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Pharmacological attributes and nutritional benefits of tea tree oil

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Abstract

Tea tree oil is obtained from different Melaleuca species (*Melaleuca quinquenervian, M. alterniolia, M. leucadendra*) which accounts for 99% of commercial oil production. Melaleuca plant is indigenous to Australia. It is cultivated because of its great medicinal and economical properties. Oil is extracted mostly from leaves of Melaleuca plants by steam distillation. Melaleuca oil is mainly composed of terpene hydrocarbons including monoterpenes, sesquiterpenes, and their associated alcohols. Tea tree oil (TTO) is well known for its disinfectant, antiseptic as well as its antimicrobial properties. That's why it is found to be most effective in treatment of skin infections. This oil also possesses nutritional properties but produce toxicity if taken in large amounts. This paper gives an overview of scientific literature available on nutritional and pharmacological properties of Tea tree oil.

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Introduction

Human diet consists of three macronutrients and several micronutrients like vitamins, minerals, antioxidants and various other beneficial phytochemicals. These macronutrients such as proteins, carbohydrates, and fats (lipids) are important source of energy. Generally it is concept that fat is an undesirable part of the diet but no doubt it is an essential requirement of body . However quantity and quality of fat consumed is important.

The lipids have important physical, chemical, and nutritional properties. These are superior to carbohydrates and proteins because they produce twice amount of energy as compared to same weight of carbohydrates or proteins. The lipids should be consumed in proper quantity recommended by nutritionists. Trans acid consumption leads to the problems of obesity and hypercholesterolemia therefore to overcome this problem there is a need to reduce Trans acids consumption in diet or replace these with omega-3 acids.

Almost all vegetable oils are obtained from beans or seeds of plants and these oils are extracted either by pressing or with solvent extraction techniques. Proportion of oils present in seeds varies among different plants. According to USDA figures for 2008-09, world average oil yields are: soybean (18%), rapeseed (39%), sunflower (41%), groundnut (32%), coconut oil (62%), and 44% palm kernel (Gunstone, 2011).

Melaleuca alternifolia occurs naturally in some areas of Australia, on the north coast of New South Wales (NSW) where it is restricted to the narrow plain between the coast and the dividing range. The tree occurs mainly in moist areas and swamps. The Australian tea tree oil industry has flourished in last 50 years (Richard L devis). The volatile oil constituents of *M. alternifolia* make it a valuable and commercially important medicinal and aromatic plant (Southwell and Lowe, 1999).*Melaleuca alternifolia*, accounts 99% of world trade. Beside *Melaleuca alternifolia* two other species of this genus, *Melaleuca linarifolia* and *Melaleuca dissitiflora*, are also exploited commercially but on a small scale. Due to its medicinal as well as nutritional value tea tree oil has been produced on a commercial scale. Australia is one of the largest producers of tea tree oil (Shelton *et al*., 2004).The present review gives the detailed physico-chemical, nutritional and health benefit of tea tree oil.

Botanical features of tea tree

Melaleucaalternifolia is indigenous to Australia, where it is found growing from Queensland to north-east New South Wales (Cribb, 1981; Penfold and Morrison, 1950) at up to 300 m altitude, on the soil with pH ranging from 4.5 to 7. Other varieties of tea tree oil have been cultivated somewhere else, but *Melaleuca alternifolia* is not produced outside Australia.

Melaleuca alternifolia occurs naturally in a very limited area of Australia, on the north coast of New South Wales (NSW) where it is restricted to the narrow plain between the coast and the dividing range. The tree mainly occurs in moist areas and swamps where it forms fairly dense stands that often contain relatively few other species. This species mostly prefer well-drained soil and suitable for light (sandy), medium (loamy) and heavy (clay) soils. It cannot grow in the shade. This species is frost sensitive and in warmer months leaves possess highest oil content (Orwa*et al*., 2009).

Melaleuca alternifolia is a narrow-leaved tree, up to 7m tall. Bark is layered and papery. Entire plant is glabrous. Leaves are 10-35 mm long and about 1 mm wide. Leaves are often arranged scattered to whorled on one branchlet. Petiole is 1 mm long. Leaves are dotted with oil glands that can be seen by using lens. The inflorescences are many-flowered spikes, 3-5 cm long, with axes bearing short hairs. The white flowers are solitary and petals are 2-3 mm long. Flowers are scattered in an interrupted spike. Stamens are 30-60 in number and more than 12 mm long united at their bases to form 5 distinct bundles. Style is 3-4 mm long.

