The Complete Book on Spices & Condiments (with Cultivation, Processing & Uses) 2nd Revised Edition
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The term spices and condiments applies to such natural plant or vegetable products and mixtures thereof, used in whole or ground form, mainly for imparting flavor, aroma and piquancy to foods and also for seasoning of foods beverages like soups. Usually spices are an ingredient used to season a dish in the meal during its preparation and condiments are for using at the table to enhance the dish as each individual's tastes prefer. The great mystery and beauty of spices is their use, blending and ability to change and enhance the character of food. Spices and condiments have a special significance in various ways in human life because of its specific flavours, taste, and aroma. Spices and condiments play an important role in the national economies of several spice producing, importing and exporting countries. India is one of the major spice producing and exporting countries. Most of the spices and herbs have active principles in them and development of these through pharmacological and preclinical and clinical screening would mean expansion of considerable opportunities for successful commercialization of the product. Spices can be used to create these health promoting products. The active components in the spices phthalides, polyacetylenes, phenolic acids, flavanoids, coumarines, triterpenoids, serols and monoterpenes are powerful tools for promoting physical and emotional wellness.

Some of the fundamentals of the book are definition of spices and condiments nomenclature or classification of spices and condiments, Indian central spices and cashew nut committee, origin, properties and uses of spices, forms, functions and applications of spices, trends in the world of spices, yield and nutrient uptake by some spice crops grown in sodic soil, tissue culture and in vitro conservation of spices, in vitro responses of piper species on activated charcoal supplemented media, soil agro climatic planning for sustainable spices production, potentials of biotechnology in the improvement of spice crops, medicinal applications of spices and herbs, medicinal properties and uses of seed spices, effect of soil solarization on chillies, spice oil and oleoresin from fresh/dry spices etc.

The present book contains cultivation, processing and uses of various spices and condiments, along with photographs of machinery/equipments with addresses of their manufacturers. The book is an invaluable resource for new entrepreneurs, agriculturists, agriculture universities and technocrats.

Content:
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First International Search for Indian Spices
Role of the ICAR in Spice Development in India
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AJOWAN
Sometimes mislabeled as lovage seeds, ajowan is a popular spice in Indian, Pakistani, Iranian and Ethiopian cooking. It is an essential ingredient in a Bengali seasoning called panchphoran. Omam water, an infusion of ajowan seeds, has been used since ancient times in India for stomach pains, colic, diarrhea and other bowel disorders.

Scientific Name(s): Trachyspermum ammi, T. copticum or Carum copticum. Family: Apiaceae (parsley family).

Common Names: ajwain, carom, wild parsley. It is also called netch azmud (Amharic), taleb el koub (Arabic), jowan (Bengali), bishop’s weed (English), nanava (Farsi), ajowan (German, Italian), ajwain/carom (Hindi), ayamodakam (Malayalam), assamodum (Singhalese) and omam (Tamil).

Origin and Varieties: ajowan is indigenous to southern India but is also cultivated in Europe, Egypt, Pakistan, Iran and Afghanistan.

Form: it is a small, caraway-like seed that is used whole or ground.

Properties: ajowan is a close relative of caraway, dill and cumin. It has large curved and ridged oval, celery-like seeds that are light brown to purplish red in color. Ajowan seed looks like celery seed and when bruised has a taste similar to thyme but stronger. It has piney, phenol-like and slight lemony notes. When crushed or ground, it has a more intense flavour. It can be bitter and slightly spicy. Its leaves, stems and roots are aromatic.

Chemical Components: ajowan contains 2.5% to 5% essential oil, mainly thymol (35% to 60%), along with $\beta$-pinene, $\beta$-cymene, limonene and $\beta$-terpinene.

Ajowan Contains Calcium and Iron

How Prepared and Consumed: ajowan is commonly used by North Indians, Pakistanis, North Africans and Iranians. It is used whole or ground and has a natural affinity with starchy foods, such as root vegetables, legumes, breads, snacks and green beans. Ajowan makes starch and meats easier to digest and is added to legumes to prevent flatulence. It goes well with cumin, ghee, garlic, ginger and turmeric. In North India, ajowan seeds are fried in ghee with other spices, and this aromatic mixture is added to cooked legumes and vegetables. The seeds are also used in a fried bread called paratha, added to snacks (pakora) and pastries and served with nuts. In Bengal, it is used as part of a seasoning called panchphoran, which goes well with fish and vegetable curries. To enhance its flavor, ajowan is roasted or fried in oil until it becomes light brown. It then provides a more intense aroma to fish curries, lentil stews and potatoes. In Ethiopia, ajowan is an integral part of a spice blend called berbere, which is used in meat stews and vegetables.

Spice Blends: berbere, chat masala, panchphoran and pakora filling blend.

Therapeutic Uses and Folklore: ajowan is highly valued in India as a stomach medicine and an antiseptic. It is combined with salt and hot water to control flatulence and indigestion. Ajowan was also a traditional remedy for cholera and fainting spells.

Ajowan is an ingredient in mouthwashes and toothpastes because of its antiseptic properties.

ALLSPICE
The English derived the name allspice because the flavors of several spices, such as cloves, cinnamon, nutmeg and black pepper are combined in it. Native to the Caribbean and the Americas, Spanish explorers named it pimienta or pepper because the allspice berry resembles a large black peppercorn. Pimienta was eventually anglicized to pimento. Also called Jamaican pepper, allspice is not related to the peppercorn. It was first imported into Europe in 1601 as a substitute for cardamom.
Pimenta dioica, formerly P. officinalis. Family: Myrtaceae (myrtle family).

Common Names: Jamaican pepper, pimento, clove pepper. Also, pepe di Giamaica, baharat, Ib'harhelo (Arabic), piment (French, German, Dutch), pimento (English, Italian), toute-épice/poivre de Jamaique (French), nelken-pfeffer (German), pilpel hodi (Hebrew) orusupaisu (Japanese), kappalmulagu (Malayalam), kryddpeppar (Swedish), pimienta gorda and pimenta de Jamaica (Spanish), kattukaruva (Tamil) and yeni bahar (Turkish).

Origin and Varieties: there are many types of allspice, each with varying tastes. It is indigenous to the Caribbean Islands, specifically Jamaica, South America (Brazil, Leeward Isle), Central America (Guatemala, Honduras) and Mexico. Allspice is also grown in India and Reunion. The U.S. buys mainly from Central America and Mexico.

Form: the berry/seed of the pimiento tree is picked green/unripe and then dried until it turns dark reddish brown in color. It is globular and has a rough textured surface. It is slightly larger than the black peppercorn. The Mexican type is the largest and darkest in color. Jamaican allspice berries are smaller. Allspice is used whole or ground. The aromatic leaves and bark can also be used to provide an allspice-type flavor to foods, especially to smoked meats and beverages.

Properties: allspice has a warm, pungent taste and the aroma of cloves with sweeter, floral background notes. Its flavor has a hint of cinnamon, mace and nutmeg with peppery overtones. Jamaican allspice is the most aromatic. The Mexican variety is less sweet and more mellow than the Jamaican or Central American types. Allspice berries lose their aroma upon ripening, so they are collected in an unripe stage and are dried in the sun until they turn dark reddish brown in color. The leaf has a different, woodier aroma and a less intense, coarse, flavor. The bark has coarse woody notes than the leaf.

Chemical Components: the allspice berry contains 1.5% to 5% essential oil, which is colorless to reddish yellow. The Jamaican type has up to 5% essential oil, Guatemalan-3%, Mexican-1.4% to 3% and Honduran-1.3% to 4%. Jamaican allspice has a minimum of 65% phenols, mainly eugenol (68-78%), methyl eugenol (2.9-13%), 1,8-cineol, ?-phellandrene, humulene, terpinolene and caryophyllene. The fixed oil content is about 6%. The Mexican variety has a high myrcene content (5%). Allspice has over 8% quercitannic acid that provides its astringency.

The Jamaican variety produces the most leaf oil-its fresh leaf contains 0.35% to 1.25% essential oil (dried leaf has higher oil, from 0.7% to 2.9%). The essential oil contains 80-90% phenols, mainly eugenol, ?-pinene, caryophyllene, limonene, 1,8-cineole and good amounts of tannin. The bark contains small amounts of eugenol and higher levels of tannin.

The oleoresin is brownish green to dark green in color. About 2-1/2 lbs. of essential oil will replace 100 lbs. of freshly ground spice, while 5 lbs. of oleoresin will replace 100 lbs. of freshly ground spice.

Dried allspice has calcium, potassium, sodium, manganese and beta-carotene.

How Prepared and Consumed: the Aztecs and Mayans flavored their chocolate drink with allspice seeds. Caribs and other indigenous Americans used it for preserving fish and meat. This practice was learned by the Spanish who also used allspice to preserve meats. During the seventeenth century, pirates in the Caribbean smoked and barbecued meat with allspice, which they called boucan.

Nowadays, allspice seeds are typically used whole as part of a spice blend for pickling and marinating fish. In the U.S., allspice is ground for use in seasonings and sauces, and its extracted oils are used in sausages. Allspice is also used in ketchup, jams, pumpkin pies, gravies, roasts and ham. It goes well with smoked pork, beef and fish and with habaneros, cumin, onions, tamarind, cinnamon and cloves. Allspice leaf is used in baked goods, chewing gum, candy, ice cream, fruit soups, teas and liqueurs.

Allspice is the most important spice in Caribbean cooking and is used in curries, stews, barbecues and sweet potatoes. Jamaica's popular jerk seasoning has ground allspice as its main ingredient. It is rubbed over pork, chicken or fish that are then cooked over a fire. It gives a smoky and spicy flavor to the
barbecued product. Allspice leaves are sometimes stuffed into the meat that is then barbecued over allspice wood or bark to give it the typical flavor of "jerk."

In Oaxaca, Mexico, allspice is used in certain moles. In India, it becomes part of some curry blends. Scandinavians use it to preserve herring. The English use ground allspice in cakes, puddings, mincemeats, pickled vegetables, sausages and cured meats. In North Africa, allspice is used in Ethiopian berberes and Moroccan ras-el-hanout spice blends. Middle Easterners flavor stews, kibbeh (ground lamb with cracked wheat) and pilafs with ground allspice.

**Spice Blends:** jerk seasoning, berbere, ras-el-hanout, quatre-epices, fish pickling blend, ketchup blend and Jamaican curry blend.

**Therapeutic Uses and Folklore:** the Aztecs and Mayans used allspice to embalm bodies because of its preservative qualities. It was also considered an aphrodisiac.

Allspice has been used to promote digestion and remove gases from the upper intestinal tract. It is used as a mild anaesthetic for aching gums and teeth and as a mild pain reliever for muscles and joints.

Allspice has bactericidal, fungicidal and antioxidant properties.

**ANISE/ANISEED**

Anise/aniseed is a popular spice used throughout the world. It was called anysum by early Arabs, anison by Greeks and then anise by the English. Ancient Assyrians used anise as a medicine, Greeks found it to be a digestive aid, and the Romans used anise to soothe sore throats. It was used as an aphrodisiac and as a charm against nightmares.

Associated with the taste of licorice, the Portuguese called anise erva doce, the "sweet herb," and the Indonesians called it jintan manis, the "sweet seed." Asian Indians often confuse anise with fennel because its flavor and name, saunf, are similar to fennel. In China, anise is commonly used with fennel and star anise to add a savory, sweet flavor to barbecues.

**Scientific Name(s):** *Pimpinella anisum*. Family: Umbelliferae (carrot family).

**Common Names:** sweet cumin, aniseed and common anise. It is also called yansoon (Arabic), anisjs (Dutch), anisun (Farsi), anis vert (French), anis (German, Swedish, Russian), anison (Hebrew), patli saunf (Hindi), anise (Italian), anisu (Japanese), jintan manis (Malaysian, Indonesian), huei shiang (Mandarin), erva doce (Portuguese), anis (Tagalog), shombu (Tamil, Malayalam), anis (Spanish) and cay vi (Vietnamese).

**Origin and Varieties:** it is indigenous to Greece, Egypt, Crete, Turkey and Lebanon. Anise is also grown in Mexico, Chile, Argentina, Syria, Spain, Italy, India, Pakistan, China, Russia, Japan and Germany.

**Form:** anise is a dried ripe fruit or seed. It is small, oval, greenish gray to yellow brown, with a ridged or ribbed surface. Anise is sold whole, cracked or ground. When it is ground into powder, anise quickly loses its flavor.

**Properties:** anise seed has a sweet licorice-like taste and is warm, fruity and camphoraceous. Anise's flavor is similar to fennel and star anise, but it is more delicate. Its leaves are also aromatic.

**Chemical Components:** depending on its source, anise seed has 1-1/2% to 6% essential oil, mainly trans-anethole (80-90%), methyl chavicol (10-15%), iso-anethole (2%) and anisaldehyde (less than 2%). It has 8% to 20% fixed oil. The leaf has a much lower level of essential oil.

About 2-1/2 Ibs. essential oil is equivalent to 100 Ibs. freshly ground spice. and 8-1/4 Ibs. oleoresin will replace 100 Ibs. freshly ground spice.

Anise contains iron, potassium, phosphorus and calcium.

**How Prepared and Consumed:** the early Romans used anise to flavor a special cake called mustaceum that was served as a dessert to aid digestion. They also mixed anise with vinegar and honey and used the mixture as a tonic to soothe sore throats. This spice tends to be used in sweet foods in Europe, while in Asia, anise is combined with pungent, spicy ingredients for savory applications. Anise goes well with fruits,
sugar, fennel, wine and cinnamon. Anise leaves and stalk can garnish fruit salads and are sometimes added to fish soups and cream sauces. They are roasted or sautéed in oil with other spices to enhance stewed vegetables, roasted meats, curries and tomato sauces.

The Portuguese, Germans, Scandinavians, French and Italians use anise to flavor cakes, sweet rolls, cookies, sweets, applesauces, rye bread, churek, pancakes, cheeses, relishes, marinated meat and fish, beef stew, salad dressings, sausages and luncheon meats.

Europeans flavor many liqueurs and spirits with anise, such as anisette, arrack, sambuca, pernod, pastis and even juice drinks and teas.

Middle Easterners use anise in sweet and savory dishes, and it is the fundamental ingredient in their local spirits, ouzo and raki. Syrians use it in a beverage called miglee and in their popular fig jams.

**Spice Blends:** curry blends, hoisin, tomato sauce blends, sausage blends and betel leaf mixture.

**Therapeutic Uses and Folklore:** traditionally, Europeans used anise to treat epilepsy and to ward off evil. The Aztecs drank tea made from its flowers and leaves to relieve coughing. Anise can dispel gas and aid digestion, improve appetite and alleviate cramps, nausea and colic in infants. Anise is commonly used in lozenges and cough syrups because it is a mild expectorant. It also soothes insect bites and is chewed to induce sleep. In India, anise seeds are served after meals to aid digestion and sweeten breath. Anise shows antifungal activity.

### Forms, Functions and Applications of Spices

**INTRODUCTION**

Spices are the building blocks of flavor in food applications. Food developers who wish to use these building blocks effectively to create successful products must understand spices completely. The word "spice" came from the Latin word "species," meaning specific kind. The name reflects the fact that all plant parts have been cultivated for their aromatic, fragrant, pungent or any other desirable properties including the seed (aniseed, caraway, coriander), leaf (cilantro, kari, bay, mint), berry (allspice, juniper, black pepper), bark (cinnamon), kernel (nutmeg), aril (mace), stem (chives), stalk (lemongrass), rhizome (ginger, turmeric, galangal), root (lovage, horseradish), flower (saffron), bulb (garlic, onion), fruit (star anise, cardamom, chile pepper) and flower bud (clove).

For people throughout the world, spices stimulate the appetite, add flavor and texture to food and create visual appeal in meals. Called rempah (Malaysian and Indonesian), beharat (Arabic), besamim (Hebrew), epices (French), kruep tet (Thai), masala (Hindi), specie (Italian), especierias (Spanish), sheng liu (Mandarin), specerijen (Dutch), kroolder (Norwegian) or kimem (Ethiopian), spices have been savored and sought around the world from the earliest times because of their diverse functions.

Nowadays, food professionals continually search for "new" and unique spice flavorings because of the growing global demand for authentic ethnic and cross-cultural cuisines. Consumers are also seeking natural foods and natural preservatives for healthier lifestyles and natural ways of preventing ailments. So, spices are also being sought for their medicinal value, as antioxidants and as antimicrobials.

This chapter describes: the different forms in which spices are sold and their composition, the primary and secondary functions of spices in applications, the techniques for preparing spices, the methods for applying spices in product development, and the methods for assuring proper quality control in spices.

**SPICE FORMS AND COMPOSITION**

Spices are available in many forms: fresh, dried, whole, ground, crushed, pureed, as paste and as extractives. Each form has its respective qualities and drawbacks. The form chosen by the food product designer will depend on the specific application, processing parameters and shelf life.

**FRESH WHOLE SPICES**

Consumers prefer the taste of freshly made food. The "fresh" taste consumers seek from spices comes
initially from their aroma. This aroma is due to the volatile component of the spice. It can be lost during harvesting, storing, processing or handling. For some spices, the fresh forms have different flavor profiles than the dried forms, examples include ginger, cilantro or basil. Fresh ginger has been found to be less pungent than dried ginger because fresh ginger has less shogaols (non-volatile constituents that cause pungency) than dry ginger.

Fresh ingredients, especially whole spices, when freshly ground give prepared foods a fresh taste. Fresh spices provide crunchy, crispy textures and colorful appeal. Fresh whole spices also become very aromatic when they are roasted or fried in oil, and their aroma transfers to the application. This is especially true of whole or cracked seeds and leaves, such as bay leaf, kari leaf or mustard seeds.

Whole spices provide aroma and, most importantly, texture and visual effect. Certain spices have a strong aroma when fresh, such as basil, garlic, onion and cilantro, due to their high volatile (essential) oils. The essential oils disappear quickly at high temperatures, especially if the spices are processed in an aqueous system, but they can also be lost at room temperatures or when the spices are cut or bruised.

While uneven distribution of whole spices in a product can be problematic, this effect is sometimes desired to achieve nuttiness or a sensation of "bite" into a whole spice, such as whole sesame seeds on a breadstick or ajowan seeds on Indian naan bread. In this regard, whole spices can become the major flavor characterizing a product. Also, whole spices, especially the leafy spices, provide great visual appeal as garnishes.

Flavor is intact in the whole spice and is more slowly released than with the ground spice, especially when subjected to preparation techniques such as frying or roasting, during which time, the whole spice slightly cracks open.

In a whole spice, the chemical components that provide the flavors vary in concentration throughout the spice. In chile peppers, the greatest concentrations of pungent compounds are found in the inner portions, such as the veins and seeds.

In many whole spices, cooking or processing changes the spices chemical compounds and their proportions to varying degrees, often giving rise to different flavors. For example, smoking, grilling or drying certain chile peppers significantly changes their flavor and color. When jalapeno is smoked and dried, it changes its flavor and color completely, giving it a new identity, called chipotle.

Spices that do not have a strong aroma, such as bay leaf, chile pepper or sesame seed, develop intense flavor after roasting or boiling. Mustard seed, star anise and fagara (Szechwan pepper) are generally dry roasted to intensify their flavors for meat, fish and poultry dishes.

Many spices, such as lemongrass, spearmint, basil and chile peppers, are blended fresh and are used in making sauces and condiments with water, oil, wine or vinegar. The fresh pureed or paste forms have intense flavors and need to be mixed well before application in sauces, soups or gravies. Since the paste form usually contains oil, it can become rancid in a shorter period of time.

Consumers want to use "fresh" spices, but usually their flavors, colors and textures are lost during storage and prolonged processing. Preliminary preparations, such as grinding, roasting or flaking of whole spices, need to be done before adding them to processed foods.

Consistency is also more difficult to achieve in fresh spices because their origin, age and storage conditions cause flavor variations. Therefore, dry spices and spice extractives are, by necessity, the forms most often used to formulate foods or beverages. Fresh whole spices are not frequently found in processed foods, but are generally used in restaurants, in home cooking and in other smaller scale applications.

The goal for a food designer is to develop products that will have the "fresh" quality desired by consumers but that have spice-sensory attributes that can withstand processing, freezing and storage conditions.

