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Feature article

FRANKINCENSE AND MYRRH RESOURCES OF ETHIOPIA: II. MEDICINAL AND INDUSTRIAL USES

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ABSTRACT: Oleo-gum resins such as frankincense and myrrh are some of the economically and culturally valuable products obtained from trees and shrubs of the genera *Boswellia* and *Commiphora*, respectively. They are important natural plant products used in several industries that include pharmacology, food, flavour, liqueur and beverage, cosmetics, perfumery and others. Moreover, frankincense and myrrh have several local applications in medicinal, hygienic, and insecticide areas that could be developed through research. They are widely used in traditional medicines of several countries for treatments of a wide variety of ailments from embalming to cancer, leprosy, bronchitis, diarrhea, dysentery, typhoid, mouth ulcers, inflammatory complaints, viral hepatitis, female disorders, infections/wounds, coughs, tumour, and others. Although Ethiopia is one of the few countries that are endowed with large frankincense and myrrh resources, little proper exploitation of these resources has been made so far. In this paper a review is presented on pharmacological and industrial applications of these valuable resources. The information is expected to prompt the enormous economic opportunity that these resources could provide both at national and local levels. Concurrently, this opportunity, if properly exploited, will contribute significantly towards the conservation and management of the vegetation resources that yield frankincense and myrrh as well as their ecosystems.

Key words/phrases: *Boswellia*, *Commiphora*, folk medicines, industrial use, pharmacology

INTRODUCTION

Ethiopia is well endowed with various species of *Acacia*, *Boswellia* and *Commiphora* that are known to produce economically valuable products, principally oleo-gum resins such as gum acacia, frankincense and myrrh. Particularly, the aromatic resinous plant exudates, frankincense and myrrh, have been treasured for their sacred and ceremonial uses since long, even before biblical times (Hillson, 1988). Above all, frankincense and myrrh have been employed for several millennia in a number of medicinal contexts (Grieve, 1979; Hillson, 1988; Bhatt *et al.*, 1989; Michie and Cooper, 1991; Thulin and Claeson, 1991), many of which hold true still today (Tariq *et al.*, 1985; Thulin and Claeson, 1991; Yen, 1992; Shao *et al.*, 1998; Huang *et al.*, 2000). They are used for medicinal purposes in Europe, India, Africa, China and Middle East (Grieve, 1967; Grieve, 1979; Tariq *et al.*, 1985; Michie and Cooper, 1991; Yen, 1992; Brown, 1995; Al-Harbi *et al.*, 1997). Much in use from ancient times, frankincense and myrrh have continued to find modern pharmacological applications, most of them as predicted by the traditional therapies (Fratkin, 1986; Claeson *et al.*, 1991; Michie and Cooper, 1991; Yen, 1992; Duwiejua *et al.*, 1993; Safayhi *et al.*, 1996; Al-Harbi *et al.*, 1997; Shao *et al.*, 1998; Huang *et al.*, 2000; Gupta *et al.*, 2001; Massoud *et al.*, 2001).

Furthermore, frankincense and myrrh have been and still be used as raw materials in many industries such as perfumery, food, beverage as well as for religious rituals and several other local uses (Hall and Oser, 1965; Council of Europe, 1981; Tucker, 1986; Hillson, 1988; Ford *et al.*, 1992; Farah, 1994; FAO, 1995; Anonymous, 2001; Mulugeta Lemenih *et al.*, 2003). Stiles (1988) emphasized that an even greater potential lies in developments to be made through research in the pharmaceutical, fragrance and flavour, food technology, epoxy resin/ plastics and coating industries to develop more products that would make use of these renewable resources.

Although frankincense and myrrh constitute an integral part of the Ethiopia's economy since

several millennia (Ahmed, 1982; Tucker, 1986; Thulin and Claeson, 1991; Farah, 1994; Kuchar, 1995), little is known about their pharmacological and industrial uses in Ethiopia so far. Consequently, little use of them has been made in the country. We presume that lack of knowledge and information could be one possible reason for their under exploitations. Thus, a review is made in this paper on pharmacological and industrial uses of these valuable plant resources. The information can be used as an indicator of the rich potentials in the vegetation resources of the arid and semiarid lowlands of the country with the implication of the need to plan for extensive studies of their management, conservation and economic utilizations.

CHEMISTRY OF MYRRH AND FRANKINCENSE

Both frankincense and myrrh are essentially mixtures of volatile oils, resin, gum and impurities. Their chemical compositions are provided as follows.

