

# ESSENTIAL OIL EXTRACTIONS PRINCIPLES AND PRACTICE

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## INTRODUCTION

In this universe more than four hundred thousand species of plants exists of which approximately two hundred yield essential oils. Tiny glands present at the petals, leaves, stems, roots, bark and wood of plants and trees produce essential oils. They are produced in the inner most cell membrane of the parenchymatous tissue of leaves and petals of flowers or in the cytoplasm or separate cell centres when found in other plant parts.

### Typical examples detailing the distribution of essential oil in nature

<b>Plant Part</b>	<b>Plant Name</b>
Bark	Cinnamon, Cassia
Beans	Vanilla
Bulb	Garlic
Bud	Clove
Entire Plant	Oak moss, Tree moss
Aerial plant parts	Geranium, Lavender, Spike Lavender, Rosemary, Labdanum
Flowers	Jasmine, Orange Flowers, Rose, Tuberose, Clove (dried bud)
Flower Stigma	Saffron
Fruit	Coriander, Pepper
Fruit Peel	Lemon, Lime, Bitter Orange, Sweet Orange, Bergamot
Kernel	Nutmeg
Leaves	Cinnamon, Citronella, Clove, Lemongrass, Palmarosa, Patchouli, Mint, Basil
Rhizomes	Ginger, Turmeric
Roots	Vetiver
Stems	Benzoin, Styrax, Peru Balsam, Tulu Balsam
Seed	Cardamom
Wood	Sandalwood, Cedar wood



## ESSENTIAL OILS

Essential oils from plants releases slowly to the surroundings under normal natural conditions. Essential oil containing glands break when we heat it or crush it releasing the plant aroma. Essential literally means the presence of an essence or odour and oil because they leave an oily spot on paper. Natural essential oils are complex chemical compounds having a small molecular structure and are volatile by nature. The individual chemical substance present in this complex mixture determines the essential oil property and its fragrant odour quality. Essential oils are neither greasy nor fatty nor do they leave any oily residue on skin and are freely soluble in alcohol, vegetable oils, and water. It is easy to spot the difference between good quality oil and a bad one. When we keep a bottle of oil on the table and open the lid, it will give a whiff of its aroma. If one has to move closer to sniff it is poor quality oil.

Essential oils are terpenes or hydrocarbons in unsaturated straight chain molecules based on isoprene (C<sub>4</sub>H<sub>8</sub>) ring structure. Terpenes easily combine with other organic groups and act as a carrier of aromatic substances. Essential oils besides being rich in terpenes and oxygenated terpene derivatives, it may also contain alcohols, phenols, aldehydes, ketones, oxygenated and sulphouretted oils. Essential oils being natural antioxidants normally do not get rancid however; they generally react with water and oxygen. The composition of an essential oil alters on extraction from its original plant source even by the use of the most gentle of the processes. Some essential oils on processing become vastly different from what it was when in the living plant. Some plants in their natural living state are odourless, but become fragrant on drying or on enzymatic fermentation under suitable conditions.

Clove buds when green are odourless in its natural living state. The buds on sun drying become fragrant. The dried buds subsequently when distilled gives clove bud oil with a distinct spicy odour. Similarly, Iris pallidia rhizome when dug up fresh has a faint uninteresting vegetable kind of smell. The rhizome when peeled and dried at a moderate temperature develops a very interesting appreciable powdery violet like fragrant note. Oleoresins and oleo-gum-resins are resinous plant exudations containing essential oils, exuded naturally during the plant life cycle for e.g., Olibanum Frankincense, Opoponax, Myrrh, etc. However, Benzoin, Styrax, Tulu Balsam, and Peru Balsam yields are due to the pathological response to wounds inflicted on the tree trunks or on removal of the bark. The perfumery industry, earlier obtained all the important natural aromatic materials from the wild, but now most of them are cultivated.

All natural plant materials are prone to spoilage and deterioration due to bacterial, viral, or fungal infection in addition to destruction from insects and pets. It is important to use appropriate preventive measures to keep the plants in a healthy state, through out the period of cultivation, during and after harvesting. Similarly, other critical factor for high yields of good quality aromatic ingredients includes the correct time and condition for harvest. Subject the flowers gathered to extraction within an hour's time in order to minimise loss of essential oil through evaporation and spoilage due to fermentation.

Essential oils are liquid products of steam or water distillation of plant parts namely stems, bark, seeds, fruits, leaves, roots, and plant exudates. Expression is in use exclusively for the extraction of citrus oil from the fruit peel, because the chemical components of the oil damages easily by heat. Citrus oil production is now a major by-product process of the juice industry. An essential oil may contain up to several hundred chemical compounds and this complex mixture of compounds gives the oil its characteristic fragrance and flavour. An essential oil may also be fractioned and sold as individual natural components alongside essential oils. Extraction with organic solvents of plant parts produces oleoresins, concretes, and absolutes. Extraction with a near or supercritical solvent such as carbon dioxide produces very high quality extracts. These oleoresins and extracts contain not only the volatile essential oil but also the concentrated non-volatile flavour components having wide application in the food industry.





## PRE-TREATMENT BEFORE PROCESSING

Essential oils formed in plants are stored in oil cells and glands. The process selected to extract the essential oil present should be such that it is able to release the same in the most natural form as practically possible. In case of flowers, generally no pre-treatment is necessary. However in case of hardy, woody, tissues, the essential oil glands are buried deep inside them and so they have to be broken up by powdering the material or allowed to soften by soaking them in water. This process known as “comminution” ensures easy release of the oil during processing. For example, in the case of Aniba rosaeodora chip the wood first then, soften it by soaking it in water. Distill the wood then to get “Bois de Rose Oil” also called Brazil “Rosewood Oil”. Similarly Cedar wood and Sandalwood is chipped or powdered and then distilled to get the respective essential oils.

Distill herbaceous materials like Lavender, Thyme, Rosemary, etc., directly as harvested. Coarsely crush caraway and coriander just before the distillation process to avoid losing the top note of the essential oil produced. Clove, Turmeric and Orris require drying. “*Gaultheria procumbens*” leaves do not contain any essential oil in the living state. However when the leaves are placed in warm water it undergoes fermentation due to enzymatic action producing “Oil of wintergreen”. Patchouli leaves have to undergo light fermentation and so the leaves are kept in light to weaken the plant cells to facilitate the easy release of essential oil.

## PRIMARY PRODUCTS

In the last chapter, we studied the various plants producing essential oil we are interested for our study. We can broadly classify the primary products harvested for essential oil production into six categories: seeds and fruits, leaves and stems, flowers and buds, roots and rhizomes, and bark, wood and resins. Essential oils are valued for their distinctive flavours, colours, and aromas but they can have heavy contamination of microorganisms because of the environmental and processing conditions under which we produce them. The microbial load has to should be either substantially low or almost nil, before incorporating it safely into any products. High temperature treatment can cause significant loss of flavour and aroma from a spice because the volatile oils are lost. Steam also results in a loss of volatile flavour and aroma components and colour changes. Steam can also result in an increase in moisture levels.

Destroying contaminating microorganisms with irradiation has since emerged as a viable alternative resulting in cleaner, better quality herbs, and spices compared to those fumigated with ethylene oxide. Irradiation, is a cold dry process, and is ideal to kill the microorganisms. Irradiation of herbs and spices is now widely practised on a commercial scale. The use of irradiation alone as a preservation technique will not solve all the problems of post-harvest food losses, but it can play an important role in reducing the dependence on chemical pesticides. The main purpose of the irradiation is to decontaminate the spices, herbs, and vegetable seasonings of microorganisms and/or insect pests. It is important to note that irradiation is not preferable for the preservation of these ingredients and the process of preservation is only through proper drying, packaging, and storage.

Please note that irradiation will not correct quality deficiencies. The code details pre-irradiation treatment, packaging requirements, the irradiation treatments, and the dose requirement for radiation disinfection together with threshold doses that cause organoleptic changes.



## **PRE-HARVEST OPERATIONS**

Pre-harvest operations involve the preparation of the facilities for the harvest material, which will ensure the crop is stored and dried quickly under hygienic conditions. The main reasons for low quality product are harvesting the crop when it is not mature; poor drying systems where there is a high risk of moisture retention and microbial contamination (dirt floors), and frequent rain during the drying process, which upsets the drying process. There is need to have buildings or structures at the harvesting area or to have a common facility for drying and curing products. Many growers of spices use traditional methods and high moisture retention, microbial contamination, and contamination with extraneous matter are common processing problems. International sanitary and phytosanitary agreements define measures we have to take to protect against risks arising from additives, contaminants, toxins, or disease causing organisms in food or foodstuffs. In particular, there are problems with mould, high moisture contents, and aflatoxin contents. Difficulties in reducing these problems to a low level are due to poor weather conditions at harvest associated with low cost processing technology, poor storage facilities, and small-scale production units. Poor storage facilities and unhygienic and improper storage methods also contribute to contamination with mammalian and other excreta, as well as moulds or other microbes. Use of mechanized, handling after harvest can overcome these problems completely.

All personnel (including field workers) involved in the propagation, cultivation, harvest and post-harvest processing stages of plant production should maintain appropriate personal hygiene and should have received training regarding their hygiene responsibilities. Only properly trained personnel, wearing appropriate protective clothing (such as overalls, gloves, helmet, goggles, facemask), should apply agrochemicals.

## **HARVESTING**

Harvesting is the primary process of collecting the target crop product from the field, where it is open to the vagaries of the climate and the growing environment, and placing that product in controlled processing and stable storage conditions environment. The harvesting requirements will differ for the final product sought, and there are specific needs such as maturity and evenness, that will dictate the harvesting management and timing.

Normally harvesting of plants should be during the optimal season or time to ensure the production of plant materials and finished spice products of the best possible quality. The time of harvest depends on the plant part we have to harvest and use. However, we all know that the concentration of biologically target active constituents varies with the stage of plant growth and development. The best time for harvest should be determined according to the quality and quantity of biological target constituents.

