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The essential oils market is expected to experience a major upturn due to demand from new applications. Ile Kauppila writes

Scents carry significant meanings for us. Foul smells warn us of rotten food, for example, while pleasant scents are used in relaxation, medicine and fragrance. As the saying goes, sometimes it is good to stop and smell the roses in the middle of our hectic schedules. But what happens when one wants to smell the roses but there are none to go around?

Many solutions to the issue have been developed, one of them being essential oils. They have been used for millennia for medicinal reasons in various ways, in fragrances and in consumer products. The industry is still strong today and is projected to experience significant growth, driven by growing demand worldwide.

By the dictionary definition, essential oils are hydrophobic – or non-water soluble – liquids containing volatile aroma compounds from the plants they have been extracted from. Despite the name, they are not essential as in being indispensable, although the industry would surely argue so.

Instead the word “essential” refers to the liquids containing the “essence”, or the characteristic fragrance, of the plant they originate from. Other

names commonly used include volatile oils, ethereal oils or, as they were historically called, essence or oil of the extracted plant, such as the oil of bergamot.

Archaeologists have discovered what could be earthenware distillation apparatus used in essential oil production dating back to the third millennium BC. In the fifth century AD, the Greek alchemist Zosimus of Panopolis wrote of the distilling of “divine water and panacea”. Extensive trade of odoriferous substances existed in Asia and the Roman Empire.

During the middle ages, floral and aromatic waters were used in perfumes, as digestive tonics and in cooking and trading. In the 12th century, Arab scholar Ibn al-Baitar wrote down the earliest known recorded mentions of how to produce essential oils.

With the advent of modern chemistry, the production of essential oils became more refined as scientists and producers began to understand how to separate the actual chemical components that make up the essential oils. This also had an effect on language, as scientific works began to discuss, for example, “methyl salicylate” rather than the “oil of wintergreen”. This better understanding paved the way for modern mass production of essential oils.

Traditional production methods

Two key essential oil production methods have been used throughout their history, namely distillation

and expression. These ancient ways have since been joined by more modern practices, such as solvent and carbon dioxide (CO₂) extraction.

Out of the four, distillation is by far the most common. It is used to produce the most widely traded essential oils, including lavender, peppermint, tea tree and eucalyptus oils. Essential oils can be extracted either through water, steam, water/steam or percolation distillation. All these methods have the advantage, according to the US National Association for Holistic Aromatherapy (NAHA), of extracting the volatile compounds at lower temperatures than the boiling points of the individual constituents. These components can then be easily separated from the condensed water.

In the distillation process, the raw plant material – consisting of bark, flowers, leaves, roots and/or seeds – is placed into an alembic, or a still chamber, over water. The still is sealed and as the water is heated, the steam and/or water rises up, slowly breaking through the plant material and vaporising the volatile compounds.

The compounds rise up along with the steam and flow through condenser coils. As water and essential oils do not mix, the oils can finally be siphoned off the top or bottom of the collecting dish, depending on the weight of the oil.

The remaining water, with some water-soluble constituents and a small amount of the essential oil still mixed in, is called a hydrosol, hydrolat or floral water. The hydrosol can be used in applications similar to essential oils, including fragrances and



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skin care products.

Expression, or cold-pressing, is an extraction method similar to olive oil production. It is primarily used to extract citrus oils, such as orange, tangerine, lemon and lime. The modern production method involves placing the rind of the citrus fruit into a container, which incorporates spikes or needles for puncturing the rind. With a prodding action, the constant penetration of the rind releases the essential oil, which is collected in a smaller dish under the container.

Traditionally the extracted liquid is allowed to stand to separate it into the oil and water/juice parts, with the oil finally siphoned off. In most commercial facilities today, however, the separation is performed by using centrifuges, making the process faster and less labour intensive. The citrus oils produced through expression are generally cheaper than distilled oils, as citrus peels are often available in abundance from the food industry.

New methods

Solvent extraction is mostly used on plant materials that are too delicate or fragile to undergo expression and whose volatile compounds are too easily denatured to withstand distillation. This extraction method uses solvents – such as petroleum ether, ethanol or hexane – to collect the odoriferous lipophilic compounds from the plant. In addition to the essential oils, solvent extraction also draws out the chlorophyll of the plant, resulting in a

very colourful and viscous extract called a concrete.

