

## Advanced Review on Anthelmintic Medicinal Plants

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**Abstract:** Medicinal plants have played a central part in combating many ailments in human and livestock in many indigenous communities including Africa. In Ethiopia, it is also played a significant role in treating health problems. Ethno veterinary medicine refers to people's beliefs, knowledge, skills and practices relating to care of the animals. Helminthosis is one of the major problems of livestock production throughout the world, particularly in tropical and subtropical areas. The disease is especially prevalent in developing countries in association with poor management practices and inadequate control measures. Different parts of anthelmintic plants are used for various parasitic diseases and disease conditions for example, extracts of *Hagenia abyssinica*, leaves of *Myrsine Africana*, *Rhus glabrous*, *Jasminum abyssinicum*, *Rhus vulgaris*, *Acokanthera schimperi* have anthelmintic activities. However, these plants are suffering from several threats due to a number of natural and anthropogenic activities including the clear-cutting of forests, conversion of grasslands into cultivated lands, industrialization, urbanization, overgrazing, soil erosion and desertification. Dosage form of the plant is still the major problem in developing countries. Thus, it is need to determine the dosage form of anthelmintic medicinal plants.

[Feyisa Kuma, Tadesse Birhanu and Eyob Hirpa. **Advanced Review on Anthelmintic Medicinal Plants**. *Rep Opinion* 2015;7(5):6-16]. (ISSN: 1553-9873). <http://www.sciencepub.net/report>. 3

**Key Words:** Anthelmintic, Developing Countries, Medicinal Plants, Parasitic Diseases

### 1. Introduction

Ever since ancient times, people have searched for rescue for their diseases in nature. The beginnings of the medicinal plants use were instinctive, as is the case with animals [1]. In view of the fact that at the time there was not sufficient information either concerning which plants and how it could be utilized as a cure, everything was based on experience. In time the reasons for the usage of specific medicinal plants for treatment of certain diseases were being discovered; thus, the medicinal plants' usage gradually abandoned the empiric frame work and became founded on explicatory facts. Until the advent of iatrochemistry in the sixteenth century, plants had been the source of treatment and prophylaxis [2]. The medicinal plants are the useful plants for primary health care and as a remedy for diseases and injury, and plants used traditionally for foods and drinks and which are believed that they are good for health; they include foods, drinks, herbs and spices [3].

The wide spread use of traditional medicine could be attributed to cultural acceptability, economic affordability and efficacy against certain types of diseases as compared to modern medicines. Thus, different local communities in countries across the world have indigenous experience in various medicinal plants where they use their perceptions and experience to categorize plants and plant parts to be used when dealing with different ailments [6].

Plants have played a central part in combating many ailments in human and livestock in many

indigenous communities including Africa [8]. Traditional healers, particularly medicinal plant herbalists have a detailed knowledge-base of traditional medicine in Africa. But, it is transferred orally from one generation to the next through professional healers, knowledgeable elders and/or ordinary people [10]. The term of medicinal plants include various types of plants used in herbalism and some of these plants have medicinal activities. These medicinal plants are considered as a rich resource of ingredients which can be used in drug development and synthesis. Besides that these plants play a critical role in the development of human cultures around the whole world [4, 5].

Similarly in Ethiopia, traditional medicine has played a significant role in treating both livestock and human health problems [7]. The plant-based health care persists and remains as the main alternative treatment for different ailments in the country. This is largely due to shortage of pharmaceutical products, prohibitive distance of the health service stations, unaffordable prices by small holder farmers and pastoralists for conventional drugs, emergence and re-emergence of certain diseases and appearance of drug resistant microbes and/or helminthes [9].

The plant is used to treat different diseases and disease conditions in different parts of the country. However, Helminthic infections continue to be a major health hazard of people, especially those living in tropical developing countries. Current estimates suggest that over half of the world population is

infected with intestinal helminthes such as *Ascaris*, *Hookworms*, *Trichuris*, *Enterobius*, *Strongyloides* and *tapeworms*. Most of the infected people live in remote rural areas in the developing countries [11,12]. Infections with gastrointestinal helminthes often lead into malabsorption, diarrhea, anemia and other states of poor health, particularly in infants and school-age children [13, 14].

