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A REVIEW ON ETHNOBOTANICAL USE AND PHARMACOLOGICAL PROPERTIES OF THYMUS SCHIMPERI

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ABSTRACT

Medicinal plants played an essential role in the development of new drugs and many of the modern medicines. Studying medicinal plants helps to understand plant toxicity and protect human and animals from natural poisons. This article aims to provide a comprehensive review on the Ethnobotanical use and pharmacological Properties of Thymus schimperi. Thymus schimperi is one of the 350 plant species in the genus Thymus, which is an aromatic plant belonging to the Lamiaceae family. It is endemic to Ethiopia and widely distributed in central, eastern, and northern part of the country. Medicinal and aromatic plants have been used for the extraction of essential oils from their secondary metabolites. Essential oils and extracts from Thymus schimperi exhibit antioxidant, antibacterial, antifungal, antiviral, anti-parasitic and other properties.

KEYWORDS: Antimicrobial activity; Antioxidant activity; Distribution; Endemic; Essential oils; Lamiaceae; Thymus schimperi; Traditional uses.

INTRODUCTION

Thymus schimperi is one of the 350 plant species in the genus *Thymus* which is an aromatic plant belonging to the Lamiaceae (Labiatae or mint) family.[1-3] The Lamiaceae is a large family represented by about 236 genera and above 7200 species.[4] *Thymus schimperi* and *T. serrulatus* are the two known endemic species of the genus *Thymus* in Ethiopia. Both of them locally in Ethiopia named as Tosign (Amharic). These species are endemic to highlands of Ethiopia ranging from 2200-4000 meter above sea level.[5,6] They are restricted to the afromontane and afroalpine zones of the country.[7,8] and grow on edges of roads, in open grassland, on bare rocks and on slopes.[9,10,6]

Thymus schimperi is a perennial herb, woody at the base and 5 to 40 cm high.[4,11,10,6] They have a crowded inflorescence with pink corollas and have ovate to elliptic leaves with entire margins.[4] Its name is derived from Greek, which refers to courage, sacrifice and fumigation.[8] The different parts of this species are used for treatments of various health ailments such as cold, fever, and cough.[12,3] for medicinal and spice purposes almost everywhere in the world.[1,13,5] The non-medicinal use of thyme is in the food and aroma industries it is widely used as culinary ingredient and it serves as a preservative for foods especially because of its antioxidant effect.[13]

Fig. 1: Thymus schimperi.

Distribution of thymus in Ethiopia

The genus *Thymus* was distributed worldwide and mainly originated from Mediterranean region of the temperate zones.[2] It is largely distributed in temperate zones and is uncommon in the African tropics.[13-15] In Ethiopia *Thymus* is an abundant genus in the family Lamiaceae growing at different regions of the country having a variety of wild growing species.[15] *T. schimperi* is widely distributed in central, eastern, and northern Ethiopia and *T. serrulatus* is restricted to the northern parts of the country.[11,8] However, some reports indicate that *T. serrulatus* was found from Jimma, South West Ethiopia.[16]

Distributed of *T. schimperi* in Amhara region, it is found in Denkoro Forest,[17] Menz Mamma district,[18] Tarma Ber wereda of North Shewa and Gondar areas,[19] Tarmaber, Sheno and Bahir Dar.[13] In Oromia region, *T.*

schimperi is found in Adaba Dodola area,[20] Gole forest Dodola woreda,[21] Sanka meda forest Arsi zone,[22] Dinsho,[1,23] Goma Wereda, Jima Zone,[24] Asendabo areas around Jimma,[25] Debre Zeyit,[8] Awash National Park,[26] Menagesha Suba State Forest,[27] Gedo forest, West Shewa Zone.[28] And in Southern region *T. schimperi* is found in Biteyu Forest, Gurage Zone,[29] Forest Patches of Gurage Mountains.[30]

Chemical composition of Thymus schimperi

Medicinal and aromatic plants have been used for the extraction of essential oils from plants secondary metabolites all over the world due to their antimicrobial capacity.[31] Essential oils are volatile oily liquids of scented plants, which are obtained from different plant parts, such as flowers, leaves, seeds, bark, fruits and roots.[12] The chemical constituents of plant essential oils differ between species, in quality, quantity and composition due to the climate, soil composition, plant organ, age and vegetative cycle stage.[32] In order to obtain constant composition of essential oils, they have to be extracted under the same conditions from the same organ of the plant which has been grown on the same soil, under the same climate and has been picked in the same season.

