

Practical Manual
on
Medicinal and Aromatic Crops
HFL 321 3(2+1)

(For Undergraduate Horticulture students)

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2019

College of Horticulture & Forestry
RANI LAKSHMI BAI CENTRAL AGRICULTURAL
UNIVERSITY, Jhansi-284003

Syllabus:

Practical: Collection of medicinal and aromatic plants from their natural habitat and study their morphological description, nursery techniques, harvesting, curing and processing techniques and extraction of essential oils.

Name of Student

Roll No.

Batch

Session

Semester

Course Name :

Course No. :

Credit

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CERTIFICATE

This is to certify that Shri./Km. ID No.....has completed the practical of course.....course No. as per the syllabus of B.Sc. (Hons.) Agriculture/ Horticulture/ Forestry semester in the year..... in the respective lab/field of College.

Date:

Course Teacher

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Practical No. 2

Objective: To collect samples and prepare herbarium of medicinal and aromatic plants

Exercise: The plant species with the medicinal and aromatic values have to be collected from the field for correct identification, naming and to be preserved for longer periods in the form of herbarium.

Material Required: Herbarium sheets, wooden block press, old newspapers, pencil/marker, thread etc.

Steps in preparation of herbarium:

- **Collection:** Healthy and ideal plants which are free from insect-pests and diseases are selected. The specimen(s) should include if possible, all plant parts (underground parts, stems, leaves, flowers& fruits).
- **Pressing and drying:** Once the plant specimen is rooted out at right stage (at seedling, flowering and fruiting), it is necessary to press it and fit well inside the limits of folded sheets of paper. The pressed plants must be thoroughly dried prior to storage and mounting. Best results are obtained with the use of an electric drier that holds the presses and provides steady bottom heat between 45°C and 60°C.
- **Poisoning:** The plant specimen once dried need chemical treatment to protect them from insect attack and other destructive organisms. Thus, dipping of specimens is essential
- **Mounting:** After the specimens are dried and poisoned, they are mounted on herbarium sheets. Generally, the size of the herbarium sheet is 42 cm x 29 cm. The herbarium sheet should be of good quality and medium in weight. The specimens are placed in the centre of the sheet.
- **Labelling:** The lower right-hand corner of the herbarium sheet should bear the label containing the information. It consists of two steps-

A. Preparation and fixing of identification label.

- (i) Location
- (ii) Date
- (iii) Habitat
- (iv) Occurrence of plant.
- (v) Noting of essential characteristics
- (vi) Features of special reference

B. Filling of format of identification label

State :
District :
Location of and habitat :
Common name :
Scientific name :
Description :
Date and time :

Exercise: Each student has to collect 25 plant species with the medicinal values from the local vicinity. Prepare the herbarium specimens for each collected species as per the above guidelines

Practical No. 4

Objective: To study morphological description and identification of given medicinal plants

Exercise: Identify the assigned medicinal plant and note down the distinguishing morphological characteristics, on the basis of below mentioned features as well as taxonomic classification

IDENTIFICATION HINTS:

1.	Common name & Botanical Name
2.	Family
3.	Habit
4.	Root
5.	Stem
6.	Leaf
7.	Inflorescence
8.	Flower
9.	Calyx
10.	Corolla
11.	Androecium
12.	Gynoecium
13.	Fruit
14.	Floral Formula

Draw well labelled diagram of the identified morphological features of the plant



Practical No. 5

Objective: To study morphological description and identification of given aromatic plants

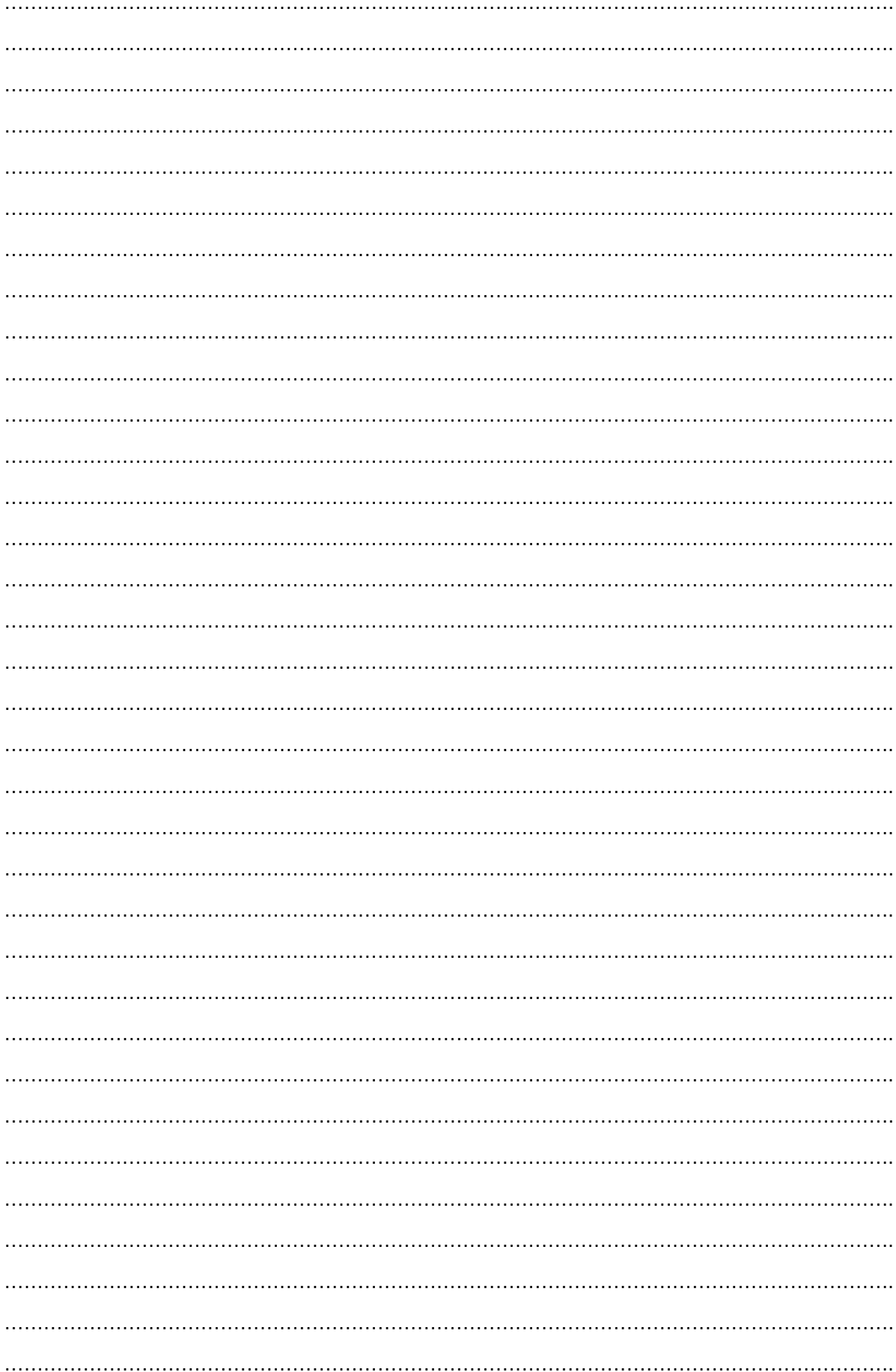
Exercise: Identify the assigned aromatic plant and note down the distinguishing morphological characteristics, on the basis of below mentioned features as well as taxonomic classification.

IDENTIFICATION HINTS:

1.	Common name & Botanical Name
2.	Family
3.	Habit
4.	Root
5.	Stem
6.	Leaf
7.	Inflorescence
8.	Flower
9.	Calyx
10.	Corolla
11.	Androecium
12.	Gynoecium
13.	Fruit
14.	Floral Formula

Draw well labelled diagram of the identified morphological features of the plant





Practical No. 8

Objective: To study the nursery raising techniques of given medicinal plant.

Methodology: Students will raise the nursery of selected /assigned species from their course or locally available species. The students will record all the procedures pertaining to seed treatment, germination, survival, management practices and transplanting stages etc.

The nursery raising data will be recorded on routine basis and will be tabulated as follows

Description of Species:

.....
.....
.....
.....
.....