Most of the parasite control programs are based upon a combination of chemotherapeutic control, grazing management, dietary management, biological control, vaccination and ethnoveterinary medicine (EVM) treatment [15]. Various problems have been evolved with chemotherapeutic control practices such as parasites are developing resistance to several families of chemical anthelmintics, chemical residues and toxicity problems, un-economical, non-adaptability and non-availability of drugs in remote areas [16]. Anthelmintic activity of some plants has been reported akin to that of sorghum, *Allium sativum*, *Zingiber officinale*, *Cucurbita mexicana*, *Ficus religiosa*, *Artemisia brevifolia*, *Calotropis procera*, *Nicotiana tabacum*, *Butea monosperma* [17]. The anthelmintic activities of different plants are reported in different country by many researchers [18].

With respect to use of anthelmintic plants, a perusal of literature reveals that in the beginning quite a few studies on anthelmintic activity of traditional anthelmintic plants, their oils or extracts frequently employed earthworm, *Pheritima posthuma* as a test worm. The essential oil of Piper betle (Piperaceae) has revealed anthelmintic effect on earthworms *in vitro*. Anthelmintic studies of the essential oils of *Cymbopogon nardus* (Graminaceae), *C. citrates* (Graminaceae) and *Zanthoxylum alatum* (Rutaceae) have revealed that the oil of *C. nardus* has very good effect against earthworms, while the oils of *C. citratus* and *Z. alatum* have moderate activity. Merely on the basis of some morphological similarity of parasitic roundworms with earthworm, the workers in their studies very often advocated that substances which kill and/or are toxic to earthworms may also bring the similar actions in parasitic worms and thus may result in their withdrawal from the host [19].

Many literatures had been reported regarding anthelmintic medicinal plants in Ethiopia, but still there is lack of well documented information with regard to these plants that used as anthelmintic, parts used as medicinal value, dosage, major threats and routes of administration especially in veterinary practices. Therefore; the objective of the present seminar paper is to review on anthelmintic medicinal plants, preparation methods, dosage form and routes of administration in Veterinary and Medical practices.

## 2. Anthelmintic Medicinal Plants

### 2.1 Anthelmintic medicinal plants in medical practice

According to the WHO [21], about 80% of the world's people depend on traditional medicine for their primary health care. The medicinal species that reside in natural areas have received increasing scientific and commercial attention in recent years. In glob between 50,000-80,000 flowering plants are used medicinally [23, 24].

Parasitic infections are important public health issue particularly in developing world in which Social and economic deprivation, Poor hygienic condition, Warm climates are the major challenges. Globally, 3.5 billion people are affected by intestinal parasites. In Ethiopia, more than half million visits of OPD were due to intestinal parasitic infections. *Taeniasis* is among the most prevalent Intestinal Parasites infections in the country. Conventional drugs used praziquantel and niclosamide. In addition Traditional herbal remedies such as *Embelia schimperi* (*Enkoko*), *Maesa lanceolata* (*Kelewa*), *Myrsine Africana* (*Kechemo*) have been used in treating tapeworm infestations for ages. However, there is a lack of scientific based evidences regarding efficacy studies, safety studies, phytochemical analysis and appropriate dosage form formulations those plants despite their frequent use as anthelmintics [20]. Currently, anthelmintic use by far is the least complex of control options which is preferred method for internal parasite management [22]. Unfortunately, after many years of heavy reliance on anthelmintics for internal parasite control, parasite resistance has emerged. Anthelmintic resistance has been documented across the world, including Africa, Asia, and North America. The resistance of internal parasite populations exists for all current drug families including benzimidazoles, levamisole, ivermectin, and tomorantel [25].

