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Multifunctional Finishing of Textiles using Microencapsulated Vetiver Essential Oil: A Review

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ABSTRACT

Consumers awareness toward usages of natural ingredient for finishing textiles has built an ever-growing demand. New textile technologies have empowered the application of new ingredient on the fabric to provide its functional benefits to the end product. Essential oil has gained popularity as they symbolize "green" alternative and have been used to add specific function to textile due to their eco-friendly and biodegradable nature. Some essential oils, which can be used to infuse textiles with aroma, are also known to attain antimicrobial, antifungal, antiviral, antiseptic and antioxidant properties that can be useful for different textile applications. Aromatherapy is a form of an alternative medicine in which essential oils are used to impart therapeutic effects. It is important to develop textile materials with added functional properties in order to promote healthy and eco-friendly life style. Vetiver is one of the multipurpose essential oil that is economically and ecologically important. The main action of vetiver esssential oil is on the nervous system and it is both sedative and strengthening in effect. It has been traditionally used in aromatherapy from a long period of time for relieving stress, anxiety, depression, tension and insomnia. Therefore, vetiver essential oil can be used to impart finishing onto the textiles to develop functionalized textiles with useful properties.

Key words: Aromatic and therapeutic properties, Microencapsulation, Multifunctional textiles, Vetiver essential oil.

In present decade, the consumers' needs, demands and expectations for a healthier and more comfortable life are increasing everyday even when it comes to clothing. After fabricating the mansions of fashion and comfort, textiles are now moving towards high-tech era of performance, which has brought up diversification and expansion of technologies. The recent interest in multifunctional textiles is mainly directed to the use of specific textiles in medical therapy and prevention of deficiencies (Sanjay and Malpani, 2013; Thite and Gudiyawar, 2015).

Buyers always expect a high degree of wearing comfort and finishing plays an important role in achieving it. Functional finishes from the natural substrates comprises of those substances that are obtained from plants and animals that possess many advantages such as nontoxic, non-irritant, biodegradable, cost effective, easy availability *etc*. Natural oils such as essential oils are being promoted to be used for finishing application due to their good efficacy without any harmful effects (Naikwadi *et al.,* 2017; Sayed *et al*., 2017). Aroma or fragrance finishing is considered as an emerging area which has tumbledown the textile industry that enhances the value of the product by utilizing the controlled release of different fragrance into fabrics, leading to the production of fragranced fabrics. The fragrance applied by use of essential oil not only provides a pleasant smell but also the beneficial effect of aromatherapy (Ali *et al.,* 2015).

Vetiver oil is one of the essential oils that have multifunctional values and it can be used as an eco-friendly finishing agent to impart functional properties to textiles. *Vetiveria zizanioides* (Linn.) Nash is the member of the Poaceae family, also known as the *Khas-Khas*, *Khas*, or *Khus* grass, native to India. Vetiver grass is a tall, tufted, perennial, scented grass, with a straight stem, long narrow leaves and a lacework root system. The root is the most valuable part of the grass as it contains the majority of the essential oil which has valuable aromatic and biological properties (Bhushan *et al*., 2013). The cultivation of vetiver essential oil is widely scattered over Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Rajasthan and Uttar Pradesh therefore, its production can support the livelihoods of Indian farmers. The North Indian type vetiver essential oil has a good export potential due to the high quality of vetiver oil manufactured in India as compared to other countries such as Indonesia, Pakistan, Senegal, Sri Lanka, Brazil and Haiti. As a result, it is considered to be the best in the global market and attracts a very high price in international market. In 2019, the global vetiver essential oil market demand was estimated to be 408.8 tonnes. It is expected to grow at a volume-based CAGR of 7.8 per cent from 2020 and 2027 (Krishnaveni, 2016).

