INDUSTRIAL USES OF MEDICINAL AND AROMATIC PLANTS

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Contents

Summary

Medicinal aromatic plants constitute a huge group of plants group with a great interest due to its pharmaceutical, cosmetic and nutritional applications, among others. They are also an alternative to traditional crop with species in high demand at the current international market.

The main purpose of this document is to provide basic knowledge and skills related to the production, uses and chemical features of essences and extracts from medicinal and aromatic plants, to give an approach to economical importance, uses, botany and harvested processes of the most significant medicinal aromatic and seasoning specie plants. The objectives of this course are to be able to classify and identify aromatic plant, seasonings and medicinal plant; to understand cultivation techniques and effectively apply current methodology for problem solving; to learn and understand the most important active constituents; to identify the useful application of this kind of plant in cosmetic, perfumery, food and liquor, and pharmacological industries.

1. Introduction to Maps (Medicinal and Aromatic Plants)

Many plants synthesize substances that are useful for health. Most of these substances are products of secondary metabolism of plants, bacteria and fungi, of which about 12,000 have been isolated, that is 10% of the total. Often, these substances serve as mechanisms of plant defense against microorganisms, insects, pathogens, predators or adverse environmental conditions such as high temperatures or drought.

These plants can be used in parts (roots, stems, leaves, etc.) or processed to extract their essential oils or extracts. They are used in the food industry, pharmaceutical, perfumery and cosmetics, among others.
In recent years, the use of medicinal and aromatic plants, from now on MAPs, has greatly increased in many countries, like the United States, Europe, India and China. At least 2000 species of MAPs are traded, of which than 1000 are native to Europe.

Its growing demand has depleted some of their natural populations, so their collection should be regulated. According to WHO, there is a list of 14 plants that are endangered by over-harvesting.

1.1 History

The origin of the use of these plants is as old as agriculture. First, they were harvested all together, and after, a selective harvesting and domestication of them was developed. Medicinal use of plants is some thousand yeasr old. The first graphical document known is a clay table, found in Mesopotamia. Other record are the egiptian papirii, the chinese phamacopoeias, the ayurveda tradition in India, etc.

According to FAO, 35,000 to 70,000 plant species have been used in some culture for medicinal purposes. China, Hong Kong, Korea, Indonesia, Malaysia, India, Pakistan, Bangladesh, Sri Lanka and Nepal are the countries with more tradition in the uses of medicinal plants, 80% of chinese medicines rely on plants (ICS UNIDO, 2006).

1.2 Uses of Medicinal and Aromatic Plants

Medicinal and Aromatic Plants (MAPs) have the common characteristic of having a high content in substances called ACTIVE PRINCIPLES, with very specific chemical, biochemical or organoleptic properties, which suit them for therapeutic, aromatic and gastronomic uses.

The possibilities of their use for food, cosmetics, drugs, domestic and industrial products is practically unlimited. The different types of plants used in industry are the following.

Aromatic Plants: they have essential oils, mostly in their leaves, for instance, rosemary (*Rosmarinus officinalis*), citronella (*Cymbopogon nardus*), and patchouli (*Pogostemon cablin*).

Spices: they have substances with antiseptic and flavouring properties, for instance, cinnamon, (*Cinnamomun verum*) or nutmeg (*Myristica fragrans*), among many others.

Colorants: they have chemical components such as carotenes and antocyans which can dye fabrics, food and cosmetics. Curcumin (*Curcuma longa*) is one of them.

Bitter Plants: They have bitter substances used in the spirits industry. plantas que cuentan con sustancias amargas, empleadas en la industria de licores. Quina (*Cinchona spp*), cuassia (*Quassia amara*), and cedrón (*Simaba cedron*).

Resins: they exude substances used for incenses, resins, and many other uses. For instance *Protium spp;* Colophny (*Pinus*).

1.3 Industrial Sectors that use MAPS

The principal industrial sectors that consume MAPs are in order of importance: the medicinal one and herbalist's, food and perfumer - cosmetic. Inside these sectors, there are the pharmaceutical industries and herbalist's, food, conditioning, manufacturers of essential oils and extraction and formulation.