The phytochemical analyses of naturally available plants and control anthelmintic trials along with contemporary knowledge of parasite control strategies may offer new opportunities for effective and economical control of parasitic diseases. Saponins and tannins present in medicinal plants have been reported to exhibit anthelmintic activity. Alcoholic extracts of stem of *Helleborus niger* (Ranunculaceae), rhizomes of *Zingiber officinale* (Zingiberaceae), seeds of *Carum copticum* (Umbelliferae), *Agatigratifola* (Leguminosae) and *Mangifera indica* (Anacardiaceae) have shown appreciable anthelmintic activity against human *Ascaris lumbricoides* [19].

Medicinal plants such as *Hagenia abyssinica* (Kosso) and *Glinus lotoides* (Hirta) contain substances with nematocidal activity. The ability to control nematode infestation in humans through use of plants with anthelmintic properties has been recognized and

is widely used in countries such as Ethiopia (Table 1) [26].

**Table 1:** Summary of common Medicinal plants used as anthelmintic in Medical Practice

Plant species	Parasites
<i>Agatigratifola</i>	<i>Ascaris lumbricoides</i>
<i>Agrimonia eupatori</i>	Anthelmintic
<i>Butea fondosa</i>	Anthelmintic, Ascardia
<i>Carica papaya</i>	<i>Ascaris lumbricoides</i>
<i>Combretum mucoreatum</i>	<i>Ascaris lumbricoides</i>
<i>Cucurbita moschata</i> and <i>Hagenia abyssinica</i>	Cestodes
<i>Helleborus niger</i> and <i>Mangifera indica</i>	<i>Ascarides lumbricoides</i>

Source: [30, 31].

## 2.2 Anthelmintic medicinal plants in veterinary practice

Parasitic diseases are the prime causes of poor livestock productivity in many developing countries [27]. The aggregated annual economic loss in Ethiopia from livestock diseases (through direct mortality, reduced productivity and reproductive performance) was estimated at US \$ 150 million. Although disease-free livestock products (for in-house consumption and export purposes) are mandatory to ensure consumer's health and to reap more earnings from the sector, it is hardly possible to provide an overall conventional veterinary service in Ethiopia and hence the sector remained with low output [28]. Inadequate veterinary health professionals, scarce and erratic supply of veterinary drugs, high cost of equipment and drugs, absence of government-based livestock health policies, presence of counter-productive livestock health policies and poor infrastructure are mentioned as some of the major factors that made livestock raisers in developing countries to rely more on Ethnoveterinary medicine than the modern medical system [29]. Settled and nomadic livestock raisers from many countries have developed their own indigenous knowledge on ethno veterinary practices through age-old cultural contact with curative plants, trial and error experiments and empirical observations to treat various livestock ailments [32]. Traditional knowledge on use of medicinal plants, however, is subjected to loss in the absence of incessant cultural interaction with medicinal species. Reliance on ethno veterinary knowledge in different countries is mostly reinforced by the strong dependence on livestock for livelihood and the richness in cultural history, ancestral knowledge and biodiversity [33].

EVM refers to people's beliefs, knowledge, skills and practices relating to care of the animals. In Ethiopia, ethnoveterinary practices were reported to be

the only options to cure livestock ailments till the advance of modern veterinary services which were started as late as 1908. Although a gain from the richest livestock wealth of the country is directly related to safeguarding livestock health, conventional veterinary medical system is yet very poor in the country. Traditional plant remedies are major sources of therapeutics for nearly 90% of the livestock population in Ethiopia. Moreover, about 95% of all forms of traditional medicinal preparations in the country are also reported to be of plant origin [34]. The rich indigenous knowledge on many of the traditional plant remedies is subjected to loss as it has mainly been passed orally for generations without being neither properly nor scientifically documented [35].

Despite the significant role played by ethnoveterinary plants for treating livestock ailments in both settled and pastoralist areas of Ethiopia, a very limited attempt has been done to explore, document and promote these widely used ethnoveterinary plants in the country [36]. Hence, it is a timely endeavor to document, promote and conserve the country's ethnoveterinary medicinal plant lore. Such documents are important to define and maintain cultural identity of the people in addition to serving as keys towards establishing people centered natural resource management systems and potentials for scientific discovery of new lead compounds used in the development of modern drugs [37].

