Chapter 1—Aromatics

Description of the Product and Its Uses

Essential oils are the concentrated aromatic oils of plant leaves, flowers, seeds, bark, roots, and the rinds of some fruits. They vary in strength but are always very potent, and often smell best when diluted (as in other oils, colognes, and shampoos). Those essential oils obtained from trees are generally produced by a lengthy steam distillation process applied to either the chopped wood or the leaves and branch ends of the tree (table 1–1). There are other methods of producing oils from citrus fruits, flowers, and herbs as well (see appendix).

Table 1–1. Aromatic oils

Balsam fir oil	Spruce oil
Birch oil	Cedarwood oil Texas
Cedar leaf oil	Cedarwood oil Virginiana
Hemlock oil	Wintergreen oil
Sassafras oil	

Essential oils have a great many uses and may be obtained from cultivated or wild plants. Examples of plants cultivated for their oils (among other uses) include peppermint, spearmint, mentha citrate, basil, clary sage, dill, tansy, wormseed, lemongrass, hops, and a host of other oil crops that are generally grown under contract (angelica, anise, chamomile, coriander, parsley, and tarragon). One commercial source of essential and fragrance oils (Frontier Herbs) lists over 50 essential oils: 25 oils used in cooking and over 20 oils used in potpourri crafting, cosmetics, and massage, among other uses. The most common essential oils used as insect repellents are the oils of cedar, lavender, eucalyptus, pennyroyal, and citronella. They are mostly used on pets and humans to repel fleas and mosquitoes.

Oils of commercial importance obtained from trees and wild plants include cedar leaf oil (from eastern white cedar or arborvitae, *Thuja occidentalis* L.), and from western redcedar (*Thuja plicata* Donn.), balsam fir oil (*Abies balsamea*), hemlock oil (from eastern or Canadian hemlock, *Tsuga canadensis*), spruce oil (from *Picea* species), cedarwood oil Virginiana (from *Juniperus virginiana*), cedarwood oil Texas (from *Juniperus mexicana*), sweet birch oil (*Betala lenta*), and wintergreen oil (from checkerberry wintergreen, *Gaultheria procumbens*). Some of this last group of oils will be discussed in this section.

Cedar leaf oil has been an item of commerce for over 100 years. Thuja cedar leaf oil is produced from the ends of branches and adherent leaves of the eastern arborvitae and western redcedar. It is a common ingredient in pine and cedar blends which are used in room sprays, talcs, and insecticides. It is a component in embalming fluids, microscope slide slips, industrial cleaners, deodorants, pharmaceuticals, cleaning fluids, salves, liniments, perfumes, shoe polishes, and soaps. Perhaps its largest use is in the preparation of patent medicines. For example, it is used in Vicks Vap-O-Rub, a cold-remedy salve that helps clear the nose and loosen the chest. A rather recent use is in the reodorizing of sawdust in "sawdust logs" or instant fire logs.

The main areas of production of cedar leaf oil have traditionally been in New York, Vermont, eastern Quebec, and southeastern Ontario, although some distillation has taken place in the Upper Peninsula of Michigan and in British Columbia (western redcedar).

Balsam fir oil is used in fragrance formulation, particularly in industrial and household products such as detergents, room fresheners, household cleaners, and disinfectants.

Hemlock oil and spruce oil are used for household products, detergents, and soaps. Hemlock oil is not well defined, since there are four hemlock species native to North America, but true hemlock oil is obtained exclusively from eastern hemlock. Spruce oil is obtained from the young branches and adherent leaves of black and white spruce. Spruce oil has a pleasant, pine needle odor and is a major constituent in pine and cedar blends such as sprays, deodorants, soaps, and disinfectants. Both oils are used for personal care products and some cosmetics. There are many blends of hemlock, spruce, and fir needle oils that are produced, and the terms spruce and hemlock oils are often used interchangeably.

Cedarwood oil Virginiana is obtained from steam-distilling sawdust, waste shavings, old stumps, and chipped logs of eastern redcedar. Most of the production comes from North Carolina. This oil is widely used in the fragrance industry in products such as soaps, air fresheners, floor polishes, and sanitation supplies. It is also used in deodorants, insecticides, mothproof bags, floor polishes, and janitorial supplies. In addition, a large percentage of the oil is used as a starting material for cedrol and cedryl acetate.