Infusion of textiles with aromatic essential oils makes them of immense value enriched for the aesthetic dominated

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fashion consumers to attain cosmeto-therapeutic and medicinal benefits. However, longevity of aroma on the textile with passage of time and subsequent launderings is a major concern for researchers and consumers too (Wang *et al.,* 2009). Therefore, microencapsulation is found to be a solution to this problem. Microencapsulation is a process that encapsulates active and volatile substances to form micro or nano-scale capsules. It may be able to protect the core materials from the surrounding environment and provide some new applications and release characteristics (Zhao *et al.,* 2019). Essential oils have skin permeability properties hence, aroma textiles can be used to penetrate these oils through the human skin surface with marked aura. Various products such as fibres, fabrics, non-fabrics and garments can be chosen to enjoy the pharmaceutical and emotional effects of aroma oil treated textiles (Anitha *et al.,* 2011).

Properties of essential oils and aromatherapy

Essential oils are volatile and liquid aroma compounds derived from natural sources, usually plants. These have gained their importance in therapeutic, cosmetic, aromatic, fragrant and spiritual uses. Aromatherapy uses essential oils, as the main therapeutic agent which are said to be highly concentrated substances. These are used to treat illness as well as to enhance physical and psychological well-being and can also be used as natural alternatives to synthetic preparations to prevent and treat infectious diseases (Firenzuoli *et al.,* 2014). According to Anonymous (2019) essential oils do not exist in plants as free-moving substances, but are stored in microscopic cellular containers. They are extracted from varied parts of the plant *viz.* root, seed, trunk, leaf, fruit and flower. Each essential oil has a unique chemical composition which can react with chemicals present in the body and mind when applied, inhaled or ingested. Essential oils contain the odour, taste and medicinal properties of the plant itself but in a very concentrated form, with no base oil, alcohol, water or diluting agent added. These are antiseptic to varying degree; some have antiviral, antifungal and antibacterial properties and come in many different colours, viscosities and scent strengths.

Ahmad *et al.* (2016) highlighted that essential oils and their volatile constituents can be used widely to prevent and treat human diseases. These oils play an important role in the prevention and treatment of cancer, cardiovascular diseases including atherosclerosis and thrombosis and also act as antibacterial, antiviral, antioxidants and antidiabetic agents. Due to their therapeutic properties, these oils can be used in transdermal drug delivery as natural skin penetration enhancers in aroma and massage therapy.

Aromatherapy is the treatment of ailments using 100 percent pure plant essences for healing body, mind and spirit. It is one of the techniques of holistic, complementary or natural medicine. Aromatherapy unifies physiological and spiritual processes to enhance individual's innate healing process therefore, is a good adjuvant in the treatment of insomnia. The smell of essential oil transmit signal to brain, as it can interfere with the capability of brain to release neurotransmitters stimulus and helpful to generate analgesic effect and it can influence physical, emotional and mental health, sense of wellness and relaxation. Some of the essential oils which induce sound sleep are vetiver, lavender, chamomile, ylang-ylang, jasmine, marjoram *etc.* Therefore, these essential oils can be used for treating insomnia (Panneerselvam, 2017).

Lakhan *et al.* (2016) noticed significant positive effect of aromatherapy in reducing pain recorded on a visual analog scale. Analysis revealed that aromatherapy is more consistent for treating nociceptive (pain caused by an injury to body tissues) and acute pain than inflammatory and chronic pain, respectively. Further, aromatherapy was also found to be most effective in treating post-operative pain and obstetrical and gynecological pain. The cost associated with aromatherapy was far less than the cost associated with standard pain management treatment. The findings of the study indicated that aromatherapy can successfully treat pain when combined with conventional treatment.