Parasitic nematodes especially *Haemonchus contortus*, are among the most common and economically important causes of infectious diseases of sheep and goats owned by pastoralists and small holder farmers in East Africa. In Kenya, control of these infections mainly relies on the use of anthelmintic drugs. However, EVM preparations are widely used by pastoralists and small holder farmers (SHF) for treatment of their livestock against helminth parasites. The plant species selected, and prepared for animal dosing with the help of traditional healers (THs) were: *Aframomum sanguineum*, *Albiziaanthelmintica*, *Ananas comosus*, *Annona squamosa*, *Azadirachta indica*, *Dodonaeaangustifolia*, *Hagenia abyssinica*, *Hildebrandtia sepalosa*, *Myrsine africana*, *Oleaeuropaea var. africana*, and *Rapanea melanophloeos*. Male fern *Dryopteris filix-mas* was used against the cestode *Moniezia* spp., the nematode *Ascaridia* spp., as well as other gastro intestinal nematodes of ruminants such as *Cooperia*, *Haemonchus*, *Nematodirus*, *Ostertagia* and *Trichostrongylus* spp. Plants of the genus *Artemisia* were used against the nematodes *Ascaris suum* and *Toxocara* spp. as well as cestodes of poultry [39].

The anthelmintic efficacy of the EVM preparations was monitored through faecal egg count

(FEC) reduction at regular intervals for a period of two to three weeks post treatment in sheep. Oil of chenopodium (frequently combined with a laxative) derived from *Chenopodium ambrosioides*, was used for many years in the UK and US to treat nematode parasite infections (*Strongylus*, *Parascaris* and *Ascaris* spp.) in monogastric animals including humans. Ascaridole is believed to be the active ingredient in the oil of this plant. However, the use of this oil was discontinued in the 1960s. Recently it was shown that short-term administration of the oil, or freshly ground plant material, administered to infected goats was ineffective in reducing adult *H. contortus* populations [38].

### 2.3 Major anthelmintic medicinal plants in Ethiopia

WHO [21] defined traditional medicine as the total combination of knowledge and practices that can be formally explained or used in prevention and elimination of physical, mental or social imbalance and relying exclusively on practical experience and observation handed down from generation to generation, whether verbally or in writing [40].

Helminthosis is one of the major problems of livestock production throughout the world, particularly in tropical and subtropical areas. The disease is especially prevalent in developing countries in association with poor management practices and in adequate control measures [21]. Most of the parasite control programs are based upon a combination of chemotherapeutic control, grazing management, dietary management, biological control, vaccination and ethno veterinary treatment. Chemotherapeutic control practices have evolved a number of problems including resistance of helminthes to various groups of anthelmintic [42]. In South Africa, 90% of the sheep farms have parasite strains resistant to at least one anthelmintic group and 40% have parasite strains resistant to all the three major groups of anthelmintics [43].

The major anthelmintic drugs commonly used in Ethiopia for the control of helminthes parasites in small ruminants are benzimidazoles (albendazole, triclabendazole, fenbendazole) and levamisole (tetramisole) and Oxytocanide. Since country wide surveys for anthelmintic resistance have not yet been carried out, the current prevalence of anthelmintic resistance in Ethiopia might be underestimated. In addition to anthelmintic resistance, inadequate availability and high cost of commercial anthelmintics are the other important constraints of helminth control in developing countries. Such problem diverted the researchers' attentions towards the development of alternate methods for the treatment of Helminthosis. Ethiopia indicates that several traditional healers use medicinal plants for treatment of various animal health

problems including treatment of helminth infections [41]. Despite the dosage form problem, herbal medicine has gained much importance due to good efficacy and cost effectiveness of in recent years. Plants provide a huge part of traditional veterinary practices and are a rich source of herbal anthelmintics for centuries. Moreover, many currently available therapeutic compounds are plant derived and/or synthetic analogues derived from plants [39].