Myrrh

Myrrh is oleo-gum resin exudates obtained from several species in the genus *Commiphora*. It contains ca. 57–61% water-soluble gum, 7–17% volatile oils, and 25–40% alcohol-soluble resins and 3–4% impurities (Karamalla, 1997; Massoud *et al.*, 2001). The alcohol-soluble resins of myrrh consist of commiphoric acids, commiphorinic acid, heeraboresene, heerabomyrrhols, and commiferin (Bradley, 1992; Leung and Foster, 1996; Newall *et al.*, 1996; Rao *et al.,* 2001). Furthermore, the resins were found to contain α-, β-, and γ-commiphoric acids, commiphorinic acid, α- and β-herrab-omyyhols, heerboresene, commiferin, kerto-steroids, compesterol, β-sitosterol, cholestrerol, α-amyrone and 3-epi-α-amyrin (Rao *et al.*, 2001). Two triterpenes have been identified in the resins of *C. incisa* and *C. kua* and their potential chemotaxonomic significance indicated (Provan and Waterman, 1986).

The volatile oil fraction contains different terpenes, sesquiterpenes, esters, elemol, cinnamaldehyde, cuminaldehyde, cumicalcohol, eugenol, heerabolene, limonine, dipentene, pinene, m-cresol, cadinene and numereous furano-sesquiterpenes (Rao *et al.*, 2001), myrcene and α-camphorarene; steroids including Z-guggulsterol, and I, II, III guggulsterol (Kapoor, 1990; Huang, 1999), aldehydes and alcohols (Treas and Evans, 1978).

The water-soluble gum or mucilage fraction is composed mainly of acidic polysaccharide with galactose, xylose, 4-0-methyl-glucuronic acid and arabinose in a ratio of 8: 7: 2 with ca. 18–20% protein (Bradley, 1992; Wichtl and Bisset, 1994), and also on hydrolysis the gum yields arabinose, galactose, xylose and 4-0-mythylglucuronic acid (Leung, 1980; Evans, 1989). Characteristic constituents of myrrh are mainly terpenoids, including furanosensequiterpenoids with eudes-mane, germacrane, elemane, or guaiane structures (Bradley, 1992; Witchtl and Bisset, 1994), wheras íts characteristic odor is due to the furanoses-quiterpenes (Bruneton, 1995), which may also be the characteristic components of pharmaceutical myrrh (Wichtl and Bisset, 1994).

Extraction of gum myrrh with 90% alcohol yield a crude polysaccharide (PS) in the ranged of 27%–60% (Treas and Evan, 1978) while the crude PS of myrrh is found to contain 18% protein (Anderson *et al.*, 1965).

Frankincense

Frankincense is oleo-gum resin obtained from several species of *Boswellia* trees. Frankincense is composed of about 5–9% essential oil, 65–85% alcohol-soluble resins, and the remaining water-soluble gums (Tucker, 1986) or 8–9% essential oil, 45–50% resin, 30–40% gum and 4–5% impurities (Murthy and Shiva, 1977).

The oil portion contains 62.1% ester, 15.4% alcohol, 9.9% monoterpene hydrocarbons and 7.1% diterpenes (Wahab *et al.*, 1987). About 27 sesquiterpene hydrocarbons have been identified in the steam-distilled oils of *Boswellia* species (Yates and Wenninger, 1970). The oil materials have shown to contain α-pinene, α-thujene, β-pinene, camphene, myrcene, o-methylanisole, α-terpinene, methoxytoluene, hexyl acetate, limonene, 1, 8-cineole, n-octanol, linalool, octyl acetate, bornyl acetate, cembrene A, incensole, incensole acetate, sabinene, o-cymene, ρ-cymene, 1,8-cineole, cis-β-ocimene, trans-β-ocimene, ϒ-terpinene, 1-octanol,

terpinolene, linalool, 1-decanol, terpinen-4-ol, α-terpineol, 1-octyl acetate, citronellyl acetate, neryl acetate, geranyl acetate, hexyl hexanoate, 1-decyl acetate, hexyl octanoate, α-campholenic aldehyde, caproic acid, oenanthic acid, caprylic acid, pelargonic acid, lauric acid, and verbenone (Tucker, 1986; Wahab *et al*., 1987).

