Standardising essential oils for purity & quality – a dire consumer need!

Introduction

Essential oils are extremely concentrated plant extracts not only benefiting the plant itself but also several other life forms depending on the plant. They are aromatic concentrated hydrophobic volatile liquids extracted from leaves, flowers, stalks, roots, resin or bark of plants for human use. Essential oils have the exceptional ability to enter the human body through the skin, olfactory senses, ingestion or intravenous means and interact with various human body systems helping it enhance the innate ability to achieve physical and mental well-being. People belonging to all walks of life and professions like medical doctors, naturopaths, chiropractors, aromatherapists, cooks, psychiatrists, massage therapists, dentists, nurses, perfumers in personal, fabric & home care industry and flavourists in food and beverage industry, etc., to name a few, use essential oils in various application techniques for human benefit.

The standards for essential oil quality and purity are highest in aromatherapy as they affect their therapeutic value, whereas aroma, colour and flavour are important for the flavour and fragrance industry. Higher quality essential oils with specific characteristics, sell at higher the price and vice-versa – a huge inducement for suppliers to adulterate and sell. Unfortunately, today unscrupulous organisations reverse engineer natural essential oils, making them artificial, while many others adulterate with fillers (that we cannot easily smell) wherein the real oil percentage itself is very small. When a consumer buys an essential oil altered with ingredients other than the pure oil, it does not provide the desired or expected results, or worse, cause unwanted side-effects. When such conflict arises in a consumers mind, it damages the utility of essential oils for therapeutic practice, with a likelihood of damaging the reputation of the entire business. There is obviously a need for essential oil standards so that consumers feel safe to use and benefit from them. Incidentally, today a regulatory agency for the standardisation of essential oils does not exist, even though users are present all over the world.

All essential oils are not equal

Many factors affect the therapeutic property of herbal plants and it is critical that the oils have the therapeutic chemical constituents intact for aromatherapy or other medical uses. '100% Pure' essential oil does not mean all the vital therapeutic and medicinal chemical components are present, as we get true therapeutic essential oils only from the first distillation. Second and third distillation essential oils, even though smelling similar, have significantly lowered potency. The temperature and time of distillation is also vital to bind the full chemical potential of the plant. Distilling large batches at high temperatures and pressure destroys therapeutic properties, even though it is able to maintain the desired fragrance or smell. In addition, for getting essential oil with optimum desired chemistry the plants selected need to be of the highest quality, grown in virgin soil uncontaminated by chemicals and harvested during the correct time of the year (even precise time of day) under strict environmental conditions. Plants when distilled immediately on harvesting at farms have better therapeutic properties.

A 'therapeutic essential oil' standard must encompass everything from planting to marketing. It means verifying the correctness of the plantation species, the purity of the soil, manner of cultivation (without use of synthetic chemicals), the proper time of harvest, the distillation process to capture the right chemical therapeutic compound compositions thereby optimising the healing properties in the oil, and the purity of the packaging. In short, right natural means nothing added, nothing taken out and stored in amber or blue coloured light-protected glass or ceramic bottles, or Teflon or stainless steel in stable temperature and environmental conditions. A plant grown in

one region might have slightly different chemistry than that grown in another region. Similarly, distilling a plant when too green or harvesting at the wrong time of day may yield chemical constituents at incorrect levels, not meeting the therapeutic essential oil quality, even though the oil may be '100% pure'. Apart from being therapeutic, essential oils for aromatherapy use should also be unadulterated without addition of any synthetic chemicals or potentially toxic compounds. It is vital to use only that essential oil that meets the rigorous standards and contain the medicinal plant potential to treat any health issues. It is also obvious that essential oils having therapeutic benefit are significantly more expensive and work more efficiently at lower dosage levels.

