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Antimicrobial and antioxidant activities of Tea plant

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Abstract

Many complementary and alternative medicines have enjoyed increased popularity in recent decades. Efforts to validate their use have seen their putative therapeutic properties, which come under increasing scrutiny *in vitro* and in some cases *in vivo*. One of such products is tea and its tree oil (TTO); which is a secondary metabolite derived from tea plant (*Melaleuca alternifolia*). Both black and green tea has several polyphenolic compounds with possible antibacterial effects. It is employed largely due to its antimicrobial properties, and is incorporated as the active ingredient in many topical formulations used to treat cutaneous infections, in addition to being marketed as a remedy for various ailments. The essential oil of *M. alternifolia* exhibits broad-spectrum antimicrobial potential. The TTO may help to treat severe yeast infections. Results also suggested that TTO exerts a greater bactericidal potency against biofilm-grown methicillin-resistant *Staphylococcus aureus* (MRSA), and methicillin-sensitive *Staph. aureus* (MSSA) strains. Moreover, tea has inhibitory efficacy against the carcinogenic bacteria.

Keywords: Tea, Tea tree oil, Antimicrobial, Antioxidant activity

1. Introduction

Plant materials are widely used in developed and developing countries as home remedies, over the counter drug products and raw materials of the pharmaceutical industry. They represent a substantial proportion of the global drug market (Kunle *et al*., 2012). Many complementary and alternative medicines have increased their popularity in recent decades (Kyungseop, 2017). According to previous studies of Martins, (2013); Napatt *et al*., (2019), tea (*Camellia sinensis*) is the second most consumed beverage in the world next to water. In a recent study, Reygaert, (2017) reported that tea belongs to the family Theaceae, and is a product made by processing the leaves or buds. All tea varieties such as, green, oolong and black tea, are harvested from this species. Tea extracts work as effective treatments for patients who suffer from damaged skin following radiation treatment for cancer. Several previous studies of Priyanka *et al*., (2012); Ohishi *et al*., (2016); Arina *et al*., (2017)

revealed that this might partly be due to the anti-inflammatory properties of tea. Moreover, Arina *et al*., (2017) added that tea acts at the cellular level by inhibiting the inflammatory pathways, and lowering the release of pro-inflammatory cytokines including; IL-1beta, IL-6, IL-8, TNF alpha, PGE2, and white blood cells in human cell lines. Green tea extract had been shown to be potent in neuro-protectant (Orly *et al*., 2009). A study conducted by Qin *et al*., (2012) suggested that the intracellular amyloid beta (iAβ)-induced toxicity was significantly inhibited by green tea polyphenols in cultured rat primary cortical neurons. Previous studies of Li *et al*., (2007); Qin *et al*., (2012) reported that the intracellular iAβ toxicity is related to the development of Alzheimer's disease. In another study of Cong *et al*., (2016), it was explored that green tea polyphenols inhibit glutamate-induced neurotoxicity which is linked to neurodegenerative diseases.

2. The effects and mechanism of action of tea

Tea contains several naturally occurring dietary polyphenols such as catechins, which possess anti-carcinogenic activity that act as effective chemo-preventive agents against the initiation, promotion and progression stages of multistage carcinogenesis. Usually, all the four types of tea could lower the total cholesterol levels (Aleksandra *et al*., 2016). Black tea has only about one-sixth of the antioxidant power of green tea, owing mainly to the former's low levels of catechins (Anton and Sheila, 2003). On the other hand, Duh *et al*., (2004) reported that although the polyphenolic compositions of all the four types of tea were dramatically different, they have nearly identical levels of antioxidant potential. Agnieszka and Wilfried, (2014) suggested that the strong antioxidant catechins in green tea are destroyed by the fermentation reactions, leading to oolong, black and Puer teas. Previously Jie *et al*., (2006) revealed that there is a compensatory gain in the antioxidant activity of tea due to the new compounds produced.