Use	Product	Aplications
Pharmacological	Powdered plants Extracts Essential Oils	Phytotherapy Homeoppathy Aromatherapy
	Isolated Active Principles	Drugs
Industrial raw matter	Powdered plants Essential Oils Extracts Isolated Products	Food complements Food Perfumery Cosmetics

2. Raw Materials. Cultivating and Processing Maps

Raw materials are matter extracted from nature and which are used to produce consumer goods. They are classified according to their origin: vegetable, animal, or mineral. A first look at the MAPs market allows us to distinguish between two major types of products:

- Plants or parts of plants, fresh or dried, whole or treated.
- Extracts, essential oils, and oleoresins, extracted as a primary treatment of the vegetable matter.

Both the above groups are raw materials for industries such as perfumery, cosmetics, pharmacy, foodstuffs, and chemistry, which are the main users of primary transformation. To obtain these materials from farmed vegetable matter, the following processes are followed:

- Harvesting (mechanised or by hand).
- Primary transformations (drying, milling, refrigeration, lyophilisation, freezing, distillation, extraction).
- Secondary transformations (packaging, labelling, transport, conservation).

Each of these steps must be taken with strict quality controls to make sure that the raw material is suited to market demands and requirements, and therefore competitive.

2.1 Cultivating Maps

All cultures from ancient times to the present day have used MAPs which are still harvested from the wild. Little by little consumers have increasingly demanded more both quality and supply of MAPS. Nowadays, direct collection from the wild supposed a risk for many MAPs survival in its natural habitats, therefore it is recommended to ensure its conservation, a suitable MPAS cultivation and a regulation of its collection from the wild. The main reasons to cultivate aromatic and medicinal plants are:

Quality tests and products homogenization: purchasers of raw material (dry or fresh material), such as herbal industry or laboratories are more demanding with MAPs quality. If the herb is purchased by herbal industry, homogenization and visual test are required. If material is purchased by laboratory, as well as homogenization, it is required active constituent richness and in the case of essential oil is also required purity.

Conservation of local species and its natural habitat: Thyme, rosemary, lavender, labdanum, bearberry, Gentian are collected from the wild. Among of them it is currently selling a not sustainable amount of Maps which is leading to depletion and destruction of their natural habitat. Some of them, such as Gentian (*Gentiana lutea*), Bearberry (*Arctosthaphyllos uva-ursi*), bogbean (*Menyanthes trifoliata*) and Arnica (*Arnica montana*), are in a critical state, so it is necessary to take serious conservation action.

In addition, the implementation of MAPs in agriculture land should be taking into account as a real alternative in land with poor benefits. According to future guidelines for Common Agriculture Policy (CAP) which are aimed to reducing surpluses crop

production, MAPs cultivation could be an alternative and suitable extensive agriculture. On the other hand, MAPs are suited for these particular soil and climate conditions, especially dryness and poor nutritional soil. It is pointed out that many aromatic, medicinal and season plants belong to local native Mediterranean species.

2.2 What is Organic Agriculture?

Organic agriculture is a production system which avoids or excludes the use of synthetic preparations-artificial fertilizers, pesticides, growth accelerator and fodder additives. The plant receives nutrients by using natural organic or mineral fertilizers and weeds or pests are controlled and prevented by stimulating the population of useful insects.

It is pointed out that the higher quality of this product in organic agriculture involves more dedication than in conventional agriculture; as a result it is necessary more both manual and mechanical workforce. Therefore the final product should be a price higher. Organic agriculture is a production system which avoids or excludes the use of synthetic preparations-artificial fertilizers, pesticides, growth accelerators and fodder additives. As an alternative to these means, OA applies a number of modern preventive methods to maintain the natural soil fertility, such as:

- Alternating sowing of cultures (with leguminous plants inclusive)
- Suited use of manure
- Stimulating the populations of useful insects (entomophages and pathogens for the pests)
- Vegetation associations (combined cultivation of two or more species in the same place)
- Use of mechanical methods for weed control
- Use of sustainable plant varieties and live stock breeds that are well adapted to the relevant environmental conditions.

These environment-friendly processes, above mentioned, are based on natural cycles and ensure the sustainability of soil life, its structure and the well balanced of useful microorganisms.

Negative aspects: the produce from OA yields less as compared to the produce from conventional agriculture and the prime cost of organic products is higher.

