New Zealand Institute for Crop & Food Research Ltd
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CROP & FOOD RESEARCH
Mana Kai Rangahau

Essential oils and their production

Plant essences and extracts that have developed into modern essential oils have been used for centuries. The variety of uses for essential oils and their components is very broad and is determined by their chemical physical and sensory properties.

History of essential oils

The essential oils which were regularly used in ancient Rome, Greece, and Egypt and throughout the Middle and Far East had, as a common feature, the essence of a plant; an identifiable aroma, flavour, or other characteristic that was of some practical use. They were used as perfumes, food flavours, deodorants, pharmaceuticals, and embalming antiseptics. Usually, plant material was steeped in a fatty oil or wine that acted as a solvent for the desired flavour or aroma. The extracts (usually impure and dilute) were used as oils or creams. They were introduced into Europe, without further development, to become the subject of specialist craftsmen (the English Guild of Pepperers and the French court perfumers of the 12th Century) and early publications ("The Book of Nurture", 1430).

In Spain and France from the early 1300s, distillation was developed to produce more concentrated essences of rosemary and sage. The demands of medieval pharmacy improved the distillation process. By 1550, different trends had become obvious:

- spike lavender oil was being produced in France for export as a trading commodity,
- flavours and aromas were being distilled or expressed from an increasing number of new plant sources, and
- pharmacists, chemists, and physicians were studying the physical, chemical, and medicinal properties of the oils.

Since then, the numbers and types of individual oils have increased enormously. International markets and industries have evolved to deal solely in essential oils. As a result of twentieth century distillation technology, essential oils can now be regarded as industrial raw materials. Their complex mixtures of chemical compounds can be separated and the individual components used as building blocks to introduce a particular flavour or aroma into a product.

In New Zealand, enterprising growers have shown interest in the commercial production of peppermint dill, parsley, fennel, lavender, boronia and manuka oils. Crop & Food Research is actively involved in all aspects of the

production process - crop agronomy, chemical analysis of oil composition, selecting suitable lines for New Zealand from imported material, harvesting (Fig. 1) and extraction.

This research has successfully identified the areas of expertise and information that are needed for successful essential oil crops (Fig. 4).

How are essential oils produced?

First, the raw material that contains the oil must be obtained - usually by harvesting some part of a growing plant population. There are three different approaches.

The original approach involved collecting plants from wild populations and extracting oils for local use. Cheap manual labour of peasant or native workers was used. Where external demands exist, plant populations are encouraged and maintained with irregular cultivation. This approach is still used in areas that cannot be cultivated easily. There is little control over supply or quality and marked fluctuations occur.

The second approach is today's intensive cropping industry used in New Zealand and other agriculturally "developed" countries. It uses all of the modern methods of mechanisation and crop and financial management. Selections for high yields, high quality oil, and good agronomic features have greatly improved crop performance. Increased control over oil production processes has improved and stabilised quality and supply.

A third approach is still at the research stage. Artificial cultures of plant cells of a few species can produce some of the chemical compounds that characterise an essential oil. Attempts are being made to find and establish high producing lines of cells, using genetic manipulation together with tissue culture and liquid culture engineering. This system will probably produce single components rather than a complete essential oil. This is also true of production by synthetic chemical engineering which is now common for components used in cheaper products.

From paddock to product

Table 1: A summary of some common methods of essential oil extraction.

Whatever production system we choose, the raw plant material is the starting point of a long and complex sequence, very briefly described in five steps. Essential oils are easily transported throughout the worldwide network of multi-national dealers, importers and end users.

Selection of raw plant material. Extensive analytical and sensory evaluation is necessary to select the plant cultivar/race/chemotype, the part of the plant growth and the stage of development for harvest that gives the best yield of the particular oil character desired.

Extraction. Table 1 summarises the most common ways in which oils are removed from plant material. The state of the material (dried/fresh, crushed/intact, soft/fibrous) can significantly affect the yield, composition, and character of the oil. The stage of development is particularly important.

Processing. If it is necessary to reinforce a particular flavour or aroma characteristic, this may be done by eliminating unwanted fractions of the extracted oil or by selecting a particular fraction of the oil. Individual or groups of compounds may be separated by physical (fractional or molecular distillation, freeze concentration) or chemical (absorption chromatography, solvent partitioning) methods.

Description of properties and composition. The human senses of taste and smell are indispensable. Expert, trained noses and taste panels are used to describe diluted oils and products subjectively, so that the characteristics can be easily related to what is required and understood in the market place. The objective, numerical data from analytical methods describe the physical and chemical characteristics of the oil. They are used to confirm some of the subjective evaluations or to indicate processing properties, the presence or absence of some individual chemical component, or the purity of the oil.

The quality and price of some oils are based on the percentage content of a single chemical component, so separation and measurement of individual components is very important. This is usually done using some form of chromatography, the most powerful is gas chromatography using capillary columns. Rigorous identification of components commonly employs a form of spectroscopy (mass, UV, IR, NMR) to indicate the molecular structure.

Formulation. To formulate a successful product, a sound knowledge of all of the physical and chemical properties of the oil must be combined with evaluations from an expert nose/palate, so that the specifications and characteristics dictated by market requirements are satisfied.

What products use essential oils?