Cedarwood oil Texas has different uses and does not compete in the marketplace with cedarwood oil

Texarome distillation plant for extracting natural oils. Courtesy of Texarome, Leakey, Texas. (SFP–13)

Virginiana. The chemical composition of the oils is similar, but Texas cedar oil is used almost entirely as feedstock for the manufacture of chemical derivatives of the oil, whereas cedarwood oil Virginiana is used mostly as is in fragrance formulas. Unlike the cedarwood oil Virginiana, the cedarwood oil Texas is not a by-product from the furniture industry—the Texas cedar is felled almost exclusively for land clearing to increase grazing lands for cattle ranching. Cedar trees from such clearing operations are sold to the distillation plants. It is estimated that 70 to 80 percent of this oil is used for cedrol isolation and subsequent acetylation.

Sweet birch oil is primarily produced in eastern Pennsylvania and in South Carolina. It is used in the flavor industry in the manufacture of chewing gum, dentifrice products, and baked goods. It has also been used as an antirheumatic medicant and as a disinfectant. Since the wide availability of synthetic methyl salicylate, the demand for natural methyl salicylate oils has decreased greatly.

Wintergreen oil is produced from the leaves of the low-lying evergreen plant called checkerberry wintergreen. It is used in flavoring chewing gum, other confections, soft drinks, and dentifrice products. In addition to a limited fragrance use (in fern and cypress perfumes), it has been used in a number of over-the-counter pharmaceuticals and personal care products, in particular, to reduce the swelling of tissues. A tea brewed from wintergreen leaves has been used to treat rheumatism, dysentery, and delayed menstruation, and to promote milk flow in nursing mothers.

In addition to the above wild plant oils, erigeron oil (from *Erigeron canadensis*, a common weed in the Midwest known as marestail), pennyroyal oil (from *Hedeoma pulegeoides*), and goldenrod oil (from *Solidago odora*) have all been used to some degree as fragrances. Sassafras oil, from the bark of the root of the sassafras tree, is used for scenting soaps.

Market and Competition Considerations

Essential oils are at the core of the $10 billion U.S. food flavorings and cosmetic industry. Despite their being a very small volume commodity, the oils and their chemical derivatives have a strategic importance because of their irreplaceability in certain formulas that have been well established and on the retail market for years. Most of the users of essential oils are located in highly developed and industrial countries such as the United States, Europe, and Japan.

There are nonetheless severe drawbacks to entering the essential oils and aromatics business. China (mainland) has historically been an aggressive promoter of crops with extractable essential oils. Theoretically, China's State-owned or subsidized producers have the lasting power to bankrupt most private competition in the free world. Small producers in the United States also must contend with a virtual price control by a few large companies on the East Coast.

More recently, since the beginning of the current economic depression, the prices for essential oils have fallen at the same time that consumption has decreased. For example, cedarwood oil Texas has dropped from a total production of 600 drums per month to 350 drums per month, and this oil is one of the highest volume oils. The price for cedarwood oil Texas is now at 1975 levels ($2.75 per pound). The same is happening for a number of other essential oils. A low-grade Chinese cedarwood oil is being offered in New York at $1.70 per pound, which is below the cost price of any of the Texas producers.

Global competition and marketing have another peculiar pitfall. The currency exchange rate and the black market value of the U.S. dollar in certain essential oil-producing countries are such that these countries can afford to sell their goods for very low U.S. dollar prices. One can perhaps expect similar situations to occur with goods and commodities from Eastern Europe and the Commonwealth of Independent States (CIS) as soon as these countries return to some degree of production; many of these countries are essential oil producers.