Fruit is many seeded, cup shaped and 2-3mm in diameter. A hole of 1.5-2.5mm diameter is present which enables the release and dispersal of seeds by wind. Fruits are spaced sparsely along the branches.

Tea tree oil

Tea Tree oil is not extracted from the plant commonly associated with tea as a beverage. So it is not related to Tea Oil, which is extracted from the seed of the Tea plant (*Camellia sinensis*). Instead, Tea tree oil is obtained from the leaves of any species of *Melaleuca* that conforms to the ISO standard.

Provenance and nomenclature

The provenance of TTO is not always clear from its common name or those of its sources. A number of synonyms, including "melaleuca oil" and "ti tree oil," are used for TTO, the latter being a Maori and Samoan common name for plants in the *Cordyline* (Weiss, 1997). Even the term "*melaleuca* oil" is potentially confusing, as several chemically distinct oils are distilled other *Melaleuca* species, such as cajuput oil (also cajeput or cajaput) is obtained from *M. cajuputi*and niaouli oil from *M. quinquenervia* (often misidentified as *M. viridiflora*) the term has been adopted by the Australian Therapeutic Goods Administration as the official name for TTO. The use of common plant names further confounds the issue. In Australia, "tea trees" are also known as "paper bark trees". Collectively these terms are used to refer species in the *Melaleuca* or *Leptospermum* genera. For example, "swamp tea tree" and "paper bark tea tree" are the common names for *M. cajuputi* while common names for *M. quinquenervia* include "broad-leaved tea tree" and "broad-leaved paper bark" (Lassak and McCarthy, 1983). Many ornamental species of *Leptospermum* are often mistakenly identified as the source of TTO. In addition to this, the essential oils kanuka and manuka, derived from the New Zealand plants *Kunzeaericoides* and *Leptospermum scoparium*, respectively, are referred to as New Zealand TTOs (Christoph *et al.*, 2000) although these are very different in composition from Australian TTO (Perry *et al.*, 1997).

Other names

Different names used for tea tree oil includes: Australian Tea Tree Oil, Huile de Melaleuca, Huile de Théier, Huile de Théier Australien, Huile Essentielle de Théier, Aceite del Árbol de Té, , Melaleuca Oil, Oil of Melaleuca, Oleum Melaleucae, Tea Tree, Tea Tree Essential Oil.

Tea tree oil extraction method

There are various methods of essential oil extraction such as distillation, CO2 supercritical extraction, and solvent extraction.

Water extraction

In water extraction water act as a solvent and the chopped plant matter is submerged directly in boiling water so that carbohydrates, peptides, glycosides, and tannins are extracted in it. Leaves and flowers are usually steeped, and roots and barks are usually decocted (simmered). Unfortunately, water extracts have limited longevity because it is susceptible to fermentation. The Bundjalung Aborigines, who live North of New South Wales extract oil by crushing and soaking the leaves of the Tea Tree in water to use in compress or infusions.

Steam distillation

Today mostly essential oils are extracted by steam distillation. It's the oldest method of essential oil extraction, quite simple and the best method for distilling leafy materials. Only minimum changes in composition of essential oil occur by using this method of extraction. Steam distillation is cheap and non hazardous and can be easily recycled. So it is used to collect crude TTO (35 – 45% of volume of Terpinen-4-ol) (Carson *et al.*, 2006).

TTO is extracted by steam distillation from the leaves and terminal branches of *Melaleuca* tree. Dry materials are obtained after 24 hours of drying, and then determined the moisture of these materials (representative sampling). Steam for distillation is supplied from outside boiler of which capacity is 350 kg water per hour. The main device for this process is distillation vessel of which dimensions are 1110 mm

in diameter, 1689 mm in height. The steam flow rate is adjusted automatically by controller connected to the temperature sensor and the pressure sensor. The operation parameters of distillation vessel are 120 °C and 2 bar in 3 hours. Mixture obtained from condenser includes water and essential oil. In seperator two liquid phases are observed because oil and water have different specific gravity. The amount of essential oil that dissolved in the distillate water is small (negligible) and therefore recovery of essential oil dissolved in the water is unnecessary.

Refinement of tea tree oil

After steam distillation TTO should be refined as the commercial value of TTO is not high. It should be refined to increase its commercial value and to meet with tea tree oil standard. Vacuum distillation is preferred for refinement of TTO as it decreases the boiling point of TTO and as a consequence it limits the degradation of heat sensitive volatiles.