During harvest, take care to ensure that no foreign matter mixes with the harvested plant materials. Whenever possible, harvest plant parts under the best possible conditions, avoiding dew, rain, or exceptionally high humidity. If harvesting occurs in wet conditions, transport the harvested material immediately to a drying shed and drying started to expedite drying so as in order to prevent any possible deleterious effects due to increased moisture levels, which promote microbial fermentation and mould. Cutting devices, harvesters, and other machines should be clean and adjusted to reduce contamination from soil and other materials. They should be stored in an uncontaminated dry place, free from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals.



Soil can have a high microbial content, and contact between the harvested crop and the soil should be avoided to minimize the microbial load on the harvested plant materials. Where ever, necessary, place large drop cloths, preferably made of clean muslin, on the soil surface before the plants as an interface between the harvested plants and the soil. Whenever, we harvest the underground parts (such as the rhizomes roots), remove any adhering soil from the plant material as soon as possible. Mechanical damage or compacting of the raw plant materials because of overfilling or stacking of bags may result in fermentation composting or rot other damage. Avoid this taking the fullest care possible. Discard all rotting plant materials during harvest, post-harvest inspections, and processing, in order to avoid contamination and loss of product quality.

## **HARVESTING SEEDS AND FRUITS**

### **Maturity**

The selection of seed or fruit to harvest which is at the correct maturity or ripeness, based on colour, is critical to obtaining a product of even high quality. Find three examples below for but remember to adopt maturity standards specifically and locally for each spice.

### **Maturity for end use and pre-drying treatment**

The time of harvest maturity is often dependent on the end usage for the spice. Collect the harvest always into clean sacks. Post-harvest handling is crucial to obtain a high quality product. For example in case of pepper berries blanching, with warm water for one minute is required which cleans the fruit and removes other contaminants giving a shining black colour, by activating the responsible fruit enzymes. Blanching also allows the fruit to dry at a faster rate. The washed and blanched fruits can then be graded and air-dried to remove the surface moisture and then placed in a drying yard or in a drier.

### **Cultivar difference**

The correct harvest maturity is often dependent on the choice of cultivars (e.g., cardamom) and local experience is necessary to judge the correct harvest time. After harvest, washing thoroughly in water to remove adhering soil is necessary before final drying.

### **Continuous harvesting**

In the tropics, a crop can produce and ripen continuously. **Nutmeg & Mace** trees bear fruit all year. The fleshy drupe turns yellow when ripe. The pulpy outer husk (pericarp) splits into two halves exposing a purplish-brown seed surrounded by a red aril. Allow the fruits to split and fall to the ground before harvesting, and collect it as soon as possible to prevent discolouration and the risk of mould or insect damage. We can also use a long pole to take partially opened pods directly from the tree as this ensures a better quality aril. However, take care to pick the right pods as this can result in damage to flowers and younger fruit. The frequency of harvesting the nutmegs are dependent on the availability of labour, level of production and the market price, but a daily harvest to every 2-3 days in off-peak times is typical.

### **Chemical manipulation of ripeness**

Colour stage, that is the ripeness, also dictates the harvesting maturity. Experience is necessary to judge the correct harvest time. After harvest, washing thoroughly in water to remove adhering soil is necessary before final drying.

## HARVESTING LEAVES, GRASS, AND STEMS

We are aware of the usage of aromatic herbs to extract essential oils. The aroma, which is a function of their essential oil composition, is dependent on chemotype and so we can choose specific chemotypes depending on its end-use. The essential oil composition and yield will also change during the seasons, and we should direct crop harvest accordingly to maximise both the essential oil content and its quality parameters. Generally, cutting of the plant leaves and stems should take place when the growth has matured to an elongated flower stem but without full flower or significant aging of the lower leaves. It is also important that distillation of the essential oil is either from fresh or dry plant material. Avoid harvesting the plant material when the environment is wet and rainy. If dry plant material is the requirement, then spread the plant material to dry evenly onto the drying racks or drier to ensure there is no sweating, fermentation, and microbial invasion.

## HARVESTING FLOWERS AND BUDS

When flowers and buds are the source of essential oil, the harvest time can be throughout, the year as in the tropics or during a limited flowering season as in temperate regions. Gather the flowers, a source of essential oil, during dry weather or principally after the rainy season. When the flowers are drier, they contain more oil and the oil is of higher quality. Harvest flowers during early part of the day. Pick only fully developed flowers, as otherwise we will only produce poor quality oil. In order to avoid fermentation, do hold the flowers in a mass pack or bundle and undertake the distillation as soon as possible without unnecessary loss of time interval.

## HARVESTING ROOTS AND RHIZOMES

The length of time or maturity requirement to harvest roots and rhizomes is dependent on cultivars. Hand digging is the most common form of harvesting the rhizomes although we can also use diggers and lifters. The leaves must be cut prior to mechanical lifting or after hand digging. Care is necessary to avoid damage to the rhizome (splitting or bruising) as injuries can result in fungal infection and rejection. Rhizomes are lifted whole, washed, sun dried. We can keep the rhizome fingers as seed material for the next crop by separating it from the mother rhizome.

## HARVESTING BARK, WOOD, AND RESINS

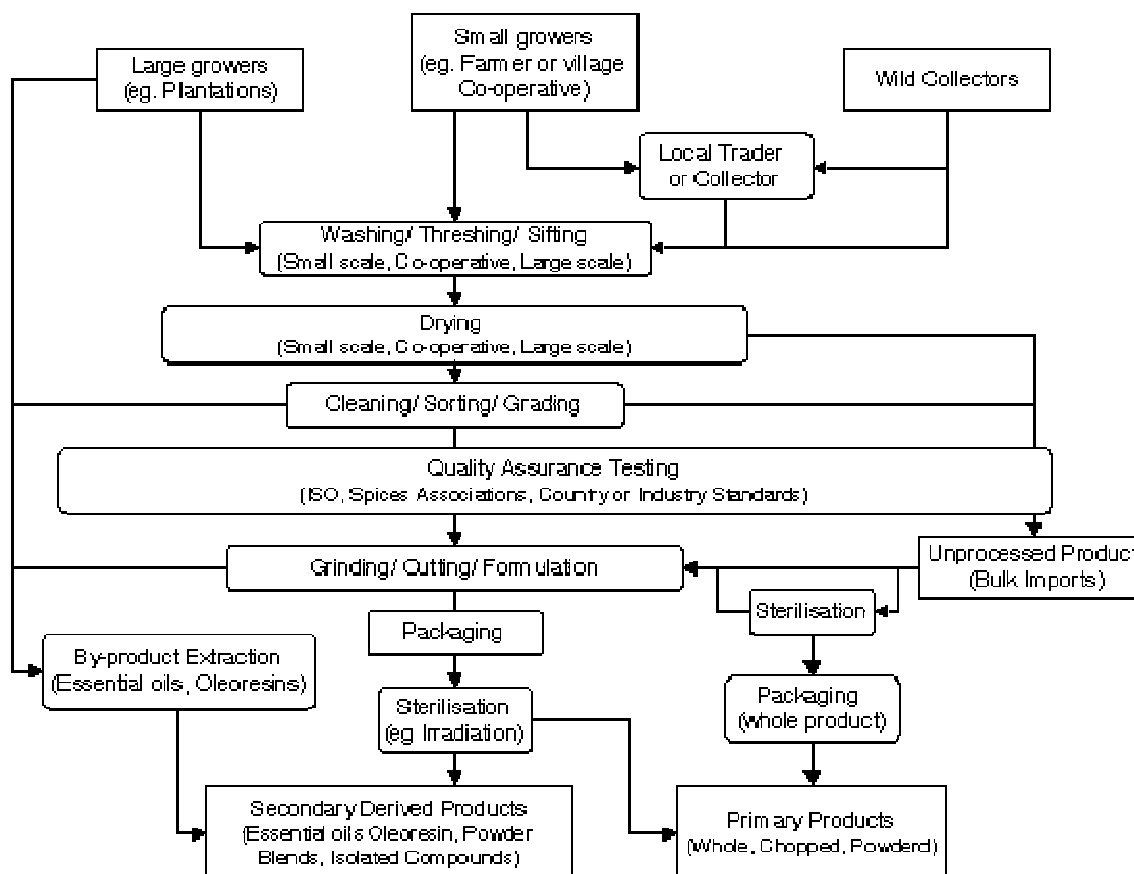
Many plants, which we harvest for wood or bark products, are managed under coppice plantation systems. **Cinnamon** production is an example of such a practice. Normally we undertake harvesting of the shoots during the rainy season two years after coppicing. The selected shoots must have a uniform brown colour of bark and have at least two years of growth. Scrap off the rough outer bark of the selected shoots and peel off the young tender inner bark carefully from the stem. The inner bark curls naturally into the well-known quills. Pack the best pieces of the peeled bark and roll it tightly to preserve the flavour. Allow it to dry. Leave the coppiced shoots for fermentation for about 24 hours, and dry it in the shade for one day and then in the hot sun for four days. Insert the smaller quills into the larger ones to form compound quills. Grade the products as quills, quillings, featherings, scraped chips, and powders. The finest quality bark is



obtained from shoots (<1.25 m by 1.25 cm diameter) with uniform brown thin bark harvested at six-month intervals.

## POST-PRODUCTION OPERATIONS

Spice and herb production can be sub-divided into a number of activities, and although there is a route to market through by-product extraction, most spices and herbs have a series, of post-harvest operations, which follows a logical sequence. The post-harvest processing tree shows each stage in the process (See figure below)



**Figure 1: Post harvest processing and products produced from spices and herbs**

## TRANSPORT

Transport the harvested raw plant material of the spice crop promptly and in a clean dry condition. Place the crop in clean baskets, dry sacks, trailers, hoppers or other well-aerated containers and carry it to a central point for transportation to the final processing facility. All containers used at harvest should be kept clean and free from contamination by previously harvested plant products and other foreign matter. If plastic containers are used, pay special attention to any possible retention of moisture that could lead to the growth of mould. When containers are not in use, keep them dry and in an area, protected from insects, rodents, birds and other pests, and inaccessible to livestock and domestic animals. Keep conveyances used for transporting bulk plant materials from the place of production to storage for processing clean. Take care to clean it between loads. Clean bulk transport, such as ship or rail cars,



whenever appropriate. Keep it ventilated to prevent condensation of moisture from plant materials that can turn detrimental to the product.