There are two options available to the entrepreneur desiring to enter the essential oils market. The first is to enter the market in a fairly major way, for example, with an investment in an essential oil distillation plant of between $1 million and $2 million. Such a plant would need to be set up to process 50 tons of raw material a day. According to Mr. Gueric Boucard of Texarome, a fragrance material producing these conditions would

need to be met for this strategy to succeed (Boucard, personal correspondence):

1. The raw material must be either site-specific (for example, Texas cedarwood, Virginia cedarwood, and cedar leaf) or must be of a good chemovariety that produces a high yield of oil and can be raised as a fully mechanized crop (for example, basil oils, spice oils, tea tree oils, lemongrass oils, and coriander oils). In either case, the biomass by-products of the distillation must have enough value that the overall cost of the oil itself is drastically reduced. Such value might be either as boiler fuel or as cattle feed additive. Ideally, boiler fuel materials would not only generate the steam for the distillation but also generate enough electricity needed to grind the materials and operate the plant.
2. The raw materials must be processed in a sufficiently large volume to achieve economies of scale, yet such volume should not constitute more than 25 percent of the current world production in the first phase.
3. The most cost-efficient and automated distillation technology must be selected for the job.
4. The plant should be designed to include a vacuum-refining section with a fractionation column to allow the redistillation of the oil to remove dark colors and resins or to fractionate the oil into its different constituents. This would allow reblending to meet a customer's exact specifications.
5. Preferably, a new producer should have a contract in hand for at least part of the production before going into business. Alternatively, the new producer could be in business with a line of products that will use the oil.
6. A new producer should start with sufficient operating cash to produce for at least 6 months without sales. (Large producers in the United States have been known to have sold oils for a full year below their manufacturing cost price in order to put a new producer out of business.)
7. The new trend in the flavor and fragrance industry is to keep inventories to a minimum and rely on essential oil dealers to deliver the raw materials on time as needed, out of their own inventory. For this reason, producers must be able to offer substantial quantities of merchandise "ex warehouse" and available for immediate delivery, for example, spot New Jersey, spot Amsterdam, and spot Marseille. This requires considerable credits for product inventory, shipping, and warehousing costs.
8. Preliminary calculations need to show that the oil can be produced for one-half to two-thirds of its lowest list price during the past 10 years.

These are fairly sizable conditions certainly, and care is advised in pursuing this strategy. Basically, there is nothing that can be raised and distilled in this country that cannot be done cheaper elsewhere. The only valid niche is where one is raising and processing a crop or material that has other value as well, for example, as a feed crop for cattle feedlot operations. Celery, coriander, and related crops with high oil seeds can be high-quality feed crops. In such cases, their oils become almost by-products.

This raises the second alternative for essential oils production that is probably more consistent with rural small business development. This alternative is to develop a very small-scale distillation process in conjunction with an herb or other botanical already being harvested or grown for other reasons.

For example, a producer of an herb such as rosemary might consider building a very small-scale "back yard" distilling operation capable of using excess harvests of this herb to produce a small quantity of oil. A small distillation unit capable of using about 500 pounds of excess herbs might produce a gallon of rosemary oil, which could be carefully and attractively bottled and sold. Even such a relatively small amount of production could add value to the business if this oil were bottled in half-ounce bottles and sold for several dollars a bottle, perhaps through a retail shop associated with the grower's business. Such a small-scale approach effectively raises the value of the oil from $30 per pound (its price on the world market) to about $150 per pound. The distillation process itself could be a drawing card for visitors and tourists.

The biggest problem for the very small entrepreneur trying to sell a manufactured oil is the reliability of his or her production. It is difficult to get enough production to convince a buyer—for example, a cosmetic company—to buy the product. A consumer-based product line cannot be introduced only to find that the oil for that commercial product is not in dependable supply. If a reliable supply and sufficient quantities of the raw material cannot be identified, the project will be dropped.

The "harvested from the wild" forest materials for aromatics are predominantly the eastern white cedar and balsam fir. In particular, cedar leaf oil production has almost always been a "pocket money" production controlled mainly by farmers who distill the oil in fairly crude equipment during times when they are not doing usual farm work. Cedar oil was selling at about $9.50 a pound in 1978, although the market can widely fluctuate. It is estimated that 25 metric tons were produced in Canada and the United States in 1984.