It would be strongly recommended an ecological production for MAPs. For instance, in Spain there are a large number of species which may support organic cultivation; as well as these species are not sensitive to disease and pest. However, Organic agriculture weakness is weed control and fertilization; because many of these species are perennial. Currently, in Spain species under organic farming conditions are: Sweet balm (*Melissa officinalis*), field marigold (*Calendula officinalis*), mint (*Mentha x piperita*), peppermint (*Mentha pulegium*), thyme (*Thymus vulgaris*), ajedrea (*Ajedrea officinalis*), salve (*Salvia officinalis*), Cone flower (*Echinacea purpurea*), oregano (*Origanum vulgare*), parsley (*Petroselinum sativus*), basil (*Ocimum basilicum*), Lemon verbena (*Lippia citriodora*), lavander (*Lavandula sp.*) and camomile (*Matricaria recutita*).

2.2.1 Organic Agriculture Meaning

Organic agriculture means a farming system which produce healthful and quality products, improvement of the quality of life, preservation of the organic diversity, improvement of the soil structure and the balance of soil inhabiting microorganisms; without any application of synthetic product.

2.2.2 Principles of Organic Agriculture

Following the above mentioned principles and processes ensure to archive the main principles of International Federation of Organic Agriculture Movements (IFOAM), which are:

a. Production of enough high quality and nutritious food.
b. Organic farming, pastoral and wild harvest systems should fit the cycles and ecological balances in nature. Organic management must be adapted to local conditions, ecology, culture and scale.
c. Maintenance of natural soil fertility
d. Inputs should be reduced by reuse, recycling and efficient management of materials and energy in order to maintain and improve environmental quality and conserve resources.
e. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty
f. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of health and well-being. Consequently, any harmful action should be stopped.

2.2.3 Selection of Favourable Agro-Organic Conditions

A major factor to influence the physical, chemical and organic qualities of medicinal plants is **the climate and the soil conditions**.

When choosing the **climate** one should take into consideration the duration of daylight, the amount of rainfalls and the temperature range. These factors together with the day and night temperature amplitudes directly affect the physiological and biochemical processes in plants, especially the ones which involve enzyme reactions. These factors will inevitably influence their growth and the synthesis of organically active substances. Medicinal plants require different climatic conditions to grow depending on their natural origin. These conditions need to be identical or at least similar to the conditions of their natural habitats. If one ignores climate, it is quite possible that yields would be very low and the percentage of active substances – much reduced. Most medicinal plants require sunny, aerated places sheltered from strong winds and late winter frosts.

The **soil** must be fertile and contains the required amounts in optimal combination of Na, P, Cu, minerals, organic and other elements needed for the plants to grow. Each medicinal plant requires soil conditions that are specific for its species. Most medicinal plants require **neutral pH** of the soil (between 6.5 and 7.5).

The **sowing alternation of cultures** is very important for the organic cultivation of medicinal plants.

The most suitable preceding cultures for most medicinal plants are the winter grain crops, the leguminous plants, all sorts of vegetable crops, berries and fodder cultures (vetch, alfalfa, grass mixtures, etc.). They are usually removed at an earlier time and make the preparation of soil possible and timely for the next sowing or planting.

One species of medicinal plant can be grown in the same area usually for a period from 1 to 5 years. After the fifth year the yield would normally fall down and the plants would be infested with pests and diseases.

2.3 Fertilizing, planning and selection

2.3.1 Fertilizing

Fertilizers can be classified into either mineral (synthetic) or organic (product coming from animal dejection).

Depending on the specific needs, soil should be fertilized once or twice but always immediately prior to earthing up or irrigation. The amount of fertilizer to be used shall be dosed taking into account the reserves in the soil and the species that is being cultivated. The use of artificial nitrogenous fertilizers is unacceptable since they make the soil acid and thus have a negative impact on some micro organic processes in there. All organic fertilizers mentioned below are rich in nitrogen.

Phosphorus is very important for the running of some processes that determine the growing and development of plants. Phosphorus is intensively consumed during the initial stages of growing.

Potassium helps with the synthesis of carbohydrates, the nitrogen exchange processes and the synthesis of proteins.

Nitrogen: is involving into protein synthesis, nucleic acid, ATP and chlorophyll. It is required during blossoming stage.

Microelements (magnesium, iron, copper, zinc, manganese, molybdenum, cobalt, boron, etc.) make part of the enzymes and activate them.

Magnesium: is a macro element. It is made up of chlorophyll structure as well as an enzymatic cofactor; so it may have a lack of this element during bud sprout.

The aim of fertilizing is to supply the plants with nutritious substances necessary for the entire period of their vegetation and sometimes even for years to come, therefore the time periods and types of fertilizer application are very different.