## **THRESHING**

Threshing is the process of removing and separating the fruit or seed from the unwanted flower stems or plant stalks as well as removing damaged or immature material. This process can be undertaken by hand, assisted by sieves and screens, by use of winnowing or by mechanical shakers and sorters.

## **DRYING AND DRYING SYSTEMS**

This is the most critical process in the production of dried herbs and spices. The aim of drying is to reduce the moisture content of the product when actively growing in the field to a level that prevents deterioration of the product and allowing its storage in a stable condition. Drying is a two-stage process. Firstly, transferring external heat to the moist product to vaporize the surface water in the product and secondly mass transferring of the moisture from the interior of the plant product to its surface from where it can easily evaporate. The most important and immediate management concern is to ensure the harvested crop will not rot or become grossly invaded with yeasts, bacteria and mould (producing aflatoxins) or become contaminated by pests.

Drying is the start of the preservation process, which is a requirement for most spice crops, to enable long-term crop storage. A dry crop also gives us an opportunity for further processing. The drying phase of post-harvest management can include the following preliminary stages.

1. The selection of high quality produce from the field;
2. Cleaning the crop by washing and disinfection;
3. Preparing the crop for drying by peeling or slicing;
4. Pre-treating the crop with anti-oxidants, blanching it or sulfurizing it;
5. In some cases, washing prior to processing is desirable to remove field contaminants (dust, soil) using anti-microbial solutions to reduce the microbial populations to a low level prior to the drying process.

There are four main types of drying. The most basic method of drying is to spread the crop on a surface exposing it to the sun. In this case, we can aid the process by utilising a cover system that prevents wetting with rainfall. An improved method, to speed up the drying process, is to use a fuel source (wood, oil/diesel, gas, or electricity) to heat the drying room. Solar drying systems together with solar powered fans are also available. The drying process should dry the crop as quickly as possible, at temperature levels, which do not drive off the volatile flavour and aromatic compounds. The drying temperature regime will be specific to each crop as will be the final moisture percentage for storage.

The traditional open sun drying that is widely used in developing countries has major inherent limitations when trying to preserve product quality. High crop loss and low product quality result from inadequate drying, long drying times, fungal spoilage, insect infestations, bird and rodent damage and contamination plus the effects of sunlight and the weather. Even in the most favourable climate, it is often not possible to





get the moisture content of the product low enough for safe storage. In the tropics, the high relative humidity of the air prevents drying of harvested crop products during the wet season.

The objective of a dryer is to supply the product with more heat than is available under ambient conditions. A relatively small amount of heating can greatly enhance the moisture carrying capability of the air. For example, When we heat air from a temperature of 20°C at 59% relative humidity (RH) to a temperature of 35°C at 25% RH the moisture holding capability increases by three times. The major requirement of a dryer is to transfer heat to the moist product by convection and conduction. The absorption of the heat by the product supplies the energy necessary for the vaporization of water from the product. The process that occurs at the surface of the product is simply, evaporation of the moisture. The moisture replenishment to the surface is by diffusion from the interior plant part and this process depends on the nature of the product. Spices and essential oil crops derived from leaves or flowers are relatively thin and therefore relatively easy to dry due to their small diffusion thickness. Conversely, in thick and fleshy materials such as roots, the drying process requires a more careful control of temperature, temperature rise rate, and airflow rate. If the temperature is too high or elevated too quickly or if the airflow rate is too high 'case hardening' may result especially when drying thick fleshy products that is only the outer surface or case will dry. This dry layer becomes impervious to subsequent moisture transfer for the inner part of the product during subsequent storage leading to spoilage.

In many rural locations, grid electricity and supply of other non-renewable sources of energy are too expensive, unavailable, or unreliable and drying systems that use mechanical fans and electric heating systems are inappropriate. The high capital and running costs of fossil fuel powered dryers presents an economic barrier to use by small-scale farmers. Solar energy drying systems are a good forward technology for small rural farmers and enterprises in developing countries like India but are capital intensive currently.

## SOLAR DRYING SYSTEM

We can classify solar dryers into two generic groups, passive or natural air circulation solar dryers, and active or forced convection solar-energy dryers (see figure below). Forced convective dryers employ motorised fans for circulation of the drying air. The electricity for the fan can come from a solar photoelectric panel and battery. We can again subdivide each group further into three subgroups:

- I) **Integral types:** In direct solar dryers, we place the crop in a drying chamber with transparent walls, and the solar radiation falls directly on the crop, coupled with convection airflow from the heated surrounding air. The integral type dryers are simple in both construction and operation and require little maintenance. However, they are likely to operate at lower efficiency due to their simplicity and there is less control of the drying operation.
- II) **Distributed type:** In these types of dryers, there is indirect heating, where solar radiation heats a solar collector external to the drying chamber. The distributed type are much more elaborate structures so require greater investment in materials and running costs, but have higher efficiency and as a result product quality is generally higher.
- III) **Mixed type:** Where there is both direct and indirect heating.

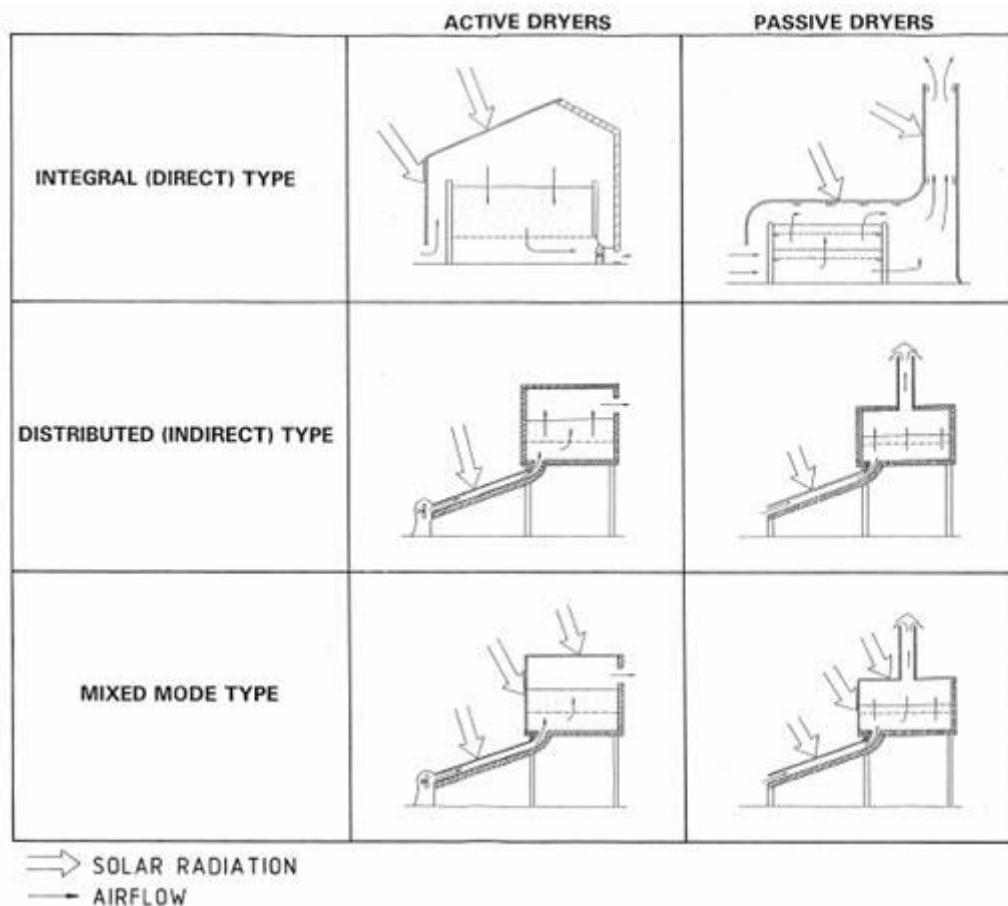
The solar dryer has two significant disadvantages:

- I) It has limited ability to process crops when the weather is poor; and



II) Drying can only occur during the daytime.

This not only limits production and extends the drying time but also may have an adverse effect on production and product quality particularly fleshy crop products such as roots, tubers, and stems that typically have drying times of several days. This has led to the development of hybrid systems with auxiliary heating systems.



**Figure 2: Typical Solar Dryer Designs**

### HYBRID SYSTEMS WITH AUXILIARY HEATING SYSTEMS

Hybrid systems with auxiliary heating systems such as burners use biomass, biogas, or fossil fuels. Alternatively, to achieve more efficient energy use, some active solar dryers are also designed with thermal storage devices (mainly rocks or gravel) to extend the drying time during the nights and in periods of low sunshine. We can also incorporate desiccants (such as clay and rice husk) in the design to reduce the relative humidity of the drying air to improve the moisture carrying capacity. The use of desiccants is only possible in forced convection systems as they increase the resistance to airflow.

### DRYING SEEDS AND FRUITS

Dry Nutmeg & Mace fruits in their shells in the sun. Turn them around each day to prevent fermentation. When the nuts are sufficiently dry they rattle. Drying takes about one week. When drying in the sun turn over the spice periodically to aid uniform drying and discourage mould infestation. The main disadvantage





of sun drying is the lack of uniformity and potential contamination by microorganisms. Moreover in areas where there is rainfall all year round or a high humidity levels, the quality of the fruit produced is dependent on drying.

Drying also, helps retain colour of the spice, as it is an indication for highest quality. Dry nuts can be stored for a considerable time. Flatten the separated mace by hand and dry it on mats in the sun. This takes between 2-4 hours. Cured mace with dark storage for 4 months produces a brittle pale yellow mace commanding a premium price.

Correctly, dried spice should have a pleasant characteristic odour and low microbial counts. We can meet these objectives easily by artificial drying, under controlled conditions. Artificial dryers are sometimes used. Artificial driers (wood fired) are more common in areas where berries ripen in the wet season. Mechanical and solid fuel driers have only had limited success at farm level because the cost of drying using fossil fuels is relatively high. Solar driers are more efficient but require a higher standard of post-harvest management although we can keep microbial contamination to low levels with good drying and storage management. Keep the dry berries cleaned and bagged, in a clean dry store.