Devprakash *et al.* (2018) investigated ethanolic and aqueous extracts of *Vetiveria zizanioides* plant for *in-vitro* antimicrobial activity against pathogens namely *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Bacillus subtitils* by disc diffusion method and compared with standard antibiotic. Ethanolic and aqueous extracts of *Vetiveria zizanioides* showed toxicity against all the bacteria. The ethanolic extract of plant showed better antibacterial activity than aqueous extract. However, the activity was less than the standard levofloxacin. The extract showed increasing inhibitory activity with increase in concentration (100-1000 µg). Minimum inhibitory concentration (MIC) assay were determined for these two extracts against bacterial strain. *Vetiveria zizanioides* displayed more antimicrobial activity against *Escherichia coli* and *Pseudomonas aeruginosa*. Phytochemical analysis of vetiver extract revealed the presence of flavonoids, glycosides, phenols, tannins, saponins and alkaloids. According to Thomas (2012) and Gaware *et al.* (2013) the sedative properties for the pharmaceutical and emotional effects of essential oils are given in Table 1.

Chemical composition and taxonomy of the vetiver essential oil

Taxonomy is the system of grouping like things together to give order to all that exists (plants, animals, minerals *etc.*). Its main aim is to provide a convenient method of identification and communication about taxa and provide a classification which is based on natural affinities of plants as far as possible. The vetiver essential oil is extracted from the roots of vetiver plant using steam distillation method and in India, vetiver oil is known as the "Oil of Tranquility". The vetiver essential oil is reddish dark brown when matured and has a woody, earthy smell that is almost musty. It is mostly composed of sesquiterpenes (3-4%), sesquiterpenols (18-25%) and sesquiterpenones (7-8%). Among these, the most economically important active ingredients are khusimol, -vetivone and -vetivone, which account for

approximately 35% of the oil. Vetiver essential oil and its components such as vetivone, zizanal, epizizanal and nootkatone have anti-inflammatory, anti-septic, aphrodisiac, cicatrisant, nervine, sedative, tonic and vulnerary characteristics and are widely used in aromatherapy. The oil is also used extensively in perfume industry, scented toiletries as fixative, as odour contributor in base as flavour agentin the food industry *etc*. (Chahal *et al*., 2015). Taxonomical position of *Vetiveria zizanioides* is given in Table 2 (Balasankar *et al.,* 2013).

Raja *et al.* (2018) investigated the chemical constituents of vetiver essential oil obtained by steam distillation from the roots of *Vetiveria zizanioides* (L.) Nash by Gas Chromatography Mass Spectrometry (GC/MS) and found that about 32 compounds were present in root oil mainly sesquiterpenes. The characteristic constituents found to be present were Valerenol (19.88%), Beta-Vatirenene (8.61%), Longiverbenone (3.46%), Germacrene D (3.82%), Aristolene (3.20%), Selin-6-en-4-o (2.99%) and Globulol (2.18%). According to Snigdha *et al.* (2013) vetiver is the most versatile, multifarious grass with immense potential, known for its ability to produce essential oil from the roots. A major portion of oil consists of sesquiterpenoide, hydrocarbons and their oxygenated derivatives. Phytochemical screening of the powdered leaves showed the presence of alkaloids, flavonoids, tannins, phenols, terpenoids and saponins. The roots are aromatic, antifungal, cooling, antiemetic, diaphoretic, haemostatic, expectorant, diuretic, stimulant, mosquito repellent and antioxidant. Different parts of vetiver grass *i.e.* stem, leaves and roots are used for several health complications like mouth ulcer, boil, epilepsy, burn, snakebite, fever, rheumatism and headache *etc.*

Table 1: Sedative properties for the pharmaceutical and emotional effects of essential oils.