Organic agriculture is determined to maintaining and raising the soil fertility the natural way, that is, by the use of organic fertilizers.

Fertilizers may be applied using fertilizing machines, combined seeders, special plant storing cultivators and manually.

Manure is obtained from the solid and liquid excrements and the padding of live stock animals after being left to decay. The manure which has matured is good for agricultural use. In addition it is the most suitable for agriculture for the following reasons:

- It is produced in the own farmhouse
- It is made up of 4 basic nutrition elements: nitrogen, phosphorus and calcium with useful micro flora.
- It improves physical and chemical properties of soil.

Organic agriculture uses also the liquid type of manure. It is actually the urine of animals collected straight from the stables and sheds or the liquid formed as a result of the decay and draining out from the manure-heap. The urine and the liquid manure have a fast action. Their composition consists mainly of nitrogen and potassium, which are easily consumed by the plants. The liquid manure should be normally diluted with water since it is very strong, in proportion 1:5.

Bird manure is the richest one of all organic types of manure. It is three times richer in nitrogen and potassium and about four times richer in phosphorus than the ordinary mixed manure produced from live stock animals.

Ashes are alkali fertilizer. They neutralize the soil acidity and improve the functioning of nitrogen-fixing bacteria. Ashes may also be used for whitewashing.

Compost. A widely used fertilizer in the agricultural practice is compost. It is an organic fertilizer made of live stock manure, urine, wood ashes, weeds, vegetables, etc. which are not suitable for use as fodder, bush branches, dried leaves, hey, straw, paper, food leftovers, organic waste, etc.

2.3.2 Technical Planning

There are many aspects to take into consideration, for instance:

- Monocultures or diversification, it depends on the future predictable sales. For instance, monoculture saves investment costs but work tasks focus on specific period, whereas crop diversification has the advantage that less risk and a scaling work.
- Plant species: it is selected depending on demand. Some species have a stable market, whereas others suffer great variations in demand level, so it is necessary to have be able to absorb future risk.
- Each plant species has its specific ecological requirement, so soil and climate conditions should be taken into account. Previously to the plant establishment, it is strongly recommended to test soil in order to correct possible nutrient deficiency in soil (by amendment). Among MAPs there are species very well adapted (local), little nutrients and water demanding. However, a good product yield involves a suited selection of specie, varieties well-adapted, that provides homogenate product.

- The target medicinal plant could be dry plant, essences, etc. It is linked to level of demand, agriculture technology, facilities and workforce, investment costs and the level of intensive agriculture at the present moment.
- Water supply, location of the field, proximity to point of sale and suppliers and road network should be taken into consideration.

2.3.3 Selection of Vegetal Material

Seeds and the vegetative reproductive organs to be used should have as possible a certification of origin and be clear from contamination and chemical treatment. Material vegetal (seeds, sprouts and all vegetative reproductive organs) should be provided by available cultivars of organic seed, except from in the initial stage of the project. It is not allowed the use of any genetically altered organism as seed or as reproductive vegetal material.

Seeds, sprouts and all vegetative reproductive organs like roots, root systems, tendrils should be carefully and precisely specified from botanical point of view according to genus, species, variety/genotype. Their origin should be known and their genetic history traced back. When using seeds or sprouts, it is recommended to select them from varieties or improved populations acknowledged officially on national level. It is also desirable that the seeds be harvested the same or previous year and manifest the required qualities for sowing such as purity, % germination, survivability, moisture, authenticity of species and varieties.

Seed, Seedling or sprout can be supplied by cultivar in a first moment and then propagation can be carried out from our plants. In this kind of crop, it is advisable to be able to produce the target medicinal plant in your own, because it is very difficult to find plant very well adapted to edafo-climate conditions in our field. Moreover, it is pointed out that European regulations insist that any reproductive vegetal material provides from an Organic farming, cultivar or a private farming.

2.3.4 Vegetal Material Propagation

MAPs can be propagated, like many plants, sexually (seed) or asexually (sprouts, coppicing)

2.3.4.1 Propagation by Seeds

Seeds can be come from wild collection, previous plantation or commercial cultivar. If seeds are collected from the wild, precautions previously mentioned should be respected. Seeds must be in optimal conditions (mature/ripe) in order to obtain a suited future germination rate.

2.3.4.2 Vegetal Propagation

The advantage of this method is that provides “identical” plants with the same features from mother plant, so it is interesting when it has been a previous selection of vegetal material.