The gum portion was found to contain 2 polysaccharides: I) composed of 1 galactose: 1 arabinose and II) composed of 2 galactose: 1 galacturonic acid (El-Khadem and Megahed, 1956). The terpenoid portion contains boswellic acids and albanoresin. The boswellic acids components are shown to be the active constituents in *Boswellia* for many of its medicinal uses (Safayhi *et al*., 1992; Ammon *et al*., 1993). Boswellic acids are further known to contain β-boswellic acid, acetyl-α-boswellica acid, and acetyl-β-boswellic acid, and associated 3-acetyl-11-hrdroxy-β-boswellic acid and 11-keto-β-boswellic acid acetate chemicals (Corsano and Iavarone, 1964; Huang *et al*., 2000). Today, extracts for frankincense are typically standardized to contain 37.5–65% boswellic acids (Ammon *et al*., 1993).

^{13}C NMR analysis of crude steam distillation of frankincense from *B. papryfera* in Ethiopia indicated that the main component (88%) of the resin is octyl acetate, a result also confirmed by GC-MS analysis supported by NIST and Wiley database (Ermias Dagne *et al*., 1997). The purified PS from *B. papyrifera* has 4–8 % protein (Anderson *et al*., 1965) while Abdel Kariem (1992) has recently reported that the protein content of crude PS of *B. papyrifera* is only 3.9%.

PHARMACOLOGICAL USES OF FRANKINCENSE AND MYRRH

Uses in folk medicine

The application of fragrant oleo-gum resins known as frankincense and myrrh for medicinal values is among man's oldest therapies. The Papyrus Ebers of about 1500 B.C is perhaps the oldest list of prescriptionin which the priests who supervised funerals, mummification and cremations describe the value of both resins in each of these procedures, as well as in the treatment of wounds and skin sores (Michie and Cooper, 1991). Furthermore, until the beginning of the twentieth century, frankincense and myrrh were components of European pharmacopoeia, but they have since fallen into obscurity during the era of synthetic drugs (Krieglstein *et al*., 2001). Nevertheless, frankincense and myrrh are still widely used therapeutically in regions raging from North Africa to China (Krieglstein *et al*., 2001), and especially in the traditional Ayurvedic medicines of India, Arabia and China (Al-Harbi *et al*., 1994; Safayhi, *et al*., 1996; Shao *et al*., 1998; Krieglstein *et al*., 2001; Rao *et al*., 2001), as well as in Ethiopia and Somalia (Martinetz *et al*., 1989; Thulin and Claeson, 1991; Farah, 1994; Claeson and Samuelsson, 1998; Mulugeta Lemenih *et al*., 2003).

The oleo-gum resin of *Commiphora myrrha Engl.* locally called 'mur' or 'myrrh' is highly reputed and commonly used in Arab medicines for the treatments of some inflammatory conditions, as an antipyretic, anti-septic, stimulant, anti-infections, bronchial complaints; mouth wash and to cure different stomach problems including stomach cancer (Chopra *et al*., 1958; Tyler *et al*., 1981; Hartwell, 1982; Tariq *et al*., 1985; Angeel *et al*., 1987; Evans, 1989; Iwu, 1990; Brown, 1995; Rao *et al*., 2001). Myrrh is also used in Arabia to cure tumors of the spleen, liver, stomach, breast, head, nose and eye (Angeel *et al*., 1987; Hartwell, 1982; Evans, 1989). Today, crude myrrh is dispensed throughout eastern Africa and Saudi Arabia as an anti-inflammatory and anti-rheumatism drug (Iwu, 1990).

Myrrh and frankincense have a long history of therapeutic use in Indian Ayurvedic system of medicine (Bhatt *et al*., 1989; Brown, 1995; Majeed *et al*., 1996; Huang *et al*., 2000). For instance, gum resin exudate of *Boswellia serrata* is used as a commercial herbal medicine (Majeed *et al*., 1996). Myrrh is used in India to treat mouth ulcers, gingivitis, pharyngitis, respiratory catarrh (Karnick, 1994), to treat rheumatoid arthritis, heart ailments, neurological disorders, skin infections, and obesity (Bhatt *et al*., 1989). Externally, it is used as an astringent topical application to ulcers and as a gargle for spongy gums (Nadkarni, 1976), as astringent demulcent, expectorant, alternatives, stomachache, carminative, aphrodisiac and antiseptic (Bhatt *et al*., 1989). As a treatment for stomatitis (inflammation of the mouth), it is combined with honey and rectified spirit, then

dissolved in rose petal infusion, and taken as a mouthwash. Myrrh tincture (mixture) is also used to treat many disorders associated with the female reproductive cycle, particularly dysmenorrhea and amenorrhea, and to help relieve some of the uncomfortable symptoms of menopause (Frawley and Lad, 1986; Nadkarni, 1976). Frankincense from *Boswellia serrata* is also widely used in India for several disease treatments, particularly inflammation bowl diseases (IBD) (Huang *et al.*, 2000; Gupta *et al.*, 2001).