DRIED SPICES
Spices are often used in their dried forms because they are not subject to seasonal availability, are easier to store, are more uniform and have a longer shelf life. 

DRIED SPICES
to process, have longer shelf life and have lower cost. These dried forms are most frequently used for processed products or for wholesale usage. Dried spices come whole, finely or coarsely ground, cracked and as various-sized particulates. Spices are ground by milling them to various sized particulates. This grinding also generates rapid air movement and heat that dissipate some of the volatile oils and even change some natural flavor notes through oxidation.

Depending on its form, the same dried spice will deliver different flavor perceptions in the finished product. Ground spices have better dispersibility in food products than fresh whole spices. Some volatile oils are released through grinding, which partially breaks down the cellular matrix of the spice. In some spices, flavor is intensified through drying because of the elimination of most moisture. This leaves a greater concentration of the low volatile compounds that give stronger flavor but less aroma due to the loss of the volatile constituents. Dried spices can better withstand the higher temperatures and processing conditions than fresh spices.

Some dried spices can be used to characterize an application’s flavor and texture. Garlic and onion, which come powdered, granulated, ground, minced, chopped and sliced and in various sized particles, characterize flavor and texture in garlic bread, onion bagels or chips.

Whether a dried spice is used ground, granulated, cracked or whole will depend on its use in specific applications. Many ground spices need to be “rehydrated” in order to develop their flavor, such as ground mustard that becomes pungent only when water is added. This addition of water triggers an enzyme reaction that releases the spice’s aroma. Acidulents, oil or vinegar are also added to preserve the pungency or intense flavors of the spice in the finished product.

In processed foods, dried spices can be more economical to use than fresh spices. For example, dried leafy spices do not require the cutting, chopping or grinding preparation that the fresh forms do. Also, most dried spices retain a higher overall flavor concentration than fresh spices. For example, one pound of dried garlic has an equivalent flavor of five pounds of fresh garlic.

The sensory, physical and chemical characteristics of dried spices are determined by environment, climate, soil conditions, time of harvesting and post-harvest handling. The same type of spice can have different sensory characteristics depending on where it was grown and how it was harvested, stored and processed. For example, dried ginger from India has a subtle lemon-like flavor, dried ginger from southern China comes with slightly bitter notes and ginger from Jamaica has more pungent flavor. Similarly, ground black pepper, which comes from a dried berry called peppercorn, varies in flavor intensity depending on its origins. Black peppercorns from Tellicherry are highly aromatic (India), while Lampong (Sumatra) pepper is less aromatic with more pungency. The Malaysian and Brazilian peppercorns, in contrast, have milder aromas with stronger bites.

For most spices, the time period between harvesting and storage and between when the spice is ground and added to a food are crucial for obtaining its maximum potential.

The way a spice is treated or processed before being ground, and the conditions of storage before delivery to the food processor, create flavor and color differences. Spice flavor can be readily oxidized, and losses occur during milling and storage of spices.

Most spices such as cumin, coriander and cardamom give more aroma and flavor when freshly ground than when bought as a pre-ground spice. When spices are ground, the oils tend to volatilize, causing aroma losses. Anise, black pepper and allspice lose their aroma quickly as soon as they are ground. To better retain color, flavor and aroma, spices are sometimes milled using lower temperatures. While spices lose more aroma as they are ground more finely, the advantage is that finely ground spices blend better in finished products that require a smooth texture.

Ground spices should be stored in tightly closed containers and should not be exposed to light, high temperatures or humidity. Moisture and high temperatures will help mold growth that will cause spoilage.
Generally, the moisture content of spice is 8% to 10%. High storage temperatures cause flavor loss, color changes and caking or hardening of the ground spice. Spices need to be stored at 50°F to 60°F (10°C to 15°C) with a relative humidity (RH) of 55% to 65%.

Dried spices can have some disadvantages. Some, have poor flavor intensity, can cause discoloring in the finished product and can create an undesirable appearance in the product. For example, dried ground cayenne can cause irregular variations in flavor and color, sometimes creating "hot" spots in food products. Anticaking agents are added to ensure better flowability of dried spices. In applications with high moisture content, such as salad dressings or soups, where particulates are desired for visual and textural effects, there is a great risk in using dried spices, unless they are sterilized.

**SPICE EXTRACTIVES**

Flavor is a combination of taste and aroma. The sensations of sweet, piney, sour, bitter, spicy, sulfury, earthy and pungent are derived from an overall combination of aroma (due to volatile components) and taste (mainly due to nonvolatile components) in a spice.

Spice extractives, which are highly concentrated forms of spices, contain the volatile and non-volatile oils that give each spice its characteristic flavor. The volatile portions of spice extractives, also referred to as essential oils, typify the particular aroma of the spice. Most spices owe their distinctive "fresh" character to their essential oil content that generally ranges from 1% to 5% but even goes up to 15% in certain spices. The non-volatiles include fixed oils, gums, resins, antioxidants and hydrophilic compounds, and they contribute to the taste or "bite" of a spice.

Certain spices are prized for their bites and coloring, such as black pepper, chile peppers, ginger, saffron and turmeric. These properties are due to the non-volatile portions of spices.

Volatile oils contain several chemical components whose amount and proportion give rise to the spices characteristic aromas. These can include one, two or several components. The major chemical components of essential oils are terpene compounds-monoterpenes, diterpenes and sesquiterpenes. Monoterpenes are the most volatile of these terpenes and give out strong aromas when spice tissues and cells are disintegrated through heating, crushing, slicing or cutting.

The taste of a spice such as sweet, spicy, sour or salty, is due to many different chemical components such as esters, phenols, acids, alcohols, chlorides, alkaloids or sugars. Sweetness is due to esters and sugars; sourness to organic acids (citric, malic, acetic or lactic); saltiness to cations, chlorides and citrates; astringency to phenols and tannins; bitterness to alkaloids (caffeine and gly-cosides); and pungency to the acid-amides, carbonyls, thio ethers and isothiocyanates.

The ratio of volatiles to non-volatiles varies among spices causing flavor similarities and differences within a genus and even within a variety. Within the genus Allium for example, there are differences in flavor among garlic, onions, chives, shallots and leeks, which differ in this ratio. They vary depending upon the species of spice, its source, environmental growing and harvesting conditions and storage and preparation methods. Even the distillation techniques can give rise to varying components-through loss of high boiling volatiles, with some components not being extracted or with some undergoing changes.

Non-volatiles in a spice also vary with variety, origins, environmental growth conditions, stage of maturity and post-harvest conditions. For example, the different chile peppers belonging to the Capsicum group, such as habaneros, cayennes, jalapenos or poblanos, all give distinct flavor perceptions, depending on the proportion of the different non-volatiles, the capsaicinoids.

Spice extractives come as natural liquids (which include essential oils, oleoresins and aquareisins) and dry encapsulated oils (spray-dried powders and dry solubles). Developed from fresh or coarsely ground spices, spice extractives are standardized for color, aroma, and, with some spices, for their antioxidant activity. They are more concentrated than dried or fresh spices and so are used at much lower levels. These extractives provide more consistency than dried spices in prepared foods.
ESSENTIAL (VOLATILE) OILS

Essential oils, such as oil of basil, oil of caraway or oil of black pepper, are produced by grinding, chopping or crushing the leaf, seed, stem, root or bark; then cold expressing, dry distilling or extracting through steam distillation (water, steam, steam and water) and recovering the distillate oil with a solvent. Sometimes the oil is distilled from a whole spice, such as the leaf or flower, or from a broken spice. Depending upon the method of extraction, the nature of the volatiles can differ with the same type of spice.

Essential oils are the major flavoring constituents of a spice. Each essential oil has many chemical components, sometimes even up to 15, but the characterizing aroma generally constitutes anywhere from 60% to 80% of the total oil. The essential oils are composed of hydrocarbons or terpenes (e.g., \(\alpha\)-terpinene, \(\beta\)-pinene, camphene, limonene, phellandrene, myrcene and sabinene), oxygenated derivatives of hydrocarbons (e.g., linalool, citronellol, geraniol, carveol, menthol, borneol, fenchone, tumerone and nerol), benzene compounds (alcohols, acids, phenols, esters and lactones) and nitrogen- or sulfur-containing compounds (indole, hydrogen sulfide, methyl propyl disulfide and sinapine hydrogen sulfate).

Terpenes usually contribute to the freshness of a spice and can be termed floral, earthy, piney, sweet or spicy. The oxygenated derivatives, which include alcohols, esters, acids, aldehydes and ketones, are the major contributors to the aromatic sensations of a spice. The compounds with benzene structure provide sweet, creamy and floral notes, while the sulfur- and nitrogen-containing compounds give the characteristic notes to onion, garlic, mustard, citrus and floral oils.

Essential oils are soluble in alcohol or ether and are only slightly soluble in water. They provide more potent aromatic effect than the ground spices. Essential oils lose their aroma with age. Essential oils are very concentrated, about 75 to 100 times more concentrated than the fresh spice. They do not have the complete flavor profile of ground spices, but they are used where a strong aromatic effect is desired.

Essential oils are used at a very low level of 0.01 to 0.05% in the finished product. They can be irritating to the skin, toxic to the nervous system if taken internally (by themselves) and can cause allergic reactions and even miscarriages.

Examples of Characterizing Essential Oil Components in Some Popular Spices

<table>
<thead>
<tr>
<th>Spice</th>
<th>Components in Essential Oils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allspice seed</td>
<td>Eugenol; 1,8-cineol; humulene, (\alpha)-phellandrene</td>
</tr>
<tr>
<td>Basil, sweet</td>
<td>Linalool; 1,8-cineol; methyl chavicol, eugenol</td>
</tr>
<tr>
<td>Cardamom</td>
<td>1,8-cineole; linalool; limonene; (\alpha)-terpineol acetate</td>
</tr>
<tr>
<td>Dill leaf</td>
<td>Carvone, limonene, dihydrocarvone, (\alpha)-phellandrene</td>
</tr>
<tr>
<td>Epazote</td>
<td>Ascaridol, limonene, p-cymene, myrcene, (\beta)-pinene</td>
</tr>
<tr>
<td>Fennel</td>
<td>Anethole, fenchone. limonene. (\beta)-phellandrene</td>
</tr>
<tr>
<td>Ginger</td>
<td>Zingiberene, curcumene, farnescene, linalool, borneol</td>
</tr>
<tr>
<td>Juniper</td>
<td>(\alpha)-pinene, (\beta)-pinene, thujene. sabinene, borneol</td>
</tr>
<tr>
<td>Kari leaf</td>
<td>Sabinene, (\beta)-pinene, (\gamma)-caryophyllene</td>
</tr>
</tbody>
</table>
Tissue Culture and in Vitro Conservation of Spices

INTRODUCTION

The productivity of many of spice crops is considerably low due to various factors such as inadequate availability of high yielding varieties, absence of genotypes resistant to pests and diseases and absence of variability in many of the introduced crops. Biotechnology with its apparently unlimited potential offers new and exciting opportunities to address the above crop specific problems. Some of the important applications of biotechnology in spices are; micropropagation and rapid clonal multiplication of high yielding 'elite' genotypes to generate good Quality planting material; exploiting somaclonal variation and genetic engineering techniques for crop improvement; in vitro selection for resistance to biotic and abiotic stresses; in vitro conservation and safe exchange of germplasm and production of flavour and volatile constituents in culture.

This paper reviews the present status of biotechnology of spices with emphasis on the work done in India.

CARDAMOM

'Katte' disease caused by virus is one of the major production constraints in cardamom. Utilisation of virus-free planting material is considered the most important input in disease management programme and to check disease spread.

Clonal Multiplication

Cardamom is multiplied vegetatively as well as through seed. Being a cross pollinated crop, clones are ideal for generating true to type planting materials from high yielding clumps. However, due to inadequate availability of clonal planting material, farmers still prefer seedlings. In vitro propagation method for clonal propagation of cardamom has been standardized.

High rate of multiplication coupled with additional advantage of obtaining uniform and disease free planting material makes micropropagation a preferred method to conventional method. Field evaluation of tissue
cultured plants was carried out at Indian Institute of Spices Research (IISR). Preliminary results showed that the micropropagated plants performed on par with suckers of the original mother plant. However, Nadgauda, Mascarenhas & Madhusoodanan reported that the tissue cultured plants were superior to that of seedling progenies.

Regeneration of Plantlets from Callus

Rao et al. reported successful regeneration of plantlets from callus of seedling explants of cardamom. Protocols for organogenesis and plant regeneration from rhizome and vegetative bud-derived callus cultures were also standardised (with about 20-50 plantlets per culture) at IISR which are being used for large scale production of somaclones and selection of useful genotypes. High amount of variability was noticed among the somaclones for the morphological characters in the culture vessels itself. Somaclones are being evaluated in the field at IISR for their genetic variability. Efficient plant regeneration systems are essential for future genetic manipulation to evolve resistant genotypes for combating biotic and abiotic stress.

Inflorescence Culture

Immature inflorescences form an excellent source for clonal multiplication of cardamom through tissue culture especially when other sources are prone to high rate of contamination. Kumar et al. reported the successful conversion of immature floral buds to vegetative buds and subsequently to plantlets.

BLACK PEPPER

The conservation of the precious genetic resources of black pepper is highly essential. Phytophthora foot rot and slow decline diseases are major diseases affecting pepper plantations. None of the existing genotypes is resistant to these diseases.

Clonal Multiplication

There are many reports of in vitro multiplication of black pepper from mature shoot tip explants and from seedlings. The multiplication rate is around 6 shoots per culture in about 90 days. Earlier reports on micropropagation of black pepper reported phenolic exudates from the cut surface and bacterial contamination severely hampered the establishment phase. Methods for reducing phenolic interference and systemic contamination in the in vitro cultures have been reported.

Callus Cultures and Regeneration of Plantlets

Efficient plant regeneration system is an important step in genetic manipulation attempts. Protocols for plant regeneration were standardised and plants were regenerated from leaf tissues directly without intervening callus phase and leaf callus.

MICROPROPAGATION OF RELATED SPECIES OF PIPER

*Piper betle* is an economically important species cultivated extensively in India. *Piper longum* L. (Indian long pepper) and *Piper chaba* Hunt. (Java long pepper) are another group of medicinally important spices. *Piper colubrinum* is a South American species found to be resistant to *Phytophthora capsici* and *Radopholus similis*. *Piper barberi* Gamble is an endangered species from South India. Protocols for rapid clonal multiplication of *P.longum* from shoot tip explants are available and have been standardised. Plants were regenerated from leaf and stem explants of *P.longum*, *P.chaba* and *P.colubrinum* through both direct and indirect organogenesis. In *P.betle*, different ex-plants from shoot, leaf and root developed multiple shoots and regenerated into plantlets either directly or through intervening

callus phase. Conversion of root meristem into shoot meristem and its subsequent development to plantlets were reported in P. longum and P. colubrinum. Micropropagated plantlets of these species are being evaluated for their field performance at IISR.

**GINGER**

Rhizome rot caused by *Pythium aphanidermatum*, bacterial wilt caused by *Pseudomonas solanacearum*, and leaf spot caused by *Phylosticta zingiberi* are major diseases of ginger. Shoot borer (*Conogethes punctiferalis*) and rhizome scale (*Aspidiella hartii*) are major pests and plant parasitic nematodes like *Meloidogyne incognita* and *Pratylenchus* sp. are affecting ginger production. These diseases and pests are mostly spread through infected seed rhizomes. Crop improvement programmes in ginger are hampered by lack of seed set leading to limited variability. Somaclonal variation could be an important source of variability that could be exploited to evolve high-yielding, high-quality lines and to develop lines resistant to disease and pests. Tissue culture techniques could also be used for in vitro pollination, embryo rescue and possible production of 'seed' in ginger.

**Clonal Multiplication**

Clonal multiplication of ginger from vegetative buds has been reported by many workers. Tissue culture technique would help in production of infection free planting material. At IISR, field evaluation of tissue cultured plants indicated that they cannot be used directly for commercial planting as two crop seasons are required for the micropropagated plants to develop rhizomes of normal size that can be used as seed rhizomes.

**Regeneration of Plantlets from Callus**

Regeneration of plantlets through callus phase has been reported from leaf explants. The techniques for plant regeneration from leaf, ovary and vegetative buds were standardized. This system could be used for inducing somaclonal variability in ginger. This is very important in crops where conventional breeding is hampered by lack of seed set. Somaclones could also be used for screening against biotic and abiotic stress.

**In Vitro Selection**

Kulkarni, Khuspe & Mascarenhas reported isolation of *Pythium*-tolerant ginger by using culture filtrate. In vitro selection for resistant types to *Pythium* and *Pseudomonas* is in progress at IISR using culture filtrates of the pathogen or pathotoxin.

**Inflorescence Culture and in Vitro Development of Fruit**

In nature, ginger fails to set fruit. However, by supplying required nutrients to immature inflorescence in culture, it was possible to make the ovary develop in vitro into ‘fruit’ and subsequently plants could be recovered from the fruits. It is also possible to convert the immature floral buds into vegetative buds and their subsequent development into complete plants.

**In Vitro Rhizome Development**

In vitro rhizome formation was reported in 10 per cent of the cultures when ginger plantlets were maintained in the culture medium for more than 100 days. In vitro formed rhizome may form a source of disease-free planting material. Probably they can also be coated with alginate to facilitate longer storage and transportation.

**TURMERIC**

Rhizome rot caused by *Pythium graminicolum* is a major production constraint. Curcumin is the important colouring material obtained from turmeric and development of varieties with high recovery of curcumin is the need of the hour.

**Micropropagation**
Successful micropropagation of turmeric has been reported. Micropropagation of turmeric was standardized at IISR using young vegetative buds as explants.

**Plant Regeneration from Callus**
Organogenesis and plantlet formation were achieved from the callus cultures of turmeric. Variants with high curcumin content were isolated from tissue cultured plantlets.

**VANILLA**
In India vanilla is an introduced crop and practically there is no variability in the cultivated form of this spice. Vanilla, though produces numerous minute seeds, these do not germinate under natural condition. Hence, the crop is commercially propagated by means of stem cuttings. Further, root rot, caused by Fusarium batatatis var. vanillae, is a devastating disease which wipes out a plantation in a short period. Tissue culture techniques could be used for germination of seeds, rapid multiplication and for getting disease-free planting material.

**Micropropagation**
Micropropagation of vanilla using apical meristem of aerial roots was standardized for large scale multiplication of disease free and genetically stable plants. Vanilla is known to have many meiotic and post-meiotic chromosomal abnormalities. As a result of these aberrations, it is quite possible to get various cytotypes in the seed progenies. Culturing of seeds can thus give many genetically variant types.

*In vitro* germination of vanilla seeds has been reported. A population of vanilla progenies are being established at IISR so that the variations among them could be used for crop improvement. Variations among the progenies from seed and ovule cultures were reported based on morphological and isozyme characterization. Callus induction and shoot regeneration were also reported.

**SAFFRON**
Saffron is a triploid and sterile genotype propagated vegetatively by means of corms.

**Micropropagation**
Reports are available on the micropropagation and plant regeneration in saffron. However, most of the reports in this crop are on the in vitro proliferation of stigma and in vitro synthesis of colour components and metabolites. Successful micropropagation and regeneration were reported from corms.

**TREE SPICES**
Clove, cinnamon, allspice and nutmeg are important tree spices grown in India. Though all these crops could be propagated vegetatively, non-availability of enough quality planting material is the limiting factor. Long pre-bearing period makes crop improvement programmes time consuming. In all these perennial tree crops, identification and clonal multiplication of high-yielding genotypes become an immediate priority. Standardization of micropropagation methods will help in rapid multiplication of ‘elite’ planting materials in these crops.

**Micropropagation**
Micropropagation of clove from seedling explants have been reported. Successful micropropagation from shoot tip of mature cinnamon has been reported. Micropropagation of in vitro raised Murraya koenigii was reported by Hazarika, Nagaraju & Parthasarathy.

