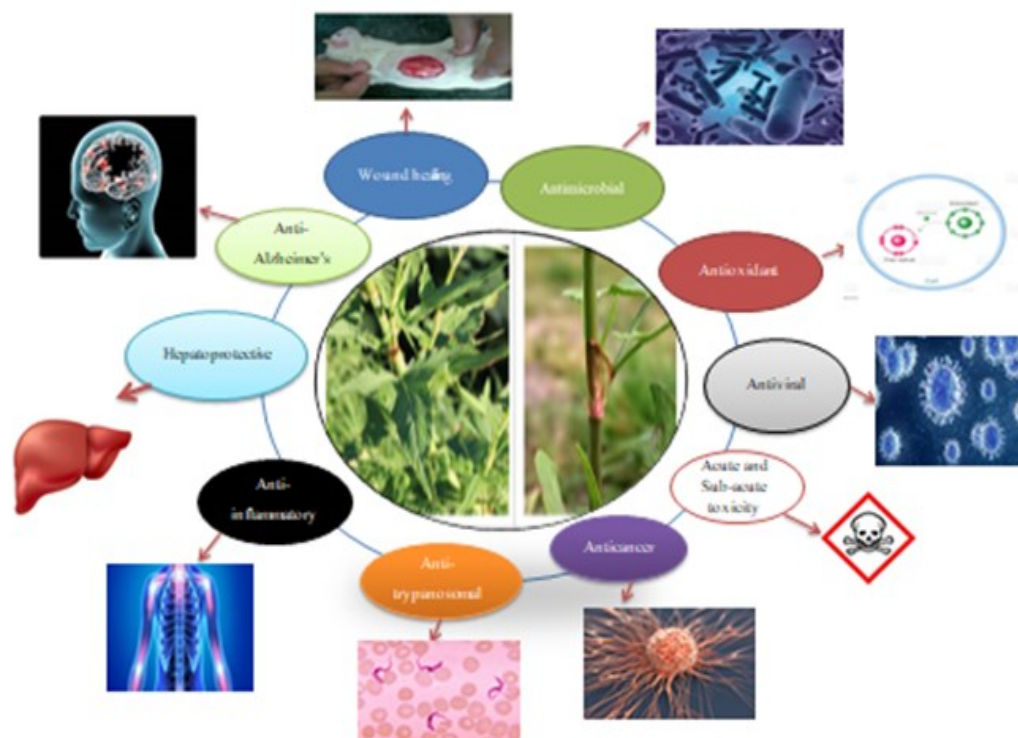
Compound	Plant part (s)	Ref
Anthraquinones		
Emodin (1)	Rhizome, root, tuber, root bark, whole plant	(Augustin <i>et al.</i> , 2020; Awoke & Gedamu, 2020; Fassil <i>et al.</i> , 1985; Kengne <i>et al.</i> , 2021; Munavu <i>et al.</i> , 1984; Shifa <i>et al.</i> , 2021; Tala <i>et al.</i> , 2018)
Chrysophanol (2)	Rhizome, root, tuber, whole plant	(Augustin <i>et al.</i> , 2020; Fassil <i>et al.</i> , 1985; Kengne <i>et al.</i> , 2021; Munavu <i>et al.</i> , 1984; Shifa <i>et al.</i> , 2021; Tala <i>et al.</i> , 2018)
Physicon (3)	Rhizome, root, tuber, whole plant	(Augustin <i>et al.</i> , 2020; Fassil <i>et al.</i> , 1985; Kengne <i>et al.</i> , 2021; Munavu <i>et al.</i> , 1984; Shifa <i>et al.</i> , 2021; Tala <i>et al.</i> , 2018)
Helminthosporin (4)	Rhizome	(Augustin <i>et al.</i> , 2020)
Palmadin C (emodin-chrysophanol bianthrone) (5)	Tuber	(Fassil <i>et al.</i> , 1985)
Emodin-8- β -D-glucoside (6)	Tuber	(Fassil <i>et al.</i> , 1985)
Emodic acid (7)	Root	(Tala <i>et al.</i> , 2018)
Emodin-8-O- β -D-glucopyranoside (8)	Root, whole plant	(Kengne <i>et al.</i> , 2021; Tala <i>et al.</i> , 2018)
Physicon- 8-O- β -D- glucopyranoside (9)	Root, whole plant	(Kengne <i>et al.</i> , 2021; Tala <i>et al.</i> , 2018)
6-hydroxyemodin (10)	Whole plant	(Kengne <i>et al.</i> , 2021)
Flavanol		
Epicatechin (11)	Root	(Tala <i>et al.</i> , 2018)
Epicatechin-3-O-gallate (12)	Root	(Tala <i>et al.</i> , 2018)
Epicatechin-3-O-(4''methyl) gallate (13)	Root	(Tala <i>et al.</i> , 2018)
Terpenes		
Betulone (14)	Root	(Fufa <i>et al.</i> , 2016)
Ergosta-6,22- diene-3,5,8-triol (15)	Whole plant	(Kengne <i>et al.</i> , 2021)
Fatty Acid		
Oleic acid (16)	Root	(Fufa <i>et al.</i> , 2016)
Organic acid		
Methylgallate (17)	Root	(Tala <i>et al.</i> , 2018)