The concrete can be sold as is, but most of the time it will contain large quantities of non-fragrant waxes and resins, which are generally undesirable. Another solvent, such as ethyl alcohol, is added to the concrete, which extracts the fragrant oils from the mixture. The alcohol solution is then chilled to -18°C for more than 48 hours, causing the waxes and other lipids to separate. After filtering and ethanol removal, the final product is called an absolute. The absolute will still be more colourful, viscous and fragrant than pressed or distilled essential oil.

Hypercritical CO_2 can also be used to extract essential oils. This technology is a relative newcomer in the industry. It relies on the fact that under a high enough pressure, CO_2 turns from a gas into a liquid, which can be used as an inert liquid solvent. The liquid CO_2 can diffuse through aromatic plant materials, drawing the volatile compounds out with it.

As a side effect of CO_2 extraction, the solvent also draws out elements not found in essential oils. At their best, these can include beneficial substances, such as in the case of frankincense, which contains anti-inflammatory compounds as a CO_2 extract, unlike its pure essential oil.

However, this can also be a risk, as any potential pesticides remaining in the plant will be drawn out with the volatile compounds. According to Australian essential oil expert Ron Guba's book *'The Modern Alchemy of Carbon Dioxide Extraction'*, the pesticide concentration in CO_2 extracts can

be seven to 53 times higher than in essential oils. Additionally, this method is often prohibitively expensive to use in large-scale production.

Uses and market situation

Having extracted the essential oils, producers naturally need a processor to sell the product to. Essential oils find use in the pharmaceuticals, cosmetics, food and beverage, soaps and home cleaning products industries. In the first two, they are sought for their medicinal and pharmacological effects, while the latter industries use them mostly for their colour, flavour and fragrance. Demand is steadily growing, and Grand View Research projects that the market, which passed the US\$6bn mark in 2015, could be worth US\$13.94bn by 2024.

Some essential oils are produced by plants to act as natural biocides, protecting them against threats such as insects and fungi. These properties contribute to their traditional use in medicine and pesticide production. For example, carvacrol found in oregano oil inhibits the growth of several bacteria – among them *E.coli* – while thymol from thyme oil reduces bacterial resistance to common drugs, such as penicillin. Eucalyptus oil, on the other hand, has been found to have fungicidal properties, which could make it an effective, natural pesticide. Additional 'medicinal' uses for various oils include antidepressant, antiseptic, aphrodisiac and diuretic treatments.

However, the largest market segment for ▶

▶ essential oils is food and beverage, which accounted for over 34.6% of the global overall demand of 178,800 tonnes in 2015, according to Grand View Research. Essential oils will continue to be in high demand due to growth in emerging economies and the rising interest in natural products in western markets, the market consultancy said.

Another fast growing market is the spa and relaxation sector, which made up 29% of the market share in 2015 and is expected to grow at a CAGR of 8.7%. The rising popularity of aromatherapy and other alternative medicine is increasing consumer demand, as are the relaxing effects of essential oils when applied through a massage.

Despite growing demand, however, there is a risk of dwindling supplies of essential oils. Both Ultra International, a Dutch aromatherapy and essential oil product supplier, and US-based Global Essence estimate essential oil prices will be driven higher by limited supply and strong demand. Additional concerns for the industry include environmental concerns caused by essential oil production, climate change that could affect the growing conditions of many aromatic plants and globalisation, which might drive farmers to switch to different crops. However, if production can be boosted, the steadily increasing demand over at least the next five to six years should keep the industry healthy and growing.

Actual global production volumes for essential oils are difficult to estimate, as they are highly dependent on the produced plant and the place and methods of production. According to Grand View Research, however, orange oil is the largest product in the marketplace, accounting for 29.4% of global total market volume in 2015. Corn and peppermint, eucalyptus, citronella and tea tree are also among the top five essential oils.

Orange oil

The oil of orange is produced from the orange

plant *Citrus sinensis* and is extracted by cold-pressing the rind, a by-product of the orange processing industry. The extraction process yields approximately 0.3-0.5% of orange oil. The oil has a sweet and tangy scent, is yellow to orange in colour and close to water in viscosity. Around 90% of the oil is composed of d-limonene, a hydrocarbon that gives citrus fruits their distinctive aroma.