### **DRYING LEAVES AND STEMS**

Drying is the transformation of the harvested leaf and stem, containing 80-90% water, to a stable state containing 5-10% water. It is important to minimise the holding time between harvest and drying, and these activities should be co-ordinated to prevent delays in drying and the chance of spoilage. The temperature during drying is critical. If the drying temperatures are too hot, the volatile components in the essential oils will reduce and will be lost. In general, terms drying temperatures should be below 40°C with forced air movement.

### **DRYING FLOWERS AND BUDS**

Generally, extract essential oils from fresh plants. However, in certain cases say, like Saffron stigma dry it on the same day as picked from the field, following separation from the floral parts. The stigma is about 85% moisture at field picking and to enable long-term storage of the filaments, a dry matter level close to 1% – 2% is required after the drying. Drying temperatures above 30°C but below 70°C will provide good quality saffron, and irrespective of the drying method, it is important not to over-dry to a brittle stigma. The duration of drying is dependent on the drying temperature used and the higher the temperature used, the shorter is the drying time. Unlike flowers buds e.g. cloves, are spread onto matting and dried in the sun. Occasional gentle raking will aid even drying and it is important to overcome heating and mould formation. Remove damaged and spoiled flowers and buds during this phase. In case of buds, complete drying takes place in 4 – 6 days with buds losing about two-thirds of their weight.

### **DRYING ROOTS AND RHIZOMES**

Cure turmeric rhizomes after harvest for both colour and aroma. The traditional method of curing rhizomes is to steam or boil fresh rhizomes in lime or a 0.1% sodium bicarbonate solution. The 'curing' is to remove the raw odour, reduce the drying time, gelatinise the starch and produce a more uniformly coloured final

product. Spread the cooked rhizomes in the sun to dry and this process takes 10 – 15 days. The final moisture level should be close to 6% moisture content.

Today the majority of internationally traded turmeric rhizomes available are by the use of artificial drying systems with hot-air drums, tray, and continuous tunnel driers and in India, a maximum temperature of 60°C is in use. An important factor in drying time is the preparation of the rhizome. Rhizomes to be dried can be sliced or whole, with slicing generally producing a uniform and brightly coloured powder. The yield of the dried product varies from 10-30% depending on the variety and the crop-growing environment.

Ginger curing of the rhizome prior to drying directly affects the fibre and volatile oil content. Removal of the skin reduces the fibre content and increases the oil loss. Peeling also affects the pungency as these compounds (gingerols) are in the skin. When sun drying is not an option we can use wood-fired, solar driers, or gas-heated dehydrators. The final dry matter should be in the 7% – 12% range with a weight loss during drying of 60% – 70%. Artificial drying minimises the loss of quality eliminating microbial contamination. Drying temperature, airflow and the length of drying all affect the flavour compounds in ginger.

Subsequent to the field harvest, a garlic bulb is broken into individual cloves and the loose paper shell removed by screening and airflow. Wash and slice the cloves. Dry the sliced garlic cloves to about 10% moisture, with a drying temperature below 60°C. In the final drying procedures, take care to ensure there is no heat damage to the slices and the garlic has only 6.5% moisture.

Dehydrate onions in the form of flakes, rings, kibbles, and powder. We can achieve small-scale onion drying by solar drying, although cabinet drying at 55°C – 60°C for 10 – 15 hours gives a better product than sun drying or drying in solar huts. We can also achieve commercial dehydration by forced hot air with an initial temperature of 75°C reducing to 55°C – 60°C as the moisture content falls. Final storage moisture content close to 4% is ideal.

## **CLEANING**

Cleaning the spice prior to packaging ensures that the spice is of the highest quality and will obtain the highest price. Cleaning should remove all the foreign matter that lowers the quality and endangers the sale. Make use of sieves, grading tables, flotation tanks, and screens to ensure that we obtain a spice of even line and meet the high quality standards.

## **PACKAGING**

Pack all processed plant materials as quickly as possible to prevent deterioration of the product and as a protection against exposure to pest attacks and other sources of contamination. Implement continuous in-process quality control measures to eliminate substandard materials, contaminants, and foreign matter prior to and during the final stages of packaging. Pack processed plant materials in clean, dry boxes, sacks, bags or other containers in accordance with standard operating procedures and national and/or regional regulations of the producer and the end-user countries. Materials used for packaging should be non-polluting, clean, dry and in undamaged condition and should conform to the quality requirements for the plant materials concerned. Pack fragile plant materials in rigid containers. Whenever possible, the use packaging as agreed upon between supplier and buyer. Reusable packaging material such as jute sacks and





mesh bags should be clean (disinfected) and thoroughly dried prior to reuse, to avoid contamination by previous contents. All packaging materials should be stored in a clean and dry place that is free from pests and inaccessible to livestock, domestic animals, and other sources of contamination. In case of leaves and stems, it is essential that all material is dry to below 10% and the dried herbs should be stored in cool, dark, and dry areas of low humidity and polyethylene bags or packs used. Saffron stigma, when dried and graded, should be stored in airtight containers, in a cool dry place out of the light.

Store roots and rhizomes, in polyethylene bags with 2% ventilation to prevent dehydration and mould development. Pack rhizome for bulk shipping in jute sacks, wooden boxes or in lined corrugated cardboard boxes. Processed, roots and rhizomes should be packaged in laminated bags that have low oxygen permeability and low internal to external diffusion, and keeping the product stored cool dry and out of light.

A label affixed to the packaging should clearly detail the product name of the spice, the plant name, the place of production, the harvest date, and the names of the grower and the processor, and quantitative information. The label should also contain information indicating quality approval and comply with other national and/or regional labelling requirements. The label should bear a number that clearly identifies the production batch. We can add additional information about the production and quality of the plant materials in a separate certificate, and clearly linking it to the package carrying the same batch number. Batch packaging records should include the product name, place of origin, batch number, weight, assignment number, date, etc., and maintaining it is important. The records should be retained for a period of three years or as required by national and/or regional authorities.

## **STORAGE**

There is a need for quality storage both on-farm and off-farm, with cool stores and warehousing facilities linked to post-harvest crop management. Essential oil containing plants, flowers, leaves and spices deteriorate rapidly in adverse conditions and should be stored in well-prepared and maintained storage facilities. It is essential to maintain the moisture level of plant product to be stored is at a safe level prior to storage. This is usually below 10% moisture. The storehouses should be damp-proof, vermin-proof and bird-proof and where possible have controlled ventilation and devices to control humidity and temperature. A dehumidifier fitted to a storage room, by keeping the atmosphere always dry, can eliminate mould and insect attacks. Fumigate the room before storage, white wash the walls regularly and keep the facility kept dry. Carry out fumigation against pest infestation only when necessary, and should be carried out by licensed or trained personnel. Use only registered chemicals agents authorized by the regulatory authorities. Document all fumigation records, fumigation chemicals agents, and the dates of application. When using freezing or saturated steam for pest control, check the humidity of the materials checked after treatment.

## **EXTRACTION METHODS**

A number of different methods can achieve the extraction of essential oils from plant material.

- Pressing / Cold expression.
- Tapping



- By effleurage (Absorption of the fragrant oil in a greasy oil and then separated by solvent extraction)
- Hydro / Water distillation
- Water and steam distillation
- Steam distillation
- Hydro diffusion, that is by the application of gentle pressure during distillation.
- Solvent extraction
- Alcohol extraction
- Carbon dioxide extraction
- Molecular distillation

For each method, there may be many variations and refinements as we can conduct the extraction under reduced pressure (vacuum), ambient pressure, or excess pressure. The choice of extraction method will depend on the nature of the material, the stability of the chemical components and the specification of the targeted product. Once processed the essential oils are stored closed tight in dark glass bottles / containers in a cool place away from direct heat and light. For each of the procedure mentioned above you can affect variations and improvements as required. The final extraction procedure also depends on the nature of the plant material we require to process, and the suitability of the method to extract the essential oil in its true natural stable form and specification. Last but not the least the incurred cost of the extraction procedure also plays an important role in the selection process.

### **PRESSING / COLD EXPRESSION**

Cold expression as a method solely useful to extract essential oils from citrus fruit peels. The essential oil glands are present close to the surface of the fruit peel that easily ruptures by applying lateral pressure. Please note that essential oil present in citrus fruits damages easily by water and heat. Citrus oil production by cold expression is no longer economically viable to individual cultivators. It is now a major by product of the fruit juice industry.

### **EFFLEURAGE**

Effleurage is a process where essential oils naturally released by fragrant flowers are absorbed by highly purified odour less fat spread on a flat glass surface / sheet. Normally a series of glass plates are stacked one over another like a rack. The entire chassis is enclosed from the surrounding environment to prevent loss of fragrant matter to the atmosphere. Essential oil present in the flowers gets absorbed onto the fat within a certain time dependent on the flower blossoms used for processing. The flowers after the correct time are replaced with fresh blossoms and this process is repeated until the fat is saturated with the fragrance. The saturated fragrant fat is the effleurage pomade. The pomade when washed with alcohol to separate the fragrance ingredient from the fat base gives us flower absolute.

The flowers removed after the effleurage still carry small amounts of adherent pomade. Extract the flowers separately with alcohol to produce an absolute. However, this absolute is inferior in quality to that obtained from the pomade. One important point to note in the effleurage process is that the flowers after

initial extraction replacing the flowers at the correct time is important otherwise off odours are likely to get absorbed in the fat medium as the flowers wilt or get dry making the pomade of a poor quality.

Effleurage is a manual process requiring large number of meticulous skilled work force during the flowering season. The process being manual is commercially unviable and has now become obsolete. However, the fragrance absolute obtained by this process is of an appreciable high quality. As the flower emanates fragrant matter for a longer period in the effleurage process, the yield of absolute in per kilogram of flowers is much higher than that obtained by the solvent extraction process.

## **FACTORS DETERMINING THE CHOICE OF THE EXTRACTION METHOD TO USE**

### **I) Location of the essential oil glands and the hardness of the tissues**

Citrus fruits like lime, lemon, and orange have their essential oil bearing cells on the outer part of the rind that is fairly soft and easy to compress. For this reason, we obtain citrus oils generally by cold expression. Please note that if the essential oil bearing cells were not easily assessable or if the tissues are tough than this method is not suitable.