Propagation method/ sowing method:

.....
.....
.....
.....
.....

Seed pretreatment/ root hormone treatment:

.....
.....
.....
.....
.....

Date of sowing/transplanting:

Bed area and amount of seed sown:

Records of germination:

.....
.....
.....
.....
.....

Survival percent:

Transplanting stage:

.....
.....
.....

Student Exercise: - A group of 3-4 students will be given nursery raising exercise for 2 selected species of medicinal plants during their semester. The students are required to produce seedling/planting materials and all the work will be duly evaluated during practical examination.

Practical No. 9

Objective: To study the nursery techniques of given aromatic plant.

Methodology: Students will raise the nursery of selected /assigned species from their course or locally available species. The students will record all the procedures pertaining to seed treatment, germination, survival, management practices and transplanting stages etc.

The nursery raising data will be recorded on routine basis and will be tabulated as follows

Description of Species:
.....
.....
.....
.....

Propagation method/ sowing method:
.....
.....
.....
.....

Seed pretreatment/ root hormone treatment:
.....
.....
.....
.....

Date of sowing/transplanting:

Bed area and amount of seed sown:

Records of germination:
.....
.....
.....
.....

Survival percent:

Transplanting stage:
.....

Student Exercise: - A group of 3-4 students will be given nursery raising exercise for 2 selected species of aromatic plants during their semester. The students are required to produce seedling/planting materials and all the work will be duly evaluated during practical examination.

Practical No. 10

Objective: To study the time and method of collection of different plant parts.

Exercise: Students will be demonstrated with different methods of collection of different plant parts for medicinal and aromatic plants in general. The students will record all the procedures pertaining to method of collection of different plant parts.

Sr. No.	Plant Parts	Time and method of collection
1.	Bulbs	
2.	Bark	
3.	Root & Rhizomes	
4.	Leaves	
5.	Flowers	
6.	Seeds and fruits	
7.	Annual herbs/ whole plant	

Practical No. 11

Objective: To study time and method of collection of different plant parts.

Exercise: Students will visit the nearby forest areas to collect the plant samples and plant produce or raw material of herbal drugs. Each student will collect 20 –30 samples of plants or plant parts and these will be submitted in plastic bags or containers with proper labeling for identification and demonstration. All the information of collected material will be presented in tabular form in the practical notebook as follows.

S. No.	Common Name	Botanical Name	Part Used	Uses	Harvesting/collecting month	Major active ingredients
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						

Practical No. 13

Objective: To study techniques for primary processing and value addition of given medicinal plants.

Exercise: Students in groups will carry out collection, harvesting, drying, grading, storage, and processing and value addition for assigned medicinal plants and will note down the information under the following heads.

Description of Species:

.....
.....
.....
.....
.....
.....

Harvesting and Drying:

.....
.....
.....
.....
.....
.....
.....
.....

Grading, Packaging and Storage:

.....
.....
.....
.....
.....

Value added products prepared:

.....
.....
.....
.....
.....

Practical No. 14

Objective: To study techniques for primary processing and value addition of given aromatic plants.

Exercise: Students in groups will carry out collection, harvesting, drying, grading, storage, and processing and value addition for assigned medicinal plants and will note down the information under the following heads.

Description of Species:

.....

.....

.....

.....

.....

.....

Harvesting and Drying:

.....

.....

.....

.....

.....

.....

Grading, Packaging and Storage:

.....

.....

.....

.....

.....

Value added products prepared:

.....

.....

.....

.....

.....

Exercise: Perform extraction of essential oil using Clevenger apparatus and draw diagram of steps followed.

Observations:

Species for oil extraction-----

Quantity of biomass per batch-----

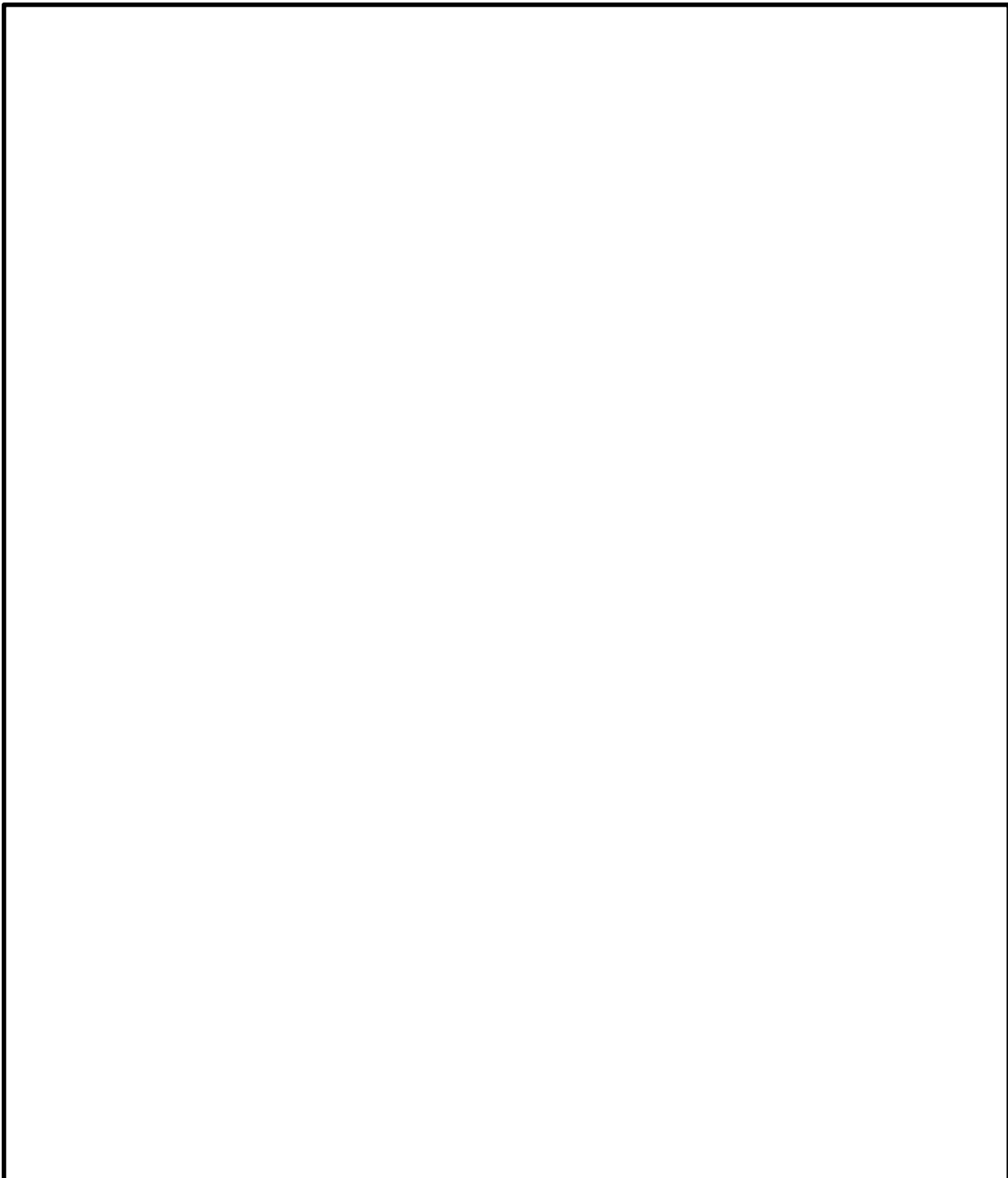
Time period for extraction-----

Yield of essential oil:

$$\text{Yield (\%)} = \frac{\text{weight of extracted oil (gm)}}{\text{weight of plant material (gm)}} \times 100$$

Any other observation-----

Draw a well labelled diagram of steps followed.



Practical No.17

Objective: To know about the Improved Genotypes identified in some commercially important medicinal and aromatic plants.

Exercise: Students will write in brief about the different improved genotypes/varieties for commercially important medicinal and aromatic plants.

