INDIAN SPICES AND EXPLORATION OF ITS INTRINSIC QUALITY

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Spices and spice products are the most important natural flavoring materials available to the food processor.

It provides individuality to otherwise insipid dishes and for adding tang and zest to beverages and appetizers. It has application in a variety of food and non food items including meat and fish, baked foods, confectionery, beverages, tobacco, pharmaceuticals and fragrance.

What are spices?

Any of a class of pungent or aromatic substances of vegetable origin, as pepper, cinnamon, or cloves, used as seasoning, preservatives, etc.

Something that adds zest or flavor.

Condiment
Seasoning added to flavour foods, such as salt, or herbs and spices such as mustard, ginger, curry, pepper, etc. They are generally used in such small quantities that they make a negligible contribution to the diet

There are 109 spices listed by International standards Organisation (ISO) and the Spices Board, Government of India had listed 52 major spices of commercial importance.

India produces around 3.8 million tonnes of spices annually, of this about 10 % of the total produce is exported to over 150 countries. The USA, Europe, Australia, Japan and Middle East are the major importers of Indian spices.

Indian Spice export in 2009 –10

502,750 **Mt – Worth Rs.** 5560.50 **crores (**1173.75 **million USD)**

Our share in world spice market

48% in Quantity, 44% in Value

In 2009-10 we have exported 40050MT of value added products worth Rs. 2088 crores

This include oils, oleoresins, curry powders and other value added products.

Black Pepper-19750 tons Rs.314.0crores

Chilli –204000 tons Rs.1292 crores

Cumin- 49750 tons Rs. 548 crores

Turmeric-50750 tons Rs.381 crores

Important flavour compounds from major Spices

Spice	Important flavor compounds
Allspice	Eugenol, β-caryophyllene
Anise	(E)-anethole, methyl chavicol
Black pepper	Piperine, S-3-Carene, β-caryophyllene
Cardamom	a-terpinyl acetate, 1-8-cineole, linalool
Turmeric	Curcumin,Turmerone, Zingiberene, 1,8-cineole
Ginger	Gingerol, Shogaol, Zingiberene, geranial
Mace	sabinene, Myristicin,1-terpenin-4-ol
Nutmeg	Sabinine, myristicin,elemicin
Cumin	Cuminaldehyde, p-l,3-mentha-dienal
Fennel	(E)-anethole, fenchone
Saffron	Safranol
Vanilla	Vanillin, p-OH-benzyl-methyl ether

Medicinal properties of Major spices

Medicinal property	Spices
Cancer Preventive	Ginger, Black pepper, Nutmeg, Cinnamon, Clove, Turmeric, Cardamom, Vanilla, Allspice, Mace
Antimicrobial	Ginger, Nutmeg, Black pepper, Cinnamon, Vanilla, Turmeric, Clove, Allspice, Cardamom, Mace
Anti-Inflammatory	Black pepper, Cinnamon, Clove, Turmeric, Allspice, Cardamom
Spasmolytic	Cinnamon, Black pepper, Clove, Ginger, Nutmeg, Turmeric
Antioxidant	Vanilla, Ginger, Black pepper, Clove, Turmeric
Antiulcer	Ginger, Black pepper, Turmeric, Cinnamon, Clove, Nutmeg, Vanilla, Allspice, Mace
Hypoglycemic	Cardamom

Most of the herbs and spices are composed of three different types of ingredients

1. Volatile compounds - which can be recovered as essential oils by various distillation techniques
2. Non volatile components - which impart taste, flavour and pungency- which may be extracted as oleoresin or resinoids by using selected solvents
3. Inert matter which is mostly cellulose comprising the basic cellular plant structure and of value as natural carrier or diluent as well as contributing bulk or weight.

Aroma of spices is contributed by essential oils or volatile oils.
It is composed of terpenes and hydrocarbons

Terpenes are a large and varied class of hydrocarbons, produced primarily by a wide variety of plants

The name "terpene" is derived from the word "turpentine".
When terpenes are modified chemically, such as by oxidation or rearrangement of the carbon skeleton, the resulting compounds are generally referred to as terpenoids.

- **Terpenes and terpenoids are the primary constituents of the essential oils of many types of plants and flowers.**

The terpenoids, (isoprenoids) are a large and diverse class of naturally occurring organic chemicals derived from five-carbon isoprene units.

Plant terpenoids are extensively used for their aromatic qualities.

They play a role in traditional herbal remedies and are under investigation for antibacterial, antineoplastic,antioxidant and other pharmaceutical effects.

Terpenoids contribute to the scent of eucalyptus, the flavors of cinnamon and other spices.
Well-known terpenoids include citral, menthol and camphor.
The steroids and sterols in animals are biologically produced from terpenoid precursors.

Black pepper

Black pepper and white pepper are the major products from pepper. **Major countries involved in cultivation and trade of pepper are India, Indonesia, Sarawak (Malaysia), Brazil, Sri Lanka, Vietnam and China**.

Pepper oil contains a range of organic compounds, which belong to the group of terpenes and hydrocarbons. The major aroma compounds of black pepper are β-caryophyllene, sabinene, myrcene, limonene and linalool.