Essential oils	Effects
Basil	Uplifting, clarifying, relieves mental fatigue, improves memory and concentration
Bay Laurel	Stimulating, effective expectorant, builds confidence, reducessleep disorders
Benzoin	Relaxing, comforting, uplifting, warming, reduces stomach aches, insomnia
Bergamot	Uplifting, refreshing, calming, provides antibacterial and antibiotic properties
Black pepper	Soothing, warming, aids digestion, provides antiviral and antioxidant properties
Chamomile	Refreshing, relaxing, calming, soothing, balancing, relieve restlessness
Cedarwood	Sedating, calming, soothing, strengthening, improves concentration
Cypress	Refreshing, relaxing, provides astringent qualities, relieves muscle and joint pain
Clary Sage	Balancing, clarifying, relaxing, soothing, stimulant, tonic, vulnerary
Eucalyptus	Head clearing, provides antiseptic, antibacterial, antiviral, decongestant properties
Fennel	Provides relief from gas and indigestion, antiseptic, antiviral, bactericidal
Frankincense	Relaxing, calming, immune stimulating, anti-aging properties
Geranium	Balancing, sedative, deodorant, diuretic, haemostatic, stimulant, mood-lifting
Ginger	Stimulating, warming, soothing, helps for apathy, shock, headache, migraine
Grapefruit	Uplifting, calming, toning, diuretic, hypertensive, insecticidal, restorative
Helichrysum	Comforting, provides anti-inflammatory properties, promotes appetite
Hyssop	Refreshing, clarifying, provides antioxidant, anti-inflammatory properties
Jasmine	Relaxing, soothing, builds confidence, effective for mental fatigue
Lavender	Refreshing, soothing, provides therapeutic qualities, reduces nervous problem
Lemon	Refreshing, stimulating, uplifting, motivating, restorative, tonic, haemostatic
Lemongrass	Toning, refreshing, fortifying, ease stress and fear, reduces high blood pressure
Mandarin	Calming, soothing, uplifting, detoxing, digestive, hydrating
Melissa	Uplifting, refreshing, nervousness, antiseptic, antiviral, bactericidal
Neroli	Relaxing, dispels fears, uplifting effect, relieves from stress related problems
Orange	Refreshing, relaxing,antiseptic, antiviral, astringent, bactericidal, disinfectant
Patchouli	Purifying, refreshing, sedating, antiseptic, laxative, relieves from grief, depression
Peppermint	Cooling, refreshing, head clearing, relieves mental fatigue and depression
Petitgrain	Stimulating, toning, clarifying, antispasmodic, antidepressant
Pine	Refreshing, stimulating, provides antiseptic, antimicrobial, antirheumatic properties
Rose	Relaxing, soothing, enhances sensuality, builds confidence, disinfectant
Rosemary	Refreshing, stimulating, prevents respiratory infections, improves concentration
Sandalwood	Relaxing, warming, grounding, builds confidence, effective for mental fatigue
Tea Tree	Act as antiseptic, strengthens immune system, relieves circulation problems
Thyme	Act as antiseptic, refreshing, strengthens immune system, relieves from stress
Vetiver	Refreshing, relaxing, calming, soothing, antimicrobial, antirheumatic, antiseptic
Ylang-Ylang	Relaxing, soothing, enhances sensuality, reduces high blood pressure

Table 2: Taxonomical position of *Vetiveria zizanioides.*

Kingdom	Plantae
Subkingdom	Tracheobionta (vascular plant)
Superdivision	Spermatophyta (seed plant)
Division	Magnoliophyta (flowering plant)
Class	Liliopsida (monocotyledon)
Subclass	Commelinidae
Order	Cyperales
Family	Poaceae (grass family)
Genus	Vetiveria bory (vetiver grass)
Species	*Vetiveria zizanoides* (L.) Nash

Microencapsulation of vetiver oil for textile applications

With the growing trend in enhancing beauty through healthy means, consumers demand for apparels and home textiles not only with their original basic characteristics such as warmth and comfort, but also ones that carry extra functions, including environmental protection, anti-pollution and most importantly, health and beauty care, for a more natural and healthier life (Cheng *et al.,* 2008). Therefore, the textile industry is currently experiencing a revolution that aims at the unique needs of the modern consumers. The integration of aromatherapy in textile application is a novel and user-friendly idea that enables an alternative means for essential substance delivery systems. Infusion of textiles with aromatic essential oils make them of immense value enriched for the aesthetic dominated fashion consumers to attain therapeutic and medicinal benefits and also make the wearer afresh and relaxed by the unique aroma of oils (Khanna *et al.,* 2015).