**In Vitro Proliferation of Mace and Synthesis of Flavour Components in Culture**
Nutmeg and mace are the two important spices obtained from nutmeg tree. Nutmeg is the kernel while mace is dried aril that surrounds the seed. *In vitro* proliferation of mace tissue has been reported by Nirmal Babu et al.. A ten-fold increase in the fresh weight of the tissue within two weeks was observed. Proliferated tissue not only retained the colour but also the flavour of original mace. Gas chromatographic analysis of the mace oil extracted from the cultured tissue was similar to that of original in qualitative profile.
This technique, if refined further, has tremendous potential for industrial production of mace tissue and in vitro production of myristicin and myristic acid.

**Tissue Culture Studies on Tree Spices**

**INTRODUCTION**

Concerted efforts on tissue culture propagation of spices especially tree spices have been few when compared to those on ornamentals, fruits, vegetables and other agricultural crops, though conventional vegetative propagation of tree spices has not been able to meet the demand of planting material. Literature survey on tissue culture of spice crops revealed that reports on tree spices are limited to those on regeneration of plantlets in cinnamon clove nutmeg and tamarind. We report here the results of our studies on the in vitro regeneration potential of 4 tree spices viz. clove, nutmeg, tamarind and curry leaf.

**MATERIALS AND METHODS**

For shoot multiplication, tender, actively growing shoots from elite trees of clove, nutmeg, tamarind and curry leaf as well as seeds of clove and tamarind were used as explant sources. Nodal segments from the shoots were collected and washed under running tap water for 1 h and surface sterilised using standard procedures. Subsequently, dissected nodal segments of clove were suspended in sterile distilled water for 30 min to allow leaching out of harmful phenolic oxidation products. The embryos of clove were isolated from fresh ripened fruits and those that were olive green were selected, washed, surface sterilised and planted radical tip downwards on different media. Likewise, seeds of tamarind were surface sterilised and implanted horizontally on the medium. The sterilant used in all cases was mercuric chloride (0.10%). Medium based on Murashige & Skoog and WPM containing a variety of plant growth regulator combinations was designed for different explants. The plant growth regulators used were BAP, KN, 2 ip, IAA, NAA and IBA.

For callus cultures, leaf segments from the seedlings of clove, internodal and leaf pieces of nutmeg and inter-nodes, cotyledons, hypocotyles and roots of tamarind were utilised. Plant growth regulators like 2, 4-D, NAA, PCPA, KN and BAP were used in different combinations.

The cultures were incubated at 16 h photoperiod (2000 lux) at 25 ± 1° C.

**RESULTS**

**Clove**

Nodal segments from mature clove trees displayed excessive leaching of oxidised phenolic products into the culture medium, proving lethal to the explants. Inclusion of PVP, ascorbic acid, citric acid and activated charcoal in the medium did not prove effective in adsorbing the phenolic products. Though frequent transfer of explants to fresh medium was moderately effective, high contamination (95%) in the explants could not be evaded. The response of surviving explants was also poor with regard to multiple shoot regeneration. However, cultured embryos exhibited relatively higher regenerative potential, enhanced percentage of multiple shoot formation. When planted on MS medium with low levels of BA ([1 mgl -1], the embryos germinated into single plantlets. At higher levels of BAP ( ]2 to 3 mg1-1) combined with IAA and NAA (0.2 mgl -1 each), 3-5 shoots initiated from each embryo, from the cotyledonary nodal region within 40 days in culture. The shoots elongated on the same medium to 4-5 cm and developed 2 to 3 nodes ruling out the otherwise essential intervention of a shoot elongation medium. Nodal segments from seedlings also responded well enough producing 8-10 buds at a range of 0.5 cm to 2 cm shoot length. The shoots could be rooted at half strength MS media supplemented with NAA and IBA at 1 mgl -1.

Segments from tender leaves were cultured on MS medium employing several auxins (2,4-D, IAA, IBA, PCPA) and cytokinins (KN, BA) at varying ratios. 2,4-D at higher concentration (J3-5 mgl -1) induced dry spongy, creamy white friable callus, whereas at lower levels ([ 2.0 mgl -1) gave rise to creamy, friable but nodular callus. The nodular callus upon transfer to medium having still lower levels of 2,4-D ([1 mgl-1)
developed embryogenic nodules. Rhizogenesis was also observed occasionally. Though BAP promoted green compact callus from explants, failed to evoke any regenerative
### Table 1

Shoot Multiplication Response From Different Explants of Clove

<table>
<thead>
<tr>
<th>Medium (MS) + Growth regulator (mg/l)</th>
<th>Response</th>
<th>(No. of multiple shoots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA 0.5</td>
<td>1</td>
<td>1-2</td>
</tr>
<tr>
<td>KN 0.5 to 1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BA 2 to 3+ AA/NA 0.2</td>
<td>3-5</td>
<td>8-10</td>
</tr>
<tr>
<td>CN 2 to 3+ AA/NA 0.2</td>
<td>1-2</td>
<td>1</td>
</tr>
<tr>
<td>2p 2+ AA/NA 0.2</td>
<td>1-2</td>
<td>1-2</td>
</tr>
</tbody>
</table>

### Table 2

Effect of Different Auxins on Callus Morphology of Clove Leaf Culture

<table>
<thead>
<tr>
<th>Medium (MS) + Growth regulator (mg/l)</th>
<th>Callus texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-D3 to 5 + KN 0.5</td>
<td>Friable, spongy, dry</td>
</tr>
<tr>
<td>4 - D 2 + KN 0.5</td>
<td>Friable but nodular</td>
</tr>
<tr>
<td>A - D 0.3 to 0.5</td>
<td>Embryogenic callus, occasional rhizogenesis</td>
</tr>
<tr>
<td>A 1 + KN 0.5</td>
<td>Callus green, compact</td>
</tr>
<tr>
<td>A 1 + 2,4-D 0.5</td>
<td>Callus green, compact</td>
</tr>
<tr>
<td>A 1 + KN 1 + PCPA 0.5</td>
<td>Callus green, shiny, compact</td>
</tr>
</tbody>
</table>
Actively growing orthotrophic shoot segments of elite nutmeg trees, cultured on various media based on WPM displayed a very poor response. Axillary buds appeared highly dormant. Medium containing a mixture of BAP, KN, 2 ip, NAA and IBA stimulated single shoot development within 2-3 months in culture. Shoot proliferation could not be accelerated irrespective of modifications in concentrations of the above growth regulators. Earlier reports on nutmeg micro propagation by Mariska, Gatidan & Sukmadijaja revealed similar culture response. Culture of seedling explants is not desirable in nutmeg due to segregation of sex in progenies from seeds. An attempt was made for regeneration through callus cultures using tender leaves and other vegetative plant parts from mature trees.

Tender leaf segments exhibited capability of callus production on medium supplemented with 2,4-D and BAP as growth regulators. Callus though slow growing, appeared green and compact with several nodular regions. Shoot like out growths (2-3 mm long) were observed to develop from one of the calli on medium with high levels of BAP (\text{1 mgL}^{-1}). However, the cultures failed to evoke any further response.

**Tamarind**

Seeds inoculated on MS basal media devoid of growth regulators germinated within 10 -15 days. Shoot tips and nodal segments excised from 4 -5 cm tall in vitro seedlings were cultured on MS medium containing BAP, KN, NAA, IAA, and IBA. On MS medium containing 0.5 mgL\textsuperscript{-1} BAP, 0.5 mgL\textsuperscript{-1} KN and 0.1 mgL\textsuperscript{-1} IAA, 2-3 multiple shoots developed from nodes and shoot tips. However, the same medium when used for direct regeneration from seeds, generated callus. At higher concentrations of BAP (\text{2 mgL}^{-1}) with IAA/NAA (0.2 mgL\textsuperscript{-1}) 3 to 5 multiple shoots developed but at the base of the shoots callus formation was noticed. The multiple shoots attained a length of 2-3 cm within 45 days. Individualised shoots were planted on medium containing IAA, NAA and IBA each at 0.2 mgL\textsuperscript{-1} for root initiation. Rhizogenesis occurred within 5 weeks in about 50% cultures exhibiting small thin roots.

<table>
<thead>
<tr>
<th>Medium (MS) +</th>
<th>Growth regulator (mgL\textsuperscript{-1})</th>
<th>Response (No. of multipleshoots/callus)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BA0.5 + KN 0.5 + IAA 0.1</td>
<td>Single shoot</td>
</tr>
<tr>
<td></td>
<td>BA1 + Kn 1 + IAA 0.1</td>
<td>1-2 shoots but callus at base</td>
</tr>
<tr>
<td></td>
<td>BA 2 + IAA/ NAA 0.2</td>
<td>2-3 shoots with callus 2-3 shoots with callus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stunted shoots with callus 3-5 shoots with callus</td>
</tr>
</tbody>
</table>

Tamarind, though mostly seed propagated, conventional methods like grafting and rooting of cuttings have also been tried with varying degrees of success. Micropropagation technique can be followed for tamarind.
for its large scale production. This method is comparatively quicker and may be used to circumvent problems associated with conventional vegetative propagation methods.

Callus initiation was observed in almost all explants cultured viz. cotyledon, in-ternodes, hypocotyl and root segments excised from in vitro seedlings. Callus was cream white to brown, soft but compact. 2,4-D and Kinetin were the growth regulators used in MS medium for callus induction.

**Curry Leaf**

Tender shoot sections from curry leaf trees when cultured on MS medium containing BAP (1-2 mgl-1) and NAA / IAA (0.1 to 0.5 mgl-1) developed 4 to 6 multiple shoots over a period of 3 weeks. The cultures were rapidly proliferating with multiple buds developing asynchronously from the nodal regions as well as adventitiously around the nodal regions. The shoot buds at a range of 0.5 cm to 2 cm in length elongated on a medium with relatively low BAP (0.5 mgl-1). Rooting of cultured shoots could be facilitated on medium supplemented with 1 mgl-1 IBA and activated charcoal at 500 mgl-1. Rooting efficiency was about 60%. Curry leaf is commercially propagated through seeds. Inadequate availability of planting materials of vegetative origin could be circumvented by using in vitro methods as an alternative propagation method, the latter being faster and the progenies true to type.

The present study thus indicates the possibility of in vitro direct organogenesis (through multiple shoots) from axillary buds for clove, tamarind and curry leaf, whereas, the same is difficult in the case of nutmeg. In nutmeg, there are several factors such as seasonal, explant juvenility, unresponding tissues etc. that might affect development of a successful in vitro regeneration system. The callus path way seems to be feasible in nutmeg and can be utilised, provided undesirable variants are checked.

**Micropropagation of Some Important Herbal Spices**

**INTRODUCTION**

Herbal spices are fragrant herbaceous plants of which the whole plants, twigs, leaves, flowers, fruits, seeds etc., fresh or dried are used as flavouring agents. Once an elite genotype is identified it can be multiplied rapidly through tissue culture. Tissue culture studies were reported in anise celery, fennel, thyme, mint, lavender. This paper reports tissue culture methods in thirteen herbal spices viz., anise (*Pimpinella anisum* L.), celery (*Apium graveolens* L.), dill (*Anethum graveolens* L.), fennel (*Foeniculum vulgare* Mill.), parsley (*Petroselinum crispum* Mill.), thyme (*Thymus vulgaris* L.), spearmint (*Mentha spicata* L.), peppermint (*Mentha piperita* L.), sage (*Salvia officinalis* L.), marjoram (*Marjorana hortensis* L.), oregano (*Origanum vulgare* L.), sacred basil (*Ocimum sanctum* L.) and lavender (*Lavandula angustifolia* Mill.) for rapid multiplication, plant regeneration from callus and minimal growth storage.

**MATERIALS AND METHODS**

**Explants**

Seeds of herbal spices used in this study were obtained from Lockhart Seeds Inc. 3 North Welsonway, Stockton, California. Seeds were treated with 0.01% fungicide (copper oxychloride) solution for 15 min and washed thoroughly several times with filtered water. They were then surface sterilised with 0.1% mercuric chloride for 3-4 min under aseptic conditions and washed with 5-6 changes of sterile distilled water. Seeds were then placed on culture medium for germination and the seedlings were allowed to grow for 30-60 days. Shoot tips and nodal segments were excised from these seedlings and used for micropropagation, callus regeneration and in vitro conservation.

**Culture Media**

Murashige & Skoog basal medium supplemented with 0.5 mgl-1 kinetin and 2% sucrose, gelled with 0.7% agar was used for the germination of seeds. The MS basal medium supplemented with Kin, BAP, NAA, and IBA (0.5 mg 1-1 and 1.0 mg 1-1) alone and in combination, sucrose (3%), gelled with agar (0.7%, 0.8% and 0.9%) was used to study the in vitro responses like multiplication, callus induction and plant regeneration.
MS basal medium at full and half strength, with sucrose (30 gl-1, 20 g1-1 10 g1-1) alone and in combination with mannitol (10 gl-1, 20gl-1), supplemented with 0.9% agar was used to induce minimal growth in cultures and to increase the subculture interval.

**Culture Conditions**
The pH of the medium was adjusted to 5.8 and autoclaved at 121° temperature and 1.5 kg/cm2 pressure for 20 min. All the cultures were incubated at 25°C and 12 h photoperiod of 2500 lux. Observations were recorded on multiple shoot production, callus induction and regeneration.

**RESULTS**

**In Vitro Seed Germination**
The rate of germination and time taken for germination varied in different species. Seeds germinated within 10-20 days in the medium. Crops like anise, celery, dill, fennel, marjoram, oregano, peppermint, spearmint, sacred basil, sage and thyme showed 70-90% germination whereas in parsley and lavender the germination was only 20-30%.

**Micropropagation and Callus Regeneration**
Shoot tips and nodal segments excised from 30-60 days old seedlings gave rise to multiple shoots, rooting and callus regeneration in MS medium supplemented with different concentrations of auxins and cytokinins. Multiple shoots could be induced in all the crops studied whereas successful plant regeneration from callus was observed in anise, dill, fennel, lavender and sage. In celery, marjoram, oregano, parsley, peppermint, spearmint, sacred basil and thyme, plant regeneration could not be induced. Multiplication rate was very high in plants belonging to Lamiaceac and produced 10-20 fold increase in the biomass in 45 days of culture.

In the case of fennel, MS supplemented with BAP (1.0 mgl-1) and IBA (0.5 mgl-1) was suitable for both multiple shoot formation and callus regeneration. Multiple shoots ranging from 4-7 were produced in 6 weeks of culture in 70 per cent of the cultures. Callusing was observed and plant regeneration was achieved in 60 per cent of the culture. The callus on transfer to fresh medium regenerated to shoots. Rooting was achieved in MS medium devoid of growth regulators. Micropropagation, callus regeneration and somatic embryogenesis were reported in fennel. Hunault, Desmareswt & P. Manior reported the difficulty in regenerating plants from callus but in the present study regeneration of shoots could be achieved in 60 per cent of cultures.

Among all the media combinations tried MS supplemented with IBA (0.5 mgl-1) was suitable for the production of 10-15 multiple shoots in about 85 per cent of the cultures in celery and rooting was also achieved in the same medium. Micropropagation of celery was reported by Toth & Lacy. In the present study no callus formation was observed in any of the combinations tried. Multiple shoots were produced in all the combinations but the highest rate was observed in MS medium with 0.5 mgl-1 IBA.

In dill 60 per cent of the cultures responded in MS with 0.5 mgl-1 kinetin. Multiple shoots (1:7) as well as callus initiation were noticed in this medium. Profuse callusing was obtained in MS supplemented with 2, 4-D (2 mgl-1). The proliferated callus on transfer to MS basal medium regenerated to plantlets (50%). In anise multiple shoots and plant regeneration from callus was induced in MS with (1.0 mgl-1) BAP and 0.5 mgl-1 IBA in 80% and 75% of the cultures respectively. Somatic embryo-genesis and cell culture studies were reported in anise.

In lavender, oregano, parsley, peppermint, spearmint, sacred basil and sage, MS medium with IBA (0.5 mgl-1) and BAP (1.0 mgl-1) was suitable for the production of multiple shoots. In sage and lavender callus regeneration was obtained in MS with BAP (1.0 mgl-1) and IBA (0.5 mgl-1). Marjoram and thyme produced multiple shoots initially in MS with 0.5 mgl-1 kinetin and later on multiple shoots and rooting was obtained in growth regulator free medium. Micropropagation and regeneration of thyme was reported by Furmanowa & Olszowska. They used Nitsch & Nitsch as the basal medium with different growth factors for thyme.
multiplication by shoot cultures, nodal segments and cotyledon segment culture. Clonal propagation of Mentha piperata was reported. Cellarova reported peppermint can be clonally propagated in Linsmaier & Skoog medium with 2 mg/l BAP solidified with 0.4% agar. In the present report peppermint seeds germinated in MS with 0.5 mg/l kinetin and the in vitro derived shoot tips and nodal segments multiplied at the rate of 1:30 in 45 days of culture in MS supplemented with 0.5 mg/l IBA and 1.0 mg/l BAP. In the present study lavender could be micropropagated from shoot tips and nodal segments from in vitro derived seedlings in MS supplemented with BAP (1 mg/l) and IBA (0.5 mg/l) and callus regeneration (80%) was also obtained in the same medium. In this medium on an average of 5-7 shoots were obtained in 40-45 days of culture. In lavender, callus induction and regeneration of callus were also obtained in the same medium in 60 days. Micropropagation by axillary budding and plant regeneration via callus was reported in lavender. In sage, plant regeneration from callus was obtained in 80% of the cultures.

**In Vitro Response of Herbal Spices**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Growth regulator (mg/l)</th>
<th>Response</th>
<th>Response (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anise</td>
<td>BA(1) + IBA (0.5)</td>
<td>MS,CR</td>
<td>80</td>
</tr>
<tr>
<td>Celery</td>
<td>IBA (0.5)</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Dill</td>
<td>Kin (0.5)</td>
<td>MS</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>2,4-D (2)</td>
<td>CI</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MS basal medium</td>
<td>CR</td>
<td></td>
</tr>
<tr>
<td>Fennel</td>
<td>BA(1) + IBA (0.5)</td>
<td>MS,CR</td>
<td>70</td>
</tr>
<tr>
<td>Parsley</td>
<td>BA(1) + IBA (0.5)</td>
<td>MS</td>
<td>70</td>
</tr>
<tr>
<td>Lavender</td>
<td>BA(1) + IBA (0.5)</td>
<td>MS,CR</td>
<td>75</td>
</tr>
<tr>
<td>Sacred basil</td>
<td>BA(1) + IBA (0.5)</td>
<td>MS</td>
<td>70</td>
</tr>
<tr>
<td>Oregano</td>
<td>BA(1) + IBA (0.5)</td>
<td>MS</td>
<td>80</td>
</tr>
<tr>
<td>Marjoram</td>
<td>MS + Kin (0.5)</td>
<td>MS</td>
<td>75</td>
</tr>
<tr>
<td>Peppermint</td>
<td>BA(1)+IBA(0.5)</td>
<td>MS</td>
<td>85</td>
</tr>
<tr>
<td>Spearmint</td>
<td>BA(1)+IBA(0.5)</td>
<td>MS</td>
<td>80</td>
</tr>
<tr>
<td>Sage</td>
<td>BA (1) + IBA (0.5)</td>
<td>MS,CR</td>
<td>75</td>
</tr>
<tr>
<td>Thyme</td>
<td>Kin (0.5)</td>
<td>MS</td>
<td>80</td>
</tr>
</tbody>
</table>

To our knowledge no detailed study has been made on tissue culture of spearmint, sage, oregano, marjoram and ocimum. In oregano, prevention of vitrification associated with in vitro shoot cultures by Pseudomonas spp. was reported. In the present study also species belonging to the family Apiaceae showed vitrification and they require frequent subculture to maintain healthy cultures. Increase in agar concentration from 0.7 to 0.9% helped in reducing vitrification to some extent. Multiplication rate was high in thyme, peppermint, oregano, celery and spearmint. Upon transferring to
multiplication medium, they produced shoots and plantlets which appeared like a clump filling the culture vessel within 30-40 days. Growth rate is very high and healthy growth ceases within 30-40 days of subculture. This may be due to depletion of nutrients in culture medium. Response was faster in mints compared to other crops. Rooting could easily be achieved in the same basal medium containing charcoal (1 gl-1) or without any growth regulators.