Improved Genotypes identified in commercially important medicinal plants

S. No.	Species	Variety/Strain	Developed at
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			

Improved Genotypes identified in commercially important aromatic plants

S. No.	Species	Variety/Strain	Developed at
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			

Practical No.18

Objective: To know the therapeutic utilization of different parts of medicinal and aromatic plants

Exercise: Each Student will identify and collect at least ten drug yielding plants

Drug obtained from roots and other underground parts			
S. No.	Botanical Name	Family	Use
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
Drugs obtained from bark			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
Drugs obtained from stem & wood			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Drugs obtained from leaves

1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Drugs obtained from flowers

1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

Drugs obtained from fruits & seeds

1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

HINTS FOR THE IDENTIFICATION OF THE PLANTS

1. **Habit:** tree, shrub, herb, climber
2. **Leaf:** acuminate, oval, venation, simple, compound, glabrous etc.
3. **Foliage:** lush green, dark brown, colourful etc.
4. **Stem:** straight, crooked, branching pattern etc.
5. **Bark:** rough, smooth, spotted, crocodile, soft, colour etc.
6. **Flower:** arrangement, inflorescence, colour, smell, petals, sepals, calyx etc.
7. **Fruit:** Pod, berry, pome etc., their colour, smell, etc.
8. **Seed:** types, colour, smell, surface, shape etc.
9. **Odour:** leaf, fruit, bark, heartwood flower etc. especially for aromatic crops.
10. **Phenology:** leaf shedding and renewal, flowering and fruiting time etc.
11. **Inflorescence:** Flowers are borne on structures called inflorescence, which is a collection of individual flowers arranged in a specific order or form spike, catkin, raceme, corymb, umbel, compound umbel, cyme, panicle, head, solitary flower.

BASICS FOR IDENTIFICATION OF FLOWERING PLANTS

To understand the form, function, habitat and essential needs of plants use all your senses (vision, hearing, smell, taste, and touch) to observe plants. A collective understanding of fundamental botanical terms helps us share and discuss our discoveries with each other.

Duration of vegetative parts

Annual: completes life cycle in one year

Biennial: completes life cycle in two years

Perennial: life cycle extends three or more years

Deciduous: plants that shed their leaves at the end of the season and become dormant

Evergreen: plants that are never without leaves attached

Broadleaf evergreens: include all evergreens except conifers which have needle or scale-like leaves

Plant appearance or habit

Herbs (Herbaceous plant): plants with non-woody stems

Shrub: woody perennial with more than one main stem

Tree: woody perennial with a single main stem

Vine: herbaceous plants with elongate, flexible, non-self-supporting stems

Liana: a woody vine

Leaf features

Blade: Flattened part of the leaf

Petiole: stalk supporting the blade

Leaf scar: a heart-shaped scar remains on the stem where the petiole was attached

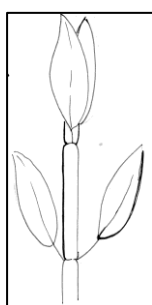
Bud: forms above leaf scar and contain the beginnings of future growth; size, color, shape and marking of the scales on buds offer identification characteristics

Leaf arrangements on plant stem

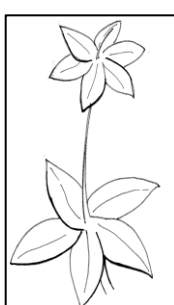
Node: area on stem from which one or more leaves develop



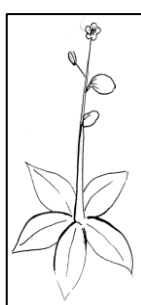
Alternate leaves 1
per node



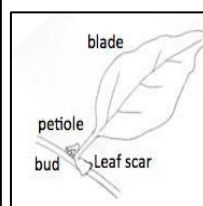
Opposite
leaves 2 per
node



Whorled leaves
More than 2 per
node



Rosette leaves
Radiating cluster
at base



Alternate leaves 1
per node

Arrangement on leaf petiole

Look for a **leaf scar** and **bud** in area where the petiole was attached. No leaf scar or bud?

Leaflet: resembles a leaf but is attaches to the axis of a compound leaf not the stem

Leaf modifications

Bract: modified leaf often associated with a flower or inflorescence

Sheath: basal portion of leaf that surrounds the stem

Spine: sharp pointed leaf or portion of a leaf

Tendrils: twining leaf or portion of a leaf

Leaf blade surface

Glabrous: without hairs

Glaucous: waxy coating

Pubescent: hairy surface--there are many kinds of hairiness

Simple

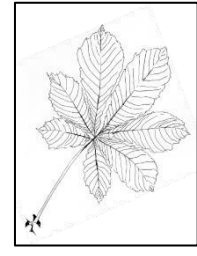


Simple leaf
undivided may
be deeply lobed

Compound

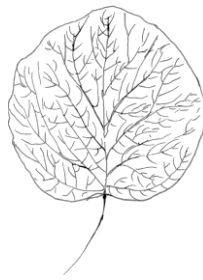


Pinnate feather-like
with leaflets
attached both sides
of central axis

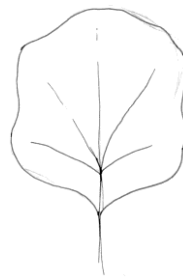


Palmate hand-
like with 3 or more
leaflets radiating
from one point

Leaf blade venation



**Net
(Reticulate)**



**form a complex
network**



**Palmate
veins radiate**



**from a central
point at base**

LEAF BLADE MARGIN



Dentate
Symmetrical
angular teeth



Denticulate
Fine teeth
angular teeth



Serrate
Coarse teeth
curved forward



Serrulate
Fine teeth
curved forward



Sinuate
Wave-like
indentations



Ciliate
Fine hairs



Crenate
Rounded teeth



Entire
Smooth



Lobate
Indented/lobed



Undulate
Widely wavy



Cuneate
Wedge
shaped



Elliptical
Oval
with
parallel
sides
no tapering



Linear
Thin; sides
parallel



Oblong
Pointed
at base



Obovate
Egg shaped
widest
towards
tip



Ovate
Egg shaped
widest
towards
base



Orbiculate
Heart
shaped



Obcordate
Heart
shaped



Reniform
Kidney
shaped

LEAF BLADE BASES AND TIPS (APEX)



Acute
Less
than 90°
angle



Auriculate
Lobes of a
human ear
shaped



Cordate
Heart
shaped



Hastate
Triangular
lobes



Sagittate
Arrow
head
shaped



Oblique
Asymmetrical



Oblique
Asymmetrical



Obtuse
Greater than
90° angle



Acuminate
Curving
inward; fine
tip



Cuspidate
Long, thin,
sharp tip



Emarginate
Notched
towards base



Mucronate
Short abrupt
point

INFLORESCENCE TYPE



Umbel

flowers originating from a common point with floral stalks of equal length



Corymb

flowers along a central axis with floral stalks of unequal length, all ending at the same height



Cyme

produces flat-topped with oldest flowers at the end of main axis



Spike

flowers without stalks along a central axis length



Raceme

flowers with short floral stalks along a central axis



Panicle

branched or compound raceme



Head
produce a short
dense arrangement
ray and disk flowers



Solitary
single flower on a
flowering stalk attached
to stem



Catkin
spike-like; often
pendent and falling as
a unit

Flower part

Pistil consists of the **ovary** at the base that contains the embryo seeds or **ovules**. At the top is **stigma** that receives the pollen. Often the stigma is on a stalk-like structure called the **style**. A flower may have one or more pistils.

Perfect flower: with "male" stamens and "female" pistil

Imperfect flower: (unisexual) contain a pistil or stamens, but not both

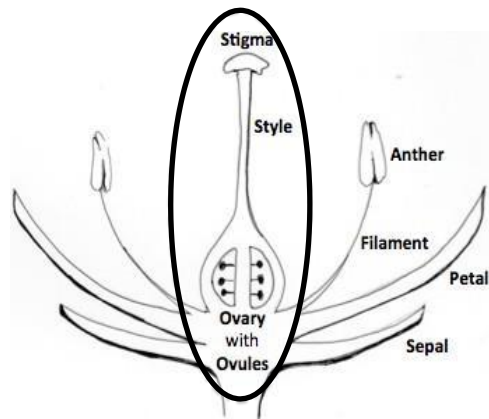
Monoecious species: with male on female flowers on same plant

Dioecious species: with male and female flowers on separate male and female plants.

Stamen is pollen producing part of a flower, usually with a slender **filament** supporting the **anther**.

Sepals are the outer parts of the flower (often green and leaf-like) that enclose a developing bud.