Vacuum distillation

In this process first the crude tea tree oil obtained from distillation process is supplied to the reboiler of the vacuum distillation column and boiled by indirect heating via thermal oil heater. To create low-pressure in system a vacuum generator is connected to the top of distillation tower. In order condense completely essential oil entrained by the vacuum line liquid Separator is set in front of the vacuum generator, cooled by liquid nitrogen. at the top of the tower, vapour was condensed and then brought to condenser.

Physico-chemical properties

The European Inventory contains 3 Melaleuca-type ingredients (INCI names): *Melaleuca alternifolia* oil (antimicrobial), *Melaleuca cajuputi* extract (tonic), *Melaleuca leucadendron* extract (tonic). Tea Tree Oil is the essential oil obtained by steam distillation of the leaves and small twigs of *Melaleuca alternifolia*, Melaleuca linariifolia and Melaleuca dissitiflora as well as other species of Melaleuca provided that the oil obtained conforms to the requirements given in the International Standard. However, TTO oil is commercially produced from *M. alternifolia* (Maiden and Betche) Cheel.

The composition of tea tree oil sold is regulated by an international standard for "Oil of *Melaleuca*—terpinen-4-ol type," which sets maxima and/or minima for 14 components of the oil (ISO, 2004). Particularly, the international standard for TTO does not specify the species of *Melaleuca* from which the TTO must be obtained. It sets out physical and chemical criteria for the desired chemo type. Six varieties, or chemo types, of *M. alternifolia* have been described by standard and oil produced by each chemo type is of distinct chemical composition. These chemo types include a terpinen-4-ol chemo type, a terpinolene chemo type, and four 1,8-cineole chemo types (Homer *et al.*, 2000). The terpinen-4-ol chemo type typically contains 30-40% of terpinen- 4-ol (Homer *et al.*, 2000) and is the chemo type used in commercial production of TTO.

TTO is composed of terpene hydrocarbons including monoterpenes, sesquiterpenes, and their associated alcohols. Terpenes are volatile, aromatic hydrocarbons and considered as polymers of isoprene with formula C_5H_8. Relative density of TTO is 0.885 to 0.906 (ISO 2004). It is only sparingly soluble in water and is miscible with nonpolar solvents.

The major constituents of TTO includes Terpinen-4-ol (max. 48%), γ-terpinene (max. 28%), 1,8-cineole (eucalyptol, max. 15%), a- terpinene (max. 13%), p-cymene (max. 8%), α-terpineol (max. 8%), α-pinene (max. 6%) and terpinolene (max. 5%). When tea tree oil is exposed to light, moisture and high temperatures, its composition gets changed. The levels of α-terpinene, γ-terpinene and terpinolene decrease whereas the level of p-cymene increases up to tenfold. Composition also changes in the presence of atmospheric oxygen. Process of Oxidation occurs which leads to the formation of peroxides such as endoperoxides (ascaridole) and epoxides. The main hydrolytic and oxidative degradation pathways are shown in another oxidation product identified was 1,

2, 4-trihydroxymenthane. Percentage of p-cymene increases with oxidation and its measurement gives a good indication of the oxidative degradation of Tea Tree Oil.

Along with the increase in the concentration of p-cymene, concentration of the oxidation product 1,2,4-trihydroxymenthane which is a supposed skin sensitizer, also increase. Tea tree oil also contain a potential carcinogen methyleugenol (Khalil *et al.*, 2004). Methyleugenol may be present in lower amounts (below 0.1%) according to (Carson and Riley, 1993). Methyleugenol is not classified as carcinogenic in the EU. According to US Annual Report on Carcinogen, Methyleugenol is classified as "Reasonably anticipated to be a human carcinogen". According to US State of California EPA Methyleugenol is classified as "Chemical known by the State to cause cancer When exposed to air and heat". According to the Code of Practice and the Guidance document introduced by the Australian Tea Tree Oil Association, safe processing and storage may be achieved by controlling the p-cymene content. TTO should be stored in dark, cool, dry conditions, preferably in a vessel that contains little air.

Table 1. Taxonomy of *Melaleuca alternifolia* Cheel.