In the other hand, their disadvantage is a high economical cost and the use of more personnel. The more popular way of vegetal propagation is sprouts and coppicing mother plant.

2.3.4.2.1 Plantation Establishment

It is strongly linked to planting or sowing. Recording all the farm activities (cultivation history) can be very useful, not only the timely application of measures such as topping, nipping, pruning and shading but also characteristic plantation (density/survival, pests/treatment and production). A good farm monitor allows to detect on time a lack of nutrient, water or incipient pests and to work quickly avoiding a reduction of yield. Plantation establishment should be after the preparation of soil.

2.3.4.2.2 Direct Sowing

It is only recommended for medium seed with a high germination rate. It is used for annual plant where is a lower cost method of establishing herbs compared to planting seedlings.

Before sowing it is necessary to.

- Break dormancy
- Pest fungi treatment: it is only applied when it is strictly necessary.

Seeds can be spreading it onto cultivated ground by hand or a purpose built machine.

2.4 Harvesting

Harvesting is the process by which we obtain the part of the plant which we will use (the drug). The drug is separated from the plant at the moment of harvesting (flower, roots), or part of the plant is gathered and the useful part (leaves) is then separated.

2.4.1 Types of Harvesting

There are two forms of harvesting plants.

- Wild plants.

Wild plants are usually harvested from March up until October/November depending on the plant we wish to pick and the use we wish to put it to. There is much legislation – though not enough- which regulates the picking of certain species which require special permission.

- Farmed plants.

These are normally harvested after the first or second year of farming. They may be farmed for 3 to 5 years (thyme, savory) or 5 to 8 years (lemon verbena, rosemary). Some plants are collected only once a year (rosemary), others several times a year, (lemon balm), and others every two or three years (valerian or purple cornflower).

- The farmer must know when to pick the plants and what part is required.
- Picking depends on the part of the plant to be used
- Buds should be harvested at the moment of flowering

- Flowers should be harvested just before flowering, preferably early in the morning
- Roots should be harvested in autumn or in winter, or –if we want seeds- just after fruits appear.

Another important factor to bear in mind is to pick just at the moment when the active ingredient content is at its highest. For example, valerian is rich in valerenic acids and valepotriates, in February - March, and the maximum essential oil content is found in September.

Harvesting may be

- Manual (savory or thyme bunches)
- Semi-manual (lemon verbena leaves)
- Mechanised (thyme, lemon balm, lavender)

Harvesting should be carried out in such a way that both the quality and the health of the product are maintained, always avoiding contamination.

Samples of vegetable matter are collected in the selected season, before, during, or after flowering. A complete sample is taken: flowers, leaves, stalks, and roots, in order to obtain the active ingredients they contain.

They are then air dried until they reach a constant weight. The leaves, flowers and stalks are separated into sub-samples which are then weighed. If required, the plants are ground in a grinder, although this can be done by hand by simply chopping up the plants.

As a general rule, plants should not be collected when the weather is wet (rain, fog…). It is better to gather in the morning once dew has evaporated.

- Leaves are gathered when they are young but completely developed, just before the flowers develop completely (when flowering starts).
- Flowers are gathered when they are fully bloom but still fresh.
- Fruits are collected when ripe.
- Roots should be strong and completely developed.
- Bark is taken from young shoots.
- Grasses are collected when flowering starts.

When harvesting in the field, plants should be gathered without breaking the roots, using appropriate tools. The sampling site should change regularly so that the plants can regenerate, and we must not take all the samples of a species from the same place, nor take more than half of the leaves. Seeds and fruits should be left.

There are machines on the market designed and adapted for harvesting certain plants. In some cases we can use modified cereal harvesters and forage cutters. For small surfaces (up to 2.5 hectares) we can use a modified cultivator for maintenance and harvesting.

2.4.2 Harvesting Times

Depending on the species chosen and the intensity of collection, reproductive cycles vary. Mint or purple cornflower may have a three years cycle, thyme, oregano and lemon balm from 4 to 5 years, lavenders and rosemary from 8 to 9 years.

In Europe, the period for harvesting starts in spring and can last up to fall. Certain species are collected 3 or 4 times a season, whereas other can only be gathered once or twice.

The moment for harvesting depends on the part of the plant which is going to be used (leaves, seeds, flowers, or roots), and it should remembered that this is a key factor for obtaining the optimal quality and richness in active ingredients.