Organic & natural

The chemistry of essential oils falls within the dominion of organic chemistry, under the broader field of general chemistry. Since the beginning of chemistry, organic means the study of life compounds. Carbon forms the basis of all compounds created by living processes and therefore we define organic chemistry as 'the study of carbon compounds.' Today scientists synthesize thousands of carbon compounds outside of the natural processes of living organisms and call them as 'organic' regardless of their origin. Consequently, petrochemicals (motor fuels, industrial solvents), pesticides, fungicides, herbicides, disinfectants, cleaning fluids, plastics, Styrofoam, paints, pharmaceuticals, etc., are 'organic' since virtually all of them are composed of carbon molecules. Carbon is the most adaptable element capable of forming long chains and complex ring structures with another carbon atom. It is an ideal building block for not only making industrial products, but also innumerable living forms including essential oils. Seeing the word 'organic' on a package label, a consumer assumes the marketed products (or its ingredients) are free of herbicides, pesticides, chemical fertilizers, hormones, antibiotics, etc., although to an expert chemist, the term only means that the product contains carbon compounds including the presence of synthetic ones. The legally defined phrase 'Certified Organic' is a much better word than 'organic' to mean what most consumers think.

Consumer also believe that the term 'organic' implies that the product was grown in healthy soil under sunlight in a clean atmosphere very naturally and not in a chemical factory or synthesized inside a laboratory. The reality is however different as government regulations do not restrict use of the word 'natural' in a label if the product contains compounds produced by natural plants even though the content of that particular product may have been produced synthetically – equating a natural living plant with that of a factory. In case of essential oils chemistry alone is not responsible for therapeutic and/or nutritional properties; the vitality of a life force is shaped by living processes that is absent in synthetic products manufactured in a dead environment like a laboratory or manufacturing plant. This becomes crucial in case of essential oils use, with synthetics becoming ineffective for aromatherapy healing. However, numerous examples of products exists in the market erroneously labelled as containing natural ingredients when, in reality it is totally manufactured in a laboratory; the list includes fruit flavours in drinks, chewable vitamins, candies, etc. Combining the right type of esters, we can create the taste of bananas, orange, lime, watermelon, apple, peach, raspberry, papaya, kiwi and just about any fruit we desire. We find small amounts of methyl anthranilate ester in many essential oils in grapes and cherries. While producing natural flavourings for beverages and confectionaries, making use of synthetic methyl anthranilate ester, adding a little colour and labelling it as a grape or cherry is quite common. Knowledge is power and being aware of the true meaning of 'organic' and 'natural' is important to decipher product labels correctly.

Understanding standardisation in essential oils

Essential oil

According to ISO, essential oils are 'product obtained from a natural raw material of plant origin, by steam distillation, by mechanical process from the epicarp of citrus fruits or by dry distillation, after separation of the aqueous phase – if any – by physical process'. Additionally, according to the ISO note added to the definition, essential oils can undergo physical treatments such as filtrations, decantation, centrifugation with no significant change in its composition.

"An essential oil can be pure while simultaneously being of poor quality. Oil that is not pure is of poor quality!"

To understand this statement better, let us delve ourselves deeper into the subject.

Pure

A pure, natural essential oil is extracted from a single species of plant from one specific geographical area. Aroma profile for such oils could differ slightly from season to season and geographical location.

Concrete (Resinoid), Absolute

Solvent extraction of botanicals using oil soluble solvents, like hexane, methylene chloride, acetone, etc., and placing the substances extracted in a distillation vessel and applying gentle heat, just enough to recover the solvent present in the mixture without removing any of its volatile constituents.

The residual solid wax-like substance left after solvent extraction is termed as a 'concrete'. If the residue is a resinous botanical material, then it is a 'Resinoid' instead of a 'concrete' (e.g., frankincense and myrrh.)

Technically absolute is not "essential oil' but "essence." It is produced by melting a concrete in warm grain alcohol and stirring it to dissolve the essential oil, some waxes, fixed oils and fats, etc. and distilling the mixture under vacuum to remove alcohol. It is the most concentrated form of a fragrance (therefore expensive) for use in the perfume industry. We generally use flower petals to get absolutes, principally for botanicals, where to unlock their fragrance and healing portions solvents are used (e.g., Jasmine and Neroli extraction).