Essential oils are very complex natural mixtures which can contain about 20–60 bioactive components at quite different concentrations. Usually, the chemical characterization of many essential oils reveals the presence of only 2-3 major components at a fairly high concentration (20–70%) compared to other components present in trace amounts,[8,32] Essential oil obtained from *T. schimperi* was rich in carvacrol and thymol as the major component. But the concentration of carvacrol and thymol differ from location to location.[1] For example, *T. schimperi* from four regions such as Bale, Gonder, Shewa, and Wollo were identified as p-cymene (9-23%), γ terpinene (8-17%), thymol (6-38%) and carvacrol (5-63%),[33] However *T. Schimperi* grows in Addis Ababa was rich in carvacrol 66.2% and *γ*-terpinene 13.2%, while thymol 50%, *γ*-terpinene 12.1%, carvacrol 10.1% and *p*-cymene 10.1% are the major constitute of *T. Schimperi* from Dinshu,[1,8] Essential oils and extracts from *Thymus* plants exhibit antioxidant, antibacterial, antifungal, antiviral, anti-parasitic and other properties.[5]

Antimicrobial activity

Medicinal plants have the capacity to inhibit the growth of a wide range of opportunistic or pathogenic microorganisms due to the presence of essential oils. Survey of different publications has shown that *thyme* oils possess antimicrobial activity.[8,32,31] The *Thyme* essential oils possess antibacterial, antifungal, antiviral, and antioxidant effect, and also the freshly collected leaf exhibit antihelmentic effects and wide spectrum of pharmacological activities.[34,5] The inhibition effect of the extracts was proportional to the concentration and higher concentration has stronger effect.[11] The essential oils extracted from different plants have variable antimicrobial effect against *Salmonella enteritidis*, *S. typhi*, *Eschericcha coli*, *Shigella* spp., *Staphylococcus* bacteria (*S. aureus*, *S. pyogenes*, *S. epidermidis*), *Trichophyton* spp, and *Aspergillus* spp. Among the different plant essential oils *T. schimperi* is effective against all the test organisms.[8,35]

The essential oils primarily destabilize the cellular architecture and cause cytoplasm granulation, cytoplasmic membrane lesion and disrupt the cell membrane of the targeted pathogens by increasing membrane permeability, inducing leakage of vital intracellular constituents, interrupting the cellular metabolism and inhibition and/or inactivation of extracellular and intercellular enzymes of the targeted pathogens,[31,32] The disruption of the cell membrane by essential oils may assist various vital processes such as energy conversion processes, nutrient processing, the synthesis of structural macromolecules, and the secretion of growth regulators.[32] The strong antimicrobial activities of *T. schimperi* is mostly due to the presence of phenolic compounds such as thymol and carvacrol, and hydrocarbons like γ- terpinene and p-cymene.[13]

4.1 Antibacterial activity of *Thymus Schimperi*

T. schimperi possess antibacterial activities and they can be used to control variety of pathogens that cause diseases in humans and plants.[11] Essential oil of *T. schimperi* show highest inhibition activity against all gram-negative and gram-positive bacteria at lower concentration,[36,35] Studies revealed that, *T. schimperi* causes higher growth inhibition zone against bacteria.[8,11,35] The essential oil of this plant is the most active against all bacteria. Thymol and Carvacrol are responsible for the strong antimicrobial effect of *T. schimperi*. The survey of different studies revealed that, *T. schimperi* extract treated samples have lower colony count (strong inhibition effect) than the other plant species and the colony count of control sample.[8,13,35]

Table 2: Antibacterial activity of four essential oils against the tested bacteria using disk diffusion assay.[8]