Use of myrrh and frankincense was also introduced into both the Chinese and Tibetan systems of medicine sometime during the seventh century (Clifford, 1984; Brown, 1995; Leung and Foster, 1996), where they are popular today as herbal medicines (FAO, 1995). In Chinese medicine, myrrh from *C. myrrha* is used to treat impact injury, incised wounds, chest pains, sinew and bone pain, menstrual block, and hemorrhoids, among other conditions, as well as various topical plaster-adhesives and lotions, including die-da-yao-jing (Traumatic Injury Medicine Essence) (Fratkin, 1986; Yen, 1992). Myrrh and frankincense are also used to treat leprosy, cancer, gonorrhea, carbuncles, bleeding disorders, wounds and as an astringent in China (Clifford, 1984; Brown, 1995; Leung and Foster, 1996).

In Somalia and Ethiopia they are also used for the treatments of allergies, snake and insect bites, colds, coughs, diarrhea, headaches, syphilis, stomach complaints, back complaints, disinfections, purifications and hygiene, to correct female disorders during menopause and topically for the treatments of wounds in humans and livestock (Martinetz *et al.,* 1989;Thulin and Claeson, 1991; Farah, 1994; Claeson and Samuelsson, 1998; Mulugeta Lemenih *et al.*, 2003).

Myrrh has always had a wider medicinal application than frankincense (Michie and Cooper, 1991; Farah, 1994). It is described in early Sumerian inscriptions detailing treatments for infected teeth and worms, while Hippocratic writings (4th century B.C.) contain some 54 references to myrrh out of 131 descriptions of the use of incenses: it was the most popular component of wounds, sepsis and worms (Michie and Copper, 1991). Moreover, myrrh's antibiotic effect had been successfully utilized before the first century B.C to prevent the fermentation of wine to vinegar a central challenge of the technology of the day (Michie and Cooper, 1991). Generally, myrrh has been used medicinally as an embalming agent, anti-infection, anti-skin inflammation, painkiller, anti-sores, to treat worm infestation, coughs, as a cure for cancer, leprosy, and syphilis since ancient times (Dörr, 1973; Groom, 1981; Brown, 1995; Archaeology, 1996). It has been also used to treat herpes (Nadkarni, 1976). It is used as an anti-infection, anti-inflammatory, antiseptic, astringent and as a tonic, as a powerful infection fighter, and an effective expectorant (Grieve, 1979).

Pharmacological uses

Several folklore claims about natural drugs have continued to be verified on modern scientific grounds. Similarly, both frankincense and myrrh have found modern pharmacological applications for several disease treatments most of them as predicted by the traditional therapies. Particularly, their unique chemical compositions, pharmacological activities and non-toxicity tend to support the safe use of these popular traditional drugs in modern therapies (Michie and Cooper, 1991).

Recently, two compounds of myrrh, furanoeudesma-1, 3-diene and curzarene, are reported to have indeed pronounced pain relieving (analgesic) properties as claimed by traditional therapies (Archaeology, 1996). The anti-inflammatory, antipyretic and antihistaminic effects of *Commiphora myrrha* (Tariq *et al.*, 1985), hypolipidemic (Malhotra *et al.*, 1977), hypocholesteremic, antiartheroscerotic (Lata *et al.*, 1991), antiarthritic potential (Duwiejua *et al.*, 1993), antigastric ulcer and cytoprotective effect (Al-Harbi *et al.*, 1997), anti-tumour potential (Queshi *et al.*, 1993; Al-Harbi *et al.*, 1994), smooth muscle relaxing effect of *C. guidottii* (Claeson *et al.*, 1991), anti-inflammatory effect of *C. mukul* and *C. incisa* (Duwiejua *et al.*, 1993), antiulcer effect (Al-Harbi *et al.*, 1997); anti-schistosomiasis (Massoud *et al.*, 1998), anti-fascioliasis (Massoud *et al.*, 2001), reduction of cholesterol and triglycerides (Michie and Cooper, 1991), hypolipidemic (Malhotra *et al.*, 1977), hypocholesteremic and antiartherosclerotic (Lata *et al.*, 1991), pediatric and blood lipid remedies in Children (Michie and Cooper, 1991), and without toxicity side effects (Rao *et al.*, 2001; Massoud *et al.*, 2001) were verified. Myrrh also has astringent properties and has a soothing effect on

inflamed tissues in the mouth and throat. Studies continue on the potential anticancer actions of myrrh resin (Al-Harbi *et al.*, 1994; Dolara *et al.*, 1996). In addition to its antiseptic and expectorant abilities, myrrh destroys putrefaction in the intestines and prevents the absorption of toxins in the blood; it stimulates blood flow to the capillaries and promotes menstruation (Nadkarni, 1976; Frawley and Lad, 1986).