Rectified oils

It is a process to remove some essential oil constituents and enhancing the fragrance character. Examples: removal of terpenes from eucalyptus oil, enhancing its fragrance by making it sweeter; removal of the prized fresh-scented monoterpenes present in Bergamot oil making it softer and sweeter, thereby resulting in an unbalanced, terpene-less Bergamot oil; Thyme oil can have some or all of its valuable thymol removed to make it softer, less skin irritating and more useable.

Reconstituted essential oil

Recreate the fragrance of expensive essential oils or absolutes entirely from isolates and synthetic constituents. Examples include: Industrial lemon oil using Citral extracted from Lemongrass and adding some d-limonene from Orange oil; Reconstituting Melissa oil artificially by making use of citronella, lemon and lemongrass.

Bases (Perfumery)

Compositions/accord that may not be complex or true like reconstituted essential oil, but forming a part of a note. (E.g., Rose base, Jasmine base, etc.)

Standardised oils

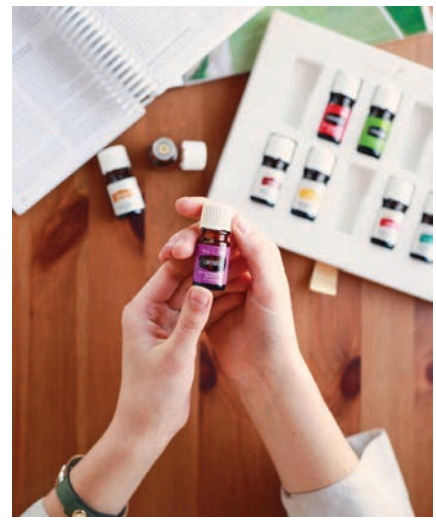
Making essential oils uniform to ensure consistency and reliability to a certain aromatic profile/constituents for specific applications.

The fragrance industry requires a standardised odour profile for most of the oils for its use, so that the fragrance they manufacture has a reliable aromatic odour. For example, Lavender oil (40/42) is a standardised oil where suppliers carry out adjustment to have the proportion of the two main essential oil constituents linalool and linalyl acetate as 40% and 42%.

We can standardise essential oils in many ways by blending different components.

- Origin blend: Blending oil from the same plant species, but from different geographical locations.
- Natural blend: Using the majority of oil (over 90%) from the named species and adding natural extractions from other oils to boost the odour profile, reflecting the standardised specification.
- Commercial blend: Oil having about 20% of the named species of plant, along with natural extracts from other essential oils to conform to the standardised oil profile requirements.
- Commercial oils (reconstituted oil): Oils majorly having synthetic ingredients.
- Rectified oils: Removing constituents to enhance the essential oils fragrance character.

True therapeutic quality essential oil should contain hundreds of compounds, necessarily in a proper balance. Few of these numerous



compounds alone significantly matter commercially in contributing to aroma and/or taste, for use in fragrances or flavours. Manufacturers and consumers do not care whether flavours or fragrance are natural or synthetic if they are inexpensive and smell and taste like naturals. Standardisation thus is a process that alters the composition of the essential oil, bringing its constituents to a required standard in consultation and agreement with the user in order to eliminate natural variations or be in line with user's regulatory requirements. Sometimes essential oils could contain constituents classified as toxic, allergic, sensitising or carcinogenic, which could require treatments in order to remove to meet regulatory requirements. Adulteration of essential oils happens without customer or user knowledge and may be deliberate or otherwise on part of the supplier. Fragrances and flavours are usually incomplete composition, in comparison to the chemical profile of a complete therapeutic essential oil. Additionally, to increase volumes and profitability it may also contain synthetic compounds, adulterants or be diluted with petrochemicals.

Adulteration

It is the act of *intentionally* debasing the quality of the product for sale

by either the admixture or substitution by inferior substances or by the removal of some valuable ingredient.