Bearing vine

Ripe Berries

Black Pepper(*Piper nigrum*)

Black pepper plantation

Black Pepper

Harvesting of Black Pepper

Harvesting is done 6-8 months after flowering

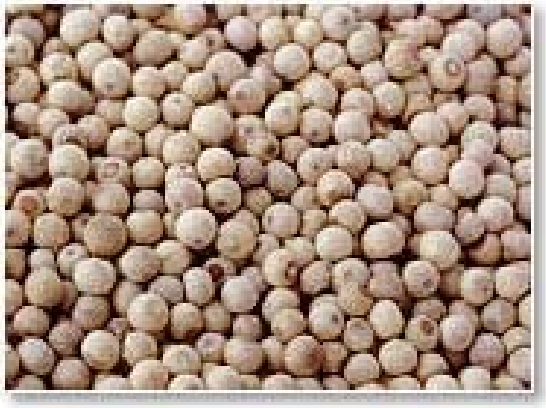
Primary processing

Threshing
Blanching
Drying
Grading and Packing

Red berries, white pepper and green pepper

Red pepper in brine (rpb) & red pepper dried

Dehydrated green pepper



White pepper

Pepper oil Constituents

Monoterpene hydrocarbons

camphene, δ3-carene, p-cymene, limonene, myrcene, cis-ocimene, α-phellandrene, β-phellandrene and β-pinenes, sabinene, α and γ-terpinenes, terpinolene and α-thujene.

oxygenated monoterpenes

oxygenated monoterpenes are borneol, camphor, carvacrol, cis-carveol, trans-carveol, carvone, carvetanacetone, 1,8-cineole, cryptone, p-cymene-8-ol, p-cymene-8-methyl ether, dihydrocarveol, dihydrocarvone, linalool

(±)-linalool, (+)-α-phellandrene, (-)-limonene, myrcene, (-)-α-pinene, 3-methylbutanal and methylpropanal as the most potent odorants of black pepper (Jagella and Grosch (1999)

Sesquiterpene hydrocarbons

β-caryophyllene is the major sesquiterpene hydrocarbon present in pepper oil.

α-cis-bergamotene, α-trans-bergamotene, β-bisabolene, δ and γ-cadinenes, calamenene, α-copaene, α- and β-cubebenes, ar-curcumene, β- and δ-elemenes, β-farnesene, α-guaiene, α- and γ-humulenes, isocaryophyllene, γ-muurolene, α-santalene, α- and β-selinenes, sesquisabinene and zingiberene.

Miscellaneous compounds

Eugenol, methyl eugenol, myristicin, safrole, benzaldehyde, trans-anethole, piperonal, m-methyl acetophenone, p-methyl acetophenone, n-butyrophenone, benzoic acid, phenyl acetic acid, cinnamic acid and piperonic acid

Variability

Of 17 cultivars of Kerala, monoterpene hydrocarbons ranged from 69.4-85%

Sesquiterpene hydrocarbons 15-27.6 % and the rest oxygenated constituents. The major monoterpene hydrocarbons viz α-pinene ranged from 5.9-12.8%, β-pinene 10.6-35.5% and limonene 22-31.1%.

The major sesquiterpene hydrocarbon, β-caryophyllene, ranged from 10.3 to 28.0%.

Cultivar	Caryophyllene
Aimpiriyan	20.3-34.7
Narayakodi	29.8-52.9
Neelamundi	17-31.0
Uthirankotta	25.1-37.8
Panniyur-1,2,3	21.57-27.7
Panniyur-4	19.0-21.10
Karimunda	19.8-45.3
Kalluvally	19.8-45.3
Arakulammunda	19.8-45.3
Thommankodi	19.8-45.3
Kottanadan	8.9-24.1
Ottaplackal	15.5-21.7
Kuthiravally	29.0-46 .0
Cheriyakaniakadan	17.4-23.1
Thevanmundi	20.3-34.7
Poonjaranmunda	24.4-30.8
Valiakaniakkadan	23.0-38.4

Black pepper oleoresin

The non-volatile part of black pepper which is extracted using organic solvents is called black pepper oleoresin. The major pungent alkaloid present in black pepper is piperine.

In general, black pepper contains about 3-5% volatile oil and 8-16% oleoresin and 2-6% piperine.

However, starch, is the predominant constituent ranging from 35% to 40% in black pepper and 53% to 58% in white pepper. Some of the traditional cultivars like Kottanadan and Kumbhakodi are rich in oleoresin and piperine. Some of the new varieties with high quality are Malabar Excel, Sreekara and Subhakara

Pepper oleoresin-extraction

The organoleptic property of the oleoresin is determined by its volatile oil and piperine contents and the abundance of these components depend on the raw material used for extraction. Good quality oleoresin contains 15-20% volatile oil and 35-55% piperine.

It is generally assumed that 1kg of oleoresin is obtained from 8 kg of black pepper, when suitably dispersed on an inert base, can replace up to 25 kg of the spice for flavouring purpose.

Oleoresins- contd

oleoresin consists of several groups of chemical compounds such as carotenoids, steroids, alkaloids, anthocyanins, glycosides etc.

Itcontributes towards taste, colour, pungency, texture and antioxidative properties of the product.

Oleoresins are commercially important because of the consistency in flavour, taste, antioxidant properties, increased shelf life and less storage space as it is a highly concentrated product.


PEPPER OLEORESIN
GINGER OLEORESIN
CHILLI OLEORESIN
TURMERIC OLEORESIN
CINNAMON OLEORESIN

Super critical extraction

This is a process for extracting spice to obtain oleoresin and fractionating the oleoresin into fixed and essential oil components.

It uses CO_2 and high pressure to separate out (or "Fractionate") all of the natural essence of plant, spice, bean, etc. without heat or chemical solvents to do it.