Tested Bacteria	Inhibition zone diameter including in mm (Mean ± SD)				
	Thymus EO	Cinnamon EO	Lemon EO	Eucalyptus EO	Chlo
E.coli	90.00±0.00a ***	42.66±1.527b **	26.66±1.527c *	16.00±2.645d *	43.33±0.577b **
Bacillus spp.	63.00±7.2 ***	43.33±1.527b **	25.66±0.577c *	7.66±5.89 -	34.00±1.000b **
Shigella spp.	90.00±0.00a ***	36.66±1.527 **	27.00±1.000c *	0.00±0.000 -	44.33±0.577b **
Streptococci	90.00±0.00a ***	41.33±2.081b **	20.33±0.577 *	14.33±0.577d *	42.66±1.527b **

(-) Essential oils with less or no effect. (*) Essential oils having weaker effect (**) Essential oils having moderate effect. (***) Essential oils having strong effect.

The experimental results indicate that, *T. schimperi* has a remarkable antibacterial effect on the growth of bacterial pathogens. It shows strong inhibition effect on the growth of all tested bacteria at lower concentration than other essential oils.

The following figures shows the antibacterial effect of *Thymus schimperi.*

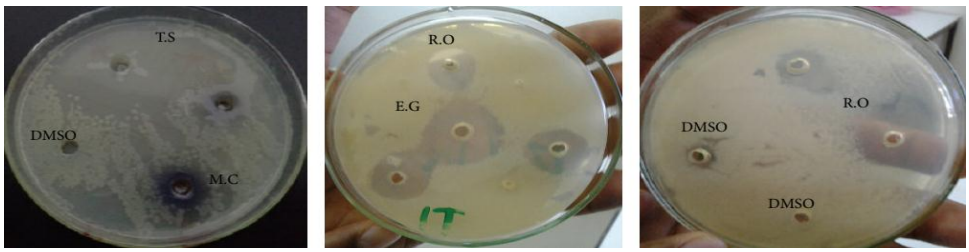

Figure 2: Growth inhibition zone on *Staphylococcus aureus* (T.S=*Thymus schimperi*, E.G=*Eucalyptus globulus*, R.O= *Rosmarinus officinalis*, M.C= *Matricaria chamomilla*, and DMSO = Negative control showed no inhibition).[35]

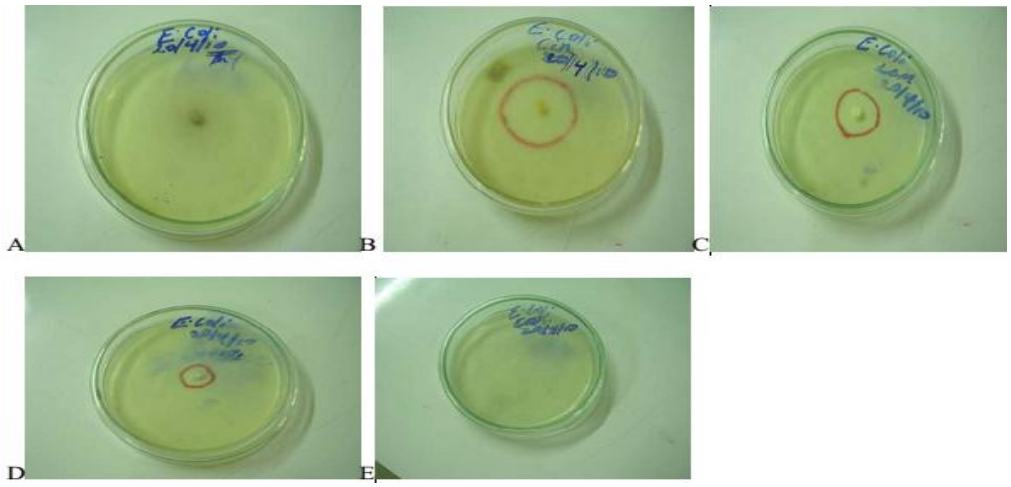

Figure 3: Growth inhibition zone on E. coli, A= *Thymus* oil, B=*Cinnamon* oil, C= Limon oil, D= *Eucalyptus*, E= Control.[8]