Other estimated levels of production based on 1984 estimates are as follows:

Fir balsam oil	10 metric tons
Cedarwood oil Virginiana	240 metric tons
Cedarwood oil Texas	1,400 metric tons

Estimated levels of production for some other oils, based on older 1979 data, were:

Hemlock oil	1,000 to 2,000 pounds
Spruce oil	4,000 to 5,000 pounds
Sweet birch oil	5,500 pounds
Wintergreen oil	2,500 pounds

The market trend for the above essential oils is currently a little downhill. The production of cedarwood oil Texas, for instance, has dropped by half, and the four plants producing this oil are all running at half capacity. The competition from China is strong, and other countries such as India and Indonesia are prepared to sell at a price below the U.S. cost price.

The primary buyers of aromatics in the flavor business are brokers and dealers, some of whom speculate in the purchase of raw materials. The companies that make the final product (perfumes, cosmetics, and foods) seldom get involved in purchasing the raw materials. Rather, it is the "recipe makers," or the intermediary companies, which are most often the point of contact for a small rural entrepreneur. These are the companies whose job it is to make "recipes" of flavors and fragrances which they, in turn, sell to the perfume, cosmetic, and food companies.

One of the hardest things in the essential oils business is getting a new product approved by an intermediary. It often takes a number of years for a user company to decide if a product is reliable, available, and wanted. Occasionally, though, one can find a smaller broker who will go out of his or her way to try to move an oil that has a new source.

Distribution and Packaging

Essential oils must be stored so that they remain unexposed to air, light, heat, and heavy metals. If allowed to deteriorate, they become less fragrant, more viscous, and darker. Because they have no fatty acids, rancidity is not a problem. Properly stored and sealed, most oils last for years and some reputedly improve with age.

Trucking freight rates are becoming disproportionately high in some regions. One producer gave as an example the fact that in 30 drum lots, it costs $45 per drum to ship by truck from Leakey, Texas, to the Port of Houston (250 miles) and $55 per drum to send the same drum from the Port of Houston all the way to London, England.

Equipment Needs, Costs, and Suppliers

A distillation unit that could achieve a very small-scale level of production would cost in the range of $5,000 to $10,000 and could be lease-purchased or bought. If purity and efficiency were not major concerns, it would also be possible to build a very small "home-made" distilling apparatus, since the overall concept is not complex. In fact, many of those in the cedar oil business design their own distilling equipment. The key is having a source of steam: the steam volatilizes the oil in the nodules of the boughs, and the steam-oil mix is put through a condenser. The oil and water separate and the oil is dipped off. Someone with a steam boiler can build a still with drums and chicken wire to hold the plant material.

Some kind of chopper is necessary to pulverize the plant material too. For example, it takes about two tons of eastern white cedar brush to fill a typical distilling tub, which means 4 to 6 days of hard work. Often the simplest of tools are used—a small axe, a handsaw to cut branches, and a machete. Depending on the season, the weather, and the quality of the brush, 2 tons yield anywhere from 20 to 40 pounds of oil (about 3 to 5 gallons).

Resource Conservation Considerations

Environmental concerns can become linked with the production of essential oils on a case-by-case basis. For example, the harvesting of Texas cedar currently is being affected in some regions because of the listing of the yellow-cheeked warbler and the black cap vireo on the endangered species list. These birds nest in cedar trees, and fines up to $50,000 are being levied for cutting a cedar tree in certain areas where birds have been sighted.

Special Factors

Society is becoming more careful about the toxicity or other adverse effects of materials. Many small companies are virtually uninsurable by insurance companies, and product liability for a small line of retail cosmetic products is very expensive. One lawsuit can bankrupt a small company at any given time.

Processing plants can require up to 2 years of preparation because of permit requirements and environmental constraints, chiefly related to air quality and water quality concerns.

There are a lot of shysters in the aromatics business. For example, "stretching" an oil with synthetic compounds

that are difficult to detect chemically is not uncommon. It has been rumored in the trade that a certain amount of the so-called natural birch oil has never seen a birch tree.