**In Vitro Conservation of Herbal Spices**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Medium</th>
<th>Storage period (months)</th>
<th>Survival(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anise</td>
<td>½ MS + 20 gl-1S</td>
<td>6</td>
<td>60</td>
</tr>
<tr>
<td>Celery</td>
<td>½ MS + 20gl-1S</td>
<td>5</td>
<td>70</td>
</tr>
<tr>
<td>Dill</td>
<td>½ MS + 20 gl-1S</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Fennel</td>
<td>½ MS + 20 gl-1S</td>
<td>4</td>
<td>65</td>
</tr>
<tr>
<td>Lavender</td>
<td>½ MS + 20 gl-1S</td>
<td>8</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>+ 10 gl-1M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marjoram</td>
<td>½ MS + 20 gl-1S</td>
<td>8</td>
<td>75</td>
</tr>
<tr>
<td>Oregano</td>
<td>½ MS + 20 gl-1S</td>
<td>8</td>
<td>70</td>
</tr>
<tr>
<td>Parsley</td>
<td>½ MS + 20 gl-1S</td>
<td>4</td>
<td>65</td>
</tr>
<tr>
<td>Peppermint</td>
<td>½ MS + 20 gl-1S</td>
<td>12</td>
<td>85</td>
</tr>
<tr>
<td>Sage</td>
<td>½ MS + 20 gl-1S</td>
<td>6</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>+ 10 gl-1M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spearmint</td>
<td>½ MS + 20 gl-1S</td>
<td>6</td>
<td>65</td>
</tr>
<tr>
<td>Thyme</td>
<td>½ MS + 20 gl-1S</td>
<td>12</td>
<td>80</td>
</tr>
</tbody>
</table>

**In Vitro Conservation**

All the species studied are very fast growing under in vitro conditions and maintenance of healthy cultures more than thirty days was difficult under normal conditions. Among the combinations of media tried, reduction of sucrose and/or reduction of nutrients helped in reducing the growth rate of in vitro cultures. The media combination, percentage of survival and storage period are given in Table 2. Shoot cultures of dill, fennel, celery, parsley, oregano, marjoram, peppermint, spearmint, anise, thyme and ocimum could be stored upto a period of 4-12 months without subculture in ½ MS medium supplemented with 20 gl-1 sucrose. Lavender and sage could be stored upto six months in ½ MS medium with 20 gl-1 sucrose and 10 gl-1 mannitol. Agar was used at 9 gl-1, so that vitrification could be reduced. In vitro conservation of herbal spices was not reported so far except in Mentha species which could be stored up to 6-13 months. The techniques standardised in the present study can be used for large scale multiplication of elite genotypes, production of biomass in the culture vessel, creating variability through callus regeneration and also for the maintenance of germplasm in in vitro genebank.

**Spices in Ayurveda**
Spices are intrinsically associated with Indian cuisine and its aroma and colour can make an ordinary dish into a sublime feast. Spices are used in meals to create a state of wellness. Cooking foods with spices is the oldest form of aromatherapy, since aroma stimulates gastric secretions that create appetites. Many of the spices that are popular today are indigenous to India, where they have been savoured for thousands of years.

Ayurveda, the ancient system of healing from India, has been singing the praises of spices as "wonder-foods" for thousands of years. The sacred Ayurvedic texts, which were formulated before 1000 B.C. and dealt with matters of health and medicine, make frequent reference to the use of spices. In about 500 B.C., the physician Susruta described 700 drugs derived from plants, including spices like cinnamon, ginger, turmeric, pepper etc. Spices are ingredients in many synergistic Ayurvedic herbal formulations and specific spices are included in Indian vegetarian diet to contribute to all six tastes (rasas) - sweet, sour, salty, bitter, pungent and astringent - at every main meal, is a basic tenet of Ayurvedic dietary wisdom. It is a matter of debate whether, in India, spices were used as an item for flavouring or an ingredient of daily diet to balance the thridosas for healthy living. These doshas have their own natural tastes or rasas. Tastes or rasas are used to balance an aggravated dosha, which give rise to an illness. For example; a vitiated vata condition is balanced by salt, sour (tamarind) and sweet (cardamom); vitiated pitta by bitter (fenugreek), sweet (fennel), and astringent (asafoetida) and vitiated kapha by pungent (garlic), bitter (ajowan) and astringent (licorice).

**AYURVEDIC CONCEPT OF TRIDOSHA**

In Ayurvedic philosophy, the five elements combine in pairs to form three dynamic forces or interactions called doshas. Dosha means "that which changes." It is a word derived from the root dus, which is equivalent to the English prefix 'dys', such as in dysfunction, dystrophy, etc. In this sense, dosha can be regarded as a fault, mistake, error, or a transgression against the cosmic rhythm. In Ayurveda, dosha is also known as the governing principle as every living thing in nature is characterized by the dosha. The three active doshas are called Vata, Pitta and Kapha.

**Dosha Related Elements**

**Vata**
Air and Ether (Space)

**Pitta**
Fire and Water

**Kapha**
Water and Earth

Vata is a force conceptually made up of elements, space (ether) and air. Vata means "wind, to move, flow, direct the processes of, or command." Vata enables the other two doshas to be expressive. The actions of Vata are drying, cooling, light, agitating, and moving. Vata governs breathing, blinking of the eyelids, movements in the muscles and tissues, pulsations in the heart, all expansion and contraction, the movements of cytoplasm and the cell membranes, and the movement of the single impulses in nerve cells. Vata also governs such feelings and emotions as freshness, nervousness, fear, anxiety, pain, tremors, and spasms.

Pitta is a force created by the dynamic interplay of water and fire. These forces represent transformation. Pitta governs digestion, absorption, assimilation, nutrition, metabolism, body temperature, skin coloration, the lustre of the eyes, intelligence, and understanding. Psychologically, pitta arouses anger, hate, and jealousy. The small intestine, stomach, sweat glands, blood, fat, eyes, and skin are the seats of pitta.

Kapha is the conceptual equilibrium of water and earth. Kapha is structure and lubrication. Kapha cements the elements in the body, providing the material for physical structure. This dosha maintains body resistance. Kapha lubricates the joints; provides moisture to the skin; helps to heal wounds; fills the spaces
Kapha is present in the chest, throat, head, sinuses, nose, mouth, stomach, joints, cytoplasm, plasma, and in the liquid secretions of the body such as mucus. Psychologically, *kapha* is responsible for the emotions of attachment, greed, and long-standing envy. It is also expressed in tendencies toward calmness, forgiveness, and love. The chest is the seat of *kapha*.

**Medicinal Applications of Spices and Herbs**

With the advent of science, the active principles residing in spices and herbs which are responsible for flavour, colour and nutritional value have been identified and tested, and there is concerted efforts to find non-traditional applications of spices such as anti-oxidant, anti-microbial properties and its use in cosmetics and health-food industry. A few companies have emerged in the recent years in the forefront of export with non-traditional usage of spices in the form of products which are having high value addition than the common spices marketed in the form of whole, broken or ground form.

Most of the spices and herbs have active principles in them and development of these through pharmacological and pre-clinical and clinical screening would mean expansion of considerable opportunities for successful commercialization of the product. A few leading manufacturers are already in the fray with the assistance of Spices Board by undertaking projects on pepper, turmeric fenugreek, garlic and the research is directed to develop applications for non-traditional and broad brand therapeutical usage.

Pure piperine extracts obtained from black pepper has shown to significantly enhance the bioavailability of various supplemented nutrients through increased absorption. Another derivative from pepper known as Tetrahydropiperine also have the property of bioavailability enhancement and its applications for human usage is being explored through clinical studies to determine the exact dosage required and for finding out the side effects, if any.

Curcumin is a powerful antioxidant obtained from turmeric. Its efficacy is comparable to standard antioxidants such as vitamin C and E. The bright yellow colour and antioxidant properties against lipid peroxidation ensured a preferential add-on role for curcumin in butter, margarine, cheese etc. Curcumin is also a non mutagenic and have shown to suppress the mutagenicity of several mutagens. It also exhibits many direct anti-inflammatory effects like for prevention and cure of rheumatoid arthritis, bronchial asthama and is also known for its cholesterol lowering effect and for inhibition of platelet aggregation. Curcumin has exhibited hepato protection properties.

Because of its therapeutical properties curcumin has been increasingly applied for various formulations in the nutraceutical industry and today another derivative of curcumin known as tetrahydrocurcumin is gaining popularity because of its better antioxidant properties and of its cosmetic applications.

The usage of fenugreek in the management of diabetes is in practice since ancient times. The anti-diabetic action of this is due to the presence of a polysaccharide, galactomanon. Another amino acid has been found in recent times and this particular compound is said to stimulate the insulin secretion, further enhancing the anti-diabetic action of the fibre. Clinical and non-clinical studies of this derivative are being undertaken to find efficacy of the product as an anti-diabetic agent.

Garlic is another spice which has considerable medicinal properties useful to human beings. The importance of selenium as a micro-nutrient mineral has already been established, and it has been reported that the selenium garlic is superior to regular garlic in mammary cancer prevention and this has been experimentally found in animal model. It is reasonable to expect that selenium enriched garlic and research is undertaken in this regard.

Concomitant with the objective of popularising medicinal values of spices and herbs several of the projects related to find out the efficacy of medicinal applications including biological and toxicological aspects are
being assisted by Spices Board through its loan scheme and up to 90 per cent of the total project cost is funded under this interest free loan scheme subject to a specified ceiling and conditions. The assistance would be for research for developing new end products, clinical trials and patenting. Leading manufacturers in India have already initiated studies on clinical and non-clinical aspects for better commercial utilisation of these natural products with the assistance of Spices Board during the IX Plan period.

Till recently several medical and pharmaceutical fraternity have so far chosen to ignore them, but today due to the rapidly expanding demand and markets for these products in the light of the significant shift seen in the choice among the people for natural products, Indian companies cannot ignore the field and should come forward to promote research and standardization of various medicinal applications of spices and herbs to the benefit of the people.

The Healing Touch of Select Spices

GARLIC
The crop is cultivated in various parts of India. The volatile essential oil obtained by distilling the bruised bulbs contain allyl, propyl disulphide and other organic sulphides or sulphur compounds. It is a clear liquid having dark brown or yellow colour of very repulsive and intense garlic odour and of repugnant taste. Parts used are the underground stem (bulbs) and oil extracted from it.

Medicinal Uses
Allicin, the principle of garlic has antibacterial properties. It is a powerful drug against amoebic dysentery. The essential oil of garlic is absorbed into the circulation and is excreted through the lungs and bronchial mucosa, acting as a good antiseptic and antispasmodic. Garlic in the form of tinct alli is recommended either alone or in combination with usual expectorant mixtures. It is said to be very effective in bronchial and asthmatic complaints. Garlic is used in curing several diseases. It acts as a prophylactic against typhoid and diphtheria infections. Given early in typhoid fever it will almost abort the disease and its action as an intestinal antiseptic makes it valuable at any stage of the disease. When used in inhalers three or four hours daily, it relieves the distressing features of whooping cough. Allyl sulphides can be used for tuberculosis of the larynx. Bruised garlic is applied to the chest for control of rheumatism and neuralgia. Garlic is rubbed over ringworm infections. "Garlic juice" mixed with 3 or 4 parts of ordinary or distilled water has been used as lotion for washing wounds and foul ulcers. A German firm prepares garlic oil capsules through cold processing without any chemical constituents. It protects the human body from the attack of bacteria especially from Bacillus infections. These capsules renew the blood, cleanse it of all impurities, regulate the digestion and remove all parasites in the intestines. It is recommended for diseases of the lungs, arterio sclerosis, high blood pressure, gout, rheumatism, asthma, chronic bronchial etarrh, intestinal complaints, loss of appetite, constipation and from worms.

MUSTARD
Common Indian brown mustard is cultivated in many parts of India. The parts used are seeds and oil.

Medicinal Uses
Mustard oil combined with camphor forms an efficacious embrocation in muscular rheumatism, stiff neck etc. The whole plant possesses bitter, aperient and tonic properties. Seeds contain about 20-25 percent of oil. An essential oil is also produced. Mustard poultice of the seed powdered and mixed water forms an efficient counter - irritant i.e., as a blister in many inflammatory neuralgic affections, in abdominal colic and obstinate vomiting. A teaspoonful or more of the powdered seeds mixed with water is given as an emetic in cases of drunkenness or in case of poisoning and when it is desired to empty stomach without causing depression of the system. In case of dengue fever also it is used with much benefit. Leaves and green pods are eaten as vegetables.

CASSIA
The crop is indigenous to Sri Lanka and Southern India. It grows in a wild state in the Western Ghats in Konkan southwards and in the forests of Burma. Parts used are the dried inner bark of the shoots and the essential oil (Oleum cinnamom B.P.). Oleum cinnamomum B.P. is distilled from the cortex. Different oils prepared from cinnamon are (1) Oil from the bark (2) Oil from the leaves (3) Oil from the root. The Sri Lankan variety is said to be the best, containing more sugars and aromatic principles.

**Medicinal Uses**
The bark in infusion, decoction or powder or oil is prescribed in bowel complaints such as dyspepsia, flatulency, diarrhoea and vomiting. It is used as an adjunct to bitter tonics and purgatives. As a stimulant of the uterine muscular fibre it is employed in menorrhagia. It is a reputed remedy given in diarrhoea and dysentery. As a powerful stimulant, cinnamon is given in cramps of the stomach, enteralgia, toothache and paralysis of the tongue. The oil is locally applied with much benefit in neuralgia and headache. As an antiseptic it is used as an injection in gonorrhoea; as germicide it is used internally in typhoid fever. It was also used in massive doses with success in the treatment of cancer and other microbial diseases by Dr. J.J. Came Ross of Manchester.

**CAPSICUM**
The plant is very largely cultivated for its fruits throughout the plains of India and in the hills in some districts. Capsicin, a volatile alkaloid; capsaicin, a crystalline acrid substance; solanine, a volatile oil; fixed oil; fatty acid; resin; red colouring matter and ash are the constituents. Its pungency and acidity is due to the oleoresin capsicin.

**Medicinal Uses**
Chillies are employed in India as an ingredient of various curries, chutneys and pickles. In chronic lumbago a plaster of capsicum with garlic, pepper and liquid amber is an efficient stimulant and rubefacient application. When made into lozenged with sugar and tragacanth it is a remedy for hoarseness; employed in the form of tincture as an adjunct to bitter tonics and other stimulants, it is useful in a tonic dyspepsia, loss of appetite and flatulence.

Capsicum has a powerful action on the mucous membrane and in hoarseness and sore throat and in putrid throat a gargle made of chillies is found particularly beneficial. An infusion with cinnamon and sugar is a valuable drink for patients suffering from delirium tremens as it satisfies the craving in dipsomaniacs. Externally a paste of it is used as a rubefacient and as a local stimulant for the tonsils in tonsillitis. In diphtheria its application is said to hasten the separation of false membranes. Capsicum is used in snakebite also.

**CARAWAY**
The crop is extensively cultivated as a cold season crop on the plains and as summer crop on the hills in Northern India, Himalayas and the Punjab, Kashmir, Kumaon, Garhwal, Chamba etc. Fruits or seed and essential oil are economically important.

**Medicinal Uses**
Caraway seeds are medicinally useful in hoarseness of voice, dyspepsia and chronic diarrhoea. Seeds are also cooling in effect and therefore from an ingredient of most preparations for gonorrhoea. Externally they are applied in the form of poultice to allay pain and irritations of worms in the abdomen. Seeds mixed with lime juice are administered in cases of bilious nausea in pregnant females, and the seeds taken internally shortly after child-birth increase secretion of milk. Seeds reduced to powder, mixed with honey, salt and clarified butter are applied to scorpion bites.

**ASAFOETIDA**
This is a small plant which grows wild in Punjab, Kashmir, Persia and Afghanistan. Aromatic gum-resin (asafoetida) obtained by invasion from the roots are the parts used.

**Medicinal Uses**
Asafoetida is in popular use in India for centuries. It is fried before being used. It is stimulant, carminative, antispasmodic, expectorant and slightly laxative. It is a valuable remedy for hysteria and nervous disorders of women and children, the asthmatic coughs of childhood and also in the advanced stages of whooping cough, pneumonia and bronchitis of children and in the chronic bronchitis and asthma of adults. A teaspoonful of a mixture 1 ml in 50 ml of water or thin gruel is very effective in relieving the flatulent colic of children. Blister of asafoetida is a good stimulant application to the chest of children suffering from whooping cough. Asafoetida is useful as an antihelminthic for round worms in children; asafetida enema is an effective means of removing thread worms from the rectum and lower bowel. In dental carries a mixture of opium and asafoetida is placed in the hollow tooth to relieve the ache. Asafoetida is given to increase the lochial discharge after childbirth. For this, it is first dried in small quantity and then mixed with garlic and palmyra jaggery and a bolus is made and given to the patient every morning. It is a valuable remedy in the treatment of habitual abortion. It is used in intestinal disorders, rheumatism, bronchitis and consumption as blood purifier and germicide. Externally in earache and ulcers in the ear or nose; it relieves pain and heals ulcers.

**Medicinal Properties and Uses of Seed Spices**

India, grows over 60 spice crops in different agro-climatic situations. Spices are obtained from roots, leaves, fruits, seeds, whole herbs etc. Among various spices, coriander, fenugreek, cumin, fennel, sowa (dill), celery and ajwain of which seeds or fruits (which are also commonly known as seeds) primarily forms the consumable product and are annual in nature, constitute the group of "seed spices". They are easy to grow, can be preserved for longer period and are costly. These seed spices, besides being important for domestic consumption are gaining increasing importance inputs for preparation of medicines. The important medicinal properties and medicinal uses of different seed spices are as follows:

**CORIANDER**

**Medicinal Properties**

Coriander seeds are rich source of vitamin A and C and are considered as appetizer, digestive, carminative, tonic, antipyretic and diuretic. Coriander essential oil is spicy, warm, aromatic, stimulant, carminative and antispasmodic.

**Medicinal Uses**

An infusion of the seeds in combination with cardamom and caraway seeds is used against flatulence, indigestion, vomiting and intestinal disorders. The roasted seeds are useful in dyspepsia. The decoction with milk and sugar is beneficial during bleeding piles. Coriander is also used to reduce intoxicating effects of spirituous liquors, prepare drink with dry seeds of coriander ground with water, add little water to it and keep for one hour then add sugar crystals and honey. The drink should be taken in short intervals in polydipsia and burning condition. Equal parts of powder of coriander, cumin and krishna jeera, boiled with jaggery should be taken to cure gout.

**FENUGREEK**

**Medicinal properties:** Methi seeds contain a volatile oil, alkaloids including trigoneline, flavonoids, mucilage, protein, fixed oil, vitamin A, B and C and minerals. Seeds are considered as digestive, carminative demulcent, diuretic, emmenagogic, astringent and galactogogue. Leaves are considered as mild purgative, cooling reduces burning sensation and swellings.

**Medicinal Uses**

In leucorrhoea three to six gm of powder of seeds and six to twelve gm of sugar candy with 50-100 ml of fresh milk of cow taken twice daily is beneficial. Methi seeds are fried in ghee, mixed with seeds of anise and salt and made into a paste, which is given to check diarrhoea. Seeds are roasted, powdered and give in infusion or a weak decoction, which is very useful in dysentery. Paste prepared from methi seeds when
rubbed frequently on the face increases the luster of the skin. Application of paste of methi seeds is useful in mitigating burning sensation of the soles and palms. Methi seeds are used to induce childbirth and for nursing to increase the flow of the milk. The seeds of methi are also useful in anemia, being rich in iron (16.5mg/100gm). Debitterized methi seeds can be made into soup, a curry and a candy and thus incorporated in bread or chapatti is a very valuable supportive therapy for diabetes. Eating salad of methi leaves increases the power of memory. Paste of fresh leaves applied over the scalp regularly before bathing lengthens the hair, preserves the natural colour and keeps the hair silky and soft. For control of pimples, blackheads, dryness of face, grind methi leaves finely with a little quantity of water. Apply this paste on face as an ointment before going to bed in the night, wash the face next day morning in warm water. It improves complexions and makes one look ten years younger.