Class	Equisetopsida
Subclass	Magnoliidae
Superorder	Rosanae
Order	Myrtales
Family	Myrtaceae
Genus	*Melaleuca*

Nutritional properties and health benefits of tea tree antimicrobial properties

Tea tree oil show strong antimicrobial activity it inhibited the growth in vitro of *Escherichia coli*, vancomycin-resistant *Enterococcus faecium*, *Staphylococcus aureus*, metacillin-resistant *Staphylococcus aureus*, and a variety of *Streptomyces* species (MIC 0.04–0.50%) (Buck *et al.*, 1994; Caboi*et al.*, 2002; Caelli*et al.*, 2000; Calde- e-Che*et al.*, 2004; Carson *et al.*,2001). It also inhibited the growth in vitro of *Trichophyton mentagrophytes*, *Trichophyton rubrum*, *Microsporum canis*, *Malassezia furfur*, *Candida albicans*, *Cryptococcus neoformans*, *Pityrospermum ovale* and *Trichosporon cutaneum* (MIC 1.1–2.2mg/ml) (Carson *et al.*, 1995; Carson *et al.*, 1996; Carson *et al.*, 2002; Carson and Riley, 1993). The chemical constituents of the tea tree oil such as, linalool, terpinen-4-ol, a-terpineol, a-terpinene, terpinolene and 1,8-cineole, inhibited the growth of various microorganisms, including *Candida albicans*, *Escherichia coli* and *Staphylococcus aureus*(MIC 0.06–0.50% v/v) (Caboi*et al.*, 2002).

Balsamic properties

Tea tree oil generally boost health due to its balsamic properties. It increases the absorption of nutrients and also provide protection from certain diseases.

Cicatrisant properties

Due to its Cicatrisant property tea tree oil quickly heals wounds and also protects them from infections. It also helps to diminish the scar marks left by eruptions, boils, pox, and acne.

Expectorant properties

It provides relief from cough and cold, congestion, bronchitis and other troubles associated with colds by rubbing tea tree oil on the chest.

Insecticidal properties

Tea tree oil is an efficient insect killer. It does not allow parasites and other insects like mosquitoes, fleas, lice, or flies to come near someone who has rubbed some of this oil on their body.

Antiseptic

Tea tree oil is an excellent antiseptic so it can be a wise preventative choice in case of wounds It can be applied on the wounds, boils, sores, cuts, skin eruptions, insect bites and stings, to protect them from infections.

Stimulant

Tea tree oil has stimulating effect on hormone

secretions, blood circulation, and most importantly, on the immune system. It act as a protective shield against many different types of infections.

Sudorific properties

Tea tree essential oil promotes sweating and the removal of toxins likes uric acid. Furthermore it help to remove excess water and salts from the body, and clean the pores. It also prevents the occurrence of acne.

Prevention from Vaginitis and cervicitis

According to a study 40% emulsified solution of TTO in 13% isopropyl alcohol is effective in the treatment of 130 women with cervicitis or vaginitis due to *Trichomonas vaginalis*or vaginitis due to *Candida albicans*. Intravaginal application of tampons saturated with a 20% emulsified solution healed cervicitis caused by *Trichomonas vaginalis* after four weekly treatments. In patients with vaginitis due to *Trichomona svaginalis*, intravaginal application of a 1% emulsified solution using a saturated tampon, as well as vaginal douching, resulted in clinical cures and restoration of the cervix (Pena, 1962). According to another study without controls, 28 women suffering with vaginitis due to *Candida albicans* were treated with vaginal pessaries (containing 0.2 g essential oil) every night for 90 days. After 30 days of treatment, 21 were free of *Candida albican and* 24 patients were free of symptoms such as leukorrhoea and burning sensation, and (Belaiche, 1988).

Table 2. Main constituents of Tea Tree Oil (From ISO 4730-2004).

Constituent	Minimum (%)	Maximum (%)
Terpinolene	1.5	5
1,8-Cineole (eucalyptol)	Trace	15
α-Terpinene	5	13
γ-Terpinene	10	28
p-Cymene	0.5	8
Terpinen-4-ol	30	48
α-Terpineol	1.5	8
Limonene	0.5	1.5
Sabinene	Trace	3.5
Aromadendrene	Trace	3
δ-Cadinene	Trace	3
Globulol	Trace	1
Viridiflorol	Trace	1
α-Pinene	1	6
Ledene (syn. viridiflorene)	Trace	3

Anti Acne properties

By the topical application of a gel containing either 5% essential oil or 5% benzoyl peroxide in the treatment of mild to moderate acne in 119 patients. The results demonstrated that both preparations significantly reduced the number of inflamed and non-inflamed lesions after 3 months of daily treatment ($P < 0.001$), although the onset of action of the gel containing the essential oil was slower than that of the gel containing benzoyl peroxide. Patients treated with the oil-containing gel reported fewer side-effects than those treated with the benzoyl peroxide-containing gel. So essential oil was more effective as compared to benzoyl peroxide (Bassett *et al.*, 1990).