Several years before, Chen *et al*., (2005) discovered that extracts of Puer and black teas were effective inhibitors of the virus protein-destroying enzyme (called 3CLPro), responsible for Severe Acute Respiratory Syndrome (SARS). In addition, they identified three compounds found in fully fermented teas mainly; tannic acid, theaflavin-3'-gallate and theaflavin-3,3'-digallate, acting as effective 3CLPro inhibitors. In another study, Kuo *et al*., (2005) reported that Puer and oolong significantly lowered the triglyceride levels, whereas green and black did not. Previously, Zhao *et al*., (2002); Blanco *et al*., (2005) reported that the properties of green tea inhibit the bacterial growth, which are mainly related to their polyphenolic components including; epicatechin, epicatechin gallate, epigallocatechin, and epigallocatechin gallate, against various Gram-positive and Gram-negative bacteria. Moreover, Zhao *et al*., (2002); Hu *et al*., (2002); Stapleton *et al*., (2004); Cho *et al*., (2008) added that green tea have a synergistic effect with β-lactam antibiotics against Methicillin-resistant *Staphylococcus aureus* (MRSA). In a previous study, Zhao *et al*., (2001) revealed that the main components of tea as polyphenols, epigallocatechin gallate, can reverse the methicillin resistance of MRSA by inhibiting the synthesis of Penicillin-binding Protein-2 (PBP2), and may also prevent adhesion to the mammalian epithelial cells (HEp-2) without any probable alteration (Janecki and Kolodziej, 2010; Sharma *et al*., 2012). It has been proposed by Lee *et al*., (2009) that green tea leaves extract can prevent the attachment of pathogenic bacteria on the host cell membrane, which in turn acts as a potential anti-adhesive agent. Chung *et al*., (2003) previously documented that green tea extract may affect the activity of dihydrofolate reductase, an enzyme that is needed by the pathogenic bacteria to synthesize purine and pyrimidine, as well as to increase the thickness of the epidermis.

3. The tea tree oil (TTO)

Recently, TTO has gained a good reputation as a safe, natural and effective antiseptic, and is employed significantly due to its antimicrobial properties. During the study of Carson *et al*., (2006), it was reported that TTO is incorporated as the active ingredient in many topical formulations used to treat cutaneous infections. The chemical composition of TTO has been well defined, and it consists largely of cyclic monoterpenes of which about 50% are oxygenated, whereas the other 50% are hydrocarbons (Cox *et al*., 2000; Carson *et al*., 2006). TTO exhibits a broad-spectrum of antimicrobial activity which can be primarily attributed to the presence of terpinen-4-ol. Previously, Cox *et al*., (2000) observed that the essential oil of *M. alternifolia* exhibited broad-spectrum antimicrobial activity, while TTO caused leakage of K ion in *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans*. Moreover, it has the ability to disrupt the permeability barrier of the cell membrane structures leading to the loss of chemiosmotic control, which is the most likely cause of its lethal action at minimum inhibitory levels. Hammer *et al*., (2000) stated that germ tube formation (GTF) by *C. albicans* is affected by the presence of and\ or the pre-exposure to sub-inhibitory concentrations of TTO. In addition, TTO has been suggested by Hammer *et al*., (2000); (2003) as a potential agent for MRSA decolonization.

In a previous study, Hammer *et al*., (1996) suggested that TTO could be useful for removing the transient skin flora, while suppressing but still maintaining the resident flora that acts as a natural defense against colonization by other pathogenic bacteria. In spite of having similar minimum inhibitory concentrations (MIC)/ minimum bactericidal concentrations (MBC) values, the microorganisms studied by Cox *et al*., (2000) expressed obvious differences in their susceptibility to TTO. Previous work of Messager *et al*., (2005) showed that the hand-cleansing formulations contain 5% TTO and 10% alcohol, or a solution of 5% TTO in water, which are more effective than soft soap in removing bacteria from the surface of the hand. Aaron *et al*., (2006) studied the *in vitro* antibacterial activity of TTO against clinical skin isolates of methicillin-resistant *S. aureus* (MRSA), methicillin sensitive *S. aureus* (MSSA), and coagulase-negative Staphylococci (CoNS) growing as biofilms, and concluded that TTO exerted a greater bactericidal potential against the biofilm-growing MRSA and MSSA isolates, than against some of the biofilm-growing CoNS isolates.

3.1. The antibacterial activity of TTO

Banes-Marshall *et al*., (2001) reported that TTO is bactericidal in nature, although it may be bacteriostatic at lower concentrations. The activity of TTO against antibiotic-resistant bacteria has attracted considerable interest, especially with methicillin-resistant *S. aureus* (MRSA) receiving the most attention so far. In a previous study, Inouye *et al*., (2001) reported that vaporized TTO can inhibit several bacteria spp. including; *Mycobacterium avium* ATCC 4676, *E. coli*, *Haemophilus influenzae*, *Streptococcus pyogenes*, and *S. pneumoniae*. Treatment of *S. aureus* with TTO resulted in the leakage of K ions (Cox *et al*., 2000; Hada *et al*., 2003), and inhibited its respiration (Cox *et al*., 2000). Reichling *et al*., (2002) stated that treatment with TTO sensitized *S. aureus* cells to sodium chloride, and caused morphological changes. Similarly, Noormandi and Dabaghzadeh, (2015) reported that the polyphenolic components of green tea have antibacterial potential.