Crude aqueous and hydroalcoholic extracts of leaves *Myrsine Africana*, *Rhusglabrous*, *Jasminum abyssinicum*, *Rhus vulgaris*, *Acokanthera schimperi* and aerial parts of *Foeniculumvulgare* were screened for possible anthelmintic activity against nematode *Heamonchus contortus*. *Myrsine africana*, (Myrsinaceae), kurjan seed (Eng) locally called "Kechemo" (Amharic) are used as anthelmintics in Ethiopia. It is an erect, densely branched, ever green shrub, usually one to three meter high. Leaves are alternate, elliptic or abrogated, usually leathery as hair dye; charred powder of fruits, seed, leaf, fruit and leaf and wing (crown) applied daily for three days. The fruit is edible and has anthelmintic and is particularly effective for expulsion of the tape worms in another ways decoctions of the leaves are used as blood purifier [44].

The medicinal plants of developing countries play major supplementary roles to the limited modern health care available. The plants have shown very effective medicinal value for some ailments of human and domestic animals, thus medicinal plants and knowledge of their use provide a vital contribution to human and livestock health care needs throughout the country. Such plants include *Phytolacca dodecandra* and many species of *Maytenus* [41].

As the well documented studies, reported endod (*Phytolacca dodecandra*) to be an effective molluscicidal which helps in the control of schistosomosis and fasciolosis in humans and animals. In addition, much work has been conducted on the isolation of various saponins, namely Lemmatoxins A, B and C [50]. *Kosso* (*Hagenia abyssinica*) was found to be effective against *Moniezia* spp. in sheep in an experiment carried out in the Asela Regional Veterinary Laboratory. *Hagenia abyssinica* is used to treat Taeniasis in human in Bale, Debark and Kofle rural communities of Ethiopia [53]. Similar, its use for treatment of livestock ailments have been also documented [45, 45, 46].

The therapeutic value of *Achyranthes aspera* is known for skin diseases and various gastrointestinal and respiratory problems [47]. *Azadirachta indica* is used to treat endo parasite and ectoparasites in the Borena pastoralists, southern Ethiopia [27]. Moreover, the efficacy of leaves of *Azadirachta indica* to reduce the parasitic load and that of the Aloe species in

treating *Trypsostrongylus* in sheep and it contain chemicals that could help to control more than 200 pest species as well as antimalarial limuloids that showed good antimalarial [49].

Indigenous knowledge of medicinal plants in Ethiopia is unevenly distributed among community members [51]. The distribution of knowledge and services are hierarchically placed. Services are obtained from the family, the neighborhood, the village or beyond. A common saying related to the knowledge goes as follows "leave alone human beings, even a goat knows which twig to nibble when bitten by snake" [52]. *Hagenia abyssinica* is used against several human and livestock ailments. Medicinal uses were categorized as intestinal, digestive, circulatory, respiratory and nervous system, among others, disorders. The anthelmintic action of this plant against tapeworm (*Taenia saginata*), whose widespread occurrence grounds in the consumption of dishes containing raw beef, has been mentioned by all informants in all study sites. *Hagenia* has been also described as a powerful remedy for intestinal parasites, especially against cestodes [10, 35, 46, 47, 54-58]. In the 19<sup>th</sup> century, the species of *Hagenia abyssinica* was included in most European pharmacopoeias as an effective drug against intestinal worms, which made it one of the most famous African plants at that time. In addition to its importance against human ailments it has anthelmintic property to treat ruminants such as cattle, goats, and sheep [35, 41, 46, 57].