Figure 2. Compound chemical structures isolated from different parts of *R. abyssinicus*



5. BIOLOGICAL ACTIVITY

Healthcare techniques that are both modern and traditional usually coexist and complement one another. In the search for new medications, ethnomedicinal approaches are becoming commonly adopted (Gurib-Fakim, 2006). Recent interest in examining plant constituents for their pharmacological activity and screening for useful and safe phytochemicals has renewed (Nigussie *et al.*, 2021). Various *in vitro* and *in vivo* pharmacological activities of *R. abyssinicus* such as antibacterial, antifungal, anti-Alzheimer's, antioxidant, anti-inflammatory, antiviral, anticancer, hepatoprotective and wound healing activity are showed in Figure 3 and mentioned below.

Figure 3. Graphical representation of pharmacological activities of *R. abyssinicus*

5.1. Antibacterial activity

Shifa *et al.* (2021) used the agar disc diffusion method using gentamicin as the standard drug to examine acetone extract of *R. abyssinicus* roots against *S. aureus*, *K. pneumoniae*, *P. aeruginosa*, and *E. coli*. The extract revealed a zone of growth inhibition against *S. aureus* (21 mm) and *P. aeruginosa* (22.5 mm) with the positive standard gentamicin having a range (34.5 to 32 mm) respectively. Additionally, chrysophanol (**2**) and emodin (**1**) exhibited comparable zones of growth inhibition to the positive standard gentamicin (26 mm) against *S. aureus* (23 mm) and *K. pneumoniae* (22.5 mm). Mekonnen and Desta (2021) used the agar well diffusion method with amoxicillin as a positive control to study ethanol extract of *R. abyssinicus* rhizomes against *S. aureus*, Methicillin-resistant *S. aureus*, *S. pneumoniae*, *E. coli*, and *S. flexneri*. The rhizome extract revealed inhibition zones (in mm) of 20.33, 21.67, 19.17, 18.17, and 21.67, respectively compared to amoxicillin with a zone of growth inhibition in the range (10 to 14 mm).

Using the Kirby-Bauer agar disc diffusion method, Getie *et al.* (2003) evaluated methanol extract of *R. abyssinicus* roots against *S. aureus*, *S. pyogenes*, *C. diphtheria*, *P. aeruginosa*, and *E. coli*. The extract exhibited poor antibacterial activity against *S. aureus*, *S. pyogenes*, and *C. diphtheria*, with inhibition zones of 8 mm, 8 mm, and 12 mm, respectively. Kengne *et al.* (2021) used a broth micro dilution method with ciprofloxacin as a positive control to examine a methanol extract of the whole part of *R. abyssinicus* and an EtOAc fraction against *S. aureus*, methicillin sensitive *S. aureus*, methicillin resistant *S. aureus*, *P. aeruginosa*, and *S. flexneri*. The methanol extract shows antibacterial activities against *P. aeruginosa*, *S. flexneri*, *S. aureus*, methicillin sensitive *S. aureus* and methicillin resistant *S. aureus* with MIC values 64 µg/mL, 128 µg/mL, 64 µg/mL, 64 µg/mL and 64 µg/mL while the maximum activity was reported against *S. flexneri* and *S. aureus* with an EtOAc fraction MIC of 32 µg/mL. Additionally, at a MIC of 8 µg/mL, Physcion (**3**) inhibited the growth of *P. aeruginosa*, *S. flexneri*, and *S. aureus*, while Emodin (**1**) and a mixture of Emodin-8-O—D-glucopyranoside (**8**) and Physcion-8-O—D-glucopyranoside (**9**) inhibited the growth of bacteria at 16 µg/mL, 8 µg/mL respectively.