Unintentional adulteration/natural degradation

Lack of knowledge and expertise, incorrect selection and treatment of raw materials, use of improper equipment and following inappropriate manufacturing practices are some reasons for unintended adulteration of essential oils. Natural alteration or degradation could also be unintentional. Improper storage and shipping is also important to maintain essential oil quality. Citrus oils are vulnerable to oxidation on exposure to air, heat and sunlight, resulting in poor quality stale oil. Storing oils and shipping in cool and dark conditions, without any air headspace in the drums or bottles, is necessary to maintain essential oil quality.

Why adulteration is rampant?

Natural essential oils supply is limited and its increasing demand for use in industry leads suppliers to adulterate the natural essential oil to increase the supply. Another important reason for rampant adulterations is the continued consumer demand for purchasing genuine oils much below the market price, wherein honest traders find themselves virtually impossible to remain and practice ethics in business. Adulterated essential oils may smell pure; however they are unlikely to have the same therapeutic effect or properties. Adulterating essential oils for profitability is widespread and is a common practice (it is wrongly termed as "to standardize") with blending occurring with either the true botanical or other similar botanicals or with synthetics; so a "100% essential oil" on a label is NO guarantee for purity.

The fragrance and flavour industry is by far the biggest user of essential oils and ironically, the practice of adulteration is accepted. Perfumers and flavourists need essential oils that have the same chemical makeup and aroma, consistently year after year. To ensure consistency and acceptability of a product, the industry carries out adulteration or rectification (putting right) so that the final product is exactly as per demand, as otherwise the same fragrance or flavour bought today would smell different from the one bought last year. Weather and environment greatly influence the aroma and taste of essential oil plant crops year to year. The chemical makeup of the essential oils too differs, based on environment and the place where the plants are grown. These essential oils (fixed, adulterated or rectified of inherent inconsistencies for the exclusive use perfumers) enter into the regular market supply chain for sale to all other consumers as pure and genuine oils, raising many safety issues.

Adulterating an essential oil modifies the naturally existing synergistic components diminishing its therapeutic benefits. Pure essential oils contain many scientifically unidentified components and its presence as a 'whole'; give each essential oil its own unique beneficial quality or adverse effect. Many people trust that changing the distribution of chiral components of essential oils by deliberate adulteration with racemic synthetic aromatics changes the beneficial properties of the oil with a possible risk of adverse side effects as apparently these unusable unidentifiable components, actually 'quench' of the negative side effects which therapeutic agents in isolation could or do cause.

Adulteration of essential oils

Every production of essential oil will produce a different composition of essential oil, affect the quality of the final product (flavours & fragrances), necessitating standard essential oils. We estimate that 95% of most oils available for open sale undergo adulteration to produce commercially standardised essential oils. The process of adulterating an essential oil to improve fragrance profile is 'bouquetting' and when it is to increase its volume, we call it 'cutting' or 'stretching'. Another form of classical adulteration is to substitute or mix pure oil with reconstituted oil.

Dangers of using adulterated oils

One can have adverse skin reactions when using such oils, but these are not reactions to true essential oils; these reactions are due to the adulterants. Adding racemic synthetic chemicals changes the enantiomeric ratios of natural essential oils and may lead to unexpected adverse physiological effect on the user, especially in aromatherapy practice. Typical examples are:

- Inhaling (+)-limonene increases systolic blood pressure, changing alertness and restlessness of users; however, inhaling (-)-limonene affects only the blood pressure of users.
- (-)-Carvone increases pulse rate, diastolic blood pressure and restlessness and (+)-carvone increase systolic and diastolic blood pressure.
- (+)-Rose oxide confers relaxing physiological effects whereas (-)-rose oxide is much simulative.

Adulterants can be very many. Some common ones are diluents like diethyl phthalate (DEP), synthetic extenders that mimic natural essential oils, non-organic raw materials like artificial fertilisers, chemical pesticides, etc. All have adverse effects on the skin, eyes, endocrine and nervous systems.