Prevention from Cystitis

A randomized, double-blind, placebo-controlled trial

assessed the efficacy of the essential oil in the treatment of 26 women with chronic idiopathic colibacilli cystitis. Patients were treated with 8 mg essential oil, in an enteric capsule form, orally three times daily for 6 months. After treatment, 54% of the essential oil-treated groups were free of symptoms, compared with only 15% in the placebo group. However, approximately 50% of the asymptomatic patients still showed evidence of colibacilli and leukocytes in their urine (Belaiche, 1988).

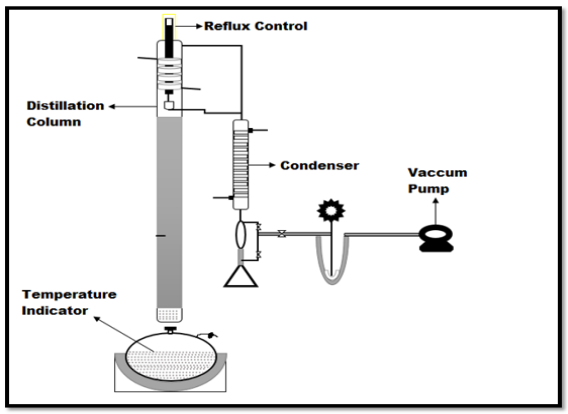

Fig. 1. The vacuum distillation system.

Antiviral activity

An in vitro study has celebrated the activity of tea tree oil against herpes simplex virus (HSV) types 1 and 2.it in some viruses and it provide protection against them by rupturing their cyst (Schnitzler *et al* 2001).. It cures different viral infections like the common cold, influenza, mumps, measles, and pox.

Anti-Dandruff activity

Tea tree oil is very effective against dandruff. According to a study conducted by a single-blind, parallel-group, the shampoo containing tea tree oil (5%) was proved effective in 126 patients with mild to moderate dandruff over 4 weeks (Satchell *et al* 2002b).

MRSA infection prevention

Various studies indicate that tea tree oil is effective in removing MRSA on the skin(Thompson *et al* 2008).A formulation of5% tea tree oil body wash and 4% tea tree oil nasal ointment was found to be better than the standard 2% mupirocin nasal ointment and. Triclosan body wash usually used for the suppression of MRSA (Caelli *et al* 2000).

Gingivitis

As chlorhexidine, Tea tree oil is effective against gingivitis which is caused by bacteria *Streptococcus mutans* (Groppo *et al* 2002). A more recent study evaluated the effects of tea tree oil gel (2.5%) and chlorhexidine gel (0.2%) in 49 patients with severe chronic gingivitis (Soukoulis & Hirsch 2004).

Other uses

Cold sores

Tea tree oil exhibits antiviral activity therefore its preparations are used in the treatment of herpes simplex.

Head lice eradication

Topical application of tea tree oil is effective against head lice (Veal, 1996). Compounds responsible for this activity include Phenols, phenolic ethers, ketones and oxides. Tea tree oil is also found to be effective against both head lice and dust mites (Williamson *et al* 2007).

Dermatitis

Tea tree oil is effective against dermatitis in dogs. A cream containing 10% Tea tree oil is effective to treat chronic dermatitis, allergic dermatitis, inter digital pyoderma, acral lick dermatitis and skinfold pyoderma in dogs. (Fitzi*et al* 2002).

Wart eradication

A study reported that daily topical application of tea tree oil for 12 days successfully eradicated warts on the hand of a paediatric patient (Millar & Moore 2008).

Dosage range

Tea tree oil is used in various forms, such as gels, creams, ointments, oral rinses, soaps, shampoos and paints. Different concentrations of tea tree oil are used to treat different diseases such as: bactericidal concentrations are generally 0.25%, for acne 5% essential oil in cream or gel, for *Vaginitis, tampons saturated in a 1% emulsified solution containing 0.2*

g essential oil are used. For Onychomycosis 100% essential oil applied twice a day.