Petals are parts of a flower that are often conspicuously colored.



Preparation of herbarium

Introduction: The plant species with the medicinal values collected from the field need to have correct identification, naming and to be preserved for longer periods in the herbarium. Collection of samples is essential so that one can know about their growth, development, competition and management under field conditions. A herbarium is a museum and a database of dried, pressed plant specimens. Each specimen is a voucher deposited for future reference because a herbarium is a repository of information: geographical distributions, taxonomic, biological and ecological data. Herbarium preparation is a very difficult task. It involves several steps from collection to identification.

Materials: Herbarium sheets, wooden block press, old newspapers, pencil or marker, thread etc.

Procedure: The scientific method of sample collection and preparation of herbarium consists of the following important steps:

Collection: Healthy and ideal plants which are free from insect-pests and diseases are selected. The specimen(s) should include if possible all plant parts (underground parts, stems, leaves, flowers and fruits). When collecting, keep in mind that the "final" specimen, after pressing and drying has to fit on a herbarium sheet of 41.5 x 29 cm. Two to three specimens may be collected to select the best one. Every species should be given identification number. The detail such as habitat, morphology etc may be noted. The identification number should accompany throughout every stage of herbarium preparation process. The following information has to be recorded in the field note book,

- Collection number
- Vernacular name
- Plant habit (erect or prostrate, herbaceous or woody etc.)
- Colour of leaves/flowers
- Types of leaves/flowers
- Habitat (soil, water regime, soil texture, associated crop etc)
- Date of collection
- Place of collection

Also make notes on any plant characteristic that may not be obvious from the dried specimen;

e.g. colour, fragrance, etc. Collection should be made during afternoon hours of sunny days.

Pressing and drying: The purpose is to extract the moisture, so that plants do not rot or go moldy. Pressing and drying preserve the morphological integrity of the plants, which can be then mounted on herbarium paper and stored for a long time. Once the plant specimen is rooted out at right stage (at seedling, flowering and fruiting), it is necessary to press it and fit well inside the limits of folded sheets of paper. Plants with long stem or leaves may be folded into V, N or W bends but should not be doubled back in such a way as to lie across itself. Pressing plants immediately after collection results in the best herbarium specimens. The pressed plants must be thoroughly dried prior to storage and mounting. Best results are obtained with the use of an electric drier that holds the presses and provides steady bottom heat between 45°C and 60°C.

Poisoning: The plant specimen once dried need chemical treatment to protect them from insect attack and other destructive organisms. Thus, dipping of specimens is essential. The following solutions are used for the treatment.

1. Mercuric chloride (25 g) + cresol (25 g) in one litre industrial alcohol.
2. Mercuric chloride (15 g) + phenol crystals (10 g) in one litre denatured alcohol.
3. 20% lauryl pentachloro phenate in methylated sprits

The plants are re-dried. These solutions are corrosive and proper care is needed to handle them.

MOUNTING AND LABELING:

After the specimens are dried and poisoned, they are mounted on herbarium sheets. Generally the size of the herbarium sheet is 42 cm x 29 cm. The herbarium sheet should be of good quality and medium in weight. The specimens are placed in the centre of the sheet. Glue or narrow strips of adhesive tape (preferable transparent) are used to mount the specimens on the herbarium sheet. Several herbarium glues are available in the market.

Glue is applied to plant specimen only. The lower right hand corner of the herbarium sheet should bear the label containing the information as:

LABEL	
State	: Rajasthan
District	: Jaipur
Location & Habitat	: 8 km east of Jobner, Kalakh
Common Name (English)	: Field bindweed
Local	: Hirankhuri
Scientific Name	: <i>Convolvulus arvensis</i>
Description	: Perennial herb, broad leaf, trailing stem & creeping roots, loamy sand, wheat field
Collector's Address	: Vibha, B.Sc. (Ag.) Pt. I
Date & Time	: March 15, 2008

OPPORTUNITIES FOR MEDICINAL AND AROMATIC PLANTS CULTIVATION:

1. Widespread use of alternative medicine
2. Preference for natural products and chemicals from botanicals / herbs
3. Dwindling forest cover and reduced supplies from natural habitats
4. Availability of markets (global/ national)
5. Availability of high yielding varieties
6. Availability of agro-technologies
7. Availability of processing technologies
8. Profitable returns on sustainable basis

Cultivation of medicinal and aromatic plants offers following advantages:

- Generate employment through development of ancillary industries and checks migration of rural population to urban areas
- Relatively higher net returns compared to agricultural/ horticultural crops and can be integrated into existing cropping/ farming systems
- Some aromatic grasses can be used as fodder after extraction of essential oil
- Bye-products can be effectively utilized for reducing cost of cultivation and increasing profits
- Foreign exchange earnings through exports
- Efficient utilization of work-force
- Longer shelf life of end products
- Low incidence of pests and diseases

- Crops can be grown in degraded, marginal and problem soils
- Crops are theft proof
- Crops are not eaten by domestic animals
- Crops are not damaged by birds
- Crops and technologies are farmer-friendly and eco-friendly

Important Aromatic Plants Species and Their Cultivation Practices.

Trade Name/Scientific Name, Family	Commercial Application	Propagation Method	Agriculture practices
Citronella java/ <i>Cymbopogon winterianus</i> / Poaceae	Oil obtained from steam distillation of leaves in rich in citronellal and geranial and is used in perfumery, cosmetics and mosquito repellent formulations.	Vegetatively through slips during July/August and Feb/March, about 55,000 slips/ha	Irrigation: 4-6 during rain free period, fertilizer: 150 N, 60P2O5 and 60K2O kg/ha/year. Leaf blade is harvested 15 cm above the ground. First harvest comes 90 days after planting, subsequently at 3-4 months interval; economic life 4 Year
Lemon-scented gum/ <i>Eucalyptus citriodora</i> /Martaceae	The oil is used in soaps, perfumes, disinfectants, germicides and for exaction of citronellal which is used in midmarket washing and washing-up detergents.	The crop is raised through seeds; seedlings are first raised in polythene bags as the root system of the seedlings is sensitive. The seeds germinate in 4-15 days. They attain 20-30 cm height in about 12-16 weeks and are ready for transplanting.	Grow well in acidic to slightly alkaline deep soil, PH 5.5 to 8.5, Spacing 2×2 (Rainfed) and 75×75 (Irrigated), Fertilizers 60-120 kg. N in 2 or 3 equal splits, 30kg. Each of P2 O5 and K2O Per/ha. Are applied every year.
Lemongrass/ <i>Cymbopogon flexuosus</i> /Poaceae	The oils used in perfumery and cosmetic industry and also in manufacture of Vitamin A.	Through vegetative slips during Feb / March, economic life: 4-5 yr.	4-5 harvests/year, 6-8 irrigation and fertilizer; N 150,60P2O5, 60 K2O, FYM 10t/ha.,Harvesting period May to December
French/sweet basil/ <i>Ocimum basilicum</i> /Lamiaceae	The oils are used in soaps, perfumery, flavor and pharmaceutical industries and for isolation of aroma chemicals like linalool, methyl cinnamate, methyl chavicol etc.	Seeds by direct seeding or transplanting of 6-7 week old seedlings is adopted where irrigation facilities exist	Fertile and well drained loamy soil, spacing 60×40, FYM-20 t/ha, 120kg./ha N, 80kg./ha P2 O5 and 40kg/ha K2O Per/ha., Irrigation weekly once, Harvesting 65-75 days after planting when the plant is in full bloom stage.
Menthol mint/ <i>Mentha arvensis</i> /Lamiaceae	Oil is source of natural menthol used in flavour and pharmaceutical industries.	Vegetative propagation through suckers; 5q suckers for direct sowing and 1q/ha suckers are required for nursery and transplantation of seedlings	It is a 6-7 months crop, soil well drained fertile loamy soils, Spacing 45×45cm, Irrigation weekly one an time, Fertilizers N160, P2O5 50 and K2O 40 kg/ha.,First harvest 100-120 days after planting, secondharvest after another 60-70 days
Palmarosa/ <i>Cymbopogon martinii</i> /Poaceae	It is used in perfumery and cosmetic industries, flavoring of tobacco and in soaps.	Propagated during rainy season through seeds 10-12 kg/ha.Seed for direct sowing and 2.5 kg/ha.Seed are required for nursery and transplantation of seedlings	Fertilizers: N 100, P2O5 50 kg/ha/year. In poor red soil of Deccan plateau, N up to 250 kg/ha gives good result.46 irrigation (during rain free period). The crop is harvested 3-4 months after planting; 2-3 harvests obtained in the first year and 3-4 in subsequently year.Economic life 4-6 year
Rose-scented geranium/ <i>Pelargonium spp.</i> /Geraniaceae	The eaves and branches are steam distilled to get "oil of geranium" used in high-grade perfumery product and soaps.	Through stem cutting, about 40000 plants/ha during November to February	Spacing 60×60, Irrigation Alternative days for a month; later on at 5-7 days interval, fertilizer: 150-200 kg N, 60 P2 O5 and 60 K2Okg/ha., 2-3 weeding and regular hoeing are required, Harvest after about 4-5 months
Vetiver/ <i>Vetiveria zizanioides</i> /Poaceae	The roots are steam distilled to get vetiver oil, which used in high-grade perfumers.	Vegetatively through slips; planting during February and July-August; 40,000 slips/ha.	Roots are harvested 18-10 months after planting. Soils of medium fertility do not require fertilizer. For red laterite soils in South India, fertilizer N20, P2O540 kg/ha is required as basal dose at the time of planting. Vetiver is cultivated as a rain fed crop; 1-2 irrigation: required if planted during dryperiod.