### **II) Compatibility of the essential oil with hot water and steam**

We can also obtain citrus oils by subjecting the fruits to hot water or steam distillation. However, they have a tendency to react with hot steam that destroy or alters the natural ingredient composition and odour profile adversely. Similarly, presence of hot water and steam destroys flower oil present in Jasmine flowers and so water and steam distillation is not advisable for use. Rose petals also undergo change in its ingredient composition due to hot water and steam, but the resultant essential oil obtained by distillation has a very appreciable odour quality. This single feature has made steam distillation the preferred choice, as a simple inexpensive technique for rose oil extraction from rose petals.

Likewise Ylang – Ylang and orange blossoms are also suitable for steam distillation. Most flowers are normally solvent extracted, as it is gentler process than water or steam distillation. Oils are extracted by the solvent extraction process is not very much different or altered from its natural state compared to water or steam distillation thus making the solvent extraction process the most preferred one for extracting essential oils from natural flowers.

### **III) Product Volatility**

When essential oils present in the aromatic material is not sufficiently volatile and does not yield odorous ingredients to distillation, then solvent extraction is the preferred choice. Typical examples include Vanilla beans, oak moss, benzoin, etc.

### **IV) Product Suitability**

Jasmine and tuberose produce and extrude fragrance for some time even after their picking from the plant. This makes them suitable for effleurage a process treatment where essential oil produced is absorbed or adsorbed onto a suitable medium like odourless oil, grease, or fat.

### **V) Quality and quantity of yield obtained by the selected process**

The specification required and the yield obtained in addition to the cost incurred to get the desired quality determines the choice of the selected process.



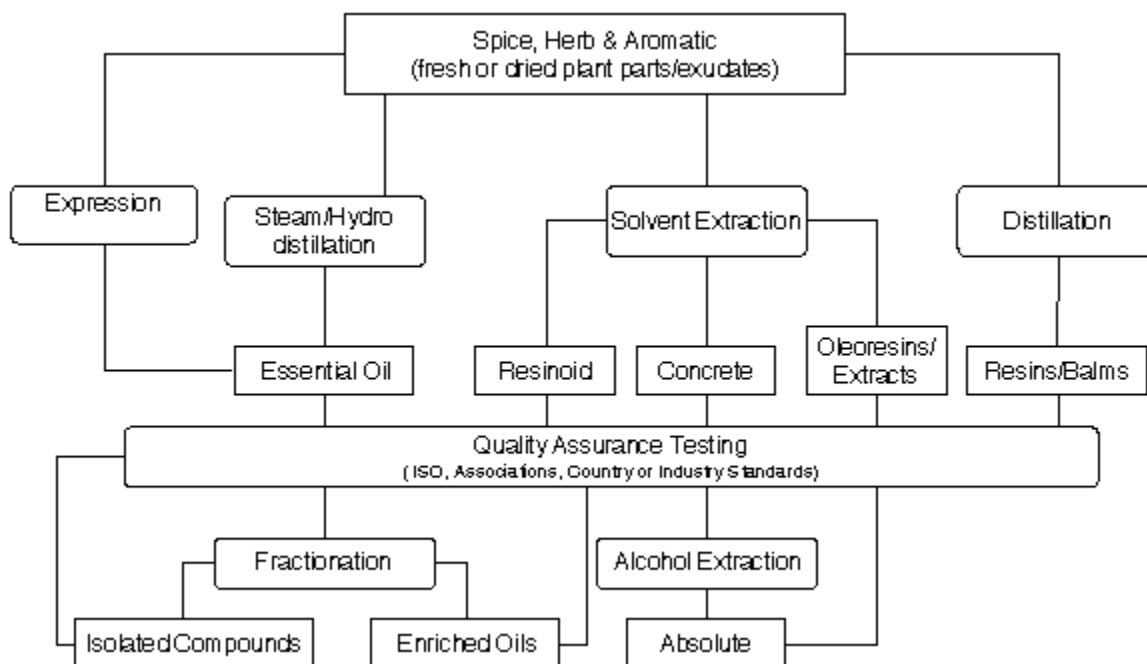


Figure 3: Extraction processes used and products from spice, herb, and aromatic plants.

## DISTILLATION

Distillation is still the most economical method of extracting essential oil from spices and aromatic plant materials. The main advantage of distillation is that we can generally carry it out with some very simple equipment, and close to the location of plant production. Even in relatively remote locations, we can process large quantities of material in a relatively shorter time. Distillation is less labour intensive and has a lower labour skill requirement than solvent extraction. However, blindly adopting the simplest or cheapest extraction methods may prove to be false economy because of low yield, poor or highly variable oil quality, and low market value.

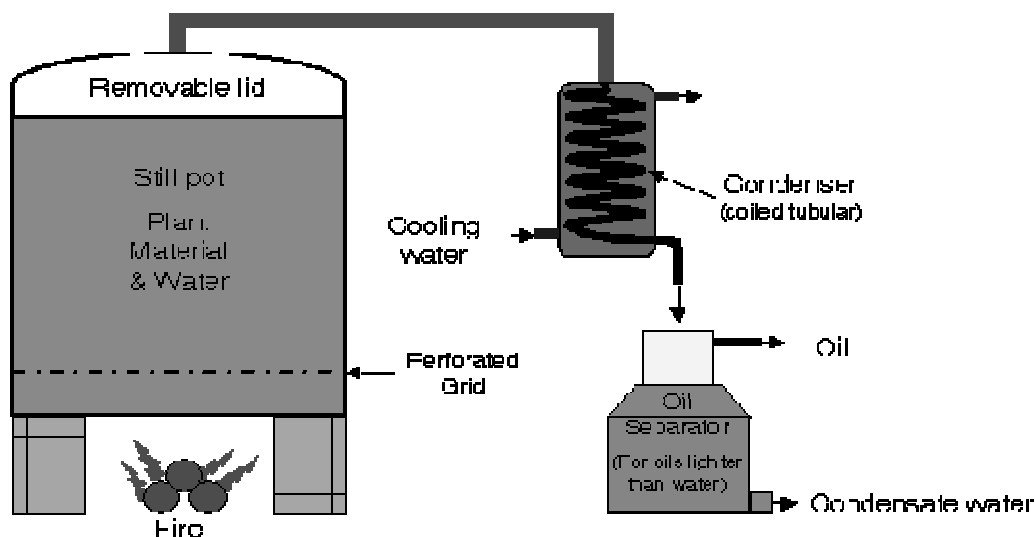
## WATER DISTILLATION

Water distillation is the simplest of the three distillation methods. Mix the plant material directly with water in a still pot. Insert a perforated grid above the base of the still pot to prevent the plant material settling on the bottom, or coming in direct contact with the heated base of the still, and charring (see figure below).

Water distillation is probably the simplest and cheapest method of extracting essential oils, but at the same time, this method has the potential to modify the quality of the oil greatly due to the effects of direct heating and the water contact. Moreover, the water content in the still must always be sufficiently more, otherwise the plant material can over-heat and char. The plant material must be kept agitated as the water boils otherwise it may settle in the bottom of the still and become damaged by the heating. Chopping or grinding the material into fine particles may help to keep the material dispersed in the water. It is very easy for still 'off-notes' to be generated, since some components of the oil are more susceptible to chemical change and oxygenated components tend to dissolve in the still water.







**Figure 4: Diagrammatic representation of water distillation unit where the plant material is suspended in the water.**

Some plant materials like cinnamon bark contain high levels of mucilage and as these leaches out, the viscosity of the water increases, and there is a high risk of charring. The stills tend to be small and therefore it takes a long time to accumulate sufficient oil and each batch may be highly variable containing better quality oil mixed with poor quality.

Water distillation is a slower extraction process than the other distillation types. It is also therefore less energy efficient. The only advantage of water distillation is that, the cost of the equipment tends to be extremely low and the designs of the stills, condensers, and oil separator are simple. Moreover, operating and maintaining in very remote locations is easy.

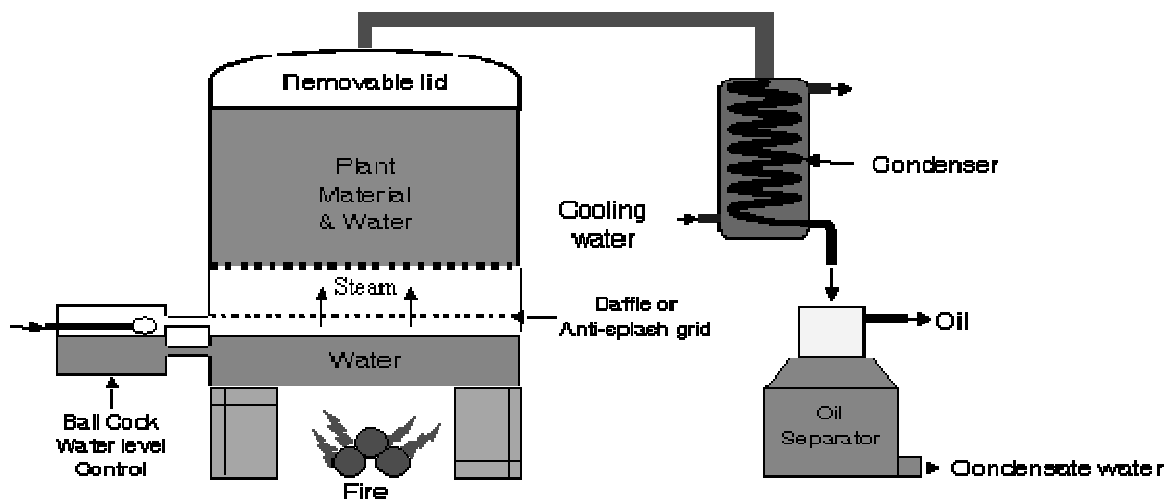
The water-distilled oils are commonly darker in colour having stronger still ‘off-note’ odours than oils produced by the other distillation methods, and thereby making it to be of the lowest value. The disadvantage of the water distillation method thus generally outweighs the advantages except for local market use.

### STEAM AND WATER DISTILLATION

In steam-and-water distillation, the basic still design is very similar to that of water distillation. Pack the plant material into the still pot sitting on a grid / grill or perforated plate above the boiling water.

The additional grid/ grill is the only difference in the still structure and although this reduces the capacity of the still pot volume it may be possible to achieve a high packing density because the plant material is not suspended in the water.