The above study result showed that Carvacrol and thymol disintegrate the outer membrane of bacteria, increasing the permeability of the cytoplasmic membrane. This distortion of the physical structure causes expansion and destabilization of the membrane, increasing membrane fluidity, which in turn increase passive permeability.[32]

4.2 Antifungal activity of *Thymus schimperi*

Fungal infections are a serious public health problem and have been increasing due to several factors like, increased international travel, immigration, changing climate conditions, and the increased incidence of high-risk patients.[31] Dermatophytes are pathogenic fungi that have a high affinity for keratinized structures like nails, skin or hair, causing superficial infections known as dermatophytoses in both humans and animals.[37]

Figure 4: Common types of Dermatophyte diseases A=Tinea corporis (Ringworm), B=Tinea pedis (Athlete's foot), C= Tinea unguium.[8]

The spread of multidrug-resistant strains of fungi led to a search for therapeutic substitutes among aromatic and medicinal plants. Different essential oils extracted from aromatic and medicinal plants are used against fungal pathogens. About 60% of essential oils show antifungal activity.[31] Fungal growth inhibition by essential oil was accompanied by marked morphological and cytological changes.[38] Essential oils, derived from plants like *T. schimperi* have been reported to be active against fungal pathogens.[8,39,32,31] Thymol and carvacrol effectively inhibit the growth of different fungal microorganisms by penetrating and disrupting fungal cell wall, cell membranes, cytoplasmic membranes, and finally causing damage to mitochondrial membranes.[40,8,35,32,31]

According to,[38] most of the isolates fungi have resistant to amphotericin B (except *Aspergillus minutes*) but *T. schimperi* essential oil showed antifungal activity against all of the tested fungal isolates with minimal inhibitory concentration values. The experimental result of,[31] shows *T. schimperi* has a strong antifungal effect on the different fungal microorganisms, such as *Penicillium chrysogenum*, *Verticillium* spp., *Aspergillus tubingensis*, *Aspergillus minutes*, *Beauveria bassiana* and *Microsporum gypseum*. The survey of experimental result of different researchers,[8,2,35] indicates that *T. schimperi* has a maximum antifungal activity, showing greatest inhibition zone of all tested fungi in a lower concentration than the other essential oils (like *E. globules* and *R. officinalis).*

The following figures show the antifungal effect of *T. schimperi.*

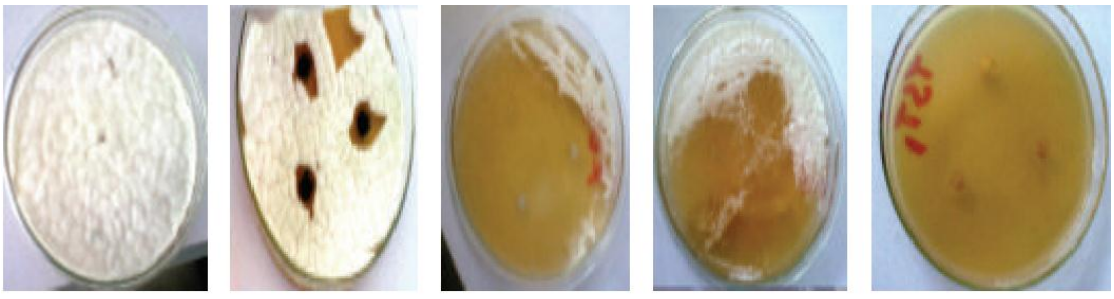

Figure 5: Growth inhibition zone on Trichophyton spp.