FENNEL

Medicinal Properties
In fennel seeds(fruits), leaves, roots and volatile oil present in the seeds have medicinal values. Leaves are diuretic and roots are purgative. Seeds are aromatic, stimulant and carminative useful in diseases of chest, lungs, spleen, kidneys and used in diseases like cholera, bite, nervous disorders, cough and cold constipation, dysentery and diarrhoea.

Medicinal Uses
Hot infusion of fruits is used in indigenous medicine to increase lacteral sacretion and to stimulate sweating. The consumption of fennel seeds also aid to weight loss and longevity. Fennel oil is used in preparation of medicines for treatment of post-menopausal syndrome and regulates menstrual periods; oil is also used in cosmetics and medicinal preparations like in infantile colic and flatulence. Local application of fennel is beneficial in giddiness, headache, specially in the summer season. A paste of seeds/fruits is used in a cooling drink in fevers, burning mictuaration and scalding of urine.

CUMIN

Medicinal Properties
Cumin seeds are highly aromatic, carminative stimulant stomachic, astringent and a strong anethelmintic. It is also considered as an appetizer, digestive, aphrodisiac promotes strength and is beneficial for eyes.

Medicinal Uses
The cumin seeds are important ingredient preparation of gonorrhea, chronic diarrhoea and dyspepsia. Cumin seed powder, mixed with honey, salt and clarified butter are applied against scorpion bites. Cumin relieves flatulence and bloating and stimulates the digestive process. Seeds powder of cumin with jaggery taken internally is beneficial in malaria. A paste of cumin and coriander taken internally in small doses every day is useful in hyperacidity, indigestion, vomiting, loss of appetite etc. Cumin seeds are also used in insomnia, colds and fever. Cumin oil is effective against eczema.

AJWAIN

Medicinal Properties
Ajwain subsides vitiated vata and cough, cure piles and useful in flatulence, collic, atonic dyspepsia, diarrhoea, hysteria, spasmodic affections of the bows, skin diseases and bronchitis.

Medicinal Uses
Most frequently used in conjunction with an asfoetida and rock salt to relative rheumatic and neuralgic pain. Ajwain with cumin along with sheedhu is beneficial in piles. For stomachic, cough and indigestion, the seeds are masticated and swallowed followed by glass of hot water is a common domestic remedy. Ajwain powder with old jaggery should be taken internally for seven days and is useful for urticarea. In tonsillitis, the seeds of ajwain should be kept in mouth day and night. The ajwain leaves are used as vermicide and roots are diuretic and carminative.

CELERY
Medicinal Properties
Celery leaves are more nutritious and good source of protein, vitamin A and C. Celery seeds are stimulant tonic in asthma and liver diseases carminative and diuretic. Celery oil is antispasmodic and nerve stimulant.

Medicinal Uses
As a domestic medicine, celery seeds are used as nervine, sedative and tonic in asthma and liver diseases. It is also employed in rheumatoid arthritis and gout. The celery oil is very useful in treating high blood pressure. The celery roots are given in anasarca and colic. The preparations from celery are infusion, tincture and powder. The main constituents of celery are: volatile oil (1.5 to 3.0 per cent), limonene (60-70 per cent), furanocououmarin (bergapten and flavonoids(appiin).

DILL (SOWA)
Medicinal Properties
Dill seeds is an important stomachic, especially in the ailments of children and women. It is also carminative, digestive aromatic, diuretic and resolvent. Essential oil extracted from dill is more useful in flatulence, colic and abdominal pain in children and women.

Medicinal Uses
The essential oil, dill oil or its emulsion in water (dill water) is considered to be an aromatic carminative especially useful in control of flatulence colic and hiccups in infants and children. Sowa as a drug is useful in inflammatory and painful conditions of piles for which it should be used with vacha as fumigation therapy. It is also useful tuberculosis and gout. This is very useful for women, especially after delivery for expulsion of placenta, promotion of milk. This drug is advised to be taken with various vehicles for various purposes such as, for digestion with honey, for complexion with milk and ghee, for strength with oil, in anaemia and jaundice with milk and urine of buffalo, in gulma with caster oil, in leprosy with decoction of Khadira, in dry stool with mamsa rasa. Local application of dill seed paste with sandalwood is beneficial in headache. In case of inflammatory joint conditions, applications of leaves and roots paste locally is very beneficial.

In Vitro Microrhizome Production in Four Cultivars of Turmeric (Curcuma Longa L.) as Regulated by Different Factors
ABBREVIATION
BA = 6 benzyladenine
MS = Murashige and Skoog medium

INTRODUCTION
Microrhizomes can be produced in vitro independent of seasonal fluctuation like induction of tubers and bulbs in culture. These organs serve as planting material, stored and sown like seeds. Microrhizomes are very useful for transport, field delivery and help in improved field establishment of plants and hence, can be profitable from commercial point of view as has been seen in the application of potato minitubers in germplasm storage, conservation and exchange programme. Therefore, experiments were conducted to induce rhizome formation in tissue culture of four cultivars of turmeric (Curcuma longa L.).

Turmeric is a tropical spice and well known as condiment and colouring agent since time immemorial. In Indian system of medicine, turmeric is used as stomachic, tonic and blood purifier. Turmeric has got the unique combination of its properties like antioxidant, hepatotareactive and anticancer effect. Oil of turmeric has got antifungal antiinflammatory and antiarthritic activity and acts as an antacid, carminative and appetiser. Though India leads in production of these species, there is severe shortage of healthy planting material due to low multiplication rate (6Ã¬8Ã- per annum) and high incidence of fungal diseases such as leaf spot and rhizome root. Because of this germplasm collection in clonal repositories are also threatened seriously. So there is distinct need to investigate potential of turmeric for in vitro rhizome formation which can alleviate both propagation problem and maintain disease free germplasm bank. Tissue culture studies
done so far include only in vitro clonal multiplication of turmeric. This communication reports successful in vitro production of microrhizome in the species of Curcuma as effected by different factors. Microrhizome induction has been reported earlier in *Curcuma aromatica*.

**MATERIALS AND METHODS**

Four varieties of *Curcuma longa* namely Ranga, Rashmi, Roma and Suroma were used in the present investigation.

**In Vitro Shoot Culture**

Rhizomes of 4 varieties of *Curcuma* were collected from High Altitude Research Station, Pottangi and planted in sand beds in the garden of Regional Research Laboratory, Bhubaneswar and they sprouted at the onset of monsoon. Turmeric sprouts measuring 1-2 cm in length were cut from the rhizomes and washed with distilled water. After washing the sprouts were surface sterilized with 0.1 per cent mercuric chloride solution for 10-12 min. Surface sterilized sprouts were washed five to six times with sterile distilled water. These sprouts were then transferred to a sterile petridish and sprout cuttings (explants) of about 0.7 cm long were inoculated aseptically into agar-solidified Muraslige & Skoog's (MS) medium containing various hormone supplements. A single explant was placed in culture tube. Varying concentrations of BA (1,3,5 and 7 mg/l) or a combination of BA (1,3, & 5 mg/l) with either kinetins (0.5 & 1 mg/l) or naphthalene acetic acid (NAA) (0.5 & 1 mg/l) were used for shoot bud multiplication. Subculturing of shoots was done on the same media after 30 days of growth. In vitro grown shoots of about 4 cm long were then transferred to MS liquid media and maintained by regular subculturing. Shoots were associated with formation of roots in same media giving rise to complete plantlets.

**Induction of Microrhizome**

For induction of microrhizome, young plantlets (ca 4 cm long) were taken out of the culture tubes aseptically and transferred to MS liquid medium supplemented with Benzyl adenine (BA) alone at different concentration (1, 3, 5 and 7 mg/l) or a combination of BA (1,3,5 & 7 mg/l) and NAA (0.1 & 0.5 mg/l). Sucrose (30, 60 and 90 g/l) and photoperiod (0 hr, 4 hr, 8 hr & 16 hr) were tested in different combinations to study their effect on microrhizome formation. Results obtained in 16 different media mentioned below are studied in details.

- **M1** - BA (1 mg/l) + Sucrose (30 g/l) + Photoperiod (16 hr light)
- **M2** - BA (1 mg/l) + Sucrose (60 g/l) + Photoperiod (16 hr light)
- **M3** - BA (1 mg/l) + Sucrose (60 g/l) + Photoperiod (4 hr light)
- **M4** - BA (3 mg/l) + Sucrose (30 g/l) + Photoperiod (4 hr light)
- **M5** - BA (3 mg/l) + Sucrose (60 g/l) + Photoperiod (16 hr light)
- **M6** - BA (4 mg/l) + Sucrose (60 g/l) + Photoperiod (8 hr light)
- **M7** - BA (3 mg/l) + Sucrose (60 g/l) + Photoperiod (4hr light)
- **M8** - BA (3 mg/l) + Sucrose (60 g/l) + Photoperiod (0 hr light)
- **M9** - BA (3 mg/l) + Sucrose (90 g/l) + Photoperiod (8 hr light)
- **M10** - BA (5 mg/l) + Sucrose (90 g/l) + Photoperiod (4hr light)
- **M11** - BA (5 mg/l) + Sucrose (30 g/l) + Photoperiod (4 hr light)
- **M12** - BA (5 mg/l) + Sucrose (60 g/l) + Photoperiod (16 hr light)
- **M13** - BA (5 mg/l) + Sucrose (60 g/l) + Photoperiod (8 hr light)
- **M14** - BA (5 mg/l) + Sucrose (60 g/l) + Photoperiod (4 hr light)
- **M15** - BA (5 mg/l) + Sucrose (60 g/l) + Photoperiod (0 hr dark)
- **M16** - BA (5 mg/l) + Sucrose (90 g/l) + Photoperiod (4 hr light)

For solidification of media 0.8% bactoagar was used. Media were autoclaved at 121oC, 1.05 kg/cm2 for 20 min and pH was adjusted to 5.7. Cultures were incubated at 25±2°C and grown under white fluorescent light with 55 ? mole m-2s-1 light intensity. 15 replications for each treatment was used. The experiment was
repeated three times. Periodic observations on percentage of shoots forming microrhizomes, weight and number of buds per microrhizome were noted.

**Harvesting, Storage and Germination of Rhizomes**

In vitro produced rhizomes were repeatedly washed in tap water, air dried and sown in sterile soil in pot and kept in a nethouse. Rate of germination of microrhizome for each cultivars was recorded. For storage in vitro microrhizomes were transferred to fresh MS solid medium containing low amount of BA (0.01-0.1 mg/l).

**Statistical Analysis of Data**

Date were subjected to analyse the variance for a factorial experiment.

**Indian Spice Extraction Technology**

**INTRODUCTION**

Eating a well balanced spiced food preparation is indeed a stimulating experience. Spices have two major flavour attributes. The one that catches consumer's immediate attention is the typical spicy aroma. This is contributed by the essential oil, called in this case as spice oil, and detected by olfactory apparatus of nose. But even more powerful quality is the hot pungent taste that spices give to the food on chewing and felt in the mouth.

Traditionally India is known as a source of quality spices. But the last quarter of the twentieth century saw India making an impressive performance in the manufacture and export of spice oils and oleoresins. An efficient spice extraction industry emerged with many positive developments. What is more important is the fact that it is well patronized by the developed world.

Before seventies, late P.B. Kurup of Calicut had actually started producing oleoresin in small quantities. Some of the companies in Mumbai were making small quantities for their formulations. But by and large, these attempts were rather small and not founded on recent technological developments. Extraction was in small batches using soxhlet extractors and not much attention was paid to the removal of the last traces of solvent residue.

**INDIGENOUS TECHNOLOGY**

Large scale extraction process, was introduced in India in the early seventies when a plant was set up near Cochin based on a technology handed over by a major US company. But even more important development was standardization of a new process for spice extraction technology by Central Food Technological Research Institute, (CFTRI) Mysore. Indigenous technology, has a two-stage operation of steam distillation followed by solvent extraction. It has not been a mere transfer of a western processing technology into the place where raw material is available and where labour cost is also lower. There are some important special features that are added on as the industry prospered here. It can be safely said that during the last quarter of a century, one of the positive developments in Indian food industry has been the emergence of spice extraction technology.

Since the labour cost was high in developed world, there was need to use a continuous single stage operation. Removal of surplus volatile oil if any, was a secondary step involving extracted material. Solvent gets mixed with the fine aroma during the extraction and solvent removal phases. It is believed that in those days a large quantity of major spice oils were steam distilled without any involvement with spice oleoresin extraction process.

When spice oleoresin industry was introduced in India by CFTRI, the process became a two-stage operation. The volatile oil is first removed by steam distillation. The deoiled spice after suitable drying and size reduction is then extracted with appropriate solvent, which is selected as the best suited for non-volatile active principle only. Thus during solvent extraction, there is no messing around with volatiles which are important for aroma. Extraction is carried out by cold gravity percolation. Batch counter-current
technique is followed to reduce the capital cost. Required quantity of resin representing taste, notably pungent principles and colour if any, and volatile oil representing aroma are blended as per customer specification. Depending upon the raw material and polarity of the active principles, different solvents like n-hexane, ethylene chloride, methylene chloride, ethyl acetate, acetone and methanol are used.

STEAM DISTILLATION
Production of spice oils is carried out more or less in the same manner as steam distillation of any other essential oil. Being a food flavour, there is need to use food grade stainless steel for the entire equipment. Generally higher price of spice oils will enable the process to absorb the extra capital cost in the long run. Another reason for using SS equipment is to avoid darkening of the product. Many spices contain phenolic constituents. Some of them are volatile like eugenol which on contact with iron will give dark colour.

Before distillation, the spices are dried usually by sun drying, followed by size reduction. Drying and size reduction help in breaking the cells that contain the essential oils. Very fine powdering may result in channeling and therefore only coarse grinding is resorted to. In some cases after a coarse grinding and in other cases directly, the dried spices are passed through a roller mill to flatten coarse particles into flakes and break the cell walls.

Distillation stills used for spice oils consist of a raw material chamber, a condenser and a Florentine flask arrangement for receiver. It is better to use a well designed boiler as the source of steam. The capacity of chamber can vary between 100 to 1000 kilogram of ground spice. Lower capacity still is useful for oils of high value and where extraction of non-volatile constituents are not necessary like cardamom oil. For pepper, ginger, celery seed etc. which are required to be solvent extracted later, a higher capacity still is preferable. Very tall stills are not encouraged since flavour oils are valued highly for heavier sesquiterpene unlike fragrance oils.

Water cooled SS condensers are used. In order to recover every drop of oil, the condenser has to be designed based on the cooling area required, which is calculated from the average specific heat of vapours, latent heat of vaporization of steam and temperature of cooling water of the region concerned.

In the Florentine flask arrangement three-stage receiver is preferable for ensuring full recovery. While steam distilling heavier-than-water oils, it is necessary to have space for heavier fraction to collect in the bottom, by taking the overflow syphon from around the middle portion of each compartment. In heavier oils there will be lighter constituents also which will collect at the top. Both these fractions will have to be blended.

Quality is ascertained by refractive index, specific gravity and optical rotation. For oils used for food flavouring, solubility in alcohol is not always important. For detailed quality check, organoleptic evaluation and gas chromatographic examination are used. Generally flavour industry prefers more oxygenated compounds than hydrocarbons like in citrus oils. Besides, sesquiterpenes are valued for flavouring. Savory foods using spice flavours are generally eaten when warm. Elevated temperature make sesquiterpenes more volatile and therefore more acceptable organoleptically. Food is also held for a long time in the mouth during chewing. This nearness to olfactory organ enable the nose to sense heavier fraction well.

It is appropriate to point out that high quality of spice essential oils are measured in terms of quantity of some characteristic sesquiterpenes, like selinene, the dicyclic sesquiterpene, in celery seed oil and myristicine, the oxygenated sesquiterpene, in nutmeg oil. In oil of black pepper, a caryophyllene and in the oil of ginger zingiberene and arcurcumene are important.

SOLVENT EXTRACTION
There are spices where oil and oleoresins are important. Black pepper, ginger, celery seed, nutmeg etc. belong to this group. After the recovery of essential oil, the left over powder is freed of the moisture of steaming, lumps broken and then taken for solvent extraction. The resin obtained will have to be blended with required quantity of oil as specified by the customer to make oleoresin. Another group of spices do not
have oil and hence they are dried, size reduced and taken for solvent extraction. These include chilli, paprika, turmeric etc. No doubt turmeric has some essential oil, but it is not at all valued for aroma of essential oil. Some essential oil do come in the extract.

Batch counter current extraction is used in India. Percolators made of food grade SS with a capacity of 500 to 3000 kilogram of ground raw material are employed. There will be false bottom on which ground spice is loaded to near full capacity. There will be arrangement to sprinkle solvent from the top. In the bottom there is opening with a closure to remove miscella. For loading the ground spice, there will be a manhole on top and for removing the spent material, one in the bottom side. Both these manholes can be sealed with closures provided with gaskets and screws to fix and tighten without leak. Finally, there is arrangement for steam heating to remove the adhering solvent at the end of extraction.

Solvent is admitted from top. As the solvent layer percolates evenly by gravity, it will dissolve the resinous matter containing all the active principles including colour. The quantity of liquid passing through is selected so that complete extraction is achieved. To reduce the volume of solvent used, batch counter current procedure is employed. As per this, when extraction is continuing, only the first lot of miscella is taken out for distillation to produce oleoresins. This can be equivalent to one to four times of the weight of spice in each percolator. This will be the most concentrated also. The rest of the progressively weaker extract is passed on to the next percolator loaded with ground spice. Here also the first lot is taken for distillation and the rest passed on to the next percolator. Finally fresh solvent is added on top to complete the extraction. Fresh solvent used in each percolator will represent the weight of solvent removed for distillation and the weight of solvent remaining adhering to the spent powder at the end of percolation.

However quantity of solvent, in the form of progressively weaker extract and pure solvent can be regulated even up to 6 to 8 times the weight of spice in each percolator without using pure solvent very much. Thus by this batch counter current process, full efficiency of a regular counter current operation where raw material and solvent move in opposite directions, can be achieved. Because there is no moving chain, capital cost will be lower. Also it is be easier to avoid leakage especially of solvent fumes. No doubt the labour cost will be slightly higher. But this is an ideal situation in a developing country.

Miscella taken out for distillation is a concentrated solution of the non-volatile fraction in the spice. This will consist of all pungent principles, natural colour, if any, all fatty oils, any left over higher boiling terpenes, and some fatty resinous matter of undefined chemical composition. This is freed of solvent by distillation. The last traces of solvent is removed by introducing steam and by applying vacuum. The different regulatory bodies like FDA in USA, EC in Europe and BSI in India allow only 30 ppm of residual solvent. This regulation can be met. Apart from this, other items of specifications are the level of the active principle, volatile oil content in the case of spices with volatile oil, and colour value in the case of chilli. Of course organoleptic qualities are important. Volatile oil level is adjusted by blending with required quantity of spice oil.

The quality of oleoresin is determined by the active principles which give the characteristic taste and colour. The level of volatile oil gives the desired aroma. But an important requirement is removal of last traces of solvent to a permitted limit. Many customers now want aflatoxin, pesticide and heavy metal residues controlled within limit.

The indigenously developed two-stage extraction has some advantages over the single-stage Western technology. For one, spice oil is obtained without any interference of solvent. The aroma characteristics can be regulated up to a point during the first stage steam distillation. To get a quality oil, the older practice before second world war of using raw spices only for production of oils, is not necessary any more. For solvent extraction also, since spice oil is not involved, the solvent chosen can be the best suited for non-volatile constituents only. The removal of last traces of solvent from the resin is also simpler since there is no interference from volatile oil. By using a batch counter-current procedure, capital cost can be
Spice Oil and Oleoresin from Fresh/Dry Spices

From time immemorial, people in many parts of the world have been using spices and herbs extensively to improve the flavour and aroma of food materials. Initially ground spices were used for this purpose. With the development of flavour industry the requirement for flavours have shifted from ground spices to Oils and Oleoresins. It is well known that flavours of all natural products are subject to a wide range variations. Even seasonal variations are not uncommon. When spices and herbs of the same species are grown in different geographical regions, there are variations in their flavour and aroma due to the compositional difference of the essential oil and flavouring compounds present in them. Oleoresins provide a uniform standardized flavour and its application is much more process friendly than application of ground flavors.