Adulteration methods

Adulteration methods include (but not limited to):

- Adding cheaper oils to an expensive ones;
- Extraction of a valuable ingredient from an oil;

Table 1
Common adulterations in essential oils

Essential oil	Adulterants
Angelica root	Angelica leaf oil.
Anise	Technical grade anethole
Basil (exotic)	Methyl chavicol, Linalool
Basil (sweet)	Linalool plus, Basil oil exotic
Benzoin resinoid	Vanillin, Benzyl benzoate, Ethyl and Benzyl cinnamates, Benzoic acid, cheaper Sumatra benzoin
Bergamot	Lemon oil, Rectified Ho oil, Sweet orange oil & Terpenes, Linalool and Linalyl acetate, etc.
Bitter almond	Benzaldehyde
Bitter orange	Sweet orange, Orange terpenes
Black pepper	Limonene, Phellandrene, Pinene, Sesquiterpenes from the cheaper clove oil.
Buchu leaf	Cuts of monoterpene sulphide fractions synthesised from hydrogen sulphide by treating pulegone having ρ–Menthan-8-thiol-3-one.
Camomile (roman)	Moroccan wild camomile oil, Isobutyl angelate, Synthetic bisabolols.
Cardamom	Eucalyptol, Terpinyl acetate/Linalyl acetate
Cassia	Cinnamic aldehyde, Methyl cinnamic aldehyde and Coumarin
Cedarwood (virginia)	Cedarwood oil chinese
Celery seed	Lininene and (+)- carvone
Ceylon cinnamon bark	Chinese cassia oil
Cinnamon bark	Cinnamon leaf oil/Cinnamic aldehyde, Eugenol
Cinnamon leaf	Clove leaf oil, Eugenol, Cinnamic aldehyde, Benzaldehyde
Citrus oils (cold-pressed)	Distilled versions of these citrus fruits.
Clove bud	Clove leaf oil/Eugenol & Eugenyl acetate/Beta caryophyllene
Clove bud oil	Clove leaf oil
Cognac	Ethyl esters of aliphatic acids (e.g., Ethyl oenanthate)
Coriander seed	Linalool, trace amounts of certain pyrazines
Cumin seed	Cuminaldehyde
Cypress	α–Pinene, δ-3-Carene, Myrcene
Dill seed	α–Phellandrene, Limonene
Elemi oil	α–Phellandrene, Limonene
Eucalyptus globulus	Cinnamomum camphora,
Eucalyptus radiata	Eucalyptus globulus plus α–Terpineol
Floral absolutes	Schiff's bases
Galbanum resinoids	β–Pinenes, undecatrienes
Gardenia absolute	Styrallyl acetate
Garlic	Aliphatic sulphide mixtures of 2-Propenyl disulphide and 1-Propenyl disulphide, etc.
Geranium (indian)	Palmarosa oil, Citronella, Synthetic components, Diphenyl oxide