The resinous portion of myrrh/guggal carries significant anti-inflammatory, antirheumatic and hypocholesterolemic/hypolipaemic activity. It is also known for a rich source of steroids, which may find use as an alternative raw material for the synthesis of important corticosteroid drugs such as dexamethasone and betamethasone (Bhatt *et al.*, 1989). For instance, a preparation by name 'Guglip' developed from guggal (gum resin from *Commiphora wightii*) by the Central Drug Research Institute, Lucknow in India is reported to possess hypolipiemic activity equivalent to that of clofibrate (ethyl p-chlorophenoxyisobutyrate)-the present drug of choice (Bhatt *et al.*, 1989). As Clofibrate is being discontinued and phased out in the USA on account of its toxic manifestations, there is ample scope for introducing guglip on a commercial scale (Bhatt *et al.*, 1989).

In Chinese medicine, myrrh from *C. myyrha* (syn *C. molmol*) is used as a component in many patent medicines, including bu-gu-zhi-wan (Psoralea Pills) and zhi-wan (Hemorrhoid Pills), as well as various topical plaster-adhesives and lotions, including die-da-yao-jing (Traumatic Injury Medicine Essence) (Fratkin, 1986; Yen, 1992).

In Germany, myrrh gum-resin and myrrh tincture are both official in the German Pharmacopeia, approved in the Commission E monographs, and the tincture dosage form is official in the German Standard License monograph (Wichtl and Bisset, 1994; Deutsches Arzneibuch (DAB), 1997). The tincture is used as a mono-preparation and also as a component of various dental remedies and mouthwashes, toothpaste, ointments, paints, and coated tablets, where the applications by paint, gargle, and/or rinse are used in dentistry (Wichtl and Bisset, 1994). For example, the product Merfluan® is an effervescent dentifrice salt with myrrh (Mielck, 1970). Pediatric medicine, tincture of myrrh is used in Germany to treat oral condidiasis (thrush), which is common in infants (Schilcher, 1997).

In the United States, myrrh was formerly official in the United States Pharmacopeia and National Formulary (Leung and Foster, 1996). It was used as an aromatic astringent mouthwash (Taber, 1962). Myrrh's constituents include aldehydes and phenols, which stimulate drying and cleansing actions through topical administration. As a salve, myrrh is used to treat hermorrhoids, wounds, and bedsores. In tincture form, gargles and mouthwashes are considered useful in treating sore throats or other oral mucosal or gingival irritations (Tyler, 1993).

The British Herbal Pharmacopoeia (BHP) reported antiseptic action of myrrh (BHP, 1996). The Merck Index reported its therapeutic action as carminative and astringent (Budavari, 1996). Myrrh has also shown to have disinfecting, deodorizing, and granulation-promoting properties (Wichtl and Bisset, 1994). The British Herbal Compendium indicates the use of myrrh tincture as a gargle to treat pharyngitis and tonsillitis (Bradley, 1992). In France, its topical use is approved for the treatment of small wounds, for nasal congestion from the common cold, and for local application as an anodyne to treat affections of the buccal cavity and the oropharynx (Bradley, 1992; Bruneton, 1995).

The approved modern therapeutic applications for myrrh are based on its long history of use in well established systems of traditional and conventional medicine, case studies, in vitro studies, pharmacological studies in animals, and on phytochemical studies of its volatile oil, gum and resin fractions (Blumenthal *et al.*, 1998).

Frankincense has also been employed for medicinal purposes since antiquity. In all human civilizations (Egyptians, Greeks, Romans, Chinese, Arabs, Indians, etc.) it was used as anti-catarrhal, anti-depressant, anti-intiseptic, anti-tumoral, diuretic stimulant, emmenagogue, for treatment of cough and asthma, as expectorant, immune stimulant, and sedative (Wahab *et al.*, 1987; Gore enterprises (1999). In today's world as well, it is used for asthma, ulcers, aging, allergies, snake and insect bites, bronchitis, cancer, carbuncles, catarrh, colds, coughs, diarrhea, diohtheria, headaches, healing, hemorrhaging, herps, high blood pressure, inflammation jaundice, laryngitis, meningitis,

nervousness, prostate, pneumonia, respiratory problems, scarring sciatic pain, soars, spiritual awareness, staph, strep, stress, syphilis, T.B., tension, typhoid, wounds, warts and to strengthen the immune system (Leung and Foster, 1996).