Currently the oils and Oleoresins are recovered from the spices by solvent extraction using solvents like hexane, acetone, methylene chloride, ethylene dichloride, supercritical carbon dioxide etc. The solvent extracted resins are carefully processed to remove the solvent and bring it down to 25 to 30 ppm residual solvent. Chlorinated solvents are widely used by the industry and due to strict regulations being imposed by the importing countries efforts are on to change over to other safer solvents.

India is the major producer of oils and oleoresins and about 95 per cent of the world demand is met by India. Currently dry spices are used for oleoresin manufacture and efforts were on for long time to develop a suitable technology which is commercially viable and can recover the active ingredients present in the spices economically. The spices when they are dried under the sun or by artificial means loose the major aroma imparting volatiles and the oleoresins produced from them do not have the pleasant aroma of the fresh spices. Since India is the major producer and consumer of spices, the fresh spices are available and in many places they are sold under distress conditions due to lack of processing and storage facilities. Thus it will be relevant in the social as well as from the marketing point of view to process the fresh spices to make value added products like oils and oleoresins from them. Thus oleoresins from fresh and dry spices can capture the international market and India has the unique opportunity to produce both the products because of the availability of the raw materials in fresh as well as dry form.

The north-eastern regions of India offer excellent raw material for oil and oleoresin industry. The agro climatic conditions existing in that part of the country prevents them from going for drying and material is available in plenty even during off seasons at competitive prices. The technology of processing fresh material without drying assumes significance in this context. If India is to make oleoresins and oil at a lower cost the potential of the north east have to be tapped. The selection of the raw material determines the end product quality. The active ingredients are analysed prior to purchase of the raw material to see that they meet the requirements for oleoresin manufacture. The ratio of active ingredient to volatile oil, the content of the active ingredient, the yield of oleoresin etc are ascertained before procurement. In certain cases the raw materials from different sources have to be blended to meet the customer requirements. The profitability of oleoresin manufacture depends to a great extent on the sourcing of the right raw material at the right price to meet the customer requirement. Processing the material at the appropriate time when the prices are low will reduce the inventory cost drastically. The pepper produced in India have a piperine content of five per cent compared to 9 to 10 per cent in Srilankan or Vietnamese pepper. Similarly the essential oil content in Srilankan pepper is as high as six to seven per cent compared to three or four per cent in Indian pepper. Thus it is obvious that selection of raw material plays a key role in the profitability.

Size reduction, reduction of the moisture, extraction and stripping off the solvent are the major operations involved in the manufacture of oils and oleoresins. In the case of fresh spices, the high initial moisture content necessitates the reduction of moisture levels by mechanical means to accomplish the high extraction efficiencies required by the industry. The dewatered fresh spices form two streams - one
aqueous portion and another solid portion. The solid portion goes for extraction just like the dry spice where as the aqueous portion which has negligible amount of resinous matter but high percentage of essential oil goes for a simple distillation process. The distillation of the aqueous portion results in foaming and emulsion formation and proper design of the equipment and distillation conditions are to be ensured for the efficient recovery of the essential oil.

The extraction of the spices are done in stainless steel extractors provided with a jacket for passing hot water/steam. The extractors are provided with a perforated bottom plate and jute cloth is spread over it to prevent the material going along with the miscella. The material from the size reduction unit are then fed into the extractors and each extractors are designed to hold 1.5-2 tonnes of ground spices. In the case of pepper and deseeded chillies it will hold more of the spice. The material after loading into the extractors are leveled properly so that no channeling take place.

Ethylene dichloride is the most commonly used solvent by the industry. But the restrictions imposed on the use of chlorinated solvents by the importing countries have made the industry to look for alternate solvents like hexane, ethyl acetate, alcohol, methyl alcohol, acetone and/or its mixtures. Research work is underway at the Regional Research Laboratory to go for eco friendly solvents other than supercritical carbon dioxide which will replace the conventional organic solvents. The oleoresin plants currently designed have provisions to go for any solvent system and are designed to switch from one solvent to another depending on the requirements.

Extractions are done in the batch extractors with sets of 4 or 3 extractors operating with different spices. After loading the extractors with the spices solvent is added to immerse the solids completely. The solvent is then raised to higher temperature and after a few hours the concentrated miscella is pumped for evaporation. Fresh solvent or lean solvent from other extractors are added for the second and subsequent washes. The extraction is repeated until the miscella becomes lean. In certain cases the spices are subjected to steam distillation prior to extraction for the recovery of the aroma imparting essential oils.

After the complete extraction, the solvent adhering to the bed has to be recovered. This is accomplished by steaming the bed and vaporizing the solvent from the bed. The vapours rising from the bed are condensed and collected for re distillation. To ensure complete removal of solvent from the bed, the steam rate have to be maintained at half the weight of the charge.

The miscella from the extractor is concentrated in an evaporator provided with a distillation. Once the temperature in the evaporator starts raising above a certain temperature the concentrated miscella is pumped into the stripper or scraped surface heat exchanger for final de-solventisation. Scrapped surface evaporator ensures short residence time and efficient solvent removal without affecting the product quality. Final removal of the solvent is done in a stripper which is basically a reboiler provided with a rectification column. The concentrated miscella is evaporated in a re-boiler provided with a jacket steam heating and anchor type stirrer. The vapour is allowed to rise through a rectification column provided with structured packing or SS mesh packing and is condensed. Any remaining solvent will evaporate and the condensate is periodically tested for the presence of solvent. The stirring of the oleoresin and its recirculation are ensured so that proper mixing is effected. At the high vacuum and temperature maintained in the stripper, moisture and residual solvent if any, are removed. A sample of the oleoresin is then drawn for analysis. After the analysis if the oleoresin is free of solvent, it is pumped to the batching tank through the filter press. If any residual solvent is left, the oleoresin is aerated prior to pumping to achieve the permissible residual solvent level.

The products, to meet the international specifications, have to further processed to achieve the particle size and essential oil specifications. It has to be further blended with the essential oil and emulsifiers to meet the customer requirements. In the case of chilli oleoresin, the product has to either enriched or diluted to achieve the capsaicin and colour values. This is achieved by partitioning the colour and the capsaicin
portion between two organic layers and separating them out. Turmeric oleoresin have to be processed further to isolate the curcumin. Crystallization of the curcumin from the oleoresin involve leaching out the resinous and essential oil fractions completely using organic solvents and steam stripping them to meet the bacterial and residual solvent limits.

**Onfarm Post Harvest Technology for Plantation Spices**

India has been playing a major role in producing and exporting various perennial spices like cardamoms, pepper, vanilla, clove, nutmeg and cinnamon over a wide range of suitable climatic situations. The world still looks upon India as the source of many a spices for consistent supplies. No doubt, there exists considerable competition from other producing countries emerging in supplying quality materials at competitive prices. At the same time, the countries importing spices are strict at the food safety standards prescribed. In this context, to produce good quality spice products, attention is required not only during cultivation but also at the time of harvesting, processing and storing. The factors involved therein are briefly examined in respect of the important spices of perennial nature grown in India.

**(A) CARDAMOM**

Cardamom goes from the western ghats in South India. Cardamom fruits ripen over an extended period and are usually gathered at intervals of about a month. The climatic conditions, race differences and irrigation facilities influence the time and duration of the harvest. Fruits are picked just before they are fully ripe. Fully ripe fruits tend to split on drying and do not exhibit good colour once dried. Immature fruits give uneven, shriveled, and badly coloured produce. Fruits need to be harvested individually at the correct stage of ripeness on considerable experience gained to judge it in respect of races.

Sun drying of the fruits is practiced in the case of malabar cardamom (manjurabad cardamom) grown in Karnataka. The freshly picked cardamoms are laid out in the sun on sacks or rush matting. The process takes four - six days, during which time it is frequently turned to allow even drying. Cloudy weather/occurrence of rains pose problems. They are also taken indoors overnight to avoid the nocturnal dew. The produce is yellowish in appearance. The Manjurabad type of cardamom once properly cured is probably superior in regard to flavour quality. Further, bleached cardamom can be produced after sun drying by exposing to fumes from burning sulphur.

Green bold cardamom is the cardamom of commerce and usually come from Mysore or hybrid varieties. The freshly picked green cardamom are first washed to free from adhering dirt and then allowed for artificial curing in specially built curing chambers. The curing of the fruits is generally accomplished using a flue heating system placed below the floor made in a curing house where cardamom is spread/placed in trays/racks for drying. A grate furnace is constructed outside the curing chamber at just above ground level, exiting as a stack outside. Wood or L P G can be used to provide the source of heat. There exist different models of curing systems using firewood/kerosene/ LPG/electricity/diesel as fuels. In Guatemala, big drum like curing tanks blowing hot air from below is used for trader/exporter level large scale curing of cherry bought from growers.

After spreading the washed fruits evenly on the curing floor/trays racks (different types), the curing room is completely sealed and the temperature is allowed to raise below 55Â°C and maintained by adjusting ventilators/fans provided and maintained between 40 - 55Â°C for 24 - 36 hours. This treatment arrests further vegetative development in the fruit and fixes the colour of the chloroplasts. During the curing process, fruits are at times stirred to facilitate even drying. Moisture level of cured cardamom is maintained at 10-13 per cent.

Once cured, the cardamom is removed from the curing floor/trays/racks arranged above the flue pipe system, and while still hot, stalks and calyces are removed by rubbing over a wire gauze. They are finally winnowed, polished and graded by hand and stored in light proof bins/boxes/sacks layered inside with
black polythene until required for marketing.

(B) LARGE CARDAMOM

The harvesting season of large cardamom grown mainly in Sikkim and Darjeeling district of western Bengal extends from August to December. The harvesting is done by a special type of knife, locally known as 'Elaichi Churi'. By this knife each fruit bunch is cut and separated from the plant. The harvesting is done once in a year by cutting bunches containing matured fruits. After harvesting, the individual capsules are separated from the bunch by hand.

The curing of cardamom is done in 'Bhatties' wherein the cardamom is spread over platform made of materials like bamboo, wood etc. over a kiln where firewood is burnt. Such temporary bhatties are commonly made in cardamom fields itself. The cardamom is dried by the heat generated during burning. Depending on the thickness of the cardamom spread, it takes two - four days for curing. The colour of the cardamom cured should be dark brown in colour, but in this method of curing, as the smoke comes in direct contact with the cardamom it loses its original bright colour and the cured cardamom may have smokey smell and charred appearance.

The flue pipe curing system being used in small cardamom which was introduced by the erstwhile Cardamom Board even during spices late 1970s did not pick up with the local growers for easy adoption in spite of its advantages tested. Later, Tata Engineering Research Institute (TERI) developed a gasifier type small drier in which chopped firewood was used as fuel but was inconvenient to the growers.

In recent times Indian Cardamom Research Institute (Spices Board) developed a modified Flue Pipe Bhatti system which is found to be more fuel efficient, economical and time saving than the conventional Bhatti system. For curing 200 kgs of harvested large cardamom only 6' Â- 4 ' of area is required. Firewood is used, and curing is completed by about 24 hours.

Flue pipe is connected to a fire place with an exit provided out side the building. The cardamom is spread over the floor/shelves. When the firewood is burnt, hot air passes through flue pipes and cardamom gets dried by the heat generated. By proper ventilation provided, the temperature inside the room can be controlled. Since smoke does not come into contact with cardamoms, its original colour is retained. The cardamom thus cured retain deep marooned colour fetching a premium price in the market.

(C) VANILLA

Vanilla is a wonderful flavour enhancer that boosts the flavour of savoury as well as sweet products. This comes on curing harvested vanilla beans. Both the vanilla orchid and the ripe vanilla bean lack aroma. The pods mature seven to nine months after pollination. It is only during the curing process that glucovanillin, a vanillin precursor formed during the ripening of the vanilla fruit, is enzymatically converted to glucose and vanillin. The longer a bean ripening, the more concentrated the vanillin and other flavour compounds are after curing. Higher vanillin indicating higher bean quality, which impacts the beans' market value. Beans harvested immature, left on the vine split are of inferior quality. Curing should begin a week after harvest. Beans must be fully matured for harvest indicating blossom ends turning to yellow. Immature pods give inferior product.

In the Bourbon process of curing, wilting or killing of the beans stop their respiration. Heat is applied to the pods for about five minutes, submersing them in hot water (60-65Â°C). Sweating the wilted beans involves rapid dehydration and slow fermentation to develop key flavour compounds. The beans are alternatively sun-dried during the day and wrapped with woolen material and kept in boxes at night for several weeks until the beans acquire a deep chocolate brown colour. Drying the beans very slowly at low temperature results in a final moisture level of about 20 per cent to 25 per cent. Over drying or rapid drying reduces flavour quality. Conditioning is an aging process necessary for flavour development that involves placing the dried beans into closed boxes for several months. After curing, the vanilla beans are graded and bundled (50 to 100 nos) both ends tied and wrapped in cellophane paper/ butter paper. Top grade beans
are oily, smooth, aromatic and very dark brown with vanillin 2 to 2.5 percent. McCormick & Co. Inc. uses one to two week curing process in which the beans are chopped and placed into a curing tank for about 72 hours until they are no longer green. They are dried in a rotary or fluidized dryer and spread out in a perforated conditioner until the desired moisture level is achieved.

(D) PEPPER
Black Pepper has been highly esteemed from the Malabar coast of India. It takes six months from flowering of pepper vines until harvesting of berries for different products, Bamboo ladders are used to reach the higher spikes, care being taken to avoid damaging the vines. The whole spikes are picked once the fruits have turned red for white pepper or at the maturity but still green or just turning to red for black pepper or at different immaturity stages for extracting oils/ oleoresins and pickling. Approximately 25 to 28 Kg of white pepper or 33 to 37 Kg of black pepper are produced from 100 kg of newly picked green pepper. For white pepper production, the outer skin is removed from the fully ripened fruits by appropriate treatment with water over a period of one week and then sun dried as in the case for black pepper.

Black Pepper is produced from whole, unripe but fully developed berries. Sun drying is the traditional method for its preparation. After harvesting, the initial step is piling the berry clusters in heap for easy separation of berries. Trampling is done for separation of berries. The next stage involves spreading the berries out on a suitable drying floor in the sun. Bamboo mats are commonly used or cement floors for the drying operation over a period of about one week. Cowdung smeared floors must be avoided either for threshing or drying. During the process, the moisture content is reduced between 10 to 15 per cent. To accelerate the rate of drying and towards brightened black colour, blanching of the berries in boiling water for about five minutes prior to sun dry is also practiced by some growers. Once dried cleaning, grading and bagging is carried out. Debris and light berries are removed by garbling, which involves winnowing machines or wide-mesh sieves. Quality is evaluated on its appearance insofar as colour, and size concerned, and also on pungency and aroma/ flavour properties. Free from insect infestation, mould and bacterial contamination are also of great importance. Greater care in drying and subsequent stages is necessary for ensuring clean product.

(E) CLOVES
The cloves of commerce is the dried unopened flower buds. Clove clusters are picked by hand when the buds have reached their full size and most of them have developed a pronounced pink flush, but none of the petals have yet fallen to expose the stamens. The yield and quality of the harvest largely depends upon the skill of the pickers who should only pick ripe clusters. Bamboo/Aluminium ladders or some other flexible climbing structures built around the trees are used for accomplishing the arduous task of picking.

From the harvested clusters taken to drying premises, the clove is removed from the stems consisting of peduncles and pedicels. The peduncles and pedicels can be dried for the distillation of clove stem oil, of which they contain about 6 percent.

The separation of buds from the stems is normally done on a suitable clean floor. The clove buds and the stems are piled in separate heaps for individual drying. Drying is undertaken as soon as possible after the buds have been separated from the clusters. If the buds are left too long in heap they will ferment and the dried spice will have a whitish shriveled appearance giving 'khoker cloves'.

The traditional method of drying the green cloves is by exposing them to the sun on bamboo mats or on cement drying floors. The green buds are spread out in a thin layer on the drying floor and then raked from time to time to ensure the development of a uniform colour and to prevent moisture formation. In sunny weather, drying may take as little as four - five days to produce a brightly coloured dried spice of attractive appearance. During the drying, the cloves lose about two thirds of their original fresh green weight. When properly dried they will be of a bright brown colour and will snap cleanly and not bend when pressed. After the drying operations are completed, the dried cloves are sorted to remove 'khoker cloves' with final
thorough cleaning, sorting, grading and bagging. Bagged cloves are stored in dry rooms for marketing.

(F) NUTMEG AND MACE
The nutmeg tree gives the nutmeg which is the kernel of the seed and the mace which is the dried aril that surrounds the single seed within the fruit. The fruits ripen six to nine months after harvesting. The fruits may be harvested on the tree after splitting, but more usually are gathered after falling on the floor every few days. If it is allowed to lie on the ground for several days, the underside of the kernel will become dark and discoloured, and the hazard of mouldiness is increased. The seed with the surrounding scarlet aril is removed from the pericarp. Later the mace is taken off and is dried separately from the nutmeg in its shell. The proportion of dried shell nutmegs to dried mace is approximately 20:3. During drying, nutmeg lose about 25 per cent of their weight. The mace is usually dried in the sun on mats, and sun drying is normally accomplished within two to four hours. Sometimes artificial drying is resorted to, but no smoke should come to contact with the mace. Solar driers can also be developed for adoption. Depending upon drying methods mace in red form or pale orange yellow are obtained. After the removal of the mace, the nutmegs are dried in their shells on mats or on cement floors. The mats are turned over daily to prevent fermentation and to promote even drying, and in cement floors by stirring with long wooden paddles, the purpose is served. Sun-drying for about one week is necessary for curing properly. Most nutmeg rattles in their shells on drying, and those which are incapable of doing so reach this state after about one week of air drying. Nutmegs are stored in their shells in a warm, dry atmosphere prior to shelling if required. Nutmegs are then sorted and graded according to quality and size before bagged for marketing.

(G) CINNAMON
The cinnamon harvesting starts by the fourth year after planting, depending on the availability of peeler shoots after pruning. The appropriate time for cutting of shoots for peeling is determined with reference to the circulation of sap between the wood and the corky layer. The sap flow and time for peeling are judged by the peelers by making a test cut on the stem with a sharp knife. If the bark separates readily, harvesting should commence immediately, otherwise shoots that not satisfied the test must be left for a future harvest. The shoots should be of at least two years growth with the bark having a uniform brown colour and should have attained a length of 1 to 1.25 metre and a thickness of 1.5-2.0 cm. Shoots, satisfying those requirements, are cut and bundled after removing leaves and terminal shoots. Scraping and peeling of cinnamon bark are the important operations requiring skill and experience. Peeling is normally done using a specially made knife. A longitudinal slit is made from one end to the other and the bark is removed using the knife. Normally the shoots cut in the morning are peeled on the same day. The peels are gathered and kept overnight under shade for softening. The bark, as it dries, contracts and assumes the shape of a quill. The smaller quills are inserted into larger ones to form compound quills. Before drying quills can be made to required length. The quills are dried first in shade for a day and then in sunlight on mats for three-five days. When drying is complete, the quills are graded from '00000', being the finest quality, to 'o' the coarsest quality. The barks which were broken into pieces and those taken from very tender/thick shoots are not suitable for the preparation of quills. These are also dried in the sun and graded as 'quillings' and 'featherings' respectively. Cinnamon leaf oil can be distilled from the leaves left out of the process the barks made into cinnamon quills.

CONCLUSION
Spices like pepper, cardamoms, vanilla, clove, nutmeg & mace and cinnamon have had a profound influence in flavouring foods and drinks. They are of considerable importance in the present day world spice trade. On farm operations focusing harvesting and processing cannot be overlooked for ensuring quality products at the farm gates as well as in the centers of value addition through marketing channels. The
consumer will naturally look for quality products through better harvests and post harvest operations practiced in the farms.