(a) = DMSO, (b) = *Matricaria chamomilla*, (c) = *Rosmarinus officinalis*, (d) = *Eucalyptus globules* and (e) = *Thymus schimperi*. Source.[35]

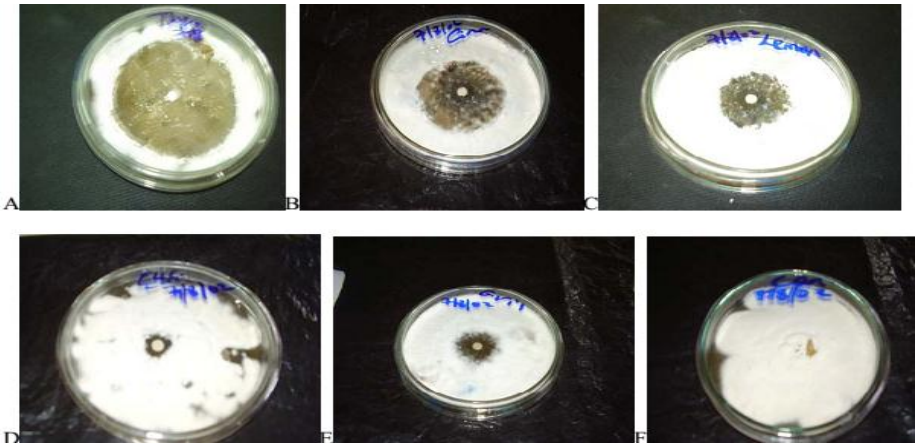

Figure 6: Growth inhibition zone on Tricophyton spp.

A= *Thymus* oil, B= *Cinnamon* oil, C= Limon oil, D= *Eucalyptus* oil, E= Grisofulvin, F= Control. Source.[8]

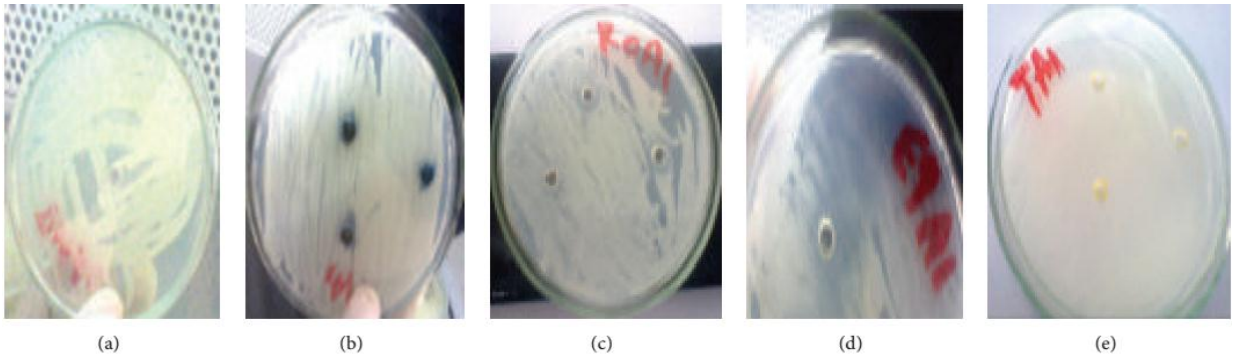

Figure 7: Growth inhibition zone on Aspergillus spp.

(a) = DMSO, (b) = *Matricaria chamomilla*, (c) = *Rosmarinus officinalis*, (d) =*Eucalyptus globulus*, and (e) =*Thymus schimperi*. Source.[35]