Essential oil	Adulterants
Geranium bourbon	Geranium oil from china
Grapefruit	Orange terpenes, Sweet orange oil, Minor amounts of (+) – nootkatones
Jasmin	Ylang-Ylang, Benzyl acetate, Indole, Cinnamic aldehydes and fractions
Juniper	Terpene hydrocarbon mixtures of α–Pinene, δ-3-Carene, poor quality oils.
Labdanum resinoids	Abitol, Ambroxan, ρ–Methylacetophenone.
Lavender	Lavandin, Acetylated lavandin, Aspic, Synthetic linalool, Linalyl acetate, Terpenyl propionate, Ho leaf fractions, Eucalyptus, White camphor oil fractions, Spanish sage oil, Bulgarian lavender oil, etc.
Lemon	Orange terpenes, Lemon terpenes, Lime oil. Grapefruit oil, Synthetic limonene, Citral, Dipentene, BHA, BHT
Lemon grass	Citral
Linden blossom absolute	Hydroxy citronellal
Mandarin citrus reticulata var mandarin	Tangerine oil plus, γ– Terpinene, Dimethyl anthranilate, α–Sinesal and Perilla aldehyde
Melissa	Litsea cubeba oil, Lemon oil (Citrus Limon), Lemon grass (Cymbopogan Citratus) or Citronella (Cymbopogan nardus).
Mentha citrata	Linalool/Linalyl acetate
Mentha piperita	Mentha arvensis oil
Moroccan myrtle	Myrtle from the Balkans.
Neroli	Linalool, Nerol, Limonene, Linalyl acetate
Nutmeg	Nutmeg terpenes, α–Pinene, Limonene, Turpentine fractions
Orange	BHA, BHT, Distilled orange oil sweet & bitters mixed,
Origanum	p-Cymene, Carvacol
Palmarosa	Geraniol
Patchouli	Cedarwood oil, Clove oil, Terpenes, Methyl abietate, Vetiver residues, Castor oil, Gurjun Balsam, cheaper chinese Patchouli oil,
Peppermint	Cornmint, L-Menthol
Petitgrain	Other citrus leaf oils and fractions, Fatty aldehydes, Linalyl acetate and Orange terpenes.
Pine needle	(-)-Bornyl acetate, Limonene, Camphene, α–Pinene
Rose	Geranium oil, fractions or natural & synthetic geranium oil, Phenyl ethyl alcohol, Citronellol, Geraniol, Rhodinol fractions, etc.
Rose (damascena)	Geranium (Pelargonium graveolens) and Palmarosa oil (Cymbopogan martini)
Rosemary	Eucalyptus globulus oil/White camphor oil, Limonene, Alpha-Pinene and Camphene from orange and other Monoterpene-Rich citrus oils, Isobornyl acetate, etc.
Rosewood	Trace amounts of Methyl heptanone, Methyl heptanal, ρ–Methylacetophenone, Linalool, 3-Octanol
Sandalwood	Amyris, Araucaria, Cedarwood oil, Castor, Copaiba, Glyceral acetate, Benzyl benzoate, Triacetin, Sandalwood terpenes, cheaper west african & west australian Sandalwood oils, Synthetic sandalwood fragrance chemicals (from α-Campholenic aldehyde.)

Essential oil	Adulterants
Siberian fir	Chinese Fir
Spearmint	L-Carvone
Star anise oil	Synthetic anethole
Sweet orange oil florida	Orange oil brazil
Tea tree	Terpinen-4-ol, α-and γ-Terpinenes
Thyme	Thymol, Para cymene
Thyme (thymus vulgaris)	Wild thyme (thymus mastichina)
Vetiver	Caryophyllene & derivatives.
Wintergreen	Methyl salicylate
Ylang-ylang	Cananga oil, Perubalsam, Copaiba, Inferior fractions & synthetics.
Yuzu	Grapefruit, Mandarin

- Blending a higher quality essential oil with a lower quality version of the same species;
- Adding isolates obtained from other essential oils (low cost lemon or orange terpenes);
- Adding individual natural, synthetic constituents (including nature identical), to improve aroma;
- Adding vegetable (rapeseed oil/ sunflower oil) or mineral oil, solvent, etc. (invisible adulterants difficult to detect by routine essential oil analysis test methods.)

Adulterators generally add Abitol (a primary hydroabietyl alcohol to resinoids), Benzyl alcohol (allergen), Benzyl benzoate (allergen), Dipropylene Glycol (DPG), Carbitol (diethylene glycol monomethyl ether or DRGME), Diacetone alcohol, *Hercolyn D* (hydrogenated methyl ester of rosin), *Isopar* (odourless kerosene fractions), Isononyl acetate, Isopropyl Myristate (IPM), *Fixateur 404* (Isotridecyl acetate, ITDA), Triacetin (antifungal glycerol triacetate), 3,3,5-Trimethyl-hexan-1-ol, and Diethyl Phthalate (DEP), Dibutyl Phthalate (DBP) as diluents as they have practically no odour and adding even up to 10-15% is difficult to notice just by smell even by experts. Using Gas Chromatography (GC) also becomes

Table 2
Passing off a cheaper essential oil with and expensive one is another type of deception