Toxicity

Topical use is safe and that adverse events are minor, self-limiting, and infrequent. The oral and dermal toxicities of TTO are summarized briefy below.

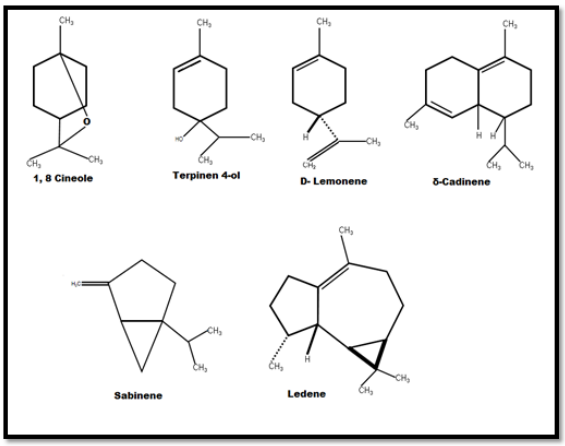

Fig. 2. Chemical structures of some main constituents of tea tree oil.

Dermal Toxicity

TTO can cause both irritant and allergic reactions. Since irritant reactions may frequently be avoided through the use of lower concentrations of the irritant, this bolsters the case for discolor- aging the use of neat oil and promoting the use of well-formulated products. Allergic reactions have been reported a range of components have been suggested as responsible, the most definitive work indicates that they are caused mainly by oxidation products that occur in aged or improperly stored oil. There is little scientific support for the notion that 1, 8-cineole is the major irritant in TTO.

Oral toxicity

TTO can be toxic if ingested, as evidenced by studies with animals and from cases of human poisoning. Incidences of oral poisoning in children (DelBeccaro, 1995; Jacobs *et al*., 1994; Morris *et al*., 2003) and adults (Elliott, 1993; Seawright, 1993) have been reported. In all cases, patients responded to supportive care and recovered without apparent sequelae. No human deaths due to TTO have been reported in the literature.

Adverse reactions

Allergic contact dermatitis after external application and ingestion of TTO has been reported (Buck *et al*., 1994; Apted, 1991; Groot *et al*., 1992; Knight and Hausen, 1994; Selvaag*et al*., 1994; Valk*et al*., 1994). No adverse reactions were reported in two patch tests using preparations containing up to 5% essential oil (Groot, 1996; Bhushan and Beck, 1997). Accidental ingestion of 10 ml essential oil caused confusion, disorientation and loss of coordination in a 23-month-old child (Jacobs and Hornfeldt, 1994). Ingestion of 2.5 ml essential oil by a 60-year-old man resulted in a severe rash and a general feeling of malaise (Elliott, 1993). Induction of a comatose state lasting 12 hours, followed by 36 hours of a semi-conscious state accompanied by hallucinations, was reported in one patient after ingestion of approximately half a cup (120 ml) of the essential oil. Abdominal pain and diarrhea lasting up to 6 weeks were also reported (Seawright, 1993).

*Conclusion**s***

The tree oil is extracted from leaves of *Melaluca* tree. This oil is extracted by water distillation as well as steam distillation but steam distillation is cheap and non hazardous method for extraction of TTO. The refinement of oil is done by vacuum distillation process; this method is preferred because it does not allow the heat sensitive volatiles in TTO to degarade. Chemically TTO is composed of terpene hydrocarbons (monoterpenes, sesquiterpenes), these are volatile aromatic hydrocarbons. TTO is more soluble in nonpolar solvents as compared to water. TTO has tremendous medicinal value because of its antimicrobial, antiviral, balsamic, cicatrisant, expectorant, insecticidal, antiseptic, stimulant and sudorific properties. It is proved to be effective in treatment of vaginitis, cervicitis, cystitis MRSA infection, dandruff, gingivitis, cold sores, head lice eradication, dermatitis and wart eradication. TTO has also remarkable role in aromatherapy.

It is used in various formulations like gels, creams, ointments, shampoos, paints and soups. No doubt the TTO has its nutritional value but its oral intake in

excess quantity is proved to toxic and can cause diarrhea and abdominal pain. Tea tree oil plays important role in curing skin infections but in some cases it may cause allergic reactions. Utilization of TTO as stimulant can boost up immune system and gives tremendous result in combating various diseases. Number of medicinal as well as other uses throws light on the importance of Tea tree oil but still there is need of comprehensive research for exploring it's all other beneficial aspects including its nutritional properties.

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