IMPORTANT MEDICINAL PLANTS SPECIES AND THEIR CULTIVATION PRACTICES

Name /family	Official part and chemical constituents /uses	Propagation Method	Agriculture practices
Abelmoschus moschatus (Kasturi bhindi), Malvaceae	Seed volatile oil contain ferisol, ambrettolide oil used in perfumery, flavouring and cosmetic industries	Seeds are sown at a spacing of 60x45 cm during April- May Seed rate: 6kg/ha	Transplanting after 20 days of sowing Spacing: 60x30 cm.FYM 15 t/ha, NPK: 120:35:40 kg. ha. The pods are harvested in about 6 months during Nov.-Dec. when turn black and dried under shade. seed yield 1.5-2.0 q/ha
Andrographis paniculata (kalmegh) Acanthaceae	Whole plant Andrographolide. Flavonoids. bitter tonic used in fever, worms, dysentery, liver and digestive complaints.	Seed sowing; June Seed rate:400 g/ha Can also be propagated by cuttings	Transplanting after 45-50 days Spacing: 30x30 cm.FYM: 25t/ha NPK: 75:75:50 kg/ha. Ist harvest after 90-120 days. 2 nd harvest after 60 days of ist harvest. Before storage the harvested plants are dried for 3-4 days under shade. Dry herb yield 2-2.5 t/ha
Asparagus racemosus (Shatavar) Asparagaceae	Tuberous roots, asparagins, saponins Used for nervous disorders, cough, burnin sensation, enhance lactation	Propagated by seeds and root tubers Seed sown: April-Lune Seed rate: 1.5-2.0 kg/ha. Vegetatively through division of tuberous roots	Seedlings are transplanted when they are about 8-10 cm long. spacing: 60x60 cm.FYM: 30t/ha NPK 95:45:30 kg/ha. Roots are harvested after 18 months of sowing, washed, dried and stored in air tight containers. Fresh root yield: 140-150 q/ha Dry root yield: 12-15 q/ha.
Cassia angustifolia (Senna). Leguminosae	Leaves and pods Glycosides (Sennoside A and sennoside B). it also contains senoside D. useful in constipation, jaundice and laxative.	Can be grown in February- march or October- November. Seed rate 20 kg/ha broadcasting and seed soaking in water for 12 hrs give maximum germination of seeds.	Transplanting after 8 weeks Spacing: 45x30 cm. FYM: 5-10 t/ha NPK: 100:50:30 kg/ha. Foliage harvested after 50-90 days of sowing second picking after 90-100 days and third between 130- 150 days when entire plants are removed. harvested crop is dried in 10-12 days. Dry leaves 15 q/ha pods yield: 7 q/ha.
Catharanthus roseus (periwinkle, sadabhar) apocynaceae	Roots and leaves, Ajmalicine, serpentine, reserpine from roots Diuretic, antidiabetic Vincristine and Vinblastine have importance in cancer therapy	Nursery raising in March – April Seed rate: 500g/ha. It can be broadcasted in June-July Seed rate: 2.5 kg/ha Propagated through softwood cuttings	Transplanting after 2 months of sowing. Spacing : 40x30 cm. FYM: 10-15t/ha, NPK: 40:30:30 kg/ha. The crop is harvested after 12 months of sowing. The plants are cut and dried for stems and leaves. Yield: leaves 4 t/ha stem and roots 1.5 t/ha each
Gloriosa superb (Kalihari) glory lily liliaceae	Tubers and seeds colchine. Useful in treating gout rheumatism	Propagated by seeds or tubers.seeds are sown in Feb.-March. tubers are also planted in Feb. March	Tubers are transplanted after one year Spacing: 45x60 cm. FYM:25-30 t/ha. NPK: 40:50:75 kg/ha. harvesting of roots and capsules is done in October-November, then the capsules are dried in shade to separate pericarp. seed yield :1.5 q/ha (I-yr), 2.5-3.0 q/ha (II-yr)
Rauvolfia serpentine (sarapgandha) Apocynaceae	RootsReserpine, serpentine. Useful in snake bite, inset bite, hypertension	Propagated by seeds, stem cuttings and root cuttings. seeds sown in third week of May Seed rate: 6 kg/ha	Root cuttings (1 q/ha) are planted at spacing of 45x30 cm during spring season. Root stump: about 5 cmof roots intact with a portion of stem above the collar are directly transplanted in field. FYM; 25-30t/ha. NPK: 30:60:30 kg/ha. roots are harvested after 18 months of planting. Ist year: 11.75 g/ha 2 nd yr: 22 q/ha.
Withania somnifera (ashwangadha) Solanaceae	Roots Alkaloids such as withanine, somniferine Use insomnia, weakness, inflammation, rheumatism. Valued as potent tonic	The seeds are sown in June-July in nursery beds either by broadcasting (10-12 kg/ha) or in lines (5-6 kg/ha)	Transplanting of seedlings is done after 25030 days of sowing at spacing of 60x 60 cm. FYM: 2-3 q/ha NPK: 50:20:70 kg/ha. harvesting of roots in Dec.-Feb. after 150-180 days of sowing. Roots are cut and garded according to thickness. Dried root yield: 5-7 q/ha.

PROPAGATION OF MEDICINAL PLANTS THROUGH CUTTINGS

Major factors governing success of propagation by cuttings in MAPs

1. Physiological maturity of the cutting
2. Length of the cutting
3. Leaf retention on the cuttings
4. Season and environmental conditions
5. Influence of rooting media
6. Growth regulators
7. Role of microbial inoculants
 - a) Herbaceous cuttings:**
 - These are made from succulent, non-woody plants.
 - Terminal cuttings or nodal cuttings of 7 to 12 cm long with leaves retained at the upper end are taken.
 - *Coleus*, geranium, *Bacopa monnieri*, *Centella asiatica*, *Pogostemon patchouli* etc.
 - b) Soft-wood cuttings:**
 - Softwood cuttings are prepared from soft, succulent new growth of plants and are commonly employed for the propagation of herbs. The cuttings are usually 8 to 12 cm long with leaves retained at the upper end.
 - Examples are *Nothapodytes nimmoniana*, *Pelargonium graveolens*, *Tylophora indica*, species of mints (*Mentha* spp.), brahmi (*Bacopa monnieri*) and other herbs.
 - c) Semi-hardwood cuttings:**
 - Semi-hardwood cuttings are usually prepared from partially mature wood of the current season's growth.
 - Examples are *Adhatoda vasica*, *Bixa orellana*, *Boswellia serrata*, *Clerodendrum indicum*, *Crataegus oxyacantha*, *Embelia ribes*, *Ginkgo biloba*; *Jasminum sambac*, *Leptadenia reticulata*, *Nothapodytes nimmoniana*, *Piper longum*, *Plumbago rosea*, *Plumbago zeylanica*, *Ruta graveolens*; *Salacia fruticosa* are commonly propagated by this method.
 - d) Hardwood cuttings:**
 - Hardwood cuttings are taken from dormant, mature stems of more than one year and are commonly adopted in MAPs such as Indian Myrrh, *Rosa* spp., *Henna* etc
 - Examples are *Celastrus paniculata*, *Jasminum grandiflorum*, *Lawsonia inermis*, *Nothapodytes nimmoniana*, *Premna integrifolia*, *Rauwolfia serpentina*, *Streblus asper*, *Rosa damascena*, *Taxus baccata*, *Vitex negundo*, *Wrightia tinctoria* are propagated through hardwood cuttings.
 - e) Leaf cuttings:**
 - In leaf cuttings, the leaf blade, or leaf blade and petiole, is utilized in starting new plants.
 - Adventitious buds, shoots, and roots form at the base of the leaf and develop into a new plant; the original leaf does not become a part of the plant. Examples are *Bryophyllum*, are routinely propagated through leaf cuttings.