Cheaper Oil	Expensive Oil
Cinnamomum camphora	Eucalyptus globulus
Peppermint	Cornmint
Citronella & Lemon mixture	Melissa
Micromeria fructicisa (turkish pennyroyal) & Hedeoma pulegioides (american pennyroyal)	Pennyroyal (Mentha pulegium)
Treemoss resinoid	Oakmoss resinoid
Petit grain (terpene-less)	Rosewood
Petit grain (Paraguay)	Petit grain bigarade
Siberian silver fir needle	Siberian pine oil
Sweet orange (Brazil)	Sweet orange (Florida)
Star Anise	Anise
Styrax plus chemicals	Tolu balsam

difficult for deciphering adulterants especially for an inexperienced analyst because these materials generally appear as innumerable late eluting small peaks representing their different isomeric forms. Aqueous alcohol solubility tests could indicate their presence, additionally substantiated by use of various GC columns and operating conditions or by derivatisation.

Testing essential oil purity & quality

Laboratory tests can determine an essential oil's purity and quality on subjective olfactory levels as well as quantifiably. However, independent testing, especially for direct consumers and small buyers are very expensive. Today, adulteration is highly sophisticated and detection very difficult without testing and expert analysis.

Subjective test methods

The best that a small consumer can look for is simple cautionary signs like:

- Visibly cloudy in appearance;
- Unusual viscosity (high viscosity means an aged oil or oxidised oil);
- Smelling and comparing an essential can also give a good indication of a genuine essential oil. (However, the consumer should be familiar with a genuine oil smell otherwise adulteration is difficult to detect);
- Essential oil usually evaporates after a few hours without being greasy. If a drop of the essential oil on cloth or blotting paper on evaporation leaves a ring of grease it is adulterated with another fixed oil (e.g., a vegetable oil);
- On placing a drop of essential oil in water, it floats on the top water layer. Emulsified mixtures on the other hand dissolve producing milky white opaque solution.

Quantifiable testing methods

Quantifiable tests allow scientists, producers, suppliers and end-users check their oils to determine and confirm quality, and purity required for each particular botanical. The most common testing methods include physical, chemical and instrumental methods.

1. Olfactory/Organoleptic: Physical tests using our five senses viz., smell (aroma), taste (flavour), colour, texture, viscosity.
2. Chemical methods: Acid value, esters, aldehydes, ketones, alcohols, phenols, ethers, etc.,
3. Melting Point,
4. Congealing Point,
5. Refractive Index,
6. Specific Gravity,
7. Optical Rotation,
8. Thin Layer Chromatography (TLC)
9. Gas Liquid Chromatography (GC/GLC),
10. High Performance Liquid Chromatography (HPLC)
11. Gas Liquid Chromatography & Mass Spectrometry (GC-MS),
12. Mass Spectrometry (MS),
13. Infrared Spectroscopy (IR),
14. Fourier Transform Infrared Spectroscopy (FTIR),
15. Vibrational Spectroscopy,
16. Coupled & Multidimensional Chromatography,
17. Differential Scanning Colorimetry (DSC),
18. Isotope Ratio Mass Spectrometry (IRMS),
19. Nuclear Magnetic Resonance Spectroscopy (NMR),
20. Site-Specific Natural Isotope & Nuclear Magnetic Resonance Spectroscopy (SNIF-NMR),
21. Proton Nuclear Magnetic Resonance Spectroscopy (1H NMR),
22. 13C Nuclear Magnetic Resonance Spectroscopy (13C NMR).

We require sophisticated analytical techniques mentioned above to quantify adulteration in essential oils by making use of unique/specific marker compounds, present naturally in pure essential oils, that we could use as standards constituents to authenticate purchase of oils. Presence of marker compound in essential oils in specified amounts or in an accept-