The variety of uses for essential oils and their individual components is so wide that only the broadest categories can be mentioned here. They include whole industries (paint, petroleum, mining and manufacturing), food (processing and flavouring), drink (alcoholic and non-alcoholic flavourings), pharmaceutical products, perfumes and toiletries, hygiene products, and pesticides.

The end uses of essential oils are determined by their chemical, physical, and sensory properties, which differ greatly from oil to oil. Each of the individual chemical compounds that can be found in an oil contributes to the overall character. The professional perfumer is trained to detect very slight changes in character caused by changes in the levels of individual compounds. Steam-distilled essential oils are complex mixtures of sometimes hundreds of widely differing chemical compounds. They must not be confused with fatty acid oils (e.g. soya, rape, evening primrose) whose chemical properties and biochemical origins are completely different.

The occurrence of oils in the plant

There is much speculation about the "role" of essential oils in plants. Do plants derive any benefit from their presence? Certainly several apparently "useful" effects have been described:

- attraction of pollinating insects by attractive volatile aromas,
- reduction of competition from other plant species (allelopathy) by chemical inhibition of seed germination and establishment, and
- protection against insects by an anaesthetic effect, against infectious microflora by fungicidal and bactericidal properties, and against browsing animals by adverse taste and effects on the nervous system.

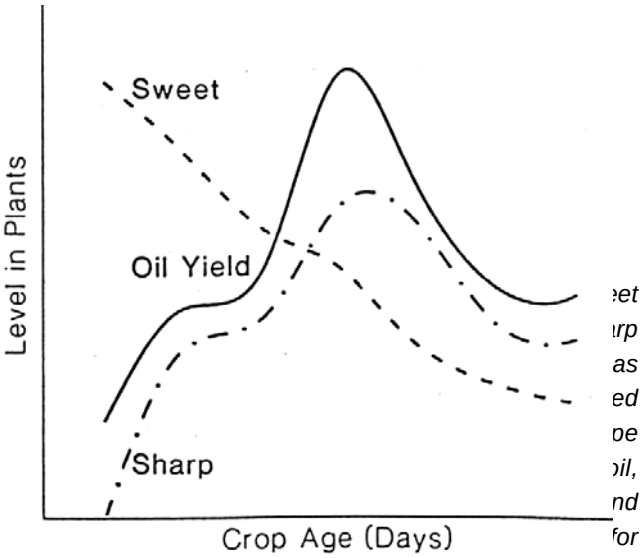
In traditional essential oil plants, several specialised structures have been described as oil sources by microscopic studies. The most common are:

- cavities or ducts - these are clusters of cells just below the epidermis, e.g. skins of citrus fruit, or the leaves of eucalypts or ngaio, and
- glands or hairs - originating from epidermal cells, e.g. the glands on lavender florets, or the modified leaf hairs of mint, geranium, and origanum (Fig. 2).

Early in the history of essential oils, it became obvious that there could be marked differences in the oils obtained from plants of the same species. These differences can affect the major aspects - content, composition, timing, and character - of oil in the plant. Contributing factors include:

- geographical source of the plant,
- climatic factors (sunshine hours, photoperiod, and temperature) and soil factors (structure, pH), activity,
- diurnal fluctuations related to photosynthetic activity,

Figure 2: Epidermal hairs on the calyx of an origanum flower.



good quality or vice versa.

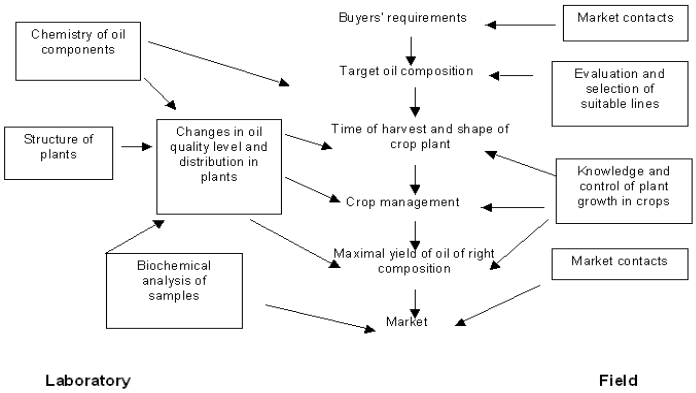


Figure 4: The information and expertise required to manage essential oil crops. This is a much more detailed and demanding approach than is normally used for essential oil cropping overseas, but local experience has shown that each input has made a significant contribution to crop performance and quality.

- the part of the plant from which the oil is taken, and
- the maturity of the plant.

Combinations of these factors can offer a wide choice of oil yield and character in a crop of a single species. But the yield and character change as the crop grows, often from day to day. This makes it difficult to achieve good crop performance and quality by traditional rule of thumb or uneducated guesswork. Figure 3 summarises information obtained from a commercial crop of dill in Canterbury, showing the dramatic changes in the oil following flowering.

The variation in oils can be of great benefit to growers if they have the information and expertise that is necessary to keep up with the changes in the essential oil in the crop. Figure 4 outlines the oil production sequence, and the necessary inputs required from the field and the laboratory of research and advisory organisations. The most important feature is the absolute necessity of understanding the changes in oil quality, level, and distribution in the plant. Done in close collaboration with the growers, Crop & Food Research has shown that the collective expertise and information to achieve world class yield and quality is available or attainable in New Zealand.

Recommended reading

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