Improved extraction techniques-
Super Critical Fluid Extraction

- The essential oil obtained by SCFE has excellent fixative character.
- There is no solvent residue problem
- Selective extraction of the aromatic constituents is possible rejecting the other constituents like waxes, sugars, pigments, proteins etc.
- The critical temperature and pressure beyond which carbon-di-oxide behaves as super critical fluid are-31.3^{0}C and 73.8 bar pressure, respectively

Aroma of pepper

Utilising present day technology like solid-phase microextraction (SPME), the odorous target components responsible for the characteristic odor of these valuable spices and food flavoring products were identified.

By means of GC-flame ionization detection (FID) and GC-MS (using different polar columns) using snifing technology(Electronic nose) specific aroma compounds can be identified.

E-nose Analysis

E-nose equipped with six doped and six undoped metal oxide semiconducting sensors.

Pepper powder (0.02g)and pepper essential oil (0.01g) taken in sample vials, and the volatiles were allowed to accumulate in the head space by holding the vials at 250^0C for120s

The volatiles are carried to the sensor chamber. Sensors in the E-nose essentially measure the change in voltage because of the presence of volatile odorous molecules and the responses were then analysed by software to get an olfactive picture of the product. It uses a preprocessor which is analogous to the olfactory bulb in the human olfactory region.

Flavour profile of pepper powder

Attribute	Panniyur-1	Panniyur-5	Com	Balankotta
Refreshing	9.0	10.1	7.0	8.6
Pepper like	10.5	10.0	10.2	8.5
Green mango	8.5	8.9	8.2	11.5
Fruity	5.5	6.5	6.0	3.0
Pungent	11.0	9.0	10.5	5.5
Spicy	10.3	9.5	10.2	6.6
Turmeric like	4.8	4.5	5.5	11.0
Earthy	6.2	6.5	6.3	10.4
Lingering herbaceous	7.0	7.2	7.8	5.5

Flavour profile of Essential oil

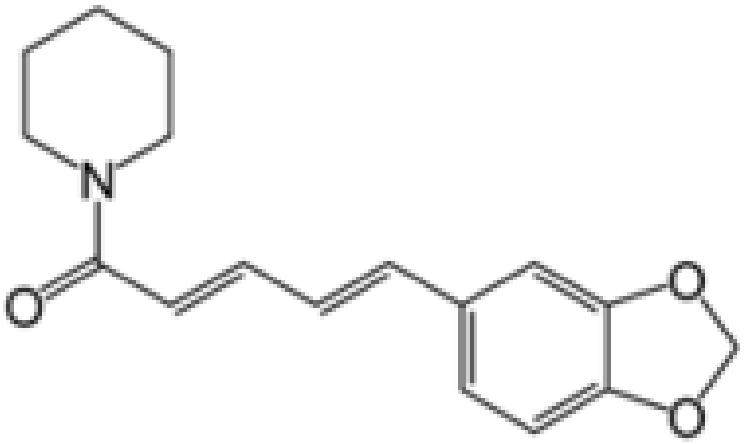
Attribute	Pan-1	Pan-5	Com	Balankotta
Lemony	3.5	4.0	4.5	5.2
Aromatic	8.0	7.5	8.2	7.3
Herbaceous	7.5	7.2	6.8	6.6
Pepper-like	11.5	11.0	11.8	7.0
Turmeric	5.0	5.5	4.6	11.0
Camphory	7.2	7.2	7.5	5.5
Citrusy	5.3	5.2	5.8	6.5
Balsamic	6.5	6.5	6.3	6.8
Green	4.0	4.5	4.2	7.5

The pungent principles

The most pungent alkaloid piperine isolated by Oersted (1820) identified as the trans - trans form of 1-piperoyl piperidine.

Piperine is undoubtedly the major pungent principle in pepper, which probably comprises over 95% of the total pungent alkaloids present, and the determination of its content is a good measure of the pungency of the spice.