DIFFERENT METHODS FOR THE EXTRACTION OF ESSENTIAL OILS.

Aim: In aromatic plants essential oils are present in different forms and quantity. Their extraction method depends on different factors like condition and form of raw material, amount of essential oil and compounds, degree of volatility and economic aspects.

Methodology: Essential oils are chemical compounds with an odoriferous nature, which are highly volatile, insoluble in water obtained from herbs, flower, wood, seeds etc. by steam distillation, expression, and adsorption in fat or solvent extraction. Chemically these are mainly terpenes which act as carrier of aromatic substances. About 2000 species belonging to 60 families contain essential oil. The important are Pinaceae, Apiaceae, Myrtaceae, Rutaceae, Lauraceae, Lamiaceae, Asteraceae, Poaceae, Aracaceae, and Zingiberaceae etc. Common methods employed for extraction of essential oils include.

A. Distillation or Hydro distillation: It is most commonly used method of extraction. It is defined as separation of the components of a mixture of two or more liquids by virtue of differences in their vapour pressure. There are three methods of hydro-distillation.

- (i) Water distillation:** In this method plant material comes directly in contact with the boiling water. Through this method, powdered material like almond and others like rose petals and orange blossom are distilled.
- (ii) Water and steam distillation:** In this method plant material is supported on a perforated grid with some distance above the bottom of still, which is filled with water. In this method steam is fully saturated, wet and never super-heated. It is employed for seeds and roots.
- (iii) Steam distillation:** In this method saturated or super-heated steam is introduced through open or perforated coils below the charge or above the grid. This method used for herbs and leaf material.
- (iv) Combination** is the process of preparation of raw material for distillation. The thick and woody plant material is fragmented before distillation. Combination apparatus necessary for this operation are of various designs.

B. Enfleurage or Cold Fat Extraction: This process is applied where the distillation may have deleterious effect on the essential oil through hydrolysis, polymerization and resinification. Where delicate oil is lost in high volume of water or where flowers continue to produce fragrance after the harvest e.g. Jasmine and tuberose. An enfleurage process is carried out in cool cellars and fat base (corps) is prepared for adsorption of fragrance. Rectangular wooden frame with glass fittings are coated with fat for spreading the fresh flowers in lower surface and fat adsorption on upper surface. Normally mixture of one part of highly purified tallow (ox or sheep fat) and two parts lard (Fat of swine) gives required corps. Flowers are charged after 24 hours and saturated fat is removed, which is called pomade.

C. Maceration or Hot fat extraction: The flowers, which stopped their fragrance after harvest like rose, orange, violet and *Acacia* are extracted by maceration. In this process batch of hot fat is systematically treated with several batches of flowers until it becomes quite saturated with flower fragrance. Fragrant fat is called pomade. For every batch, extraction lasts for one and half hours. On commercial scale 80 kg of corps is heated to about 80°C temperature and charged with 20 kg of fresh flowers each time.

D. Solvent extraction: It is comparatively a recent process in which all types of perfumes are extracted with the help of volatile solvents like petroleum ether, chloroform. Fresh flowers are charged into specially constructed extractor at room temperature and treated carefully with purified solvent. Solution is pumped out in an evaporator and condensed.

E. Expression: This method involves squeezing any plant material at great pressure in order to press out the oils or other liquids e.g. Citrus oil from rinds and juices. Oil is separated from juice by centrifuging.

F. Super critical fluid extraction (SCFE): It is most recent method of extracting essential oils from the material of plant origins, where fragrance and flavour ingredients resemble their source. The raw material is enclosed in a cylindrical container with porous ends, which is located in the extraction chamber. The temperature and pressure are selected (above its critical temperature at 31°C and pressure 73.8 bars) according to the material and desired end product. Super critical carbon dioxide circulates through the plant material, dissolving the essential oil. SCCO is an excellent solvent for a wide range of natural substrates.

Terms related to essential oils:

Absolute: It is a perfume material highly concentrated and it is entirely alcohol soluble.

Concrete: It is non-purified form of essential oil obtained mostly by means of solvent extraction; plant pigment and waxes are present. From concrete 45-55% absolute is recovered.

Extrait: It is an alcoholic solution of odorous part of pomade. This is an intermediate product in the preparation of absolute from pomade.

Fixative: The materials which slow down the rate of evaporation of more volatile material in perfume composition. e.g. Sandal wood, Patchouli.

Drying and Storage Guidelines

Sl. No.	Botanical Name	Storage moisture	Drying method	Traded Parts
1	<i>Abelmoschus moschatus</i>			Seeds
2	<i>Abrus precatorius</i>	10%		Seeds (Red, White)
3	<i>Acacia sinuata</i>			Fruits
4	<i>Achyranthes aspera</i>			Whole plant, Seeds, Leaves
5	<i>Acorus calamus</i>	10%	Sun and shade dried	Rhizomes
6	<i>Adhatoda vasica</i>	10%	Sun and shade dry	Leaves
7	<i>Aegle marmelos</i>	10%	Sun and shade dried	Fruits, Fruit pulp, Leaves, Bark, Roots
8	<i>Aloe barbadensis</i>	10%	Sun and shade dry	Leaves, Leaf exudate
9	<i>Andropogon paniculata</i>	Less than 10%	Shade dry	Whole plant
10	<i>Anogeissus latifolia</i>		Shade drying	Gum
11	<i>Asperagus racemosus</i>	2-3%	Sun and shade drying	Roots
12	<i>Azadirachta indica</i>	7-8%	Drying in sun and sha	Seeds, Leaves, Flowers, Bark
13	<i>Bacopa monnieri</i>	10%	Sun and shade dry	Whole plant
14	<i>Baliospermum montanum</i>			Roots
15	<i>Boea orellana*</i>	10%	Sun and shade dry	Seeds
16	<i>Boerhavia diffusa</i>	8%	Sun dry	Roots
17	<i>Boswellia serrata</i>	1%	Shade dry	Resin
18	<i>Buchanania lanzan</i>			Seeds
19	<i>Butea monosperma</i>	10%	Shade dried	Gum, Flowers
20	<i>Caesalpinia bonduc</i>			Seeds
21	<i>Caesalpinia digyna</i>			Seeds
22	<i>Cassia absus</i>			Seeds, Roots
23	<i>Cassia fistula</i>	10%	Sun and shade dried	Fruits, Flowers
24	<i>Cassia semina*</i>	10%	Sun and shade dry	Leaves, Fruits
25	<i>Cassia tora</i>	10%	Sun and shade dry	Seeds
26	<i>Catharanthus roseus</i>	10%	Sun and shade dry	Roots, Leaves
27	<i>Catunaregam spinosa</i>			Fruits
28	<i>Celastrus paniculatus</i>	10%	Sun and shade dried	Seeds
29	<i>Centella asiatica</i>	10%	Sun and shade dry	Whole plant
30	<i>Chlorophytum borivilianum*</i> / <i>C. arundinaceum</i>			Tubers
31	<i>Citrullus colocynthis</i>			Fruits, Roots
32	<i>Cochlospermum religiosum</i>		Shade dry	Gum
33	<i>Coleus forskohlii</i> (syn. <i>C. barbatus</i>)	8%	Sun and shade dried	Roots
34	<i>Curtallia orchoides</i>	10%	Sun and shade dry	Tubers
35	<i>Cyperus rotundus</i> / <i>Cyperus scanosus</i>	10%	Sun and shade dry	Roots
36	<i>Decalepis hamiltonii</i>	10%	Sun and shade dry	Roots
37	<i>Eclipta prostrata</i>	10%	Sun and shade dry	Whole plant
38	<i>Embelia ribes</i> / <i>Embelia tsjeriam-cottam</i>	10%	Sun and shade dry	Fruits (Red, Black)
39	<i>Embelia officinalis</i>	10%	Sun and shade dry	Fruits
40	<i>Gardenia gummifera</i>	5-7%	Shade dry	Gum
41	<i>Glonosia superba</i>	10%	Sun and shade dry	Seeds, Tubers
42	<i>Gymnema sylvestre</i>	10%	Sun and shade dry	Leaves
43	<i>Helicteres isora</i>			Fruits
44	<i>Hemidesmus indicus</i>	10%	Sun and shade dry	Roots
45	<i>Holarrhena pubescens</i>	10%	Sun and shade dry	Bark, Seeds
46	<i>Holosternia ada-kodien</i>	10%	Sun and shade dried	Roots
47	<i>Ichnocarpus frutescens</i>	10%	Sun and shade dried	Roots
48	<i>Jatropha curcas</i>	10%	Sun dried	Seeds
49	<i>Lawsonia inermis</i>			Leaves, Leaf powder
50	<i>Limonia acidissima</i>			Fruits
51	<i>Litsea glutinosa</i>	10%	Sun dried	Wood
52	<i>Madhuca indica</i>	10%	Sun and shade dried	Flowers, Seeds
53	<i>Mesua ferrea</i>			Flowers, Stamens
54	<i>Manisopus elengi</i>			Flowers, Bark
55	<i>Mucuna pruriens</i>	10%	Sun and shade dry	Seeds (Black, White)
56	<i>Phyllanthus amarus</i>	10%	Sun and shade dry	Whole plant
57	<i>Piper longum</i>	10%	Shade dry	Fruits, Roots, Stem
58	<i>Plumbago zeylanica</i> / <i>Plumbago rosea</i>	10%	Sun and shade dry	Roots, Root bark
59	<i>Pongamia pinnata</i>	10%	Sun and shade dry	Bark, Seeds
60	<i>Psoralea coriifolia</i>			Seeds
61	<i>Pterocarpus marsupium</i>	10%	Sun and shade dry	Bark
62	<i>Pterocarpus santalinus</i>	10%	Sun and shade dry	Wood, Wood chips, Wood powder
63	<i>Rauvolfia serpentina</i>	5-7%	Sun and shade dry	Roots
64	<i>Rubia cordifolia</i>	10%	Sun and shade dry	Stem, Roots
65	<i>Sapindus emarginatus</i>	6-7%	Sun and shade dry	Fruits