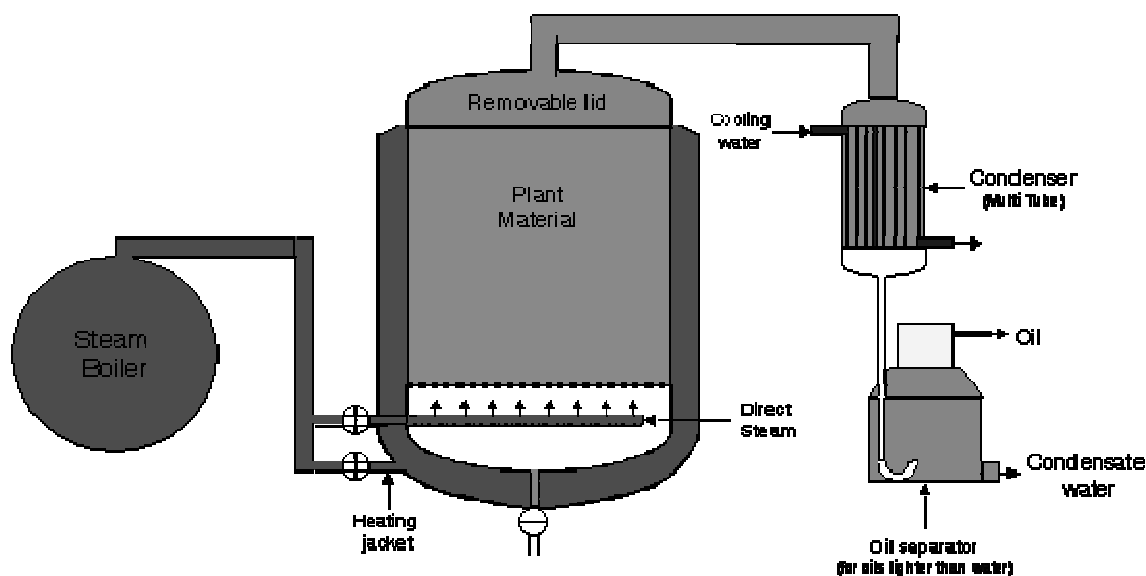


**Figure 5: Diagrammatic representation of a steam and water distillation unit with a baffle to prevent direct water contact with the plant material on the perforated grid.**

#### ADVANTAGES OF STEAM & WATER DISTILLATION OVER WATER DISTILLATION

1. It is possible to achieve a high packing density, as we do not suspend the plant material in the water.
2. We get a higher oil yield.
3. The oil component is less susceptible to change due to wetness and thermal conductivity of the still from the heat source.
4. The effect of refluxing is minimised.
5. The oil quality we obtain is more reproducible
6. As it is a faster process, it is more energy efficient.

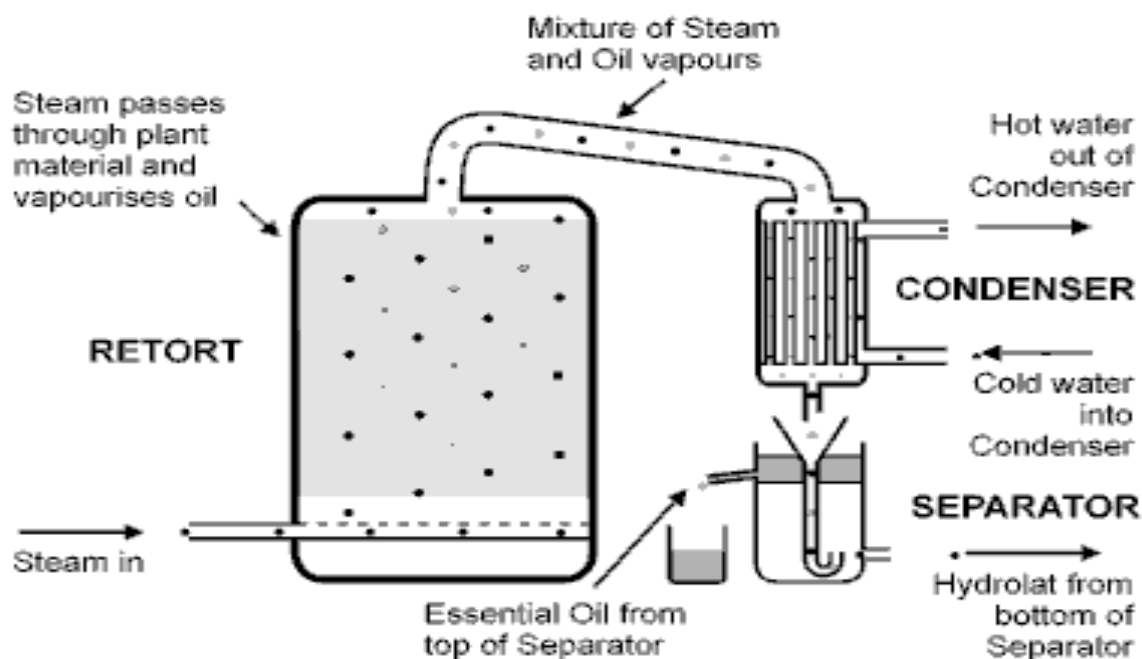
#### STEAM DISTILLATION



**Figure 6: Diagrammatic representation of steam distillation unit**



Steam distillation is the process of distilling plant material with the steam generated outside the still in a stand-alone boiler (See figure). As in the steam-and-water distillation system, we support the plant material on a perforated grid above the steam inlet.



**Figure 7: Diagrammatic representation of steam distillation unit**

**The advantages and disadvantages of steam distillation are as follows:**

1. We can control the amount of steam and the quality of the steam.
2. There is only a lower risk of thermal degradation as temperature generally not above 100 °C.
3. It is the most widely used process for the extraction of essential oils on a large scale throughout the flavour and fragrance supply industry and by that means it is the standard method of extraction.
4. There is a much higher capital requirement and with low-priced oils, the pay back period can be over 10 years.
5. It requires a higher level of technical skill and fabrication and repairs and maintenance require a higher level of skill.
6. Many variations of the process exist, e.g. batch, hydro diffusion, maceration distillation, mobile stills and continuous distillation process.

**When designing a distillation system we have to consider a number of issues:**

#### **SITE**

1. Availability of adequate water
2. Energy source: electricity, boiler fuel
3. Easy transport access
4. Skilled and unskilled labour



5. Close proximity to plant material
6. Access to fabricators and machine shop for repairs
7. Environmental zoning, plant waste and waste water discharge

### **DISTILLATION CHARGE i.e., the amount of plant material we can process in a single cycle**

1. Size of the still
2. Plant species and oil content
3. Daily volume and condition of plant material and frequency of supply
4. Distance of the plant material production to still and how it will be transported
5. Required pre-treatment (chopping, crushing, powdering, maceration)
6. Time taken to charge and discharge the still
7. Storage capacity of plant material prior to distilling in case of poor weather
8. Disposal of waste plant material after distillation

### **STILL**

1. Design determined by distillation method; seek professional advice
2. Ideally constructed of stainless steel
3. Size determined by capacity of boiler
4. Distillation time affected by height of the charge, flow rate and pressure of steam
5. Easy to charge and discharge.

### **BOILER**

1. It should produce enough steam to remove a good amount of oil from the plant material.
2. It should have the facility to produce low pressure (saturated steam) or pressurised (dry steam).
3. It is better to measure the output of home made or commercial boiler (condensing steam for set time) to determine capacity
4. Seeking professional advice on design and access for repairs and maintenance may be necessary.

### **CONDENSER**

1. It is important to choose the right type, namely coiled tube or multitube.
2. The role of the condenser is to change the oil and water vapour back to a liquid.
3. Multitube condensers are difficult to make, and needs running water. However, it has good heat transfer, and efficient water use with no pressure build up.
4. Coiled tube condensers are easy to make, and just needs a tank of water or can work with sparse use of running water. However, it has poor heat transfer, with a risk of high pressure build up during distillation.

### **OIL SEPARATOR**

1. Design of separator depends on density of the oil (If density is lower than 1 oils are lighter than water and it floats; if density is greater than 1, then oil is heavier than water and it sinks). Please note only a few wood and root oils are heavier than water.



2. It should have a large enough capacity to allow the oil particles to form droplets and readily separate from the water. It is necessary that at least a 4 minutes retention time in the separator is present before oil its eventual out flow.
3. It is possible to control the temperature to improve separation.
4. Seeking professional advice on design is advisable, as poor separation affects all the effort of distillation to extract oil

## STORAGE

1. There should be a system to filter separated oil.
2. The oil extracted should be stored in suitable containers that exclude light.
3. It is important to remove dissolved water either by the filtered bed of anhydrous sodium sulphate or by chilling
4. It is necessary to removal residual still notes and dissolved oxygen by bubbling, a stream of nitrogen and allowing oil to breathe by topping the drum to over flow level to remove all air.

Where possible fabricate the still vessel, condenser, and separator using stainless steel. Access to specialist fabricators, and equipment and skills for maintenance and repair, should be of primary consideration in the design of the distillation system. Seeking professional advice is also critical. Having an efficient separator is one of the very important factors in any distillation process. Putting a lot of effort into distilling the oil is self-defeating if the separator recovery process is less than adequate.

Majority of essential oils floats on water, i.e., their specific gravity is less than 1. However, few wood and root oils are heavier than water. Separation of oils whose density is close to that of water, or where the oil contains one major component, whose density is greater than 1, while the other components have a density less than 1, is more difficult. The design and operation of the separator thus needs to be specific according to the oil we have to extract.