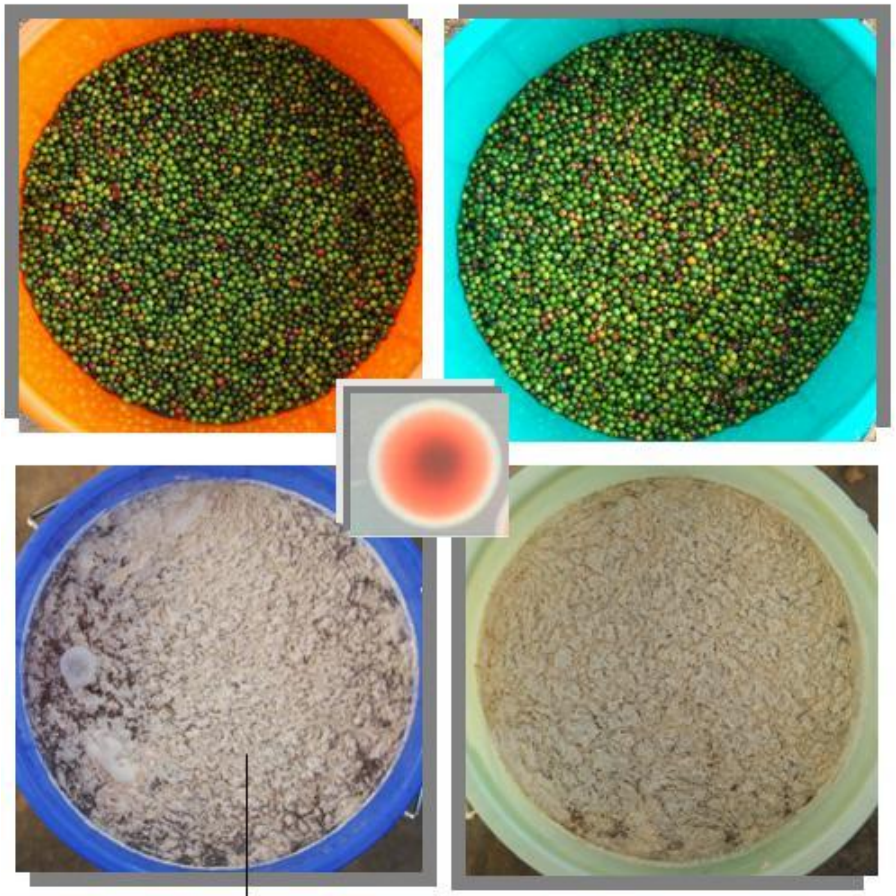
Piperine



1-[5-(1,3-Benzodioxol-5-yl)-1-oxo-2,4-pentadienyl]piperidine

$C_{17}H_{19}NO_3$

Fermentation



Bacteria

5 Days

Bacterial growth

pH and
Temperature were
Recorded every 24 hours

New IISR Technology

Cardamom(*Elettaria cardamomum*)

Annual production

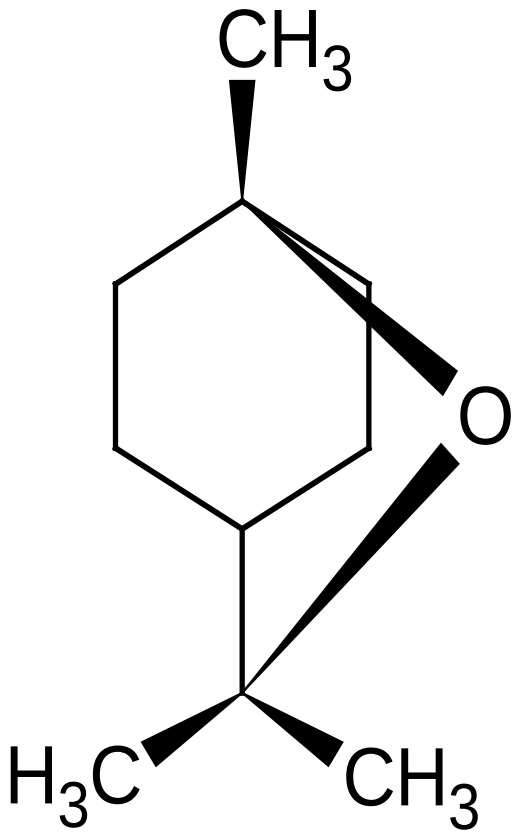
World - 30,000 MT
Guatemala - 18-20,000MT
India - 11-12,000 MT

Harvesting of Cardamom

Harvesting of cardamom is taken up at a time when the seeds inside the capsules have become black in colour.

The basic cardamom aroma is produced by a combination of the major components, 1,8-cineole and α-terpinyl acetate in essential oil

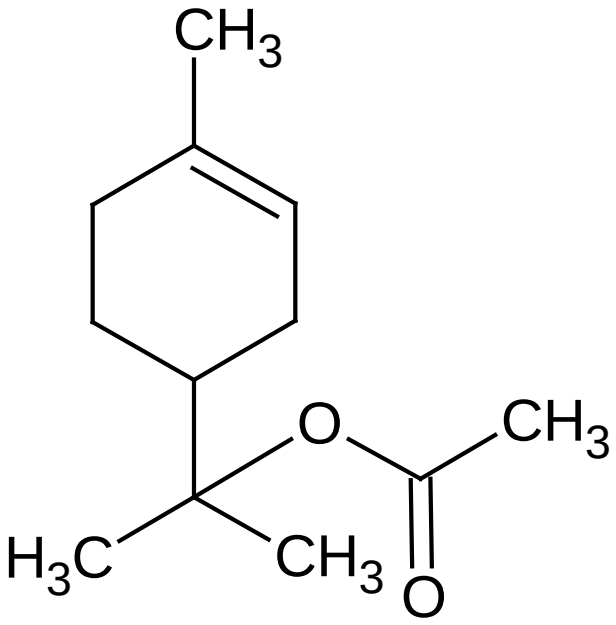
1,8-cineole, α-terpinyl acetate, linalool, linalyl acetate, α -terpineol, and terpin-4-ol ; represent almost 90% of the aromatic compounds of the essential oil from cardamom and all of them are oxygenated compounds.



1, 8 -cineole

1,8 cineole also called eucalyptol $C_{10}H_{18}O$

alpha-terpinyl acetate $C_{12}H_{20}O_2$

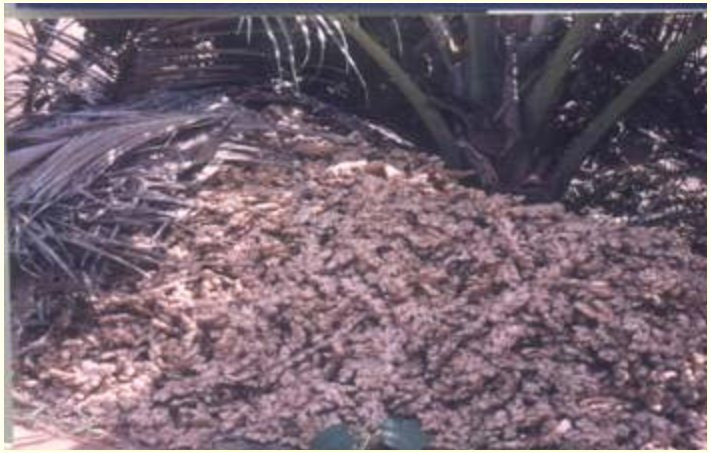


Alpha terpinyl acetate

Sweet, Herbal, Bergamot, Lavender
Olfactory Description Sweet, herbaceous, floral with lavender nuances.