A. Celery Seed

INDIAN NAMES

- **Bengali**: Bandhuri, Chanu,

- **Gujarati**: Bodiajmoda;

- **Hindi**: Shalari, Ajmud, Randhuni;

- **Marathi**: Ajmoda;

- **Punjabi**: Kernauli;

- **Sanskrit**: Ajamoda;

- **Tamil**: Ajmoda

DESCRIPTION AND DISTRIBUTION

Celery (*Apium graveolens* Linn.) is an umbelliferous aromatic herbaceous plant grown for its leaves, seeds, oleoresin and essential oil. Celery seed has been known for over 3,000 years. It was mentioned in Homer's *Odyssey*, written about in the seventh century BC, as an excellent medicament. The earliest recorded use of celery seed as a seasoning for food was not until 1623 in France.

Celery seed is the dried ripe fruit of the umbelliferous herb, which is usually 30 to 60 cm high, erect with conspicuously jointed stems, bearing well-developed leaves on long expanded petioles. The plant has a grooved, fleshy erect stalk, a tap root, radical and stalked leaves, hermaphrodite flowers and humped ovoid, light brown aromatic seeds, which are very small (up to 2 mm in diameter), and there are over 1.8 million of these tiny brown seeds in a kilogram. The rigid fruit is small, ovoid (though round appearing to the eye), 1.1 to 1.5 mm long and 1-2 mm in diameter, contains a small brown seed, with united or separated pericarp, some with stalk ends, and somewhat bitter in taste. The epicarp is intercepted with oil ducts. It is widely used as a spice. The native habitat of celery extends from Sweden to Egypt, Algeria and Ethiopia and in Asia, to India, Caucasus and Baluchistan. Celery seed is also grown in France and China. The Chinese celery seed, mainly grown in Gaungdang Province near Hong Kong and in Gansu in the North West China, is smaller and milder than the Indian celery seed (its flavour resembling that of celery leaf), and has more striations when viewed under magnification. The French celery seed is of a fine quality but still Indian celery holds the fort in the world trade in quality.

It is also claimed to be the first mentioned as a cultivated food plant in France in 1623. Of course, celery is cultivated both for salad and seed-raising in the north-west Himalayas, the Punjab, Uttar Pradesh and Haryana and elsewhere in France and USA. In Amritsar district of Punjab alone, about 1,200 ha had been put under this crop in the rabi season. Latest figures are not yet available.

In colder climate and on hills, celery is a biennial plant and produces seeds only in the second year, but in plains, it becomes an annual and produces seed in the very first year, about 4-5 months after transplantation. Indian celery seed plant is about 1.5 m (4-5 ft) tall, while that grown for vegetable/leaf/stalk, is only 0.6 m (2 ft) tall.

In India, it is commercially important more for its seeds, which have a good aroma and find a ready export market. Recently, experiments conducted at the RRL, Jammu, have established that this crop can be successfully cultivated in J & K, and the farmers can expect better economic returns with the cultivation of
improved strains of celery (RRL - 85-1) than of wheat.

VARIETIES

The IARI has recommended the following varieties of celery for cultivation for salad purposes.

- **Standard Bearer.** Early, medium tall plant, medium pink stems with white longitudinal streaks, stalks solid and of good size and flavour.

- **Wright Grove Giant.** Medium, late, tall growing plants, produces large white stalks of fine quality; immense cropper.

Little published information is available on varieties of celery recommended for seed production in India. There is a distinct difference in flavour of celery plants producing celery leaves; flakes have sweet, strong typical celery aroma and flavour, whereas seeds have a warm and slightly bitter flavour/taste.

CROP MANAGEMENT

Celery can be grown on a wide range of soils but it thrives best on fertile, well-drained loam and silt loam soils. The soil pH should be normal. Kallar infested or heavy clayey soils are not conducive to optimum yield of this crop. Celery can follow early potato (mid-September-mid-December) and rice (July-November) crop successfully. The vegetable growers' transplant celery on the ridges in the standing crops of cauliflower and tomato to save it from frost. It requires moist soil and cool climate.

Land Preparation

Celery is somewhat exacting crop and requires a carefully pulverized and heavily manured seed-bed. The land can be prepared by giving 6 to 8 ploughings, followed each time by planking. Thirty to forty cartloads of compost or well-rotted farmyard manure should be added and thoroughly mixed into the soil. Irrigation bunds should be made before planting because it is a moisture-loving plant and transplantation is to be done in moist soil.

Sowing Method

Celery seeds weighing 500 g are sown in the first week of October in 2 marlas (10m-5m) of land to raise nursery plants needed for an acre. One kilogram each of calcium ammonium nitrate and superphosphate are added to the nursery beds at the time of sowing seeds. Irrigation-water is applied through a sprinkling can after every 4-5 days till the seeds germinate in about 15 days. The nursery beds may be irrigated once a week afterwards. The nursery would be ready for transplanting in the second week of December. Irrigation-water to the nursery may be withheld about a week before transplanting to harden plants so that they can bear the shock of transplantation. The nursery beds need to be irrigated about 12 hours before transplanting to moisten the soil so that major part of the root system remains intact on removal of the plants from nursery. The transplanting may be done in moist soil at a distance of 1.5 feet (45cm) from row-to-row and one foot (30 cm) from plant-to-plant. This operation should preferably be done in the evening and irrigation-water should be applied next day.

Fertilizers

Calcium ammonium nitrate 200 kg and superphosphate 100 kg should be worked into the soil before transplanting plants. If the soil tests show potash deficiency, 30-40 kg of potash may be added. In soils of normal fertility, potash residues left by the preceding crop of potato or rice will suffice. The second dose of 200 kg of calcium ammonium nitrate may be applied in March, just prior to or during the emergence of flowers. In the case of silage farms, only superphosphate may be added.

Irrigation

One irrigation after every 10-15 days should be applied in December, January, February and March. When the weather warms up in April and May, weekly irrigation may be given. The crop is liable to lodge if fierce winds blow after irrigation. Two or three hoeings are necessary to get good growth of plants. The first hoeing should be done about 3 weeks after transplanting and subsequent hoeings, 2 weeks after each hoeing. The crop gives good response to hoeing.
Plant Protection

No incidence of disease has been reported from growers in Punjab so far. The crop is, however, susceptible to certain fungal diseases such as early blight and late blight. Bordeaux mixture is recommended for the former and sulphur dust for the latter. No insect pests attack it, probably due to the presence of alkaloids, which emit repulsive odour for the insects.

Tissue Culture

The major breakthrough in tissue culture research is the encapsulation of somatic embryos from hypocotyl segments, thus leading to the production of artificial celery seeds. Priyadarshan et al. have reviewed the subject.

Harvesting and Threshing

In early May, the flowers start giving a reddish look. That is the right time for harvest. The crop should not be allowed to stand in the field long afterwards for overripening. The harvesting should be done at night time to avoid shedding of seeds. The plants being very light, are liable to be blown away by winds. The harvested crop should, therefore, be threshed with sticks the next day and the seeds stored in the godowns. Winnowing and sieving is done by labourers, usually hailing from Jammu hills on contract charges.

YIELD

The yield of celery seed is 5-6 quintals per acre.

POST - HARVEST TECHNOLOGY

Cleaning/Preparation for the Market

After harvesting and threshing, celery seed usually contains 10-15% foreign inorganic (dust, small pebbles, etc.) and organic matter (stalks, straw, leaves, etc.) as against the permitted PFA limit of 1-2%. They are sieved, winnowed and cleaned properly before marketing.

Composition/Quality

Celery Seeds

Moisture: 5.1%; protein: 18.1%; fat (ether extract): 22.8%; crude fibre: 2.9%; carbohydrates: 40.9%; total ash: 10.2%; calcium: 1.8%; phosphorus: 0.55%; iron: 0.45%; sodium: 0.17%; potassium: 1.4%; vitamins (mg/100g): vit. B1 (thiamine): 0.41; vit. B2 (riboflavin): 0.49; niacin: 4.4; vit. C (ascorbic acid): 1.7; vit. A: 650 International Units; calorific value (food energy): 450 calories/100g.

According to another source, the variation in important quality characteristics is as follows: moisture: 5-11%; volatile oil: 1.5-3.0 (average 2.4%); non-volatile ether extract: 5.8-14.2% (average 9.4%); cold water extract: 5.9-12.6% (average 8.4%); total ash: 6.9-11.0% (average 8.8%); ash insoluble in acid: 0.5-4.0% (average 2.5%).

Fresh Celery Leaves and Stalks (for Salad)

Fresh celery leaves and stalks have the following typical composition respectively-moisture: 81.3, 93.5%; total solids: 18.7, 6.5%; protein: 6.0, 0.8%; fat: 0.6, 0.1%; fibre: 1.4, 1.2%; carbohydrates: 8.6, 3.5%; mineral matter: 2.1, 0.9%; calcium: 0.23, 0.3%; phosphorus: 0.14%; iron: 0.06, 0.05%; vit. A:5800, 7500 I.U.; vit. B1: trace; vit. C:62, 6 mg/100g, calorific value: 64, 18, calories per 100 g.

From the foregoing, it is apparent that leaves are more nutritious than stalks, particularly from the viewpoint of total solids, protein, carbohydrates, mineral matter and vitamins A and C.

Adulteration in Celery Seed

Celery seed is available both as whole or in ground form. It is subject to adulteration by addition of exhausted or spent seeds (from which oleoresin or oil has been extracted), excess stems, chaff and earth or dust etc. The ground celery is sometimes adulterated with farinaceous products, linseed meal, worthless vegetable seeds or at rimes even with weed seeds, etc.

Grading
Agmark provides 3 grades of celery seeds, viz. special, good, fair. The ISI has also laid down Indian Standards but under the PFA Act, no specification has yet been provided for celery seed. The ISO has also laid down International Standards.

**Packaging and Storage**
Well-dried and cleaned celery seeds are packed in 50 kg hessian bags and transported to terminal market for sale or to warehouse for storage.

**Balm or Lemon Balm**
**INDIAN NAMES**

- **Hindi**
  - Billotan,

- **Urdu**
  - Baranjiboya

**DESCRIPTION AND DISTRIBUTION**
Balm or lemon balm is a perennial herbaceous plant of the mint family, with a strong, agreeable odour, reminiscent of lemon; and that is why, it is also called as lemon balm. It is evergreen, 30-60 cm in height, and lasts for 2 years or longer. According to Guenther, it lasts for 10 years but is normally maintained for 4 years. The blossoms are small and of white or light-rose colour. The leaves or the herb is used as a spice and as a flavourant. A native of the countries bordering northern Mediterranean, it grows wild and is also cultivated in gardens as a medicinal herb. It has been naturalized in the USA, grows wild in the eastern USA, and is found in the temperate Himalayas. Another plant *Melissa parviflora* Benth., which is considered a good substitute for *M. officinalis* (lemon balm), is an erect, pubescent or glabrate herb, 60-100 cm high, found in temperate Himalayas from Garhwal to Sikkim, Darjeeling and Khasi, Aka and Mishmi hills, at an altitude of 1,200-3,000 m. Leaves are ovate or ovate-lanceolate. Flowers are white or pale-pink, rarely yellow, in a few or many-flowered auxiliary whorls; nutlets are narrowly obovoid, dark, rugulose. Balm is now well established in Himachal Pradesh (Solan).

**CROP MANAGEMENT**

**Soil and Climate**
The *Melissa* plant is easily affected by cold, so a sunny-and-warm location should be chosen. Although it will grow almost anywhere, deep and shaded soils of medium consistency (which can be irrigated) are preferable. The plant will thrive well in a fresh and fertile, alluvial land, but will suffer from excessive moisture. In light and dry soils, the leaves turn yellow and the yield gets greatly reduced. The soil should be prepared to a depth of about 30 to 35 cm, and during second tilling, manure and fertilizer should be applied.

**Propagation**
The plant can be propagated either from seed or from cutting. In places near Paris, the first method is usually preferred. The seed is planted in July in greenhouse, and the young plants are placed into their permanent position in October. In other regions, the seeds are planted directly into the permanent place in April. The planting of the cuttings takes place in the fall or in March-April, 50 to 60 cm apart.

**Cultural Practices**
They comprise irrigation, repeated turning over of the soil and weeding. Although the plant requires moisture, excessive watering in soil is harmful. At the beginning of the winter, land should be tilled, fertilized, and in a cold climate, the soil should be mounted at the base of the plants. The plants may last for about 10 years but are maintained for only 5 years for the purpose of obtaining the largest yield. After that period, the crop is rotated. Application of 90 kg N/ha gave mean maximum leaf-yield (127.6 kg/ha) and essential oil yield of 28.4 litres/ha. A row spacing of 30 cm Â- 45 cm was found optimum for higher yield. Wider spacings resulted in lowering of yield of growth.
Harvesting
When the plants are in full bloom, the crop is cut with a scythe or mower. In the first year, the harvest takes place in August, when the flowers are well formed; thereafter, 2 cuttings can be made, one in June, another in August. It is advisable to harvest on a clear day, after the dew has evaporated, otherwise moist leaves would turn black on drying. The plants are very susceptible to heat and sunlight and should be transported as soon as possible to the distillery or to artificial dryer if the leaves are to be used in liquor industry. In this case, the leaves are cleaned and dried; cleaning being accomplished after stalks of the suspended plants dry.

Yield
In Anjou, about 1,800 kg of cleaned and dried leaves are obtained per hectare. They are sold in the market at attractive prices to liquor industry, to the pharmaceutical trade and to herborists.

POST-HARVEST TECHNOLOGY
If flowering tops are to be marketed, the stemmy portions must be removed before or after drying. Drying is done in shade in order to preserve its natural colour. For manufacturing essential oil, no drying is necessary. Fresh flowering tops and leaves immediately after harvest give higher yield of essential oil.

PROCESSING TECHNOLOGY
Manufacturing Essential Oil
The volatile oil obtained from fresh herb is very low (0.01 to 0.014%). That is why this oil is costly. The commercial oil, therefore, is seldom, if ever, pure. It consists of mixtures; largely of lemongrass and citronella oil, or fractions thereof. In European countries, it is sometimes prepared by distilling lemon oil over Melissa officinalis Linn. herb (Oleum melissa citratum). By distilling fresh Melissa officinalis at the beginning of the flowering stage, Sehimmel & Co. could obtain 0.014% of the true oil, with a specific gravity (15Â°) of 0.924 and an optical rotation of +030'. The fresh herb during full-bloom gave 0.010% of oil, with a specific gravity (15Â°) of 0.894; the oil was optically inactive. The odour suggested presence of citral and citronella; the scent of the first mentioned oil was more agreeable, typical of Melissa.

Physico-chemical Properties of Oil
The composition of its oil has been studied by several workers which varies slightly. Briefly, it is as follows: specific gravity at 25Â° C: 0.8910, optical rotation at 22Â°C : +2Â°8'C; refractive index at 22° C: 1.4704; acid number: 2.2; ester number: 27.42; ester number after acetylation: 236.28; aldehyde content (bisulphite method): 42.0; solubility in 0.5 vol. of 90% alcohol and in 2 vol. of 80% alcohol.

USES
As Food Flavourant
Fresh or powdered balm leaves are used in fish dishes stuffings or as a substitute for lemon. Fresh leaves are piquent in salads and in summer drinks. Thus, balm leaves are widely used for culinary flavouring.

In Medicine
Leaves and flowering tops are also used in medicine. Lemon balm is said to possess stomachic, anti-tubercular and anti-pyretic properties; it is used to strengthen gums and to remove bad taste from mouth. The fruit is considered a brain tonic and is useful in hypochondriac condition. Leaves and stems are also said to be useful in brain, liver and heart diseases and also in bites of venomous insects.

The volatile oil distilled from plant is used for flavouring and also somewhat in perfumery. However, according to Guenther, this oil has not attained any commercial importance because of its excessively high price. It may, of course, be possible to simulate its odour by blending it with other oils like those of lemon, lemongrass and citronella.

The balm oil is reported to be sedative. Its properties in this regard resemble those of peppermint oil. Balm distillates can act as mild spasmyolytic agents.
BASIL OR SWEET BASIL (*TULSI*)

**Indian Names**

**Bengali**
Kali tulsi, Marua;

**Gujarati**
Damaro, Nasabo, Sabza;

**Hindi**
Babui tulsi, Gulal tulsi,

**Kannada**
Kama kasturi, Sajjagida;

**Kashmiri**
Niazbo;

**Malayalam**
Tirunitu;

**Marathi**
Marva, Sabza;

**Oriya**
Dhala tulasi, Kapur kantr,

**Punjabi**
Furrunj, Mushk, Baburi tulsi or Niyazbo,

**Sanskrit**
Munjariki, Surasa, Varvara';

**Tamil**
Trinirupachai, Karpura tulasi;

**Telugu**
Bhutulasi, Rudrajada, Vepudpacha,

**Urdu**
Niyazbo

**DESCRIPTION AND DISTRIBUTION**

Basil, French Basil or sweet basil, tulsi or niyazbo (*Ocimum basilicum*), an erect glabrous herb, 30-90 cm high, native of North-Western India and Persia, is an annual of the mint family and constitutes an important culinary herb. It is a rich source of a valuable essential oil. In India, there is widespread belief that if planted around homes and temples, it ensures happiness. Hindus consider it sacred and also good for health when its fresh leaves are taken raw and also their decoction. It is indigenous to lower hills of the Punjab and Himachal Pradesh and is cultivated throughout India. It is now cultivated in Southern France, Egypt, Belgium, Hungary and other Mediterranean countries and also in the USA. The plant grows to a height of about 60 cm. The freshly picked bright green leaves measure up to 3.75 cm in length. When dried, they turn brownish-green, whole and broken brittle, curled or folded together. Dried leaves and tender 4-sided stems of this plant are used as a spice for flavouring and for recovery of essential oil. The flavour is warm, sweet and somewhat pungent and peculiar. The odour of sweet basil is aromatic, fragrant and sweet. The leaves have numerous dot-like oil glands in which aromatic volatile oil of the herb is contained. The herb bears clusters of small, white, lipped flowers in raceme fashion. It can be easily grown at home or in gardens in ordinary soil.

The plant is very variable and its botanical nomenclature is complicated; several designations have often been assigned to one or the same type. Polymorphism and cross-pollination under cultivation have given rise to a number of subspecies, varieties and races, differing in height, habit of growth, degree of heaviness and colour of stems, leaves and flowers, and types have been confused with other spices.

"The smell of basil is good for the heart and head", wrote one of the 17th century herbalists, "and maketh a man merry and glad". This delightful annual herb of the mint family is native to India and Persia. In France,
it is called the 'herbe royale' and its aroma is highly esteemed in that food-loving nation.

Major Types of Basil

American Basil

Commercial-scale production of the basil in the USA began shortly after the World War II. Basil is a plant which lends itself well to modern American farming and processing techniques, mostly in California. Consequently, the domestic basil is highly prized for its rich colour, sweet flavour, cleanliness and uniformity of milling, to the point where it typically brings as much as 3 times the price of the most expensive imported basil. Uniformity is particularly important to spice packers because it assures them of even, attractive fills in their containers. The domestic product is mechanically dried and then milled into 4 particle sizes: coarse, primarily for retail packs; medium, popular in food service and salad dressing manufacturing; fine, much used in the pizza industry; and ground, or powdered, for use in any product where aroma and flavour are important without any evidence of leaves. The choice of leaf particle size is unique with the American product. Coarse cut runs about 0.63 cm (1/4 inch), medium about 0.27 cm (1/8 inch), fine about 0.15 cm (1/16 inch) in size.

French Basil

The French basil is the most expensive of the imported products. It is characterized by the trade as being significantly better (somewhat sweeter) in flavour, deeper green in colour, and cleaner in appearance than any of the other imports. It ranges from 0.5 to 1.1% in volatile oil, with the average of about 0.75%. Most of the commercial basil in France is produced in the Provence region.

Egyptian Basil

In recent years, Egypt has been the largest exporter of basil to the USA. Egypt is no newcomer to basil production, but for a long time, most of its output has been shipped to Europe. The Egyptian product is said, by buyers, to have a 'mintier' flavour than othersweet basils. It is priced considerably under the name French Basil in Egypt, and is produced mainly in the regions of Beni Suif and Fayoum in the vicinity at the Nile.

Indian Basil

It is also called French basil or sweet basil.