Normally, production starts after one year, but if plants are planted in autumn, many species are ready for a first harvest by the following summer.

Depending on conditions, plants can be harvested once, twice or three times a year. Thyme, for example, if irrigated, can be collected three times a year. Oregano once; lemon balm, like mint, can be harvested three or even four times; the aerial parts of purple cornflower three times; tarragon twice; sage, three times; Saint John's worth (*Hypericum perfuratum*) twice if irrigated; savory (*Satureja montana*) two or three times; lavender (*Lavandula* sp), once.

The rhythm of collection should always keep pace with the rhythm of production or transformation. Therefore, the harvesting capacity of the machinery used (hectares per day) should exactly match the capacity of the equipment used for transforming (tons per fresh plant per day), and the working capacity of the workers available and the collection periods of the species in question.

2.4.3 Post-harvesting Processes

The following post-harvesting processes are usual for medicinal plants (for pharmacological use).

Cutting: it is done in order to facilitate drying out as it increases the surface evaporation. It depends on the type of plant and on the technology employed.

Washing: drinking water is used to clean soil and other foreign matter from the part of the plant which is to be dried.

Disinfection: it consists in eliminating micro-organisms which are pathogenic for humans in different ways, until regulation levels are achieved.

Chemical treatment: before drying, plants are immersed in chlorinated saline solutions (sodium hypochlorite, calcium chlorite) so as to reduce the bacterial content to the authorised levels.

Physical treatment: before drying, plants are exposed to gamma radiation. This method is used when chemical disinfection is not efficient or when the vegetable matter comes from tech areas in which the yield flow is constant and little inorganic matter is present.

Bleaching: this process is used to prevent oxidation. It consists of a *thermal shock*, immersing the matter in hot water or steam to inhibit the effect of enzymes responsible for oxidisation.

Sulphite: this process aims to preserve natural flavour and colour, to preserve the vegetable matter, delay loss of vitamins A and C, and counteract the growth of micro-organisms. It consists in placing the vegetable matter in a sulphur dioxide concentrate (prepared by combustion) between 1.2 % and 2 % in a sealed camera for a period of time. Vegetable matter can be also immersed in a sodium bisulphite or sodium meta-bisulphite solution; concentration and time periods vary depending on the product.

2.5 Primary Transformation

Transformation includes all the processes that take place in order to preserve raw material, to select the parts to be used, to eliminate foreign matter, to grind or mill, to extract active ingredients, so that the product may be packed and labelled ready for storage or transport. The established regulations for correct manipulation must be observed.

Gathered matter must undergo a transformation or manipulation process which will depend on what the end product is to be. The main processes for transformation and preserving are:

- drying and lyophilisation if dry plant is required
- extraction of non-volatile active ingredients
- distillation of volatile active ingredients (essential oils)
- refrigeration for fresh plants
- freezing for frozen plants

2.5.1 Drying

The aim of drying is to dehydrate to below 10% so the enzymatic activity stops and the attack from bacteria and fungi, which cause mould and thus a loss of quality, is avoided. Drying also means the vegetable matter is easier to transport. The problem is not all drugs have the same degree of humidity. The texture of drugs is also different and this affects the evaporation rate. Active ingredients present different reactions to temperature. Drying should be as fast as possible and should not alter the active ingredient. After drying, humidity must be below 10%. The method used will depend on the nature of the drug, its humidity, consistency, and the type and quality of the active ingredient. Alkaloids are more resistant than glycosides and sugars. Due to their volatility, essential oils cannot be dried at high temperature. There are three methods: air drying, heating, and vacuum.

2.5.1.1 Air Drying

This process is used in areas with a warm, dry climate, for small amounts of drugs whose active ingredients are stable. Drying is carried out in the shade as the sun would cause photosynthesis in the drug. The drug is protected from night-time humidity. Drying takes place in closed but ventilated rooms, the drug being spread out in thin layers. The process is slow, and desiccation into the air may occur.