Due to their highly volatile nature, these are ineffective to utilize for profitable applications in textile. Hence, microencapsulation of natural materials is one of the methods used to increase the durability of the finish on the textile materials. In this technique, the active compounds are encapsulated using a wall material like modified starch, sodium alginate, gum acacia *etc*. and applied on the textile materials (Thilagavathi *et al*., 2007). The most commonly used microencapsulation techniques include complex coacervation, spray drying, centrifugal extrusion, air suspension coating, pan coating, emulsion hardening process, polymer-polymer incompatibility, interfacial polymerization and situ polymerization (Aziz *et al*., 2016). Microencapsulation is an effective and important tool to prepare oil-based high quality and health-beneficial products in order to improve their chemical, oxidative and thermal stability. The microencapsulation process is used to develop and modify textiles with new improved properties such as polychromic, thermo chromic, fire proofing, fragrance releasing, cosmetic, therapeutic and medical textiles (Wijesirigunawardana and Perera, 2018). Nowadays, more profitable uses of microencapsulation can be found in the textile industry for its capability of being adjusted for different functions. Aroma products with microcapsules could be applied to almost all industrial products, such as papers, plastics, paints, scented stamps, cellular phones, greeting cards as well as textiles, thereby creating scented clothing (Anitha *et al.,* 2011).

Ali *et al.* (2019) suggested that vetiver oil may be used via cross-linked polymeric microcapsules. Microcapsules were prepared by the ionotropic gelation method using alginate-gellan gum blends which cross-linked the microcapsules suitably and repeatedly. Prepared vetiver oil-loaded microcapsules were of spherical shape. Fourier-Transform Infrared Spectroscopy (FTIR) and Differential Scanning Calorimetry (DSC) analysis suggested that no chemical interaction occurred between the encapsulated vetiver oil within the microcapsules made up of alginate-gellan gum blends and were found capable of providing a prolonged release of encapsulated oil in a sustained manner, indicating the potential for the sustained release sedative application.

Naikwadi *et al.* (2017) mentioned that the diethyl phthalate is the major compound present in vetiver root extract which is suitable for functional finishing of textiles and these finished textiles can be used for home, medical and healthcare. Naikwadi and Sannapapamma (2018) treated organic cotton fabrics with vetiver root extract and vetiver oil microcapsules. The treated fabrics were assessed for their mechanical properties *viz.* fabric count, thickness, weight, stiffness and crease recovery using standard test procedures. Both the treated fabrics exhibited significantly thicker and heavier with greater crease recovery angle than the control sample. The decreased fabric stiffness was noticed in both the treated samples which indicated that the treated fabrics were found to be more flexible and pliable than the control sample. It was further revealed that among the source of treatment, the fabric treated with vetiver oil microcapsules exhibited better mechanical properties as compared to fabrics treated with vetiver root extract. It was also noticed that the fabric finished by pad-dry-cure method exhibited improved mechanical properties than the fabrics treated by exhaust method. It was concluded that the organic cotton fabric finished with microencapsulated vetiver oil by pad-dry-cure method possessed better mechanical properties than other fabric samples.

CONCLUSION

Vetiver essential oil has many end-uses such as aromatic, antimicrobial, antifungal, antiemetic, antispasmodic, antioxidant, tonic, mosquito repellent, diaphoretic, haemostatic, expectorant, diuretic, stimulant and in curing of hysteria, insomnia, skin diseases, asthma, amentia, amenorrhea, kidney problems and gall stones. Microencapsulation is very promising technique that can provide long-lasting sustainable efficient finish by controlling the release rate of microencapsulated vetiver essential oil onto different textiles. Vetiver essential oil have many reported aromatic and therapeutic properties therefore it can be used for apparel, home, medical and healthcare textiles. Hence, further research can be undertaken to use microencapsulated vetiver essential oil on different natural fabrics such as cotton, wool, silk, jute, flax *etc*. to produce

multifunctional textiles for various end-uses due to its excellent properties.

Conflict of interest: None.

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