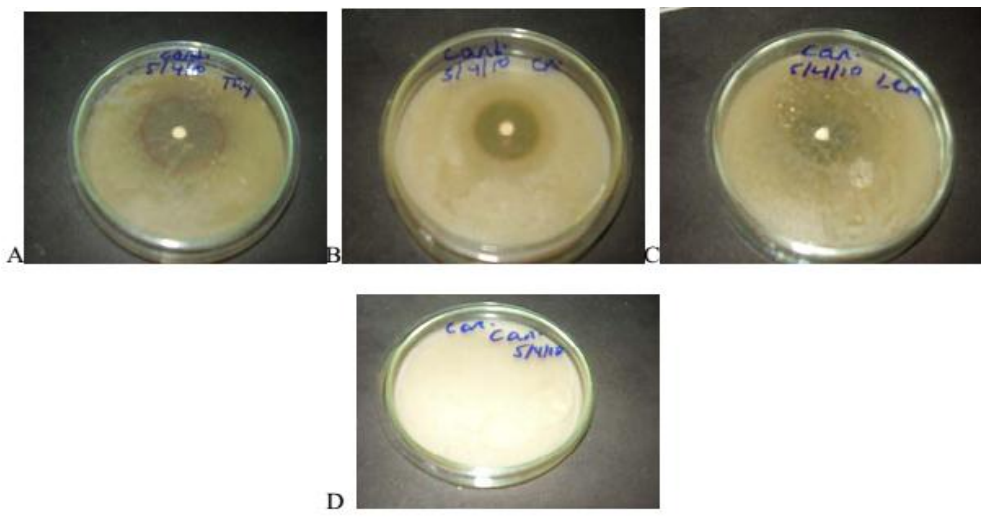

Figure 8: Growth inhibition zone on Candida spp. Source.[8]

A= *Thymus* oil, B= *Cinnamon* oil, C= Limon oil, D= control).

All the above figures revealed that *T. schimperi* has strong inhibition effect against pathogenic fungal microorganism than the other.

4.3 Essential oils with antiviral activity

Viral diseases are still a major problem for human health worldwide. So far, there is a limited number of drugs are effective against virus, which requires finding a new antiviral drug. Essential oils or their active compounds have been reported to possess a wide spectrum of antiviral properties.[12] Many essential oils were investigated towards their antiviral activity. Many essential oils possess antiviral properties against DNA and RNA viruses. Most of them were tested against enveloped RNA and DNA viruses, such as herpes simplex virus type 1 and type 2 (DNA viruses), dengue virus type 2 (RNA virus), and influenza virus (RNA virus), whereas few essential oils, were also tested against non-enveloped RNA and DNA viruses, such as adenovirus type 3 (DNA virus), poliovirus (RNA virus), and coxsackie virus B1 (RNA virus).[32]

The essential oil obtained from lemon balm suppressed influenza virus replication and its effect improved when co-administered with the antiviral agent of other essential oils. The essential oils inhibit viral activity during their early stages of infection. Thus, plant-based essential oils used as antiviral agents against several viral diseases in humans and used as alternatives to synthetic antiviral drugs.[32] Based on the traditional application of *Thyme* tea for the treatment of cold, flue and other respiratory infection is indication of antiviral capacity of *T. schimperi*. The inhibition effect of *T schimperi* oils was not investigated so far, therefore researcher need to evaluate its antiviral effect against viral infections is recommended.

1. Antioxidant activity of Thymus schimperi

Antioxidants in foods are any group of substance which is capable of delaying, retarding or preventing the development of rancidity in food or other flavor deterioration due to oxidation processes.[15,41,34] Food products are sold in areas of far distant from their production sites and need extended safety and storage stability. Rancidity from chemical and microbial processes is the major cause of lipid-based food products deterioration. Many foods are perishable by nature during production, processing, distribution and storage, and require protection from spoilage to give them longer shelf-life.[41] Significant changes can occur in product odor, taste, color, texture, nutritive value and progressing oxidation results in complete spoilage of foods. Antioxidants, however, postpone problems caused by rancidity. Thus, they are frequently used to retard oxidation processes in the food industry.[15]

Natural antioxidants are primarily plant phenolics that safely interact with free radicals and terminate the chain reaction before vital molecules are damaged.[41] In foods like meat, dairy products and fried foods, they are capable of delaying, retarding or preventing the development of food rancidity or other flavor deterioration due to oxidation.[42] Any antioxidant for use in food must be safe, easy to incorporate, effective at low concentrations, with no undesirable odor, flavor or colour, heat stable, nonvolatile and cost-effective.[41] Antioxidants have also an ability to protect the body against damage caused by free radicals, and are used in the health-related area. Some bioactive phytochemicals present in food exhibit antioxidant activity because of their free radical inhibition.[15,34]