Pharmacological applications recently justified that frankincense can be used as anti-tumor and anti-carcinogenic (Huang *et al*., 2000), anti-inflammatory activity (Shao *et al*., 1998; Safayhi *et al*., 2000; Krieglstein *et al*., 2001), anti-proliferative effects (Glaser *et al*., 1999; Hoernlein *et al*., 1999), anti-chronic colitis (Gupta *et al*., 2001), anti-bronchial asthma (Gupta *et al*., 1998; Safayhi *et al*., 2000), anti-human leukemia HL-60 cells and the DNA, RNA and protein synthesis in HL-60 cells (Shao *et al*., 1998). Controlled, double blind studies have shown that *Boswellia* extracts are very helpful for ulcerative colitis (Singh and Atal, 1986). The anti-inflammatory effects of treatment with *Boswellia* extract or AKBA (Acetyl-11-keto-β-boswellic acid) in experimental ileitis in rats are comparable to those achieved by treatments with standard drugs of Inflammatory Bowls Disease (IBD) such as prednisolone and sulfasalazin (Yamada *et al*., 1993), and pilot study in human ulcerative colitis of the same procedure reported fewer side effects of treatment with *Boswellia* extract than with steroids (Gupta *et al*., 1997). *Boswellia* extracts inhibits pro-inflammatory mediators in the body, such as leukotrienes (Singh and Atal, 1986), and as opposed to NSAIDS, long-term use of *boswellia* extracts (crude) does not lead to irritation or ulceration of the stomach (Gupta *et al*., 2001).

ACTIVE CONSTITUENTS

Myrrh

The chemistry of frankincense and myrrh is already described above. The three main constituents of myrrh: the resin, the gum, and the volatile oil are all important in myrrh's activity as a herbal medicine. The crude resin was shown to have anti-inflammatory activity (Duwiejua *et al*., 1993), a combination of resin and volatile oil in the ration of 8: 3.5 was indicated effective to treat fascioliasis (Massoud *et al*., 2001), petroleum ether extract of myrrh was also found effective as anti-inflammatory activity (Tariq *et al*., 1985), T-Cadinol of the volatile oil component was known to have muscle relaxing effect (Claeson *et al*., 1991), the aqueous suspension of myrrh was found effective as anti-ulcer and cytoprotective (Al-Harbi *et al*., 1997). The resin has shown to kill various microbes and to stimulate macrophages (a type of white blood cell) (Mills, 1991).

Myrrh has been shown to work in two complementary ways. Primarily it stimulates the production of white blood corpuscles (with their anti-pathogenic actions) and secondarily it has a direct anti-microbial effect (Sharma and Sharma, 1969; Tariq *et al*., 1977; Satyavati *et al*., 1988; Malhotra and Ahuja, 1991; Mills, 1991).

Frankincense

Frankincense consists of essential oils, gum, and terpenoids. The boswellic acids in the terpenoid portion are the active constituents in *Boswellia* (Safayhi *et al*., 1996). Studies have shown that the boswellic acids have an anti-inflammatory action (Safayhi *et al*., 1992)-much like the conventional non-steroidal anti-inflammatory drugs (NSAIDS) used for inflammatory conditions. Furthermore, among the constituents of boswellic acid, β-boswellic acids (the major constituents of boswellic acids) was shown to have anti-inflammatory and anti-arthritic pain activity, which was found to be due to their ability to inhibit 5-lipoxygenase activity (Safayhi *et al*., 1992; Ammon *et al*., 1993; Majeed *et al*., 1996). AKBA components of the boswellic acids are also identified to be among the biologically active and most potent constituents (Krieglstein *et al*., 2001).

INDUSTRIAL AND LOCAL USES OF FRANKINCENSE AND MYRRH

Industrial uses

Myrrh and frankincense are widely used today in several industries such as food, beverages, perfumes, pharmacology, insecticides, and others.