GLOSSARY

- Achene** – [Fruits] {type} A more or less small, dry fruit that does not split open at maturity (indehiscent), with a typically thin, close-fitting wall surrounding a single seed.
- Acuminate** – [Leaf apices, Leaflet apices, Petal apices, Phyllary apices, Sepal apices] {shape} gradually tapering to a sharp point, forming concave sides along the tip
- Acute** – [Leaf apices, Leaflet apices, Petal apices, Phyllary apices, Sepal apices] {shape} Tapering to a pointed apex with more or less straight sides, the sides coming together at an angle of less than 90°. (Compare with acuminate and obtuse.)
- Aerial stem** – [Stems] {type} A prostrate to erect, above ground stem.
- Aggregate fruit** – [Fruits] {type} A cluster of fruits that stick together or are fused, originating from two or more separate pistils contained within a single flower, as in blackberry (*Rubus*). (Compare with multiple fruit.)
- Alternate** – [Leaves] {insertion} Positioned singly at different heights on the stem; one leaf occurring at each node.
- Androecium** – A collective term for all the stamens and any closely associated structures in a flower.
- Axillary** – [Buds, Inflorescences, Seed cones] {position} On the stem just above the point of attachment of a leaf (or leaf scar) or branch; borne in the axil of a leaf or branch
- Bifoliolate** – [Leaves] {complexity form} Compound with two leaflets; two-leafleted or geminate.
- Bipinnately compound** – [Leaves] {complexity form} With two orders of leaflets, each pinnately compound; twice pinnately compound. (Compare with once pinnately compound and tripinnately compound.)
- Bisexual (1)** – Having functional reproductive structures of both sexes (i.e. male and female) in the same flower or cone.
- Bristle** – A slender, more or less straight and stiff, fine-pointed appendage; may be located at the tip of a leaf or bract and a continuation of the midvein, or comprising the pappus in fruits of the sunflower family (*Asteraceae*).
- Bulb** – [Stems] {type} A short, vertical, usually underground stem with fleshy storage leaves attached, as in onions (*Allium cepa*).
- Caducous** – [Petals, Sepals, Stipules] {persistence} Falling off very early, as stipules that drop soon after the leaf develops.
- Capsule** – [Fruits] {type} A dry fruit that opens (dehisces) in any of various ways at maturity to release few to many seeds.
- Carpel** – The basic ovule-bearing unit of flowers, thought to be evolutionarily derived from an infolded leaf-like structure; equivalent to a simple pistil or a division of a compound pistil.
- Catkin** – [Inflorescences] {type} A pendent, more or less flexible, spike-like inflorescence with numerous small flowers, typically of only one sex (unisexual), lacking petals and subtended by scaly bracts, as in willows (*Salix*) and birches (*Betula*); catkins are often wind pollinated and fall as a unit after flowering or fruiting.
- Caudate** – [Leaf apices, Leaflet apices, Petal apices, Phyllary apices, Sepal apices] {shape} Ending in a long, tapering, straight or curved, flexible tip; tailed.
- Cauline** – [Leaves] {position} With leaves positioned along the stem above ground level.
- Compound** – [Leaves] {complexity} Divided into two or more equivalent parts, as a leaf that consists of multiple, distinct leaflets; not simple.
- Cordate** – [Leaf bases, Leaflet bases, Leaflets, Leaves] {shape} Heart-shaped, with the notch at the base.
- Corymb** – [Inflorescences] {type} A racemose inflorescence with the individual flower stalks (pedicels) progressively shorter toward the apex so the flowers are all at about the same level, forming a flat or rounded surface across the top.
- Cymose** – In the form of a simple or compound cyme; bearing cymes.
- Decurrent** – [Leaf bases, Leaflet bases] {shape} With the leaf base extending downward along the stem.
- Deltoid** – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} Similar in shape to an equilateral triangle, with the point of attachment along one of the sides; like the Greek letter delta.
- Drupe** – [Fruits] {type} A fleshy fruit that does not split open at maturity (indehiscent), with a soft outer wall and one or more hard inner stone(s) each usually containing a single seed, as cherries and plums (*Prunus*).
- Elliptic** – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} Widest near the middle, with convex sides tapering equally toward both ends [modified from W&K, p. 36]; in the shape of an ellipse or narrow oval.
- Emarginate** – [Leaf apices, Leaflet apices, Petal apices, Phyllary apices, Sepal apices] {shape} With a notch at the apex.
- Ensiform** – [Leaflets, Leaves] {shape} Long and moderately slender, flat in cross section, gradually tapering to a pointed apex; sword-shaped; as an Iris leaf. (Compare with awlshaped, linear and lorate.)
- Fascicled** – [Leaves] {insertion}; [Needles] {presence of clusters or fascicles} In a tight bundle, several leaves appearing to arise from a common point and diverging little if at all, as the needles of many pines (*Pinus*).
- Filiform** – [Leaflets, Leaves] {shape} Long and very slender, basically round in cross section and of uniform diameter; thread-like.
- Follicle** – [Fruits] {type} A usually dry fruit, with one interior chamber or locule, and splitting open (dehiscing) lengthwise along a single line, as in milkweed (*Asclepias*).
- Fusiform** – [Buds] {shape} Elongate, broadest at the middle, evenly tapering to either end, and rounded in cross section; spindle-shaped.
- Glabrous** – [2-4-year-old twigs, Buds, Leaf lower surface, Leaf upper surface, Petals, Petioles, Phyllaries, Rachises, Sepals, Young twigs] {pubescence} Lacking plant hairs (trichomes).

