This month’s article will focus on clove oil (*Syzygium aromaticum* or *Eugenia caryophyllata*). This oil comes from the distillation of dried buds of the clove tree, which is cultivated worldwide. Extensively used as a spice, clove buds have been used in traditional medicine systems for conditions ranging from bronchitis to digestive problems to hernias (Lawless, 1992). Clove bud oil typically consists of around 89% of the phenylpropene eugenol 6% eugenyl acetate, 1.5% β-caryophyllene, and many other trace compounds (Chaieb et al., 2007).

A range of potential properties have been the subject of research into clove bud oil, the most extensive of which being its antimicrobial potential.

**Antimicrobial Properties of Clove Bud Oil**

**Bacteria**

Clove bud oil was found to possess antimicrobial activity against a wide range of bacteria, including the notable pathogens *Staphylococcus aureus* and *Escherichia coli* at concentrations as low as 0.25% (Hammer, Carson and Riley, 1999), *Staphylococcus epidermidis* and the acne-causing bacteria *Propionibacterium acnes* (Owen, Price and Laird, 2014) as well as the antibiotic resistant pathogen methicillin-resistant *Staphylococcus aureus* (Owen, 2014).

**Oral Bacteria**

Moon, Kim and Cha (2011) investigated the antimicrobial activity of clove oil against bacteria known to cause dental caries and periodontitis such as *Streptococcus mutans*.
Clove possessed strong bactericidal activity against all tested species at concentrations as low as 0.1mg/ml. It was also found to work synergistically with the antibiotic ampicillin, decreasing by 4-8 fold the concentration needed to inhibit or kill the bacteria. This suggests that clove oil could be used as a preventative for dental caries and periodontitis, or as a treatment either alone or in combination with antibiotics.

**Fungi**

In a study of common fungal species including *Candida albicans*, *Aspergillus flavus*, and *Aspergillus niger* and fungal skin infection-causing species (dermatophytes), clove bud oil successfully inhibited all strains tested, thus demonstrating its broad spectrum antifungal activity. The dermatophytes were most susceptible, with the minimum concentration needed to inhibit them being 0.16 microliters/ml (0.00016 ml per ml of medium!). This data therefore suggests that clove bud oil may be useful as an alternative treatment to antifungal agents for the treatment of fungal skin infections such as candidiasis (Pinto et al., 2009).

**Parasites**

Clove oil effectively inhibited the growth of the intestinal parasite *Giardia lamblia*, a pathogen that is a significant problem in developing countries, especially in children. After 3 hours of exposure to clove oil, adherence of the parasite to substrates, which is important in infection as it adheres to the intestinal wall, was significantly reduced. As such it may be a potential novel anti-giardial therapy or preventative (Machado et al., 2011), and due to clove oils cheapness compared to anti-parasitics this could be valuable for developing countries. Clove oil was also found to inhibit the growth of *Trypansoma cruzi*, the parasite that causes Chaga’s disease. Clove was found to successfully inhibit *T. cruzi*, with 50% of cells inhibited at 57.5 micrograms/ml (Santoro et al., 2007).

**Viruses**

One study found that clove extract was highly active at inhibiting replication of the hepatitis C virus (≥90% inhibition at 100 µg/mL) and another isolated and identified an anti-herpes simlex virus 1 compound, eugenin from clove oil (Chaieb et al., 2007).

**Anti-inflammatory Activity**

In rats, injections of eugenol significantly reduced carrageenan-induced paw oedema (swelling) compared to controls that were not treated with eugenol, suggesting that it possesses anti-inflammatory activity (Daniel et al., 2009).

**Anti-allergic Activity**

Clove oil was found to inhibit artificially-induced systemic anaphylaxis and IgE antibody-mediated passive cutaneous anaphylaxis reactions, and significantly reduced the levels of histamine in the blood, by inhibiting the release of histamine from mast cells (Kim et al., 1998). This suggests that clove has significant anti-allergic activity so may be useful for disorders such as hayfever or asthma. In another study, clove and eugenol were both found to possess significant relaxant activity upon tracheal smooth muscle, which contracts in allergic reactions such as asthma (Reiter and Brandt, 1985), further highlighting clove oil as a potential candidate for anti-allergic treatment.
**Immunostimulant Activity**

Carrasco et al. (2010) investigated the effects of oral administration of clove, ginger and sage oils upon the white blood cells of healthy and immunosuppressed mice. It was found that after seven days, the total white blood cell count of both non- and immunosuppressed mice had increased in a dose dependent manner. For example, 200mg/kg of clove oil increased the white blood cell count in non-immunosuppressed mice by an average of 71.1% in seven days. Ginger and sage oils did not have a significant effect on total white blood cell count. Clove essential oil was found to stimulate a cell-mediated response as it caused an increase in delayed-type hypersensitivity reactions. Cell-mediated responses are important for defending against viruses and intracellular bacteria and fungi, suggesting clove could help activate this response to protect against these, however further research into the mechanisms behind this response and trials in humans are needed to confirm if it would be a useful immunostimulant.

**Analgesic**

Clove and eugenol have both been used extensively as a relief for toothache and as an anaesthetic for fish, and some research has been conducted into whether clove oil does possess significant analgesic activity. In mice, 10mg/kg injections of 10% clove oil exerted significant analgesic activity, when exposed to painful thermal stimuli, compared to controls. The authors suggest an inhibition of prostaglandins and other inflammatory mediators such as leukotrienes as the mechanisms of analgesic action (Hosseini, Asl and Rakhshandeh, 2011). It was also suggested that eugenol blocks pain receptors, thus preventing the brain from receiving pain signals (Hosseini, Asl and Rakhshandeh, 2011). These results support the traditional uses of clove oil for the relief of toothache.

In 73 humans, a topical clove gel was compared to a traditional topical anaesthetic, benzocaine, used to numb the pain of needle insertion in dental surgery. 73 adult volunteers. After 5 min of material application in a randomized, subject-blinded manner, each participant received two needle sticks. Pain response was registered using a visual analogue pain scale. Both clove and benzocaine gels had significantly lower mean pain scores than placebos, and no significant difference was observed between clove and benzocaine regarding pain scores. This suggests that clove is as efficacious as benzocaine and might possess a potential to replace benzocaine as a topical agent before needle insertion.

**Antidepressant**

Acute oral administration of 200mg/kg clove oil to mice exerted significant antidepressant effects in the forced swimming and tail suspension tests (used to test antidepressant drugs). Long term administration of 50-200mg/kg clove oil orally to mice exposed to chronic unpredictable mild stress also significantly elevated the protein levels of hippocampal p-ERK, p-CREB, and brain-derived neurotrophic factor, which are usually decreased in depression (Liu et al., 2015). Eugenol was also found to induce brain-derived neurotropic factor in mice, suggesting that this may be responsible for clove oils antidepressant activity. Eugenol's activity was comparable to imipramine, an antidepressant drug (Irie et al., 2004). These results suggest that clove oil or eugenol alone may be potential alternatives to antidepressant drugs for treating depression.
References