Perfumery

Both myrrh and frankincense are highly valued for their aromatic fragrances and are common ingredients in incense, perfume and potpourris, soaps, detergents, creams and lotions, and are

often included in meditation blends, as it strengthens the psyche and aids in deepening the meditative state (FAO, 1995; Leung, 1980). The Flavour Extract Manufacturer's Association (FEMA) has given them general recognition as safe (GRAS) status as a flavor ingredient (NO. 2765) (Hall and Oser, 1965; Leung, 1980; Fragrance Foundation, 1983; Ford *et al.*, 1992).

Frankincense is a favoured ingredient in potpourris, as it is known to hold its fragrance for a very long time, some even say indefinitely (Tucker, 1986). Besides adding a special fragrance to any blend, it is also noted to have some value as a fixative in perfumes and potpourris. It is employed by perfumers as an absolute (by -alcohol extraction), oil, or resinoid (by hydrocarbon extraction) and is used in the Oriental bases, ambers, powder perfumes, floral perfumes, citrus colognes, spice blends, violet perfumes, male fragrances, soaps, lotions, creams, etc. (Leung, 1980; Tucker, 1986; FAO, 1995). It is also used in the formulation of many modern perfumes, including: *Replique* by Colonia, *Me*! by Frances Denney, *Mennen Millionaire* by Mennen, *Nino Cerruti Pour Homme* by Uniperf, *Onna* by Gary Farn, *Sculpatura* by Jovan, etc. (Tucker, 1986).

Over 2000 years ago, myrrh was one of the most desired, highly valued and most sought after items in the world (Wilford, 1997). It has been used during these times for incense, perfume and medicinal purposes. Myrrh was mentioned 22 times in Bible, as a gift, incense or as article of merchandise (Tucker, 1986). Myrrh is familiar to many religions as it is used for incense in religious rituals, and is mentioned and used in the Jewish, Christian, and Muslim holy texts (Grieve, 1979; Tucker, 1986).

The odor of myrrh is described as warm-balsamic, sweet, and somewhat spicy-aromatic, sharp and pungent when fresh, thus has been employed by perfumers as an absolute, oil, or resinoid, and is used in Oriental-spicy bases, chypres, woody bases, forest notes, pine fragrances, etc. (Tucker, 1986). Myrrh is also included in the formulation of a number of modern perfumes, including: *Fidji* by Guy Laroche, *Onna* by Gay Farn, *Volcan d'Amour* by Diane von Furstenburg, *etc*, (Fragrance Foundation, 1983). The resinoids are also used in soaps and detergent; and among the user are the multinationals such as Unilever and Proctor & Gamble (Farah, 1994).

Synthetic products as ingredients of perfumery and other cosmetics stand as major competitors for the derivatives of the natural gums. They are the advantage of being cheap, steady supply, predictable olfactory and chemical properties and immune to supply and quality problems facing the natural products (Farah, 1994; Krieglstein *et al.*, 2001). Nevertheless, natural ingredients will probably continue to be used, as certain elements are difficult to reproduce exactly by synthetic substitutes.

Food and beverages

Frankincense and myrrh products have also wide ranges of other industrial uses in areas such as food industry, beverages, candies, chewing gums, confectioneries, gelatins, nut products, puddings and canned vegetables (FAO, 1995). The U.S. Food and Drug Administration also approved myrrh for food use (21 Code of Federal Registration-CFR 172.510), while the Council of Europe included myrrh in the list of plants and parts thereof that are acceptable for use in foods (Ford *et al*, 1992; Council of Europe, 1981). Typical applications include: adhesive thickeners, thickeners, stabilizers, flavour, fixatives and emulsifying agents in food products, clarification in beverages, and release agents for rubber products. In the Middle East, particularly Saudi Arabia, approximately 500 tonnes of Somali type olibanum are imported for chewing gum manufacturing, while similar quantity are also used in these countries for burning in the home (FAO, 1995).

Insecticide

Myrrh is also used as an insecticide especially as a repellent of termites and as a mosquito repellent when blended as incense sticks (Farah, 1994). Essential oil from *B. serrata* is found to affect spermatogenesis in *dysdercu similes*, thereby acting as an effective insect growth regulator (Karamalla, 1997). Constituent of the resin from *C. rostrata* have repellent effects against the maize weevile, while the effect of gum resin of *B. papyrifera* and *C. africana* on three insect pests of economic importance, has led to morphological malformation of adults and pupa, reducing the

emergence of adults and increasing mortality rate (Karamalla, 1997).