Glaucous – [Buds, Young twigs, Leaves] Covered with a whitish or bluish waxy coating (bloom) that can sometimes be rubbed off.

Globose – [Buds] {shape}; [Seed cones] {shape before opening, shape when open} Circular in cross section and in outline when viewed from any angle; like a globe or sphere.

Glutinous – Gluey, sticky or gummy; covered with sticky exudates.

Herbaceous – [Plants] {woodiness} having little or no living portion of the shoot persisting aboveground from one growing season to the next, the aboveground portion being composed of relatively soft, non-woody tissue.

Hispid – [Buds, Leaf lower surface, Leaf upper surface, Phyllaries, Sepals, Young twigs] {pubescence type} with stiff, bristly, usually stout-based hairs.

Hypogynous – [Flowers] {perianth position} With the perianth (the whorl of sepals and petals) not fused into a floral cup of any kind and arising at the same level as the base of the ovary.

Imbricate – [Leaves] {habit} Overlapping, as the shingles on a roof.

Indehiscent – Not splitting or forming an opening at maturity, the contents being released for dispersal only after decay, digestion or erosion of the structure, as certain fruits, such as achenes and berries, that retain their seeds when ripe.

Involute – [Leaf margins, Leaflet margins] {vertical disposition} With margins rolled inward, toward the upper side.

Lanceolate – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} Several times longer than broad, widest near the base and tapering to a point at the apex; lance-head-shaped. (Compare with oblanceolate.)

Legume – [Fruits] {type} A usually dry fruit that splits open (dehiscence) lengthwise along two sutures and has a single interior chamber (locule), as in the pea family (Fabaceae). (Compare with loment.)

Mericarp – [Fruits] {type} One of the segments of a schizocarp once it has split apart, often appearing to be a separate fruit; usually one-seeded and not splitting open at maturity (indehiscent); as the small, relatively hard-coated “nutlets” in the mint family (Lamiaceae) or the individual winged samaras of maples (*Acer*)

Monoecious – [Plants] {distribution of gender} Having functionally unisexual (i.e. separate male and female) flowers or cones, which are borne on the same plant; each plant thus possessing both male and female reproductive structures.

Multilocular – With more than one interior compartment or locule.

Nearly sessile – [Flowers, Leaflets, Leaves, Seed cones] {form of attachment} With a very short, somewhat indistinct stalk.

Not persistent – [Seed cones] {persistence} Falling from the branch soon after shedding seeds.

Oblong – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} Shaped like a compressed oval, with the sides approximately parallel for most of their length.

Obovate – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} Egg-shaped with the point of attachment at the narrower end; inversely ovate.

Orbiculate – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} approximately circular in outline.

Ovate – [Leaflets, Leaves, Petals, Phyllaries, Sepals] {shape} Egg-shaped in outline, with the broader end near the base.

Ovule – The structure in flowering plants and gymnosperms which when fertilized develops into a seed.

Palmately lobed – [Leaflet, Leaves] {lobing form} With three or more main segments or lobes essentially arising from a common point near the base of the leaf or leaflet blade; lobed in a hand-like pattern

Panicle – [Inflorescences] {type} A branched raceme, the main axis either determinate or indeterminate, and the lateral branches racemose; more loosely, a much-branched inflorescence of various types.

Parietal – [Placentation] {type} Attachment of ovules on the inner wall, or intrusions of the wall, of a compound ovary with a single inner compartment (unilocular). (Compare with marginal placentation.)

Peltate – [Leaf bases, Leaflet bases] {shape} Having the leaf stalk (petiole) attached to the lower surface of the leaf, usually near the center.

Perianth – The collective term for the outer sterile parts of a flower, comprising the calyx (sepals) and the corolla (petals) when both whorls are present.

Pinnately lobed – [Leaflets] {lobing form} with several main segments or lobes positioned along and on either side of a central axis; lobed in a feather-like pattern. (Compare with palmately lobed.)

Pistillate – [Flowers] {gender} Having functional pistils, but no functional stamens, making the flower unisexual and female.

Placentation – The arrangement of ovules within the ovary.

Polygamous – [Plants] {distribution of gender} Having both bisexual (combined male and female) and unisexual (separate male and female) flowers or cones, which are borne on the same plant or on different plants of the same species.

Reflexed – [Leaves, Petals, Sepals] {vertical orientation} Bent backward or downward. (Compare with appressed, ascending and spreading.)

Reniform – [Leaflets, Leaves] {shape} Broader than long, broadly rounded and notched at the base; kidney-shaped.

Reticulate – [Leaf venation, Leaflet venation] {form} With a clearly visible network of interconnecting veins.

Rosetted – [Leaves] {habit} With leaves in a tight cluster radiating from a central axis, usually at or near the base of the stem, as in dandelion (*Taraxacum*).

- Samara** – [Fruits] {type} A winged, more or less dry fruit that does not split open at maturity (indehiscent), and contains a single seed, as in ash (*Fraxinus*) and maple (*Acer*)
- Serrate** – [Leaf margins, Leaflet margins, Petal margins, Phyllary margins, Sepal margins] {form} Toothed along the margin, the sharp teeth pointing forward; saw toothed. (Compare with crenate, dentate and serrulate.)
- Sessile** – [Flowers, Leaflets, Leaves, Seed cones] {form of attachment} Without a stalk, positioned directly against the bearing structure. (Compare with petiolate, petiolate, nearly sessile and stalked.)
- Siliqua** – [Fruits] {type} A dry fruit that splits open (dehiscence) along two sutures, the exterior walls eventually falling away in two halves, leaving a single, persistent, interior partition (septum) to which the seeds are attached; usually at least twice as long as wide; common in the mustard family (*Brassicaceae*). (Compare with silicle.)
- Sinus** – The space or recess between two divisions or lobes of an organ such as a leaf or petal.
- Spathe** – An often large, sometimes colored and flowerlike bract subtending and sometimes partially enclosing an inflorescence, as in calla lily (*Zante deschia*) or jack-in-the-pulpit (*Arisaema triphyllum*).
- Spinose** – [Leaf apices, Leaflet apices, Petal apices, Phyllary apices, Sepal apices] {shape} Ending in a rigid, tapering, sharp tip; bearing a spine at the apex.
- Staminate** – [Flowers] {gender} Having one or more functional stamens, but no functional pistils, making the flower unisexual and male.
- Stipule** – A relatively small, typically leaf-like structure occurring at the base of a leaf stalk (petiole), usually one of a pair; stipules are sometimes in the form of spines, scales or glands.
- Succulent** – [Plants] {habit} Juicy, fleshy and often thickened, as the stem of a cactus or the leaves of Aloe
- Superior** – [Ovaries] {position} With the ovary not fused to any portion of a floral cup, the whorl of sepals and petals (perianth) and/or stamens (androecium) thus arising from beneath the ovary.
- Tomentose** – [Buds, Leaf lower surface, Leaf upper surface, Petioles, Phyllaries, Sepals, Young twigs] {pubescence type} With tangled woolly hairs.
- Trichome** – Any type of plant hair (except for root hairs).
- Trifoliolate** – [Leaves] {complexity form} Compound with three leaflets; three-leafleted or ternate. (Compare with bifoliolate, biternate and triternate.)
- Truncate** – [Leaf apices, Leaflet apices, Petal apices, Phyllary apices, Sepal apices] {shape} With the apex cut more or less straight across; ending abruptly, almost at right angles to the midrib.
- Unifoliolate** – [Leaves] {complexity form} A structurally compound leaf with a single leaflet, making it appear simple, the compound nature of the leaf evident by a distinct articulation in the leaf stalk, as in redbud (*Cercis canadensis*); one-leafleted
- Unilocular** – With a single interior compartment or locule.
- Valvate** – [Bud scales] {type} With scales (usually two) meeting by the edges without overlapping.
- Whorled** – [Leaves] {insertion} With three or more leaves positioned on the stem at the same level; three or more leaves occurring at each node.
- Winged** – [2-4-year-old twigs, Petioles, Rachises] {special surface features} Having one or more elongate, relatively thin protrusions or appendages that loosely resemble wings, as the twigs of winged elm (*Ulmus alata*).