Thymus is the potential herbs for extracting natural antioxidants. The carvacrol and thymol in *T. schimperi* are responsible for its antioxidant activity.[1] *Thyme* crude extract is effective in maintaining the stability of oil and butter for extended time when treated. Butters obtained from cows eating *Thyme* together with their feeds have higher antioxidant activity than butters obtained from cows that had no access to *Thyme*.[13] In meat the colony, mold and yeast growth count values in *Thyme* extract treated samples were low.[8,13,35]

2. Traditional uses of *Thymus schimperi*

Thymus in Ethiopia traditionally used in a variety of forms, extensively for flavouring purposes.[8] The fresh or dried leaves of *T. schimperi* are locally used as condiments and tea, as ingredients in the preparation of berbere and “shirro” (pepper and bean/pea powder) as well as for the preparation of Metata ayib (a traditional Ethiopian fermented cottage cheese).[9] *Thyme* is used for seasoning fish, poultry, soups and vegetables, for flavoring liqueur, in herbal tea preparation for colds and flues, they are also used in traditional medicine for the treatment of headache, cough, stomachache, earache, liver disease and gonorrhea.[8]

According to the finding indicated in the work of,[9] *Thymus schimperi* in Ethiopian has many traditional applications and uses, to treat different illnesses like gonorrhea, cough and liver disease, renal diseases, stomach pain, hypertension,[19,33] kidney problem,[24] and dermal fungi.[31] They are checked to have antihelimenthic,[33] antibacterial and fungicidal activities.[8,38,2,35] According to,[6] *Thymus schimperi* applied for the treatment of gonorrhea, cough, inflammation, spasm, thrombosis, urinary retention, mental illness, eye disease, toothache, stomach problems, leprosy, lung TB, acne and ascaris. Thyme is used as mouthwash to treat laryngitis, as anti-acne and anti-stomatitis agents, and in the topical treatment of minor injuries.[5] The dried leaves are used to flavor tea, coffee, food and also boiled as a tea substitute and are believed to be good for diabetic patients.[9] A tea made by the herb in water is also recommended as a local medicinal remedy for respiratory problems (cough, bronchitis, sore throat), gastrointestinal disorders, (colic, dyspepsia gastritis, flatulence, and diarrhea) and liver disease.[34,9]

In addition to the traditional medicinal use, *Thymus schimperi* contributes enormous uses for the local peoples such as for honey bee forage, animal forage, food additives (condiments), and washing and

fumigating household utensils such as buckets for putting milk and for preparation dough of injera with best flavors and without rancidity. The honey from *Thymus* species has medicinal value and with special taste. Milk, yogurt, butter and meat from animals fed with *Thymus schimperi* have special taste and flavor.[9] *Thymus Schimperi* is economically used by the people living close to the town of Dinsho and near Menz (North Showa), put in plastic bags and sold to travelers on buses. Thyme feed cows butter have higher selling price in the market.[13]

3. Current status and threatening factors of Thymus schimperi

Thymus species (*T. schimperi*) exist as wild and decreasing from year to year. The most common threatening factors of *T. schimperi* are overgrazing, agricultural expansion, overharvesting, harvesting the whole plant including the roots and lack of recognition.[43,9] This reduction is high in North Shewa and Gurage zone because of the above threatening factors. However, the statue is better in Bale (Dinshu), Tigray (Alamata and Ofla) and West Gojjam (Yilmana Densa) because these sites are closed from human and animal encroachment.[9]

T. schimperi found in limited geographical areas (Alpine and Afroalpine) so that degradation of these areas may result in degradation of the whole species.[8] This species is suitable as forages for cattle, sheep and goats and the beliefs of people that, animals which fed these plants give tasty meat and milk are a big challenge. People near Dinsho and Menz in north Showa are selling the dried plant parts to travelers without conserving them.[13,9] And the other problem is that, wild species are communal and no one cares about them as cultivated species. The multiple uses as condiments forage, medicinal use, and tea increases the harvesting pressure of the plant and they are continuously declining. However the major characteristics feature that is the production of high number of seeds makes the plant to survive in this threatening environment.[9]

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