In 1964, the USA was importing only 40,000 pounds of basil a year. Today, the US annual import exceeds a million pounds (25 times!), and it is joined by at least 75% as much in the domestic production. These figures become all the more impressive when we consider that a pound of basil will season enough Chicken Cacciatore to feed over 3,000 people. The basil boom is another tribute to the popularity of pizza and Italian foods in general. Many pizza makers today are using basil in their tomato sauce and then sprinkling oregano over the top of the finished pie. Pizza brought oregano out of the realm of the unknown to an annual consumption of over 5 million pounds! And now, it seems well on the way to doing the same for basil.

The flavours of basil and tomatoes have a special affinity and this is the basis of today's increased usage of this herb in the Western World. America has adopted southern Italy's love for tomato sauces. At first, their attention was turned to oregano because of its high profile as a topping on pizza. More recently, they have discovered that good Italian cooks often use basil before oregano - that is, in preparing the basic sauce for the pizza (and for that matter, just about any sauce). Basil thus becomes 'Mr Inside' and oregano 'Mr Outside' as a football fan would describe it. This has led to wide usage of basil in all sorts of tomato-sauce recipes, from spaghetti sauces to soups, tomato juice cocktails, tomato-based salad dressing and almost countless ethnic specialities.

AREA, PRODUCTION AND EXPORTS

No statistics are yet available on these aspects in India. However, there is a considerable commercial-scale production of basil in the USA, France, Hungary, Egypt, Bulgaria, West Germany, Poland, Yugoslavia,
Belgium, Turkey, Italy and the Netherlands. The USA imported 412 tonnes of basil worth 0.4 million dollars. No production data are available for the above countries. In India, however, basil oil is now being produced on a commercial scale to a limited extent.

CROP MANAGEMENT

Varieties
There are numerous varieties of *O. basilicum*, of which 4 are identified in India. They are (1) var. *album* Benth. (lettuce-leaf basil); (2) var. *differme* Benth. (curly-leafed basil); (3) var. *purpurascans* Benth. (voilet-red basil) and (4) var. *thyrsiflorum* Benth, (common white basil). Curly-leafed basil is considered most suitable for cultivation. It is grown in France and is reported to give good yields of high quality oil.

Soil and Climate
Basil can be grown under a wide range of climates and soils. It is very versatile.

Breeding
Tesi et al. have studies on breeding of basil and varietal evaluation and also on floral biology and reproduction. Gupta analysed the genetics of some chemo-types of basil var. *glabratgum*.

Propagation
Sweet basil (*O. basilicum*) is propagated by seeds and is commonly grown in gardens as an aromatic herb. The best season for sowing it in the plains of India is October-November and in the hills, it is March-April. Seedlings are raised in the nursery beds and transplanted 30 cm apart in rows spaced 40 cm apart. The crop is ready for harvesting in 2-3 months after planting. Davis has made comparison of mulches for fresh-market basil production.

Plant Protection

Diseases
The first reports of *Fusarium* wilt of basil have been reported by Davis et al. El. Sadek et al., Dutky and Walkow Elmer et al. and Wick and Haviland. While Keinath studied pathogenecity and host range of basil for *Fusarium* and the evaluation of the control methods thereof. El Massy et al. have reported effects of herbicides on basil (sweet) and marjoram.

Harvesting
Several (3-5) cuttings of leaves and flowering tops may be made during the season. Plants are cut close to the ground, bunched and dried. The dried leaves and flowering tops are stripped from stems and packed in the closed containers.

In Assam, workers have shown that harvesting of plants should be done after twelfth week, and thereafter, at intervals of 2 months each. In all, 3 harvests become possible.

In the *tarai* area, the optimum yield of herb is obtained by taking the first 4 crops of flowers only (main sub-inflorescence) and the last crop of the entire flowering herb. The first harvest is taken when plants are in full bloom, second and subsequent harvests become available thereafter every 15 to 20 days. The last harvest is taken of the entire plant and distilled. While harvesting the crop, precaution should be taken that the root-system of the plant is not injured, otherwise yield of subsequent harvests will be affected adversely. The crop is to be harvested at the stages of maximum bloom to seed set.

Yield
A yield of 6,800 kg of leaves and flowers per hectare in 2 cuttings is reported from trial cultivation in Kanpur. In the USA, a yield of 20-25 tonnes of fresh herb/hectare has been reported, and 3-5 harvests are made per annum. Kimura et al. have reported the effects of watering on growth, yield, essential oil concentration and evapo-transpiration of basil.

POST-HARVEST TECHNOLOGY
The post-harvest shelf-life of sweet basil has been studied in fair detail by Lange and Cameron. Rocha et
al. have reported the effect of pre-treatments and drying conditions on the drying rate and colour retention in basil.

Packaging and Storage
The dried leaves are generally packed in tin containers which are kept closed. The enzymatic browning of basil has been attributed to oxidation of phenolic compounds by polyphenol oxidase, naturally present therein.

Composition
Basil herb contains protein, carbohydrates, volatile oil, fixed oil, cellulose, pigment, mineral matter and vitamins. According to the analysis report of the American Spice Trade Association (ASTA), USA, the composition of basil or sweet basil herb is as follows: moisture: 6.1%; protein: 11.9%; fat (ether extract): 3.6%, fibre: 20.5%; carbohydrates: 41.2%; total ash: 16.7%; calcium: 2.1%; phosphorus: 0.47%; sodium: 0.04%; potassium: 3.7%; iron: 0.04%; vitamins (mg/100g) - vit. B1 (thiamine): 0.15; niacin: 6.90; vit. B2 (riboflavin): 0.32; vit. C (ascorbic acid): 61.3 and vit. A: 290 international units/100g; calorific value (food energy): 325 calories per 100g of dried herb.

A good commercial sample of sweet basil has been found to contain volatile oil (min.) : 0.4%; total ash (max.) 15%; acid insoluble ash (max) : 1%; moisture (max.) : 8%; and total ether extract (min.): 4% on moisture-free basis.

Considerable variations in the various physico-chemical parameters of basil oil produced in different regions of India (Jammu, UP, Assam) are as shown in the tabulation below.

Variations in Composition of Basil Oil

<table>
<thead>
<tr>
<th>Physico-chemical properties</th>
<th>Jammu oil</th>
<th>UP oil</th>
<th>Assam oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil yield</td>
<td>0.5-0.6%</td>
<td>0.1 to 0.28%</td>
<td>NA</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.9016 (20Â°C)</td>
<td>0.886-0.9288</td>
<td>0.9183 (29oC)</td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.4892 (20Â°C)</td>
<td>1.4662-1.4757</td>
<td>1.4798 (29Â°C)</td>
</tr>
<tr>
<td>Optical rotation</td>
<td>-10Â°7</td>
<td>-4-7Â°</td>
<td>-9.0Â°</td>
</tr>
<tr>
<td>Ester value</td>
<td>1.2</td>
<td>4.60-7.10</td>
<td>7.20</td>
</tr>
<tr>
<td>Alcohol (%)</td>
<td>48.5</td>
<td>41.10 to 50.0</td>
<td>54.70</td>
</tr>
<tr>
<td>Methyl chavicol %</td>
<td>-</td>
<td>35.20 to 40.50</td>
<td>54.70</td>
</tr>
</tbody>
</table>

PROCESSED PRODUCTS
The main product manufactured from basil leaves and flower tops is the essential oil known as ‘Oil of Basil’ which is discussed below. Two types of basil oils are mainly recognized in the world market-The European and the Reunion.

Distillation of Oil

*Oil of sweet basil* is produced by the hydro-distillation of the herb. The flowers or whole herbs or both are packed into a distillation unit and hydro-distilled or steam-distilled. It takes, in all, about 4 hours to complete 1 charge. The oil, being lighter than water, is easily separated from oil-water mixture. It is advisable to use distillate after removing oil for further charge, as it contains small quantity of oil. Oil yield thus increases. Precaution should be taken that the distillation unit is clean and free from other odours, otherwise oil is likely to be contaminated with undesirable odours and colours. It is possible to produce oil worth about Rs
10,000 from 1 hectare during June-November. The expenditure involved is about Rs 2,500 to Rs 3,000 per hectare. Two grades of oil are produced, depending on the part of the plant used for harvesting.

**Yield of Herb Oil**
The flowers, on an average, yield 0.4% oil while the whole plant (Indian basil) contains 0.10-0.25% oil. By taking 3 harvests of the herb at 2-month interval about 15 tonnes of herb per hectare can be had corresponding to 30 to 35 kg of oil. By taking the initial 3 or 4 harvests of flowers (including main and sub-inflorescence) and final harvests of whole herb, about 3-4 tonnes of flowers and 113 tonnes of whole herb can be had per hectare corresponding to about 13 kg of the so-called flower oil and about 27 kg of whole herb oil; in all 40 kg of oil per hectare is obtained. In case of labour shortage, 3 harvests of whole herb at an interval of 1 month after the first harvest gives about 15 tonnes of herb corresponding to about 30 kg of oil. Oil of sweet basil, produced both from herb as well as flowers, is saleable. In the long run, oil from whole herb is economical to produce.

**Quality of Oil**
The quality of the essential oil is correlated with the composition of the oil, which is greatly influenced by the climatic as well as agronomic factors. Out of the various important agronomic factors, which influence herb and oil yields and quality of oil, are time of transplanting and stage of harvesting. These aspects have been recently studied by Randhawa et al. and the study revealed that to get maximum herb and oil yield, French basil should be transplanted from end of March to first week of May. The oil content in the herb was maximum at the vegetative stage. The refractive index and the optical rotation of the herb oil increased with the delay in planting from March 10 to May 10 and March 10 to March 25, respectively, and beyond March 25, optical rotation decreased progressively. Each delay in harvesting, from vegetative to complete flowering stage, increased optical rotation and refractive index of the herb oil but the ester value decreased significantly with delay in harvesting.

The oil obtained from flowers is better than the oil from whole herb in quality. Both oils are saleable and the yield and quality are comparable to those produced abroad. A sample of oil distilled from plants grown in Chalakkudi (Kerala) had a fine lavender odour and was rich in linalool and methyl cinnamate. Another sample obtained from plants grown at the HB Technology Institute, Kanpur, contained methyl cinnamate, linalool, methyl chavicol and ocimene. The quality of volatile oil varies greatly in composition and properties owing to differences in species, soil, climate and the part of the plant used. The European oil, known to be true to the name, shows according to results of several authors, specific gravity at 15o C: 0.895-0.930; refractive index: 1.477-1.495; optical rotation: -22o to 6o; ester number: 3-15; linalool as 34.50 to 39.66%. The methyl chavicol content of all these oils was about 55%, calculated by determining the methoxy number according to Zaisel's method.

Methyl chavicol, the main constituent of sweet basil oil, is oxidized on ageing and on exposure of oil to light and air; thus older oils usually show a higher specific gravity and higher refractive index. Sweet basil oil must, therefore, be stored carefully.

**Adulteration of Sweet Basil Oil**
This oil is frequently adulterated with the much lower-priced Reunion basil oil. This is indicated by increased specific gravity and refractive index and by a lowered levo-rotation, or slight dextrorotation depending upon the amount of Reunion oil present. These discrepancies can be partly corrected by the addition of 1-linalool; therefore, adulteration of sweet basil oil is not always detected by mere routine analysis. The expert will submit the oil to a careful organoleptic test, watching especially for the presence of camphor, which does not occur in true sweet basil oil.

**USES**
**As Food Flavourant**
Sweet basil is used for flavouring numerous foods - in soups, meat pies, fish, certain cheeses, tomato
cocktail, eggplant, zucchini, cooked cucumber dishes, cooked peas, squash and string beans; chopped basil is sprinkled over lamb chops before cooking. Basil is often used with, or as a substitute for oregano in pizza topping, spaghetti sauce or macaronic and cheese casseroles. It is also used in the manufacture of Chartreuse and other liqueurs. Sweet basil from Italy and America is known for its quality. In Italy, basil is an important seasoning in tomato-paste products. In France, it is known as the 'herbe royale'. Although not used in large quantities, the oil of sweet basil is employed quite extensively in all kinds of flavours, including those for confectionery, baked goods and condimentary products (chilli sauces, catsups, tomato pastes, pickles, fancy vinegars) and in spiced meats, sausages etc. The oil also serves for imparting distinction to flavours in certain dental and oral products.

**In Perfumery and Cosmetics**
Sweet basil oil has its place in certain perfumery compounds. For the scenting of soaps, the lower-priced Reunion oil is preferable. Reunion basil oil is employed in all cases since the high price of the true sweet basil oil makes its use prohibitive.

**In Medicine**
The plant is considered stomachic, anthelmintic, alexipharmic antipyretic, diaphoretic, expectorant, carminative, stimulant and pectoral. An infusion of the plant is given for cephalalgia and gouty joints, and used as a gargle for foul breath. The juice of the leaves is considered useful in the treatment of croup and is a common remedy for coughs. It has a slightly narcotic effect, and allays irritation in the throat. It is used as a nasal douche and as a nostrum for ear-ache and also for ring-worm. The plant is used in homeopathic medicine.

Roots, bark and leaves are cyanogenetic. Alcoholic extracts of leaves and alcoholic and aqueous extracts of flowers possess antibacterial activity against *Micrococcus pyrogenes* var. *sureus*. Seeds possess demulcent, stimulant, diuretic, diaphoretic and cooling properties. They are given internally in cases of habitual constipation and piles. They are used in poultices for sores and sinuses. Leaves are useful in treatment of croup, for which warm juice with honey is given. Root is used in bowel complaints of children. Flowers are carminative, diuretic, stimulant and demulcent.

**As Insecticide, Insect-Repellent and Bactericidal**
Basil oil possesses insecticidal and insect-repellent properties. It is effective against house-flies and mosquitoes. It is also bactericidal. The Rideal Walker co-efficient of *Salmonella typhoxii* is 12.

**Use of Basil Seeds**
The seeds of the plant are odourless with an oily, slightly pungent taste. When steeped in water, they liberate a mucilage which is semi-transparent and nearly tasteless. The mucilage (9.3%) yields on hydrolysis, uronic acid, glucose, xylose and rhamnose.

The seeds contain a drying oil with the following fatty acids composition: palmitic : 7.0%; stearic: 0.2%; oleic: 11.0%; linoleic: 60.0; and linolenic acid : 21. The unsaponifiable fraction is reported to contain ?-sitosterl, olenolic acid and ursolic acid.

Aqueous extracts of seeds are active against gram-positive bacteria and *Micrococcus pyrogenes* var. *aureus*. Seeds are also given in infusion in gonorrhea, dysentery and chronic diorrhea.

**BAY OR LAUREL LEAVES**

**Indian Names**
No information available. Other common English Names: Sweet Bay or True Laurel.

**DESCRIPTION AND DISTRIBUTION**
Laurel leaves or bay leaves are dried leaves of Laurus nobilis, an evergreen tree or shrub. The plant is grown in the Mediterranean countries and is cultivated in Greece, Spain, Portugal, Asia Minor and Central America. It is sometimes grown in Indian gardens but does not seem to thrive well there. The surface colour of the leaf is green; the underside is pale-green and somewhat yellowish. Laurel leaves are used whole or
cracked. The aroma of the crushed leaves is delicate and fragrant and taste is aromatic and bitter. The leaves should not be confused with the leaves of bay rum tree \textit{[Pimenta racemosa (Mill.) J.W. Morre]}, belonging to family Myrtaceae, from Puerto Rico and nearby islands, or with the \textit{California bay laurel} \textit{(Umbellularia californica Nutt; family: Lauraceae)}. The sweet bay or laurel leaves originate from an evergreen hardy tree or bush; cultivated since antiquity in Mediterranean countries. Size of the leaves is variable, ranging from 2.5 to 7.5 cm or more in length and 1.6 cm to 2.5 cm or more in breadth, at the widest part of the leaf. The shape of the leaf is elliptical, tapering to a point at the base and tip of the leaf. Dried berries, commonly called bay berries, have been imported into India for medicinal use. The berry is ovoid (about 1.5-cm long), black, coarsely wrinkled and contains a single seed.

\textbf{POST-HARVEST TECHNOLOGY}

\textit{Drying}

Laurel trees are pruned from September to March and the leaves are dried as usual in shade to the desired moisture level. The leaves are esteemed for their excellent flavouring property.

\textit{Composition}

According to the ASTA, the chemical composition of the dried bay leaves is as follows: moisture: 4.5%; protein: 7.6%; fat: 8.8%; fibre: 25.2%; carbohydrates: 50.2%; total ash: 3.7%; calcium: 1.0%; phosphorus: 0.11%; sodium: 0.02%; potassium: 0.6%; iron: 0.53%; vitamins (mg/100g)-vit. B1 (thiamine): 0.10%; vit. B2 (riboflavin): 0.42; niacin: 2.0; vit. C (ascorbic acid): 46.6 and vit. A: 545 international units (IU), calorific value (food energy): 410 calories/100g.

Analysis of the leaf made at the Muster Experiment Station, Berlin, showed moisture: 9.45%; protein: 8.34%; fixed oil: 4.49%; volatile oil: 3.63%; alcohol extract: 25.01%; nitrogen-free extract: 38.33%; fibre: 31.83%; and ash: 4.53% in Italian variety. The dry bay leaves also contain 13.84% of pentosans.

\textbf{PROCESSING TECHNOLOGY}

\textit{Essential Oil Recovery}

The leaves on steam distillation yield 1-3\% essential oil with a characteristic sweet and spicy odour, reminiscent of cajuput. According to another report, fresh leaves and terminal branchlets yield 0.5\% oil, while dried leaves yield about 0.8\%. Guenther has reviewed the published variation in composition from different countries.

\textit{Physico-chemical Properties of Volatile Oil}

According to Parry, laurel leaves yield 1-3\% of volatile oil having the following properties sp. gr. at 15oC: 0.915 0.9.30 (occasionally higher); optical rotation at 20o C: 15o to 22o, srefractive index at 20oC: 1.4670-1.4775; principal constituent: cineol, 25-50\%; solubility: 1 part in 3 parts of 80\% alcohol. Its principle constituent (up to 50\%) is cineol, a colourless liquid with a strong aromatic, camphoraceous odour, and a cooling taste. Other organic compounds include ?-pinene, ?-phellandrene, 1-linalool, 1-?-terpineol, geraniol, eugenol, eugenol acetate, methyl eugenol, a number of esters and acetic, isobutyric and isovaleric acids.

\textbf{USES}

\textit{Bay Leaves for Flavouring}

Bay leaves are among the oldest herbs of the world. Wreaths of laurel leaves were used by Creeks and Romans to honour their heroes. Laurel leaves are used principally in vinegar pickle when packing pig's feet and lamb and pork tongue. They are also used in flavouring soups, stews, meat and game-dishes, fish and sauces, pickling spice, and in confectionery also. The culinary uses are numerous as mentioned above. Laurel leaves are available whole or cracked, are not usually ground, and are packed in bags of 55 lb and 110 lb capacity.

Both leaves and fruits, possessing aromatic, stimulant and narcotic properties, were formerly employed for hysteria, amenorrhoea and flatulent colic. They are even used internally, though rarely, at present.
Externally, however, commercial oil of laurel berry is sometimes applied as a stimulant in sprains, but its principal use is in veterinary medicine.

**Fat from Bay or Laurel Berries**

**Extraction of Berry Fat.** The berry (pericarp 30%, seed 70%) yields 20-34% of an aromatic fat used to some extent in pharmacy, veterinary practice and perfumery. Commercial fat is obtained from whole berry by pressing or by boiling with water and skimming off the separated fat.

**Composition of Berry Fat.** The fat (melting point: 30-34°C) is green in colour and has the following characteristics - sp. gr. 20° C: 0.921-0.941; refractive index: 1.460-1.465; acid value: 5-34; sap. value: 188-216; iodine value: 75-99; thiocyanogen value: 55.8; R.M. value: 1.5-3.2; Polenske value: 2.8; and unsaponifiable matter (phytosterol, melissyl alcohol, a hydrocarbon and an unsaturated oily substance): 1-6%. The mixed fatty acids contain lauric acid: 30.35%; palmitic acid: 10-11%; oleic acid: 33-40%; and linoleic acid: 18-32%.

**Use of Berries in Medicine.** Berries are used in diarrhoea and dropsy. In Europe, they are also used to promote miscarriage.

**Laurel Wood Utilization**

Laurel wood resembles walnut wood in grain and colour and is suitable for decorative cabinet work.