The currently available anthelmintics (benzimidazoles, tetrahydropyrimidines and macrocyclic lactones) have been widely used against equine gastrointestinal helminths prophylactically and chemotherapeutically for many years. However, anthelmintic resistance is thought to be present in many populations and threatens sustainable control in future. Further, in some developing countries, where donkeys are relied upon for transportation, there may be other constraints to the use of manufactured anthelmintics, such as limited availability and excessive cost. Anthelmintics may be diluted before being sold or may be used at incorrect dose rates, which may further accelerate the development of resistance in these populations. Hence, there is a need to explore alternative methods of control of gastrointestinal helminths in donkeys in these parts of the world. Kosso (*Hagenia abyssinica*) 'Grawa' (*Vernonia amygdalina*) and 'mixed roots and leaves' were the most frequently believed to be efficacious against gastrointestinal parasites for use in donkeys, cattle and small ruminants [58].

#### 2.4 Major threats to medicinal plants

The earth's natural resources whether renewable or nonrenewable play a vital role in the human

welfare. Since the early age, human have been engaged in exploring new resources but seem to use them in a sustainable way adopting some simple techniques like deferred gratification [59]. However, during the last fifty years, following industrialization and green revolution, the exploding human population has placed a cumbersome pressure on natural resources, particularly the plant diversity [60].

The current era is facing considerable biological extinction due to a number of natural and anthropogenic activities including the clear-cutting of forests, conversion of grasslands into cultivated lands, industrialization, urbanization, overgrazing, soil erosion, desertification, etc. Similarly, overexploitation also poses a severe threat to biodiversity and has led to a number of species to extinction [48]. During the last quarter century, environmental and cultural changes, market-based economics and over harvesting of medicinal plant species have resulted in resource degradation, loss of biodiversity and the loss of indigenous and traditional medicinal knowledge [62].

Majority of the species are threatened by physical stresses and anthropogenic disturbances. The extensive uses are common threats to most of the plant species. They have narrow ecological amplitude and their unwise use has threatened their survival in the Salt Range [65]. The most serious proximate threats when extracting medicinal plants generally are habitat loss, habitat degradation, and over harvesting [66]. The majority of medicinal plants, with few exceptions, is harvested from wild habitats and cultivated, which are currently under great threat. Nowadays, both the plant materials and associated traditional knowledge are being lost due to lack of systematic conservation, research, proper utilization and documentation [61].

Generally, ecological degradation, loss of indigenous knowledge and of cultural assets, danger on medicinal plant through smuggling and misuse of resources, lack of suitable scheme for equitable sharing of benefits arising from biological resources and poor market situation may prevent enthusiastic cultivators from producing medicinal plants for the market are some examples of threat of medicinal plants [63].

#### 2.5 Conservation of medicinal plants

Medicinal plant conservation strategies need to be understood and planned for based on an understanding of indigenous knowledge and practices [64]. Many drugs contain herbal ingredients, and it has been said that 70–80% of the world's population relies on some forms of non-conventional medicine. Many countries rely on these medicinal plants for the health and well-being of its population [68]. The market demand has led to an increased pressure on the natural

resources that lend to the production of some of these plants [66].

Developing markets for natural products, particularly those that are harvested from the wild, can trigger a demand that cannot be met by available or legal supplies and demands a conservation initiative so the local populations are not exploited, causing more damage to their resources [68].

Many times populations are taken advantage of for their resources and knowledge, which can often be for financial gain. Conservation of medicinal plants in its bio-cultural perspective not only implies conservation of biodiversity but also places an equal emphasis on conservation of cultural diversity [69]. Sustainable use of medicinal plants has now grown to be a timely issue in Ethiopia because of resource degradation in the lowlands and highlands alike. Ecosystem conservation will ensure in situ conservation of medicinal plants so as to apply sustainable harvesting methods for collecting the plants from wild habitats. Experience from South Africa would be essential to develop innovative methods for harvesting individual plants [70].

Medicinal plants are considered to be at conservation risk due to over use and destructive harvesting (roots and barks collection). In a broad sense, conservation is achieved through in-situ and ex-situ means. In-situ conservation is conservation of species in their natural habitat. Some traditional medicinal plants have to be conserved in-situ due to difficulty for domestication and management. Moreover, some plants fail to produce the desired amount and quantity of the active principles under cultivation out of their natural habitats. Medicinal plants can also be conserved by ensuring and encouraging their growth in special places, this can be possible in places of worship (churches, mosques, grave yards, etc), scared grooves, farm margins, river banks, road sides, live fences of gardens and fields [51]. Medicinal plants can be conserved using appropriate conservational methods in gene banks and botanical gardens. This type of conservation of medicinal plants can also be possible in home gardens, as the home garden is strategic and ideal farming system for the conservation, production and enhancement of medicinal plants [63].