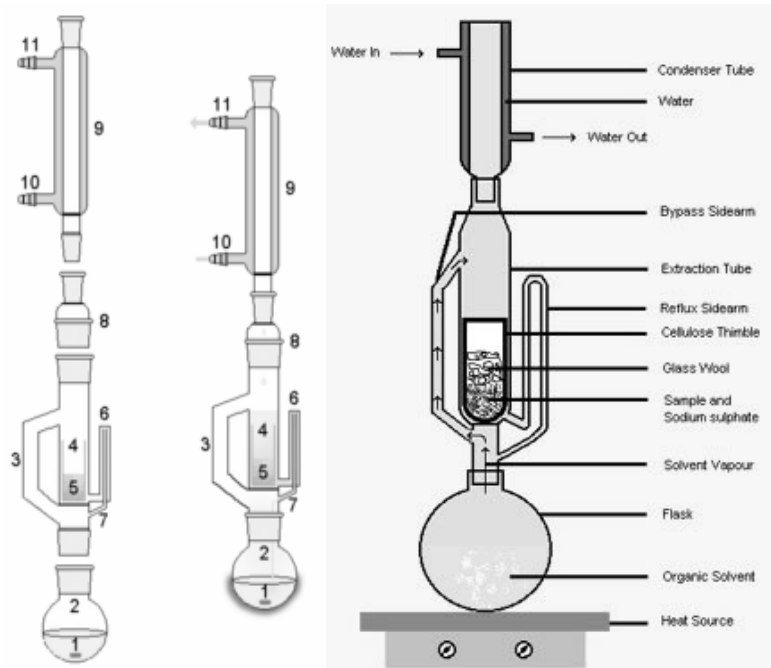
## SOLVENT EXTRACTION

### The extraction process

The very first stage in an herbal extraction process consists of leaching out the impurities or the not so useful portion of the herb by use of a suitable solvent. We have to do this to eliminate, the unusable matter namely, cellulose and lignin present in the cell wall of the plant membrane. All herbs whether dry or fresh have to undergo a comminution stage where in the herb is broken into smaller particles before extraction. This increases the surface area of the herbal matter, and ruptures the plant cell walls making extraction easy. Treat the comminuted herb first with a suitable solvent, and stir it for a prolonged period. We can otherwise also percolate the solvent through the herb mass. Alternatively, we can also use a Soxhlet apparatus for extraction.

Place the herbal sample inside a cellulose thimble (made from thick filter paper), and load it into the main chamber of the Soxhlet extractor. Place the Soxhlet extractor onto a flask containing the extraction solvent. Attach the condenser above the Soxhlet extractor. Heat the solvent and reflux. The solvent vapour travels up a distillation arm and floods into the chamber housing the thimble containing the herb. The water condenser above ensures cooling of any solvent vapours that escapes higher to drip back down into the chamber housing the herbal material. The central chamber containing the herb slowly fills with the warm





**Figure 8: Diagrammatic photo of the Soxhlet assembly**

This cycle repeats many times, over for many hours or days as required. In every cycle, a portion of the non-volatile compound dissolves in the solvent taken. After many cycles, the desired compound is concentrated in the distillation flask. The advantage of this system is that one need not pass many portions of solvent through the sample, and instead just one batch of warm solvent is recycled. After complete extraction, remove the solvent, typically by means of a rotary evaporator, yielding the extracted compound. Discard the non-soluble portion of the extracted solid that remains in the thimble.

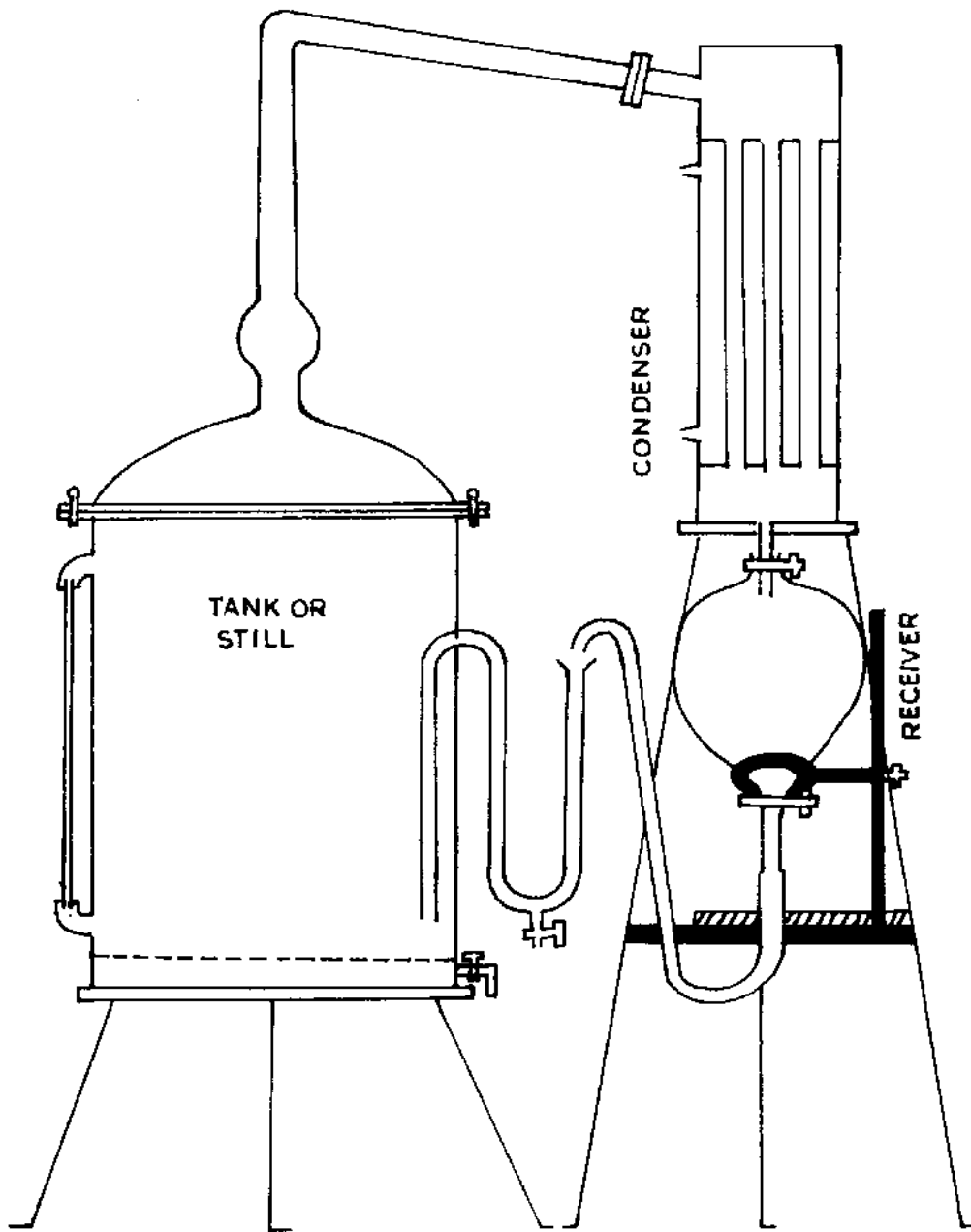
### Solvent used in extractions

The solvent selected for extraction depends on the active you have to extract and this can range right from water, ethanol, polyglycol, or their various mixtures. When water is used (*Mixing the sample with Sodium sulphate is not required*), it extracts sugar, saponins, and mineral salts. Ethanol extracts chlorophyll, essential oils, fatty materials and other organic matter. First, centrifuge the pre-extract obtained and then filter or concentrate it by evaporation to get a clarified dark syrupy liquid extract. We can also dry the extract by spray drying along with sugar or inorganic phosphate.

Finish the herbal extract so obtained by diluting with a suitable solvent, or by further clarification and addition of a suitable preservative. This yields a product suitable for use as an additive in cosmetics and personal care preparations. The second clarification is required and becomes necessary depending on the



solvent selected to carry out the first clarification. Every solvent whether Ethanol, Acetone, Diethyl Ether, Petroleum Ether, or Hexane have their positive and negative qualities.

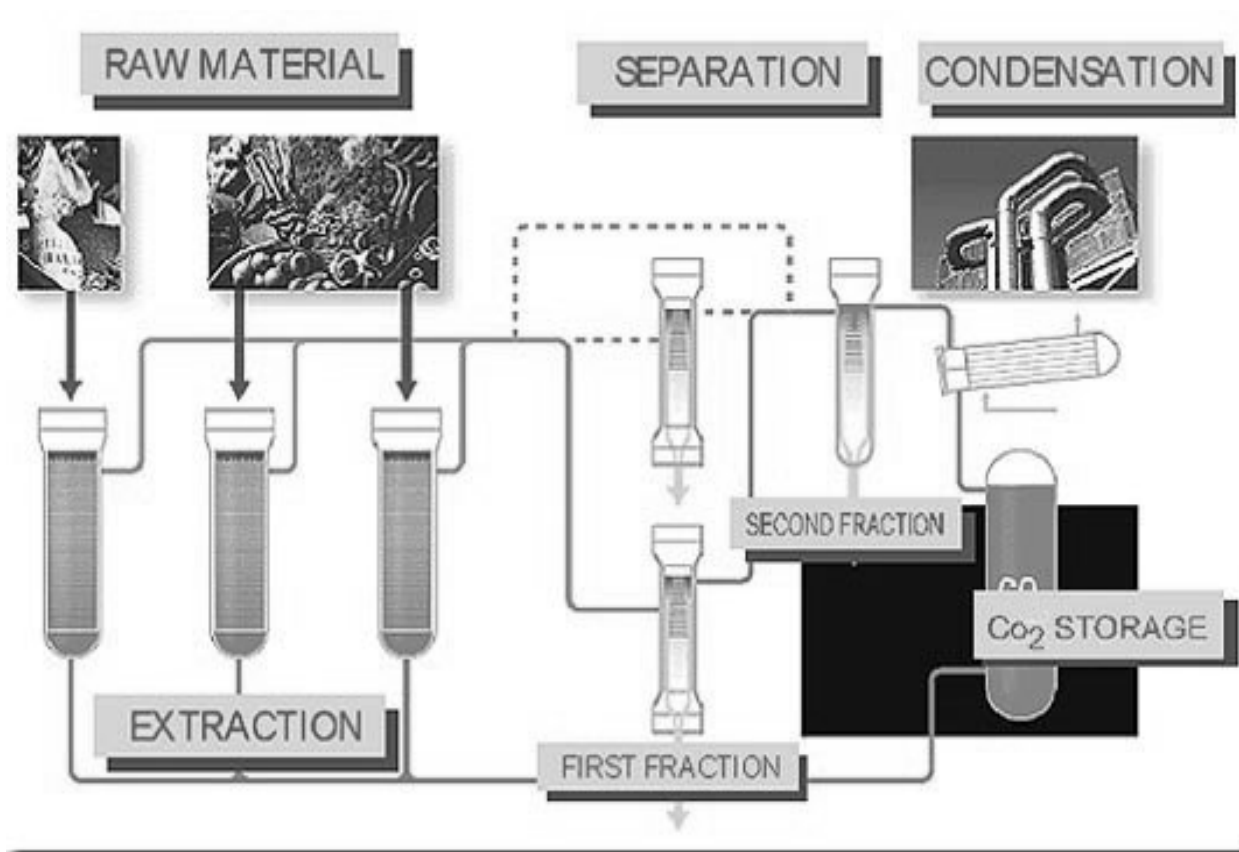


*Figure 9: Solvent extraction still*

### **CARBON DIOXIDE / CO<sub>2</sub> EXTRACTION**

In addition to steam distillation, and solvent extraction procedures, specific crops and spices, also follow the extraction procedure by using carbon dioxide as a solvent that provides standardized extracts of high quality, free from contaminants.