Using the agar disc diffusion method and chloromophynacol as a reference drug, Awoke and Gedamu (2020) investigated methanol and ethyl acetate extracts of *R. abyssinicus* roots against *S. aureus*, *L. Monocytogenes*, *K. pneumonia*, and *E. coli*. The extract revealed zone of growth inhibition against *S. aureus* (13.65 mm), *L. Monocytogenes* (13.16 mm), *K. pneumonia* (16.53mm) and *E. coli* (10mm) with the chloromofinacol positive control at the range (8.09 to 9.45 mm). Similarly, the ethyl acetate extract revealed zone of growth inhibition against *S. aureus* (16.6mm) and *L. Monocytogenes* (10.8 mm), *K. pneumonia* (13.43 mm) and *E.coli* (12.91 mm) with the positive standard chloromophynacol has the range (8.09 to 9.45 mm).

5.2. Antioxidant Activity

Using radical scavenging activities with ascorbic acid as the positive control, Adamu *et al.* (2020) investigated the antioxidant activities of the crude methanol extracts and solvent fractions of *R. abyssinicus* rhizomes. The crude extract had an IC₅₀ value of 13.1 µg/mL, which is lower than the positive control's IC₅₀ value of 4.9 µg/mL, indicating that it has weaker antioxidant activity. Similarly, the IC₅₀ values for petroleum ether, chloroform, ethyl acetate, butanol, and aqueous fractions were 34.4, 8.0, 9.9, 6.1, and 24.1 µg/mL, respectively. Using DPPH radical scavenging assays, Kengne *et al.* (2021) investigated the antioxidant properties of methanol extracts of *R. abyssinicus* whole plant. The extract had an EC₅₀ value of 62 µg/mL, which is lower than the standard drug's EC₅₀ value of 1.81 µg/mL, indicating weaker antioxidant activity. The reported compound physicon (3) showed a significant scavenging ability against the DPPH radical, with an EC₅₀ value of 3.08 µg/mL, which was close to the reference drug's EC₅₀ value of 1.81 µg/mL.

5.3. Antiviral Activity

To assess antiviral activities of methanol extracts of *R. abyssinicus* root against Coxsackie and influenza A viruses, Getie *et al.* (2003) used virus-specific phosphorothioate oligodeoxynucleotides technique with guanidine hydrochloride for CVB3 and Acute Macular Neuroretinopathy for influenza A virus as a positive control. The methanol extract demonstrated actions with IC₅₀ and IC₁₀₀ values ranging from 7.8 mg/mL to 125 mg/mL in a dose-dependent manner, and their influence altered to be similar to virustatic positive control drugs (at IC₁₀₀).

5.4. Anticancer Activity

Using quantitative colorimetric assay via the oxidation-reduction indicator resazurin method, Worku *et al.* (2013) evaluated the in vitro anticancer activities of methanol extracts of *R. abyssinicus* rhizomes. With an IC₅₀ value of 3 µg/mL, the extract indicated cell proliferation in human prostate cancer cells (LNCaP), Leukemia (THP-1) and human astrocytoma cells (1321N1). Girma *et al.* (2015) used dimethylhydrazine (DMH) induced colon carcinogenesis rats to investigate the in vivo colon cancer chemopreventive activity of methanol extracts of *R. abyssinicus* rhizomes, administering 250 mg/kg and 500 mg/kg body weight of extract orally to different groups of rats. The findings revealed that extract doses of 250 mg/kg and 500 mg/kg body weight significantly reduced the incidence of aberrant crypts (ACs) and aberrant crypt foci (ACF).

5.5. Anti-trypanosomal Activities

Using a quantitative colorimetric assay with the oxidation-reduction indicator resazurin, Worku *et al.* (2013) examined the antityposomal activity of methanol extracts of *R. abyssinicus* rhizomes *in vitro*. IC₅₀ values for the extract against *Trypanosoma brucei* cells ranged from 33 to 333µg/mL.