Orange's essential oil is widely used in the food and beverage industry as a flavouring and colouring agent, for example in fruit juices, jams, bakery products and Curacao-type liqueurs. Its pleasant smell has also led to its popularity in fragrances and cleaning agents.

Orange oil has purported antidepressant, anti-inflammatory, antiseptic and aphrodisiac properties, which Grand View Research projects will lead to growing demand in various applications. Additionally, orange oil can be used as a natural green pesticide to kill entire ant colonies and with a lesser effect to control termites.

Possible handling hazards with orange oil include skin irritation, as the high limonene content dissolves skin's natural oils. It can also have a phototoxic effect and should not be used directly on skin, particularly before going out into sunlight for extended periods. Studies have found orange oil to cause cancer in male rats, but no evidence of carcinogenicity in humans exists and the International Agency for Research on Cancer classifies it as safe for humans.

Orange oil prices soared to record highs in 2016, according to market data from Ultra International, and neither it nor other companies expect them to come down any time soon. Impacting the market was the lowest orange crop in Brazil in 10 years, Florida ending the season 17% lower

than the previous one (lowest since 1963) and drought conditions in South Africa.

"There is no doubt we're still in for a rough period as prices in January 2017 peaked at record levels and local juice stocks by June 2017 are expected to be at an all time low," Ultra International said in its spring 2017 market report.

Corn mint and peppermint oil

Mentha arvensis – known as corn mint, field mint or wild mint – and *Mentha x piperita*, or peppermint, are plants in the mint family. Their leaves are generally steam distilled to produce an essential oil containing up to 80% menthol. Most corn mint oil on the market, however, has been fractionated and dementholised, removing a large percentage of the menthol content. Nonetheless, both oils are clear, thin liquids with a strong, bittersweet fragrance.

Both mint oils are used in similar applications. They contain a high concentration of natural pesticides, such as pulegon and menthone. Their healthcare uses include digestive system stimulation, soothing headaches, muscle pain, colds and sinuses. They are also used extensively in oral care products due to their cooling effect and ability to kill bacteria.

They are popular in fragrance and food production, but in these applications corn mint oil is more common due to its lower price. They can also be used in plumbing to detect leaks through their strong scent.

As with many other essential oils, the growing global interest in aromatherapy is expected to drive particularly the peppermint market (as corn mint is less popular in aromatherapy), according to Future Market Insights. The recent outbreak of the Zika virus has also increased the demand for natural mosquito repellents and the record growth rates in the fragrance market are projected to further prop up mint oils. ▶





▶ North America has a significant share in the production of peppermint oil, while corn mint production is dominated by India. Both sectors, however, struggle with limited available raw material due to poor harvests in 2016, says Ultra International. Producers remain hopeful that better weather in 2017 would bring better harvests to keep prices at a reasonable level.

Eucalyptus oil

Eucalyptus oil is an umbrella term for essential oil extracted from several varieties of the eucalyptus plant. Traded eucalyptus oils are generally divided into three categories, namely medicinal, perfumery and industrial varieties. Out of the three, the “regular” cineole-containing oil – a colourless liquid with a strong, woody scent – is the most common, yet all of them are produced through steam distillation.

A minimum cineole content of 70% is required for pharmaceutical applications, but many varieties – like *Eucalyptus kochii* – produce oil with a cineole-content between 80% and 95%. Low-grade oil can be upgraded to have a higher percentage of cineole.

Eucalyptus oil is used medicinally to relieve the symptoms of influenza and cough, in products such as cough drops, lozenges, ointments and inhalants. It has antibacterial and decongesting effects and, as such, inhaled eucalyptus vapour is used to treat bronchitis. Personal hygiene products, including toothpastes and soaps, may also contain eucalyptus.

The oil is also used as an insect repellent and biopesticide. A 2016 Chinese study found it to be an effective antifungal agent. Food and beverage industry uses eucalyptus oil in flavouring at low levels and its antimicrobial effects prevent food spoilage. Research and practical tests have also shown that eucalyptus oil is a potential biofuel feedstock that lowers harmful emissions, particularly in the aviation industry.