**Figure 10: Diagrammatic photo of CO2 extraction**

We use hypercritical carbon dioxide for carrying out the extraction process. Although this process is expensive, it yields very good quality oils. Carbon dioxide becomes hypercritical at 33 degrees Celsius, which is a state in which it is not really gas or liquid, but has qualities of both. Carbon dioxide at this state is an excellent solvent for extraction of essential oils. The process requires only low temperature conditions and is instantaneous. Carbon dioxide furthermore is inert and therefore does not chemically interact with the plant essential oil. Removing the carbon dioxide solvent is very simple, as we only need to remove the pressure.

As this process takes place in a closed chamber for the hypercritical pressure to build up as required for carbon dioxide and that is 200 atmospheres, i.e., 200 times the pressure of normal atmosphere, heavy-duty stainless steel equipment is required to withstand this type of pressure. This involves high capital investment.

Many other solvents also find use in supercritical fluid extraction and the choice of the SFE solvent is similar to the regular extraction. Main considerations include, a good solving property, inertness to the product or essential oil present in the plant we have to extract, easy separation from the product and finally the cost incurred.

See table 1 for 'Critical conditions for various supercritical solvents'.



### Critical Conditions for Various Supercritical Solvents

Fluid	Critical Temperature (K)	Critical Pressure (bar)
Carbon dioxide	304.1	73.8
Ethane	305.4	48.8
Ethylene	282.4	50.4
Propane	369.8	42.5
Propylene	364.9	46.0
Trifluoromethane (Fluoroform)	299.3	48.6
Chlorotrifluoromethane	302.0	38.7
Trichlorofluoromethane	471.2	44.1
Ammonia	405.5	113.5
Water	647.3	221.2
Cyclohexane	553.5	40.7
n-Pentane	469.7	33.7
Toluene	591.8	41.0

#### ADVANTAGES & DISADVANTAGES OF SCF'S TO CONVENTIONAL LIQUID SOLVENTS SEPARATIONS

##### ADVANTAGES

1. Dissolving power of the SCF is controlled by pressure and/or temperature
2. SCF is easily recoverable from the extract due to its volatility
3. Non-toxic solvents leave no harmful residue.
4. We can extract high boiling components at low temperature.
5. Separations not possible by traditional processes can be effected



6. We can extract thermally labile compounds with minimal damage at low temperatures.

## DISADVANTAGES

1. Elevated pressure required
2. Compression of solvent requires elaborate recycling measures to reduce high energy costs
3. High capital investment for equipment
4. CO<sub>2</sub> is the most widely used fluid in SFE. However, water is the other increasingly applied solvent. One of the unique properties of water is that, above its critical point (374°C, 218 atmospheres); it becomes an excellent solvent for organic compounds and a very poor solvent for inorganic salts. This property gives the chance for using the same solvent to extract the inorganic and the organic component respectively

## OVERALL LOSSES

The major losses in post-harvest and production are dependent on many factors. Poor harvesting methods with immature crop product, disease- or pest-contaminated material, or rotten and damaged material, all encourage crop losses. There is a need to have facilities such as artificial driers and dry storage to minimise the problem of rainfall interrupting the crop drying. The consequences of poor drying and storage multiply into microbial invasion, which can have disastrous results on the potential sale and can lead to rejection of the crop. Poor processing methods, creating damage, can lead to loss of quality and losses, while poor storage facilities can also lead to losses to pests and to quality. Failure to comply with legislative requirements at the port of entry can also lead to rejection of a consignment. The cost of these losses is progressively greater as the products move through the post-harvest chain. This is why it is important to keep information flowing with the marketplace so that an informed decision (such as, not to harvest a crop) can be made before investing in processing, packaging and transport.

Bearing these issues in mind, we can make strategic marketing decisions to target a new crop to an affluent urban market within the growing country in order to establish the industry securely. In some cases, marketing to an international supermarket chain within the growing country requires compliance with international export standards. Once the production and post-harvest system is equipped to meet these criteria, we can overcome most of the barriers to growing for export.

## ECONOMIC AND SOCIAL CONSIDERATIONS

Global changes occurring due to eroding forest cover has led to increased environmental awareness, among people. This in turn has led to a change in consumer perception and redefining of priorities to save the eco system and re-emphasise the need to encourage use of forestland plant based products. God almighty has blessed India with different types of soils and climates that supports growth of a variety of Plants. 18000 native species are found in India of which 1300 species on the last count contain aromas. In spite of its rich natural forest vegetation and a home of many exotic natural plants, India cultivates only limited items of commercial value. There is a great scope for commercial cultivation of several aromatic crops in India as there is always a market demand for new and specific aroma ingredients for development of new exotic fragrances.



Although fragrance usage is on an increase, the availability of quality plant oils for fragrance creation is not sufficient to keep pace with the demand generated. Plant cultivation largely depends on climatic conditions. Yields vary, year after year. Availability differs season to season. Unpredictable quality and odour profile is common. Price fluctuation is rampant. Supply and demand is rarely even. Advent of biotechnology and modern farming techniques has to an extent insulated plant cultivation from the vagaries of nature but this is far too less to make a significant difference on the industry dependence on nature. Aromatic crop cultivation freshens up the polluted atmosphere and is a renewable resource in the ecosystem. The crops are useful even after the extraction of available essential oil as their conversion into artificial board for carpentry, or using it as fodder for animals, or decomposing it to get bio-fertilisers is possible. Essential oil bearing crop cultivation and processing is labour intensive generating good employment opportunities.

### STEPS NEEDED FOR SUCCESS

Even today, extraction of essential oils in India is in an unorganised manner. This industry can grow only by following scientific means and methods of propagation and extraction. Systematic exploitation of aromatic plants by Indian Industry can bring a great economic advantage to our country as, more and more plants that are aromatic are brought under use. Setting up of small-scale essential oil extraction and processing units can provide ample employment opportunities for the rural youths. Once these units come into operation, local farmers can be motivated easily for large-scale cultivation of selected aromatic crops according to the prevalent agro-climatic conditions. During the initial stages raw material requirement of these industries can be met either through collection from wild habitats or through intercropping cultivation in agricultural farms. Either way, it will provide employment to millions of youths from farming communities. Value addition through post harvest technology can also generate further agricultural income and employment opportunities to many.

Conservation of aromatic plants by promoting sustainable genetic management schemes at the community level is necessary for equitable distribution of acquired benefits eventually improving the livelihoods of rural poor. To achieve this we have to provide proper training for cultivation, primary processing, grading, packaging, storage and marketing to rural cultivators. In addition, bio-partnership, networking and providing access to information between the prime stakeholders namely local communities, R&D scientists and industry is necessary. Generating a strong database on genetic resources of aromatic plants and creation of protectorates / biosphere reserves to conserve the genetic stock of endangered species (in situ conservation) is essential. Availability of sufficient quantity of quality seed and planting material of aromatic plants for cultivators is also important. Newer agro-techniques and technology should be developed, assessed, and refined for large-scale cultivation to maintain sustainability and competitive advantage. We should adopt tissue culture transplantation techniques for species whose propagation through seeding is not easy. Establish analytical laboratories for testing and maintaining quality controls. Give utmost priority to develop skilled work force, to handle all aspects of aromatic plants through intensive training programmes. Evolving a long-term human resource development strategy for continuous improvement in competence and skills should ensure up-gradation, of the technical knowledge for field workers.

India's agro climatic conditions provide an ideal habitat for the natural growth of a variety of aromatic plants and herbs. The climatic diversity also offers large opportunities for domestication of many herbs that are in short supply and have to be imported. This will not only supplement internal demands but also save substantial foreign exchange. The fact that derivatives of aromatic plants are non-narcotic without





noticeable side effects, even if used for a prolonged time, in permissible doses fuels its demand around the world. Cultivation, processing, and use of aromatic plants are a great potential for employment generation in rural areas. Our tilt and liking towards synthetic aroma chemicals is slowly destroying nature's gift of aromatic plant species used for fragrance creation in ancient India that grows abundantly in our forests. Another reason for the disappearance of many plant species is our ignorance with regard to its identity and use. In our ignorance, we treat and consider many useful species as useless weeds and destroy without any scope for regeneration. In spite of our country's innumerable benefits there exist constraints like inequitable trade practices that allow only a very small amount of profit to percolate down to the collectors, cultivators and harvesters of aromatic plants. Inadequate government funding and prioritisation, insufficient information sharing and co-ordination among stakeholders, poor mechanism to improve resource conservation, livelihood security in rural and marginal communities, lack of co-ordination of any holistic research programme, weak linkages between stakeholders right from production to consumption value chain are all responsible in impeding the growth of this industry.

India is no exception to the global phenomenon of environmental problems and depletion of natural plant resources. However, we have to exploit the rich diversity in aromatic plants that nature has provided India needs, judiciously without disturbing the ecological balance. Harness resources for economic development, and at the same time their regeneration, preservation, and propagation to maintain its sustenance. The restoration and preservation of our biological heritage is a challenge not only planners, administrators, scientists, industrialist, entrepreneurs, and farmer's but to common individuals and citizens too. Efforts to coordinate development of quality planting material, encouraging commercial cultivation, value addition through processing, liaison with industries, and trade including export, is necessary to boost India's economy and our standard of living and that is a challenge we cannot ignore.