Ginger

- India and China –largest producers and exporters of Ginger
- Largest importer-Japan
- Highest ginger producing states
- Kerala(45300tonnes),Nagaland(63500T), Meghalaya(47100T),Sikkim(34700T)



Freshly Harvested Ginger

Peeling of ginger

Dried Ginger

Ginger

Ginger rhizome contains a little volatile oil, fixed (fatty) oil, pungent compounds, resin, proteins, cellulose, pentosans, starch and mineral elements.

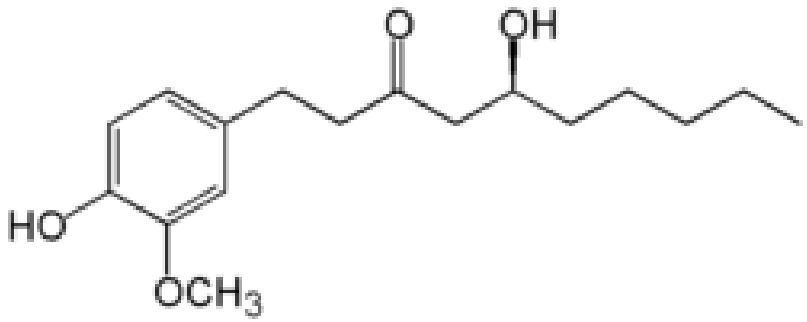
Starch is the most abundant and comprises 40-60% of rhizome on dry weight basis.

At about 9 months after planting, the volatile oil and pungent principles reach a maximum and thereafter their relative abundance falls as the fibre content continues to increase.

Most ginger varieties have about 3-6% crude fibre, 1.5-3.0% volatile oil and 4-10% oleoresin.

The major pungent principle in ginger oleoresin is gingerol. Among the gingerols 6-gingerol, 8-gingerol and 10-gingerol are very important in contributing the pungency.

Gingerol on storage gets converted to another compound called shogaol. The age of ginger oleoresin can be assessed based on the shogaol content.



$C_{17}H_{26}O_4$ (Hydroxy methoxy phenyl decanone)

Gingerol, or **sometimes [6]-gingerol, is the active constituent of fresh ginger.**

Chemically, gingerol is a relative of capsaicin, the compound that gives chilli its spiciness

Cooking ginger transforms gingerol into zingerone, which is less pungent and has a spicy-sweet aroma.

The level of gingerols and shogaols in ginger oleoresin can be determined using vanillin standard by HPLC.

Good quality ginger oleoresin will have 22-25% total gingerol. Using HPLC method ginger oleoresin or fresh ginger extract can be fractionated into 6-gingerol, 8-gingerol, 10-gingerol, 6-shogaol, 8-shogaol and 10-shogaol.

Volatile oil

The aroma and flavour of ginger are determined by the composition of steam volatile oil, which is comprised, mainly of Sesquiterpene hydrocarbons, monoterpene hydrocarbons and oxygenated compounds.

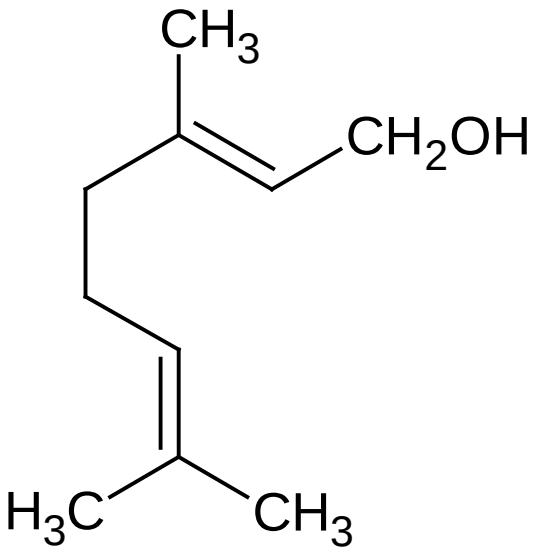
The monoterpene constituents are believed to contribute to the aroma of ginger and they are relatively more abundant in the fresh rhizome rather than that of dry ginger.

The major sesquiterpene hydrocarbon constituent of the oil is α-zingiberene. Other major constituents are sesquiphellandrene and ar-curcumene.

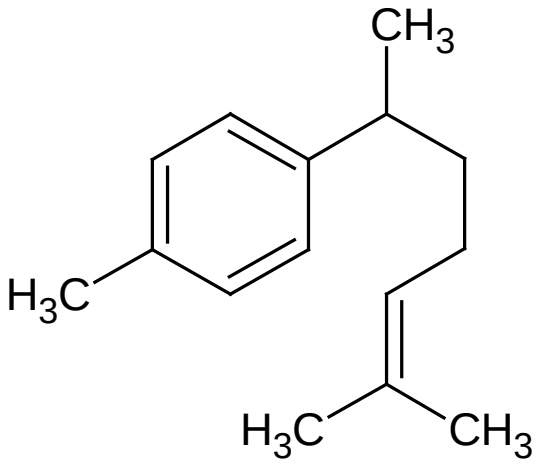
Ginger oil constituents

Scientists have identified seventy-two components in the volatile oil extracted from the dried rhizomes.