Traditionally led by its native Australia, the global eucalyptus oil market is now dominated by China, which produces nearly 75% of the global supply. However, Ultra International notes that production in China has been falling since 2014 as producers are waiting for higher crude oil prices before they begin distillation. As a result, production is growing in Australia, where more plantations are being set up, and increasing demand – once again partially due to aromatherapy – is also propping up production in Spain and Portugal.

Citronella oil

One of the essential oils acquired from lemongrass,

citronella oils is classified into two chemotypes based on the plant variety it is obtained from and the chemical content. The Ceylon type, from the *Cymbopogon nardus* variety, consists mostly of 18-20% geraniol and 5-15% citronellal, while the Java type from the *Cymbopogon winterianus* variety contains 11-13% geraniol and 32-45% citronellal. The oil – a clear thin liquid, with a lemony, sweet aroma – is extracted through distillation.

Citronella finds well-established use as a flavour additive and in fragrances, the latter of which contributes the lion's share of citronella production's revenues, according to Transparency Market Research. In addition to food and perfumes, citronella oil is used in detergents, industrial polishes, soaps and cleaning compounds.

The oil is also popular as a natural insect repellent, for which it has been registered in the USA since 1948. Elsewhere, however, citronella use in repellents has met resistance. In the EU and the UK, citronella oil may not be sold as insect repellent, and Canada banned it in this application in 2012, although the ban was repealed only three years later. According to the US Food and Drug Administration, citronella oil is safe when used according to recommendations, although some studies have discovered a risk of drug interaction.

The Asia Pacific region, including China, India and Indonesia, is the largest citronella oil producing area in the world. However, poor harvests and rising prices in the last few years might be affecting the market, Ultra International and Global Essence project.

In Indonesia, prices have risen 15% in 2017, but in China the lack of oversupply has kept prices stable at around US\$17.5/kg. Slowing production and dwindling supplies, however, could increase the price by the end of the year.

Tea tree oil

Also known as melaleuca oil or ti tree oil, tea tree oil is a yellow-tinged liquid distilled from the leaves of the *Melaleuca alternifolia* tree. With a woody, herbal aroma, commercially traded tea tree oil is standardised according to the ISO 4730-2004 standard. It determines that the oil must have a 30-48% concentration of terpinen-4-ol, 10-28% concentration of gamma-terpinene and smaller concentrations of six other chemicals.

Tea tree oil's medicinal uses include treatment of acne, nail fungal infections and athlete's foot, although no conclusive evidence of its effectiveness for these ailments exists as of yet. It is also popular in haircare products and in low concentrations in cosmetics and skincare products. As with

many other essential oils, the surging interest in aromatherapy is also increasing the sales of tea tree oil. Some antibacterial and antiseptic effects have also been suggested in recent studies.

There are, however, some safety concerns regarding tea tree oil. A 2006 review of tea tree oil found it to be toxic when ingested with a long list of possible adverse effects, including nausea, hallucinations and coma. Additionally, tea tree oil used on the skin should be diluted as it is an irritant. Some components of tea tree oil also oxidise easily when in contact with air and the oxidised oil may cause allergic reactions.

Tea tree oil production areas include Australia, China, Northern Africa and the Asia Pacific. Heavy rains in early 2017 threaten this year's harvests in Australia – where the overall crop may be reduced by up to 30%, according to Global Essence – and parts of Asia.

The crop loss may leave these areas unable to satisfy demand this year, says Ultra International. This has pushed the price of Australian tea tree oil up to around US\$50.

However, production in China and South Africa is either stable or growing, with South Africa possibly as much as quadrupling its production over the next few years. This growth is keeping the global demand satisfied and the price in these regions around US\$25 and US\$45, respectively.

Promising future

The future of the essential oils industry seems promising. Their market value is growing steadily, propelled by the industrialising and urbanising emerging economies and new demand avenues in established markets. Additionally, novel applications, such as biofuels, are opening up new possibilities for the utilisation of essential oils that could turn into lucrative future businesses.

However, there are risks as well. Climate change is threatening the business, as we have already seen in the fluctuating supply of the past two years when there has been too much or too little rain. Additionally, the plants themselves might be affected, as shown by an Australian National University study that found that a certain variety of the eucalyptus was producing lower levels of oil due to rising ambient CO₂ levels. One can only imagine the damage to the industry if all eucalyptus trees began reacting in the same way.

All in all, the growth potential for this essential commodity is well documented, provided weather conditions improve.

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