There is a labeling law in the United States related to the use of products in the food industry. All products that use the term "natural flavor" in the label must use compounds that are naturally derived. This requirement can create market opportunities in some instances. For example, there is a wild horsemint found in western Canada that is extremely rich in a compound called geraniol, which is a raw material used in the fragrance industry. If a manufacturer making a natural apricot oil that requires a little bit of geraniol uses geraniol from the horsemint plant, he or she can still continue to use the term "natural" in the labeling. A farmer in western Alberta, Canada, has begun production of wild horsemint.

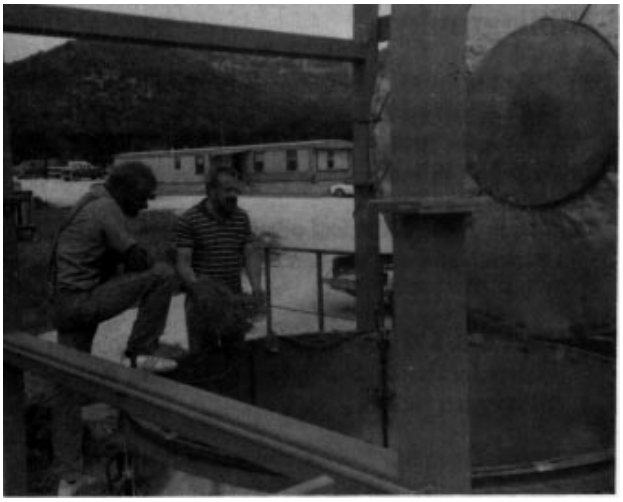
Profile

Mr. Gueric Boucard is President of Texarome Inc., a small producer of fragrance materials located in Leakey, Texas. Texarome has developed a very efficient method of extracting the natural essential oil from the native Texas cedar trees and stumps discarded by local ranchers in their land clearing operations. Through a unique continuous distillation process that uses pure steam and no chemicals, the company is able to separate and collect nearly 100 percent of the oil contained in the ground-up wood. The spent wood is used as fuel for the steam boilers, and all of the process waters are recycled. The steam is used to power and heat a cogeneration-type refining plant for breaking up crude cedarwood oil into more valuable natural fractions of the oil and a pure white crystal called cedrol. Such fractions are used by perfume chemists to produce an array of naturally based perfume chemicals used in soaps, household products, and fine fragrances.

Texarome is now developing its own line of perfumes with the introduction of "Texas Fragrances," highlighted by a Texas "homegrown" perfume base of cedar. The company also custom distills and custom builds both conventional distillation plants and continuous distillation plants.

Considerations for a Rural Development Strategy

Essential oils, like many other specialty manufactured products, are almost certainly a product about which few bankers anywhere, much less bankers in rural areas, are likely to be knowledgeable. Similarly, rural bankers would have no easy way of obtaining statistics on such products. Therefore, securing financial assistance for these enterprises would almost certainly require that these products be introduced (along with several other natural resource-based enterprises) through a concerted education program throughout a rural region. Such a program might involve bankers, small business development centers, State departments of economic development and agriculture, a university center capable of the appropriate technology transfer, and community leaders.



Sasha and Grover Corwin at Texarome portable distillation plant. Courtesy of Texarome. (SFP–12)

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Appendix A—Essential Oils as Natural Products

Essential oils are volatile odorous products obtained from natural raw materials by distillation, usually with water or steam, or, as in the case of citrus fruits, by a mechanical process. These products, which give to the plant its distinctive and often diagnostic odor, are complex mixtures of organic chemicals, the nature and relative proportions of which are determined by the genetics of the plant species and stage of development, environmental factors (such as climate), and agricultural factors (such as soil conditions, nutrition, time of harvesting, and postharvesting handling prior to distillation) (Bernath, 1986).

The chemicals present in essential oils may be classified as follows:

- Hydrocarbons of the general formula $(C_5H_6)n$-terpenes.
- Oxygenated derivatives of these hydrocarbons.
- Aromatic compounds having a benzenoid structure.
- Compounds containing nitrogen or sulfur.

These constituents are synthesized by the plant during its normal development, and the chemical composition of the oil is often characteristic of a given plant species. These oils are produced in special secretory structures such as glandular trichomes and oil or resin ducts (Fahn, 1979; Schnepf, 1974).