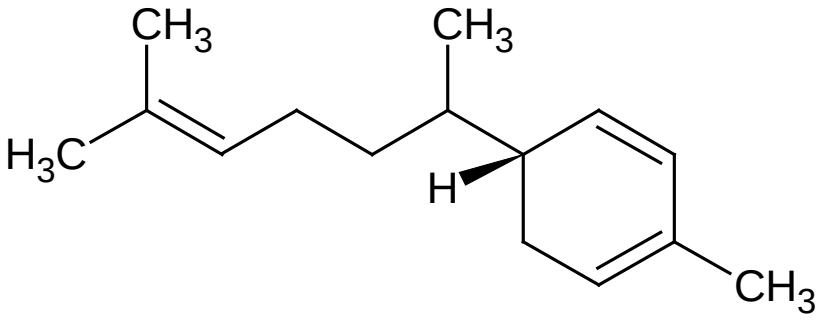
The main components were alpha-zingiberene (21.8%), geranial (9.9%), geraniol (9.4%), beta-bisabolene (7.9%), nerol (7.1%), 1,8-cineol (6.2%), alpha-terpineol (5.6%), borneol (5.4%), beta-phellandrene (3.1%), linalool (1.7%), methyl nonyl ketone (1.6%) and camphene (1.4)



Geraniol



ar-Curcumene



Zingiberene

Fresh and Dry ginger oils

Fresh, (green) ginger contains a greater proportion of the lower-boiling components.

Up to 20% of the volatile oil can be lost during the sun-drying of Indian ginger, and that the lemon-like aroma becomes weaker in the process.

The major oil loss to be expected during the drying of ginger is of the lower-boiling components, which include the citrals.

Fresh (green) ginger of Australia, Cochin and Calicut are characterized by a pronounced fresh, lemon-like aroma.

Retention of this characteristic in Australian ginger oils arises as much from more careful drying methods, in which volatile-oil losses are minimized as from intrinsic composition differences between the gingers of Australia and India.

Desirable flavour requirements for good quality ginger oil.

a)Citral and citronellyl acetate, being powerful Co-determinants of the odour.
b)Zingiberene and β-sesquiphellandrene as the main components of the freshly prepared oil.
c)ar-curcumene, increasing with storage, being indicative of the age of the oil or the process condition.
d)The ratio of zingiberene + β-sesquiphellandrene to ar- curcumene = 2: 3 as a characteristic of the oil.

The lemony note is attributed to citrals together with α-terpineol, while β-sesquiphellandrene and ar-curcumene- the characteristic ginger flavour.
Nerolidol was considered to contribute to the woody note;
and cis-and trans-β-sesquiphellandrol to be significant contributors to the ginger flavour.

Turmeric (*Curcuma longa*)

Turmeric

It is an essential item in curry powder. Curry powder usually contains about 24% of turmeric powder and may only be exceeded in quantity by coriander seeds.

Turmeric is valued for its yellow- orange colouring powder, which is determined by the content of curcuminoid pigments. Turmeric also possesses highly aromatic volatile oil, which has the peculiar turmeric aroma.

Curcuminoids are polyphenolic pigments found in the spice turmeric.
The term turmeric is used both for the plant *Curcuma longa* L. and the spice derived from the rhizomes of the plant.

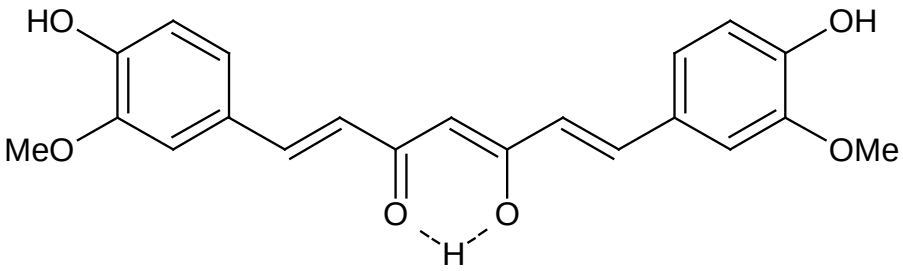
The major curcuminoids are curcumin, demethoxycurcumin and bisdemethoxycurcumin. These substances comprise 3 to 6% of *Curcuma longa*. Curcumin makes up 70 to 75% of the curcuminoids, demethoxycurcumin 15 to 20% and bisdemethoxycurcumin about 3%.

Curcuminoids are responsible for the yellow color of turmeric, as well as the yellow color of curry.

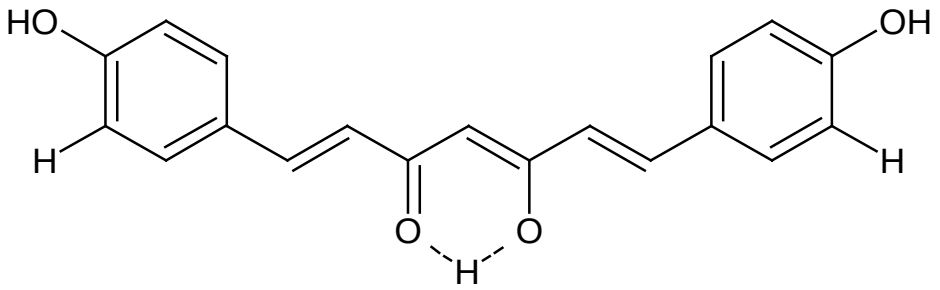
Curcuminoids are derived from turmeric by extraction with ethanol. Curcumin is the most studied of the curcuminoids. In pure form, it is an orange-yellow, crystalline powder that is insoluble in water.