3.2. The antifungal potential of TTO

Several years before, Senthaamarai *et al*., (2015) pointed that the germinated fungal conidia are significantly more susceptible to TTO than non-germinated ones, suggesting that the intact conidial wall confers considerable protection. In addition, TTO vapors have also been reported to inhibit fungal growth and affect their sporulation (Schnitzler *et al*., 2001), and they also inhibit the formation of germ tubes or mycelial conversion in *C. albicans*

(Schnitzler *et al*., 2001). Noumi *et al*., (2011) reported that at low concentrations as 0.3125 mg/ ml of tea tree essential oil and 0.078mg/ ml of eucalyptus oil, they drastically impair the maximum yield and growth rate of *C. albicans* and *C. glabrata*, suggesting that essential oils can be used as part of the efficient oral hygiene regime.

3.3. The antiviral efficacy of TTO

Previously, Schnitzler *et al*., (2001) documented that at high concentration of TTO (0.003%), it reduced *Herpes Simplex Virus* (HSV-1) titers by 98.2%, and HSV-2 titers by 93.0%. They also reported that by applying TTO at different stages of the virus replicative cycle, it had the greatest effect on the intact virus (prior to infection of cells); however, when it was applied during the adsorption period, a slight reduction in the plaque formation was observed. Another study by Mikus *et al*., (2000) evaluated the activities of 12 different essential oils including TTO for their activities against HSV-1 in Vero cells, where TTO exerted most of its antiviral activity on the free virus. They observed that 1% of the essential oils inhibited plaque formation completely, while 0.1% TTO reduced plaque formation by approximately 10%.

4. Antioxidant and antimicrobial activities of Tea

Compared with other types of tea, green tea is undoubtedly one of the most potent natural preservatives applied to many foods as antioxidant and antimicrobial agents (Zhu *et al*., 2005; Almajano *et al*., 2008; Su *et al*., 2008; Kristanti and Punbusayakul, 2009). Several previous studies of Sakanaka *et al*., (2000); Wang *et al*., (2000) have demonstrated the antimicrobial efficacy of green tea extract *in vitro* against some potent pathogens such as; *Shigella dysenteriae*, *Salmonella* sp., *E. coli*, *S. aureus* and *Listeria monocytogenes*.

The antioxidant activity of green tea extract has also been verified in raw, frozen and cooked meat patties (Jo *et al*., 2003; Mitsumoto *et al*., 2005), and in sausage (Bozkurt, 2006). Previously, Kristanti *et al*., (2014) investigated the effects of two brands of commercial Assam green tea infusion on the microbial growth, anti-lipid oxidation and color change in cooked beef, and recorded a significant reduction in the populations of *Staph. aureus*, *Listeria monocytogenes*, *S. typhimurium* and *E. coli*, to an undetectable level in the cooked beef within 2 d of storage at 4^{o}C. In previous studies, Pokorný *et al*., (2001); Michalczyk and Zawislak, (2008) pointed that besides acting as antimicrobial agents, the polyphenolic compounds in green tea are primarily known as antioxidant agents that can retard the free radical chain reaction during the process of oxidation. Dorota, (2014) studied the effect of addition of green tea on the selected properties of probiotic milk, and reported that green tea can be successfully employed as a functional supplement for probiotic milk, as it added an extra value to the known health benefits of the probiotics. Moreover, Maksum *et al*., (2013) concluded from their study that *C. sinensis* leaves extract could be useful in combating emerging drug-resistance caused by MRSA and *P. aeruginosa*.

Conclusion

Different tea products have different biochemical profiles, and are great sources of antioxidants. Tea has inhibitory activities on carcinogenic and periodontopathic bacteria. Therefore, it can be inferred that the combined use of tea and antibiotics could be useful in fighting the emerging drug resistance problem. However, there are many improvements and experiments that need to be carried out in the future to determine the effectiveness of tea products.

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