5.6. Anti-inflammatory Activity

Using the cyclooxygenase (COX) inhibition assay with indomethacin as a positive control, Getie *et al.* (2003) investigated the anti-inflammatory effect of methanol crude root extract of *R. abyssinicus*. PGE2 production was demonstrated in the extract, with IC₅₀ values ranging from 0.05 to 10 µg/mL. Mulisa *et al.* (2015) used the carrageenan-induced rat paw edema assay in adult Swiss albino mice to examine in vivo anti-inflammatory activities of methanol extracts of *R. abyssinicus* rhizomes, with 250, 500, and 750 mg/Kg body weight of the extract administered orally to different groups of mice, with indomethacin (10 mg/kg) as the standard drug. After 2 hours of carrageenan injection, the two higher dosages of the extract (500 and 750 mg/kg) as well as the standard drug significantly ($p < 0.001$) inhibited edema, whereas the lower dose (250 mg/kg) of the extract showed anti-inflammatory effect ($p < 0.05$) after 3 hours of edema induction.

5.7. Antifungal Activity

Using the agar disc diffusion method and ketoconazole as a positive control, Kebede *et al.* (2021) investigated the antifungal activity of methanol extracts of *R. abyssinicus* leaves against *C. albicans* and *T. mentagrophytes*. The methanol extract (30 µg/mL) inhibited activities with a zone of inhibition ranging from 22 to 26 mm, whereas ketoconazole, the positive control, inhibited activities with a zone of inhibition ranging from 26 to 28 mm. The MIC values for the pathogens that were tested ranged from 32 to 64 µg/mL. With positive control Fluazinan 500F, Tala *et al.* (2018) identified anthraquinones and flavanols compounds from the root of *R. abyssinicus* extract displayed plant pathogens motility inhibitory and lytic properties against *Phytophthora capsici* zoospores. With a MIC of 15 µg/mL, the isolated compound physcion (**3**) displayed the strongest motility inhibitory effect, as well as lytic activity against zoospores at 500 µg/mL. Using the broth microdilution method and fluconazole as a positive control, Kengne *et al.* (2021) examined antifungal activity of methanol extracts of whole parts of *R. abyssinicus* and EtOAc fraction against *C. neoformans* and *C. albicans*. At a MIC of 32 µg/mL, the methanol extract and EtOAc fraction showed activity against *C. neoformans*, whereas the isolated compounds physcion (**3**) and emodin (**1**) showed activity against *C. neoformans* and *C. albicans* at a MIC of 8 µg/mL.

5.8. Hepatoprotective Activity

Adamu *et al.* (2020) investigated the hepatoprotective properties of methanol crude extracts of *R. abyssinicus* rhizomes in female Swiss albino mice using the toxic carbon tetrachloride (CCl₄) technique and silymarin as the standard drug that induces liver damage. The extract of *R. abyssinicus* at a dose of 500 mg/Kg reduced elevated levels of serum alanine aminotransferase (ALT, 51.3%) and alkaline phosphatase (ALP, 63.8%) better than the standard drug silymarin 100 mg/Kg (69%) and significantly reduced the deleterious histopathological changes in the liver following carbon tetrachloride intoxication.

5.9. Anti-Alzheimer's Activity

Augustin *et al.* (2020) used the Ellman assay with donepezil hydrochloride as a positive control to investigate the anti-alzheimer effects of ethyl acetate rhizome extract of *R. abyssinicus*. The extract showed dual cholinesterase inhibitor action against acetylcholinesterase (AChE) and butyrylcholinesterase (BChE), with IC₅₀ values of 2.7 and 11.4 µg/mL, respectively, which is lower than the positive control donepezil HCl, which had IC₅₀ values of 0.049 and 5.52 µg/mL. Helminthosporin (**4**), Emodin (**1**), Chrysophanol (**2**), and Physcion (**3**), all isolated anthraquinone compounds, demonstrated substantial inhibition of acetylcholinesterase (AChE) with IC₅₀ values of 2.63, 15.21, 33.7, and 12.16 µg/mL, respectively. Helminthosporin (**4**) also demonstrated considerable inhibition of butyrylcholinesterase (BChE) with an IC₅₀ value of

2.99 µg/mL, which is higher activity than donepezil HCl, the positive control, which had an IC₅₀ value of 5.52 µg/mL.