### **2.6 Medicinal plant parts used**

Almost all plant parts including roots, leaves, stem, bark, fruits, young shoots and flowers, were cited for use in preparing the different remedies. However, roots followed by leaves represented the most common parts used for treating ailments in humans and livestock, respectively. Roots are appeared to be the main plant part commonly used by the healers in the current study area. This could be associated with the fact that roots remain in the soil

and are easily available, even during the long dry seasons in arid and semi-arid areas. In addition, the use of plants root could also be associated with early African beliefs in their powerful therapeutic effects. For example, early African Diasporas in the Americas and those migrants to Caribbean countries during the colonial period used plant roots to protect against malaria and venereal diseases and to induce abortions, but also to prepare favorite household alcoholic drinks, as roots contributed to alcohol fermentation, color, flavor, and foam formation [71].

Different parts of plants are used in preparing the traditional insecticides, insect repellents, and to treat livestock diseases. Leaves are the most commonly used parts, followed by fruit and whole plant and the rest constituted lower proportions [69].

The use of medicinal plant roots, either for immediate use of treating ailments or for commercialization purpose to generate income, could negatively contribute to local biological diversity and conservation because of complete plant removal from its natural habitat. The common use of leaf in the preparation of remedies could partly be due to the relative ease of finding this plant part. In generally as different study applied in different parts of Ethiopia reported that roots and leaves are indeed the most commonly used medicinal plant parts [71, 72]. Many medicinal preparations use roots, stem and bark by effectively killing the plant in harvest [73]. Plant parts used to prepare remedies are different; however, root is the most widely used part. Such wide utilization of root part for human and livestock ailments with no replacement has severe effect on the future availability of the plant [74].

### **2.7 Preparation methods**

Main methods used for processing the herbal remedies were; decoction, maceration, poultices and ointment. Decoction; this process was used when working with tough and more fibrous plants/ parts such as the trunk bark and root bark. The materials were boiled in water for long period of time to soften the materials and release the active chemical constituents. Maceration was preferably used for very tender/fresh plants, that were thought to lose their active compounds on heating. The mashed or ground plant materials were stirred in water to make a concoction. The poultices were prepared by mashing fresh plant materials. The mashed material would be applied directly on the affected part [75].

The ointment was locally made using cow ghee as the base. This preparation applied to only *Euphorbia candelabrum*, from which fresh sap was mixed with ghee by stirring thoroughly. Ghee was used as a base and a nullifying agent for the irritation due to the sap when used in a solitary form. In preparation of decoctions and macerations water was

used throughout as a solvent. In this case, the farmers worked on assumptions that the desired-active chemical constituents were water soluble in the herbal remedies they prepared [78]. Concoction filtrate (a liquid from which insoluble impurities have been removed), paste on (topical), pounded and smoke bath are common use forms or modes of preparations. Concoction and filtrate as the major use forms of the plants cited. The remedies are prepared using water (hot or warm), local drinks, boiled coffee or milk as a carrier and taken either orally or through inhalation of the vapor after boiling (smoke bath treatment).

The frequent use of concoction and the mixing of two or more plants by healers could be associated with healer's belief of synergistic effects of certain plant components for healing the illnesses. This finding is consistent with earlier reports [76], but disagrees with other studies where crushing and squeezing and homogenizing and crushing were the main use forms. It is likely that these differences are associated with the differences in culture and knowledge in different socio-cultural groups [77].