It is also known as diferuloylmethane and turmeric yellow. Its chemical name is (*E*, *E*) —1, 7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3, 5 dione.

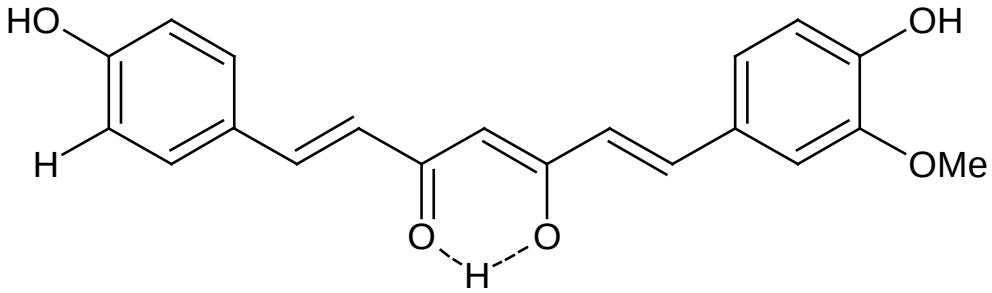
The molecular formula of curcumin is $C_{21}H_{20}O_6$ and its molecular weight is 368.39 daltons.



Curcumin



Bisdemethoxycurcumin



Demethoxycurcumin

Turmeric oil

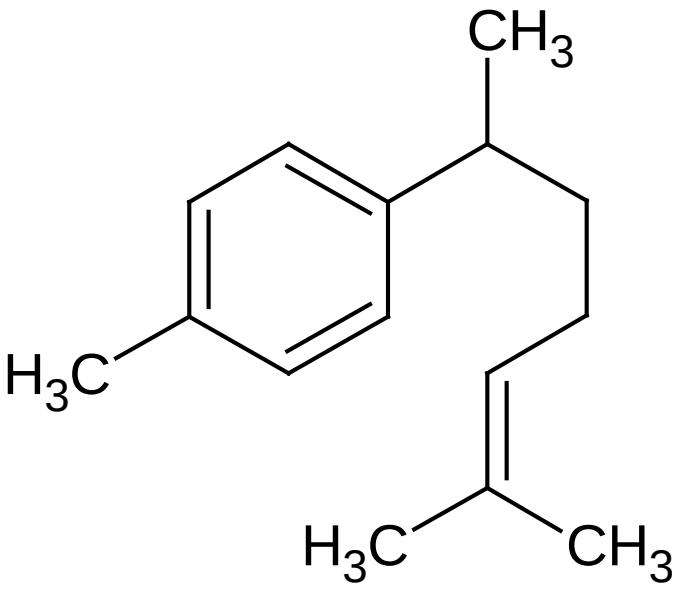
Content varies between 4 - 6%

phellandrene 4.39, limonene 2.29, zingiberene 1.21, ar-curcumene 1.43, ar-turmerone 21.81, α-turmerone 25.33, β-turmerone 16.74, 1,8-cineole 1.64

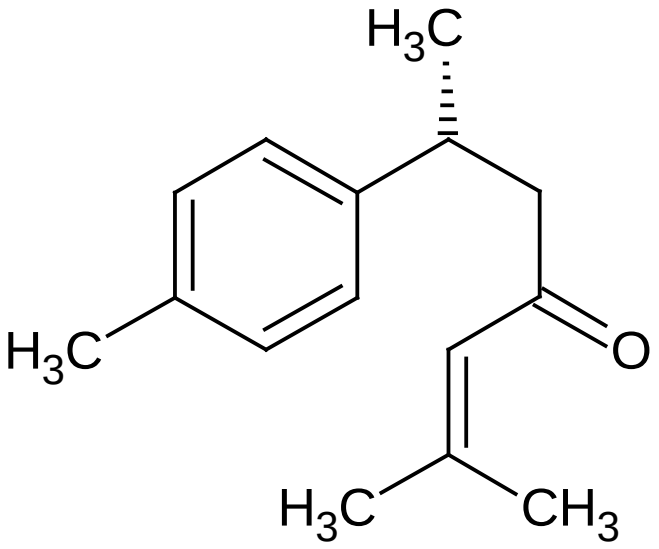
Same fresh, spicy-woody aroma

Great for oriental/fantasy type aromas

Aromatherapy properties: Relaxing and stimulating, balancing



ar-Curcumene



-ar-Turmerone

Turmeric oleoresin

Turmeric oleoresin is essentially used in institutional cooking in meat and fish products and certain products such as mustard, pickles and relish formulas, butter and cheese.
This is obtained by the solvent extraction of the ground spice with organic solvents like acetone, ethylene dichloride and ethanol for 4-5 hours.

It is orange red in colour. Oleoresin yield ranges from 7.9 to 10.4 per cent.
Curcumin, the principal coloring matter forms one third of a good quality oleoresin.

Paprika

Paprika is is always non-pungent in international trade **a sweet, dried, red powder. This mild powder can be made from any type of *C. annuum* that is non-pungent and has brilliant red color.**

Paprika comes from milling dry fruits of different varieties of *Capsicum annum* L.

Drying

This is valued principally for the brilliant red colour it gives to pale foods and also for its delicate aroma. Color is very important in paprika and chilli powder.