2.5.1.2 Heat Drying

This is the commonest method used and has the advantage that the two factors which affect good desiccation can be controlled: temperature and ventilation. A rapid elimination of humidity without changing the active ingredient must be ensured. If the temperature is too high, a rapid surface evaporation takes place and a dry layer appears, preventing further drying. Drying by this method usually takes place at 30 - 40 ºC, some degrees higher for barks (60 - 70 ºC). Ventilation ensures that air takes contact with the drug up to water saturation point. Once the air is saturated it is changed. Small scale drying takes place in ovens with air vents, and industrial drying takes place in drying tunnels. The latter have a heater at one end and a fan at the other. The drug is placed in the tunnel on trolleys with several shelves, so as to achieve progressive drying. As the trolley moves along the tunnel, the heat it is subjected to diminishes. This drying operation is used industrially: the drying areas are designed and built for a specific quantity and type of vegetable matter which is to be treated.

The conditions (temperature and humidity) for this process depend, particularly, on the species to be dried. The most important factors affecting the drying process are water content of the vegetable matter, its capacity for water retention, the maximum drying temperature, and the air humidity. When calculating the capacity of the drying equipment, it has to be taken in account the amount and volume of the fresh vegetable matter to dry in a certain time.

Natural drying (which takes longer and requires more space) by hanging or on trays, or forced drying, which involves blowing hot, dry air around a sealed area to extract moisture and cold. It is much faster, though this depends on the moisture of the plant can be employed. Appropriate drying temperatures are between 32 and 35 ºC, so as not to destabilise the active ingredients not the volatile essences. It is best to reduce drying time to avoid this.

Once the vegetable matter is dry it can be stored without risk of biological processes degrading its active ingredients.

2.5.2 Post-drying

Once the plant has been dried, the part of the plant to be used must be separated and the rest of the plants and any foreign matter (soil, stones) must be eliminated. The separation process can be done by using machines with sieves, or air tubes which separate different densities using air currents. If magnets are added, also metals can be separated.

Later, depending on the purpose or presentation, the following can be done:

- Milling (powders for capsules or tablets, condiments…)
- Grinding (tins, tea-bags…)

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Bibliography

BISSET, N. G. (1994). Herbal drud and phytopharmaceuticals. A handbook for practice on a scientist basis. Medpharm Sientific Publishers, Stuttgart, U. K.

BLUMENTHAL, M., GOLDBERG, A., BRINCMANN, J. (2000). *Herbal Medicine. Expanded Comission E Monographs.* American Botanical Council.

BRUNETON, J. *Farmacognosia. Fitoquímica. Plantas medicinales.* 2ª Ed. Zaragoza. Acribia S.A, 2001, 1100 Págs., ISBN: 84-200-0956-3.

BURR, Chandler (2003). *The Emperor of Scent: A Story of Perfume, Obsession, and the Last Mystery of the Senses*. New York, Random House.

CALKIN, ROBERT R. AND JELLINEK, J.STEPHEN (1994). *Perfumery: practice and principles*. John Wiley and Sons Inc.

CAMPS, Arcadi Boix (2000). *Perfumery Techniques in Evolution*. Allured Pub. Corporation.

CRISTÓBAL, R.; FANLO, M. Y MELERO, R. 2004. "El cultiu de plantes aromàtiques i medicinals a Catalunya, una alternativa de futur". Rural & Forests, 3: 18-21.

EDWARDS, Michael (2006). *Fragrances of the World 2006*. Crescent House Publishing.

ESCOP Monographs. The Scientific Foundation for Herbal Medicinal Products. 2nd edition. Thieme 2003.

European Spice Association. http://esa-spices.org/

FORTINEAU, A. D. (2004). "Chemistry Perfumes Your Daily Life". Journal of Chemical Education.81(1)

LEVETIN AND MCMAHON. Plants and Society.Mc Graw Hill.2003 (3rd edition),

MESKIN, M.S., BIDLACK, W.R., DAVIES, A.J., OMAYE, S.T. (2002). *Phytochemicals in nutrition and health*. CRC Press, New York.

MORÉ E.; COLOM A. (2002). Distribución comercial de plantas aromáticas y comerciales en Cataluña. Investigación Agraria. Producción y protección vegetales. Vol. 17 (1) p. 44-66. Abril 2002.

OMS. General Guidelines for Methodologies on Research and Evaluation of Traditional Medicine. Geneva.

PENGELLY, A. (1996). The constituents of Medicinal Plants. 2nd Ed. Cabi Publishing, U. K.

VALNET, J. (1983). *Phytotherapie, traitement des maladies par les plantes*. 2nd edition. Paris: Maloine.

WIJESEKERA, Ph.D.,D.Sc (ed). The medicinal plants industry.United States:CRC press 1991,pag 1-17 (chap 1).

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