5.10. Wound Healing Activity

Mulisa *et al.* (2015) used excision and incision models in adult Swiss albino mice to investigate the wound healing capabilities of methanol rhizomes extracts of *R. abyssinicus*, with nitrofurazone ointment as a control. In both excision and incision models, treatment with 5% and 10% (w/w) methanol extract ointment exhibited significant wound recovery activities, with higher activity when compared to nitrofurazone ointment.

5.11. Acute and Sub-acute Toxicity Activity

Adamu *et al.* (2020) evaluated *in vivo* acute toxicity of methanol rhizome extracts of *R. abyssinicus* using female Swiss mice. A total of five starved mice were given a test sample 2000 mg/Kg body weight orally and the numbers of deaths occurring in 24 h were noted. The extract's LD₅₀ in mice was greater than 2000 mg/kg, indicating that it was non-toxic. Alelign *et al.* (2020) evaluated *in vivo* acute and sub-acute toxicity of methanol rhizome extract of *R. abyssinicus* using female Swiss mice also showed that LD₅₀ in female Swiss mice were higher than 2 µg/kg, suggesting that the extract was of non-toxic. Similarly, Enyew *et al.* (2020) examined *in vivo* acute and sub-acute toxicity of methanol rhizome extracts of *R. abyssinicus*, LD₅₀ in Swiss Albino mice greater than 2 µg/kg.

6. EXTENDED APPLICATION

6.1. Industrial Application in The Leather Industry

Raw hides and skins are preserved before being turned into leather to protect the skin protein from microbial attack. The most extensively used preservation method in the world is the salting process, which employs around 50% w/w common salt. This typical system generates an excessive amount of saline wastewater, which adds to major pollution in terms of total dissolved solids and chlorides, and is discharged into the effluent throughout the manufacturing process. The treatment plants operational and maintenance costs increase as the soaking produces more salinity. Furthermore, ground water pollution around tanning industries is pressuring tanners to minimize or eliminate the use of salts in the leather manufacturing process (Vankar & Dwivedi, 2009).

Mohammed *et al.* (2016) investigated a less-salt preservation system based on *R. abyssinicus* root powder as a cleaner alternative to conventional salt-based preservation approach, with a positive control of 50 % (w/w) sodium chloride (NaCl). The results revealed that curing the raw goatskins with 10% (w/w) *R. abyssinicus* root powder and 15% (w/w) common salt is successful in preserving them. The pollution-reduction generation also shows a % reduction in total dissolved solids and a 70 % reduction in chloride. Aqueous root extracts of *R. abyssinicus* were employed as a cleaner way for dyeing in product production in another investigation. The 10% (w/w) aqueous root powder of *R. abyssinicus* demonstrated good fastness and organoleptic features, according to the results (Mohammed *et al.*, 2018).

7. CONCLUSION

The ethnomedicinal uses, chemical constituents, and biological activity of *R. abyssinicus* are summarized in this review. Anthraquinones, flavonoids, terpenoids, phenolic compound and fatty acid had been confirmed to be the principle active constituents of *R. abyssinicus*. Biological activity has additionally targeted on antibacterial, antioxidant, anticancer, anti-inflammatory, antifungal, wound healing and Alzheimer's from different extracts and reported compounds of *R. abyssinicus*. The various uses of *R. abyssinicus* amongst different ethnic groups and the scientific evidence of its chemical constituents and biological activities imply healing capability of the species. However, there may be need for clinical studies of crude

extracts and compounds reported from the species using *in vivo* models. Therefore, further research of *R. abyssinicus* need to attention on complete phytochemical analyses of the species and to more accurately outline its biological activities. Additionally, new biological evaluations are still needed to scientifically validate some of its ethnobiological applications in order that the species can be used as a future useful resource for disease treatment and management. *R. abyssinicus* is also now no longer completely evaluated regarding its safety as herbal medicine. Further research want to assess the toxicity of the species for further uses of the plant extracts, fractions and isolated compounds in pharmaceutical industries.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research and publishing ethics. The scientific and legal responsibility for manuscripts published in IJSM belongs to the authors.

Authorship Contribution Statement

Gashaw Nigussie came up with the idea, acquired information, wrote and edited the original paper. **Tiruwork Fanta** and **Mekdes Alemu**, proofread and modified the final version. The contents of this manuscript were read by all of the authors, and they all agreed to bear responsibility for it.

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