Plant parts of *Hagenia* are processed either in fresh or dried forms. Children or elder people collect the plant part which is intended for remedy preparation. Usually elderly men are responsible for harvesting the bark and root part. The process of preparing medicine from female flowers (here after called as kosso) is simple yet requires care. Normally the name kosso refers to the tree itself (in Amharic), the human tapeworm (*Taenia saginata* Goeza) or the medicine [79].

## 2.8 Route of administration and dosage

### 2.8.1 Route of administration

The commonly reported routes of administration are oral, followed by topical, nasal and smoke bath treatment. The choice of oral administration may be related to the use of some solvents or additives (milk, butter, alcoholic drinks, boiled coffee, and food) that are commonly believed to serve as a vehicle to transport the remedies. The additives are also important to minimize discomfort, improve the taste and reduce adverse effects such as vomiting and diarrhea, and enhance the efficacy and healing conditions [80]. Similar findings were reported by many other researchers, indicating the oral route as the most preferred mode of administration [72].

Kosso can also be consumed in the form of paste (e.g. by mixing the powdered flower with banana or honey). Usually children and very weak patients prefer to swallow the sweet paste as the medicine is bitter. Warabechara (*Girardinia bullosa* or pumpkin (*Cucurbita pepo* L.) seed, or cabbage (*Brassica oleracea* L.) or 'Hinkoko' (*Embelia schimperi* Vatke). Fruits of *Embelia schimperi* Vatke are usually grinded, macerated in water and mixed with the already

prepared Kosso solution. Another ethno botanical study conducted and reported that people in 'Dheeraa' town, Ethiopia, mix a pounded flower of *Hagenia abyssinica* with the root of *Croton macrostachyus* Hochst.exDel or leaf of *Grewia ferruginea* Juss for worm expulsion [79].

### 2.8.2 Dosage form

There is no consensus on the dosage used and frequency of the medication among healers. For example, the dosage varied according to the type of illness ranging from two spoon full (e.g. for treatment of anemia like syndrome with jaundice using concoct prepared from *Cissampelos* spp. to a cup or glass full (e.g. for treating "busino" or abdominal pain using decoct from *Centella asiatica* [81]. As some researcher explained that both self-made, and medicines prescribed by healers need to be taken in specific doses, but they stated different amounts. Common measurement units mentioned in all communities include tea cups, water glasses and cans and also the dosage depends on age, sex, physical appearance of a person, health condition and severity of pain. Similar studies have also mentioned such measurements. Eighty five percent of respondents in Bale, and all informants in Kofele and Debark believe that the dosage usually depends on age and sex (Table 2) [79].

**Table 2:** Summary of route of Administration, Dosage and Parts used

Name of Plants	Parts Used	Dosage/Administration
<i>Albizia lebeck</i>	Leave	Crush ¼ to ½ kg leaves and administer POs or put leaves in front of animal and allow the animal to eat and libitum.
<i>Allium cepa</i> L	Leave	Grind the pestle and mortar and <i>Allium cepal</i> . Sieve with muslin cloth until ½ liter of extract is obtained, administer POs.
<i>Azadirachta indica</i> A Juss	Leave	Boil 1kg leaves in 2 liters of water, when water remains 1 liter administer it POs
<i>Bambusa arundinacea</i>	Stem	Mix ½ liter seed oil with 1/4kg curd and administer POs.
<i>Capparis decidua</i>	Twing s	Crush the twings well mix sufficient quantity of jiggery in it to make the bolus and administer POs.

Source: [31].

## 3. Conclusion and Recommendations

In conclusion, only some of the traditionally used anthelmintic medicinal plants have been evaluated for

their putative anthelmintic activity. However, the plant is facing considerable biological extinction due to a number of natural and anthropogenic activities. Moreover, different parts of anthelmintic plants are used for various parasitic diseases and disease conditions, but its dosage form is still the major problem. Thus, there is need to determine the dosage form of anthelmintic medicinal plant.

### Acknowledgements

The authors would like to thank Bishoftu Elfora export abattoir, Addis Ababa University, College of Agriculture and Veterinary Medicine and all individuals who render help during the study period are highly acknowledged.

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5/8/2015