Table 3
Market compounds in essential oils

Essential Oil	Marker Compounds
Anise oil (Illicium verum)	γ–Himalchene, pseudoisoeugenyl 2-Methylbutyrate, Foeniculum, absence of cis-Anethole/Anisyl alcohol/Anisic aldehyde
Artemisia vulgaris	Vulgarone
Cinnamon bark & Cassia oils	5-Phenyl penta-2,4-Dienal should be absent.
Geranium oil (North African Type)	(-)-(4R)-6,9-Guiadiene/10-epi-gamma-eudesmol
Lavender oil (Lavandula augustifolia)	α-Santalene, (-)-lavandulol, (-)-lavandulyl acetate
Lemon oil/Mandarin oil	Delta-3-carene absent
Patchouli oil (Indonesian)	Patchulol (26-40%) only, α–Gurjunene
Peppermint Piperita	Menthofuran
Rose Otto (R. Centifolia)	(Z)-9-nonadecene
Rosewood oil (Aniba Spp.)	Eremophilene

ed range means the oil is not adulterated.

There are two main approaches in determining adulteration in essential oils:

1. Probing for the presence of specific markers in the essential oil tested.
2. Creating the global fingerprints of essential oils and monitoring it regularly.

Typical examples

Cornmint (*Mentha Arvensis*), a less expensive mint plant, is a frequently used as peppermint adulterant. However, cornmint has high menthol content while peppermint contains unique marker compounds 'Menthofuran' from 0.4% to 20% level. Cornmint does not contain 'Menthofuran' or sometimes may be present only at 0.01% levels. Similarly, biomarker, Viridifloral is found in peppermint up to 0.9%, whereas it is totally absent in cornmint.

Detecting adulteration in rose oil is difficult using routine analysis. Enantioselective capillary gas chromatograph-flame ionization and mass spectrometry however, is useful in authenticating the quality parameters of rose oil.

NMR spectroscopy is successful in detecting low-grade adulterants, in the high quality sandalwood oil.

Evaluating the natural enantiomeric ratios of essential oils can differentiate natural compounds from synthetics.

Chirality evaluation of linalool is reliable to authenticate bergamot, sweet orange or lavender oils.

IRMS is useful in detecting the botanical origin and adulteration of essential oils like Lemon, Lemongrass, Citronella, Melissa. IRMS easily differentiates between natural and synthetic thymol as natural is deuterium depleted but 18-O enriched.

Are all these test methods infallible and trust worthy?

Unfortunately the answer is NO. GC/MS and other tests are not truly reliable as testing does risk manipulation depending on the qualifications/ knowledge and moral standards of the analysts. Testing equipment is expensive and the ability to use, understand and analyse the readings requires special training. One common debate is whether olfactory testing (human nose) is superior to instrumental or vice-versa. Although it is true that a trained nose can detect minute differences and identify adulterants that may not be possible by instruments, however the human nose cannot quantify composition of mixtures accurately and quickly as an instrument does thereby indicating that both these techniques complement each other.

Conclusion

There are no regulatory bodies regulating essential oils although governing bodies like the International Organization for Standardization (ISO), International Federation of Organic Agriculture Movements (IFOAM), Food Chemicals Codex, & Food and Drug Administration (FDA), Flavour & Fragrance Associations, Essential Oil Associations and Pharmaceutical Trade organisations in various countries do exists. Some of these organisations merely puts out a GRAS 'Generally Recognized as Safe,' list without determining what grade essential oil it is, nor do they label them as such. F&F industry have their internal purchasing standards for their private use. Essentially this merely means that we as consumers can at best could believe that the listed items are safe and fit for proposed human use.

Since no governmental regulating body certifying grades for essential oils exists, most consumers who do not have the ability or knowledge to directly perform or oversee testing have no option but trust in the seller. Absence of regulations within the essential oil industry means consumers themselves should take efforts to acquire knowledge of adulteration to ensure that they are buying genuine essential oils, with full therapeutic benefits. Using pure, genuine essential oils means we will require less in order for the oil to be effective. In any production cycle, the manufactured products changes hands and in case of essential oils the possibilities for adulteration and contamination substantially increase. An ordinary consumer should therefore make themselves aware of the supply chain, reputation and ethical values of the retailer, supplier and other stakeholders before any purchase of the essential oils for personal use. It is about high time now to have an official regulatory body for essential oils sales and use in India!

Additional Reading

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