Essential oils have industrial application in providing an agreeable scent or flavor to many commodities, including perfumes, toilet articles, soaps, and confectionery. In addition, many volatile oils possess therapeutic properties and are used extensively in medical practice.

Commercial Extraction Methods

Aromatic Plants

In commercial practice, the removal of essential oils from plant material is accomplished by various methods, depending upon the quantity of oil present in the plant and the stability of the aromatic constituents of the oil. The tendency of some of these constituents to undergo changes when subjected to high temperatures makes it necessary in some cases to use special methods of extraction whereby the final product is obtained without decomposition or alteration (Guenther, 1972).

The four major extraction methods used are:

- Hydro- or water distillation—only water is used.
- Water and steam distillation—both water and steam are used.
- Direct steam distillation—only steam is used.
- Solvent extraction—a solvent is used.

In hydrodistillation, the plant material is in direct contact with water, while in steam distillation, live steam is used. In water-steam distillation, both water and steam are used, but the plant material is not in direct contact with water. In solvent extraction, the plant material is extracted with some solvent and then the solvent is removed to obtain the oil.

Each method of distillation can be carried out at reduced pressure, atmospheric pressure, or excess pressure.

Before distillation, the plant material is often field-cured, partially dried, or disintegrated to some extent. This latter disintegration process, commonly called comminution or size reduction, is used in the extraction or distillation of herbs or for their incorporation into food products (Heath, 1981). The reduction in particle size is to expose as many oil glands as is practically possible to the solvent or steam. It reduces the thickness of plant material through which diffusion must occur, greatly increasing the rate or speed of vaporization and distillation of essential oils.

For larger and fixed installations, steam distillation is the preferred method. Conventional operations use batch and semibatch systems. A more cost-effective continuous system is now in use at the Texarome plant in Leakey, Texas.

Solvent extraction techniques are also used for floral material, which is too sensitive for normal distillation methods. Enfleurage is another very long-established method of extracting delicate flora aromas by solution and adsorption into fat. The odorous fat is extracted with a solvent to recover the essential oil, and the residual fat may be used in the making of scented soap.

Recently, the liquid carbon dioxide extraction method and ultrasonics have been employed to increase the extraction rate and yield of essential oils.

Oleoresins

The nonvolatile flavoring constituents of herbs and spices are recoverable by extraction. In practice, a solvent is chosen that dissolves both essential oil and nonvolatiles present, the resulting solvent-free product being known as an oleoresin. Oleoresins have been used in the flavor industry for about half a century, and today oleoresins of many culinary herbs and spices are commercially available (Heath, 1981). Modern techniques using liquified gases such as carbon dioxide are used as well as the application of ultrasonics to increase the extraction rate and yields.

Quality Control

Quality control is the manufacturer's approach to maintaining the quality of the products produced based on precisely defined specifications. The large-scale production methods applied to so many products which are consumed involve a close and very critical control of all materials used, processing conditions, handling, packaging, and, of course, the end product. Of great importance to the end user is the color, preferably light or "water white" color of the oils. This result requires all stainless steel processing equipment and refining facilities. The most elusive quality criterion is the "odor" for which there is no analytical machine other than the human nose.

Small-scale Extractive Methodologies

Each of the three commercial distillation methods can be scaled down for smaller samples depending upon the amount of oil in the tissue. Industry most often uses amodified clevenger trap as described by the American Spice Trade Association (ASTA, 1968). This system is relatively inexpensive, requires only a moderate amount of plant tissue, and is easy to operate. This is probably the best system for growers and industry looking to quantify the essential oil content in aromatic plants. For very small amounts of sample tissue, Godefroot and others (1981) and Bicchi and others (1983) developed micro-scale extraction systems for research that required only 2 hours for complete analysis starting from 1 gram of tissue. Also, small amounts of samples can be extracted with an organic solvent and used straight for chromatographic analysis. Headspace analysis offers a potentially rapid method of extracting essential oils and requires very little plant material, but complete recovery occurs only for light volatile materials.

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