Other industrial uses

The liquid part of freshly collected boswellia oil, is very similar to turpentine oil obtained from *Pinus* spp., and readily dissolves colophony, dammar and other resins (Murthy and Shiva, 1977). The higher iodine number of the volatile oil that consists mainly dextropinene mixed with L-pinene of boswellia gum-resin indicates its suitability for paint and varnish industry, and can be a substitute for pine turpentine oil (Murthy and Shiva, 1977).

LOCAL USES OF FRANKINCENSE AND MYRRH

Ritual uses

The mysterious appeal incense has had throughout human history and with which it is still connected seems to derive primarily from its ritual importance in divine worship: that is why when people think of frankincense/myrrh they immediately think of the "incense" part (Farah, 1994). Earliest records of frankincense and myrrh list applications both as incense and medicine (Michie and Cooper, 1991). The ancient Egyptians, Babylonians, Assyrians and Jewish and latter the Orthodox and Roman Catholic Christians used them for fragrance in their religious rituals. Still today Orthodox and Roman Catholic Churches in Europe and Latine America use approximately 500 tonnes of Eriterean-type Olibanum every year as incense (FAO, 1995). Similarly an estimated quantity of 2050 tonnes of frankincense are consumed every year by the Ethiopian Orthodox Church, while the quantity of 440 tonnes are used for various ritual and domicile purposes in Addis Ababa alone (Tilahun Gebremedhin, 1997). Besides, in many countries such as Greek and Roman they were used as incense in everyday life burning on the braziers that provided heat in the domicile. In ancient Egyptian, they were used for purification of cities (Groom, 1981).

Hygienic and other uses

Many local uses, which may have potential industrial significance, can be attached to the fragrance as well as the medicinal values of both frankincense and myrrh. Domestic fumigation is very common around the horn of Africa in Ethiopia, Somalia, Eritrea, Yemen and Djibouti. The burning of incense in these countries, include: sanitation/hygienic, purification and charismatic purposes. Burning creates pleasant smell while dispelling bad smells, keeps away insects such as flies, mosquitoes and bees in restaurants. Incense burning is a companion of many ceremonies such as coffee making in traditional style, chat chewing and other ceremonies. In local areas where the gum and resins are produced smoking with incense is used to disinfect and dye water and milk vessels (Farah, 1994).

The most widely acknowledged local uses of frankincense and myrrh are probably their medicinal values (Kuchar, 1995). They have been used for several diseases (internal) and wound treatments by topical application both for human and domestic animals (Farah, 1994; Kuchar, 1995; Mulugeta Lemenih *et al.*, 2003). Internally, they have been used to treat stomachache, snakebites, venereal complaints, chronic cough, polio, tumor, disorders in women, tumor, diarrhea, chest congestion, and back complaints (Claeson *et al.*, 1991; Farah, 1994; Mulugeta Lemenih *et al.*, 2003). Some frankincense types are chewed to refresh breath, and protect teeth and strengthen gums (Farah, 1994). Myrrh is usually more valuable for local medicine than frankincense (Farah, 1994).

Uses as famine food

Many *Boswellia*, *Commiphora* and *Acacia* species also supply wild foods that are used as emergency or famine foods in several places. This is extremely important for arid lowlands characterized by frequent droughts and consequently fodder, crop and livestock failures as are often the case in the arid lowlands of Ethiopia. Some *Boswellia* and *Commiphora* species used for emergency food in different countries as well as parts used are summarized in Table 1.

Table 1. Some *Commiphora and Boswellia* species known to be used as emergency food.

Species	Part used	Country
Commiphora spp	Leaves	Kenya (Mbeere division, Embu district)
Commiphora africana	Unspecified	Nigeria (Kano State, northern)
Commiphora cærula	Yyoung roots chewed for juices	Central Tanzania
Commiphora neglecta	Leaves and roots eaten	Kenya (Mbeere division, Embu district)
Commiphora spp.	Young twig chewed for juice/water	Ethiopia (Liban zone, ESNRS)

IMPLICATION FOR THE MANAGEMENT OF THE VEGETATION

Frankincense and myrrh have been indicated to have wide pharmacological and industrial potentials. This indicates that the vast vegetation resources rich in *Boswellia* and *Commiphora* species in the dry lowlands of Ethiopia may offer enormous economic potential for the local people and the whole nation. However, this rich potential has not yet been exploited nor the vegetation resources received attention for sound management. Therefore, introduction of such industries may render the local people and the whole nation several incentives to protect, manage and develop the vegetation resources. This in turn will save the fragile arid and semi-arid lowlands from desertification and other environmental vulnerability.

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