Paprika and paprika oleoresin is currently used in a wide assortment of foods, drugs, and cosmetics, as well as for improving the feather color of flamingoes in zoos.

Technological innovations have already made great strides in separating colour components and pungent constituents.

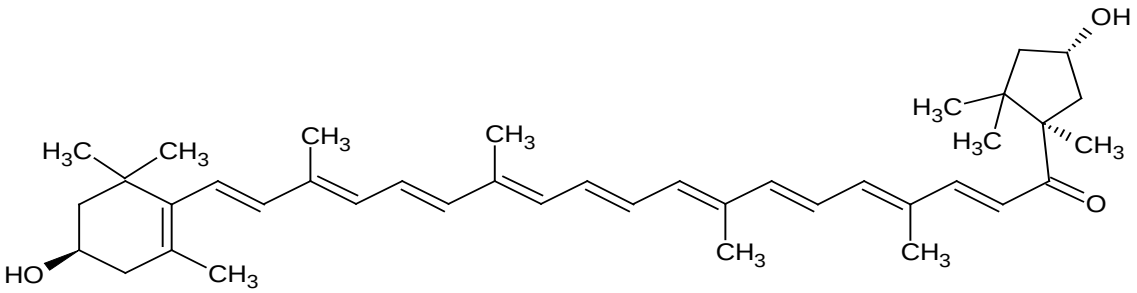
The colour of chilli spice powder is due to the presence of red-pigmented carotenoids.

The main pigments are Capsanthin, capsorubin, zeaxanthin and cryptoxanthin. Carotenoids are very stable in intact plant tissue.

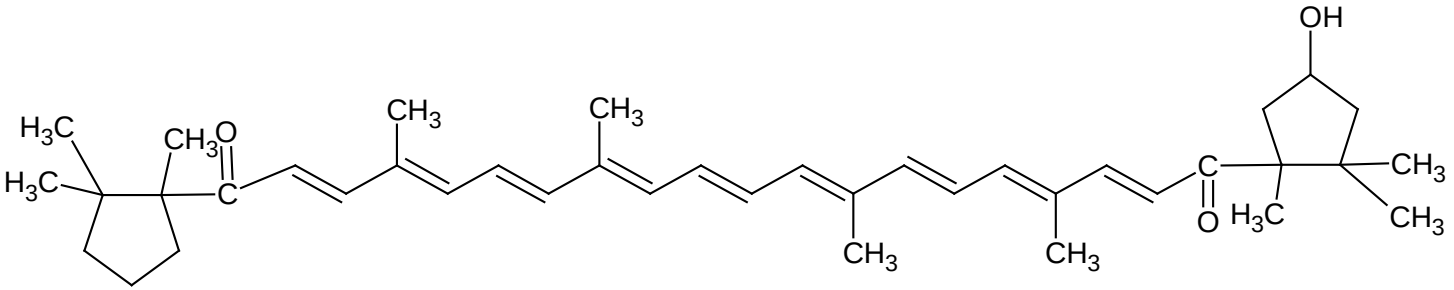
Colour is expressed as ASTA units.

Above 120 ASTA is desirable.

Capsanthin



Capsorubin



Carotenoids control pod color with approximately 20 carotenoids contributing to the color of the powder. Carotenoid compounds are yellow to red pigments of aliphatic or alicyclic structures composed of isoprene units, which are normally fat-soluble colors.

The major **red color** in chilli comes from the carotenoids capsanthin and capsorubin, while the **yellow-orange** color is from beta-carotene and violaxanthin.

Capsanthin, the major carotenoid in ripe fruits, contributes up to 60% of the total carotenoids. Capsanthin and capsorubin increase proportionally with advanced stages of ripeness; with capsanthin being the more stable of the two.

In ripe fruits, capsanthin, capsorubin, zeaxanthin, cucurbitaxanthinA and beta-carotene were the main carotenoids, the remainder being capsanthin 5,6-epoxide, capsanthin 3,6-epoxide, karpoxanthin, cucurbitaxanthin B, violaxanthin, cycloviolaxanthin, antheraxanthin, capsanthone, nigroxanthin, beta-cryptoxanthin and several cis isomers and furanoid oxides.

Pungency in chilli

Capsaicinoids, group of alkaloid compounds that are found only in the plant genus, *Capsicum – impart pungency*

The nature of the pungency has been established as a mixture of seven homologous branched-chain alkyl vanillylamides.

Capsaicin & Dihydrocapsaicin major capaicinoids

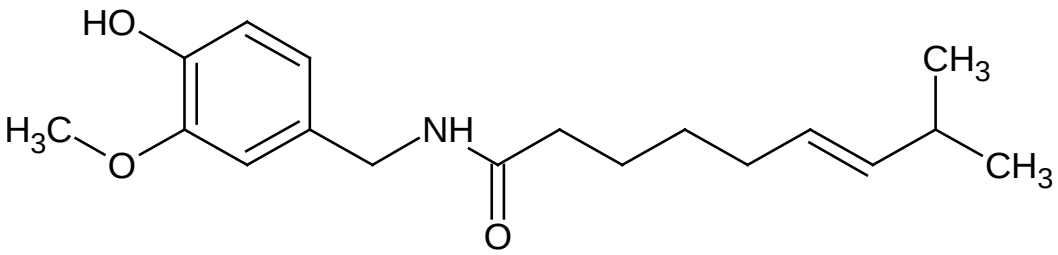
nor capsaicin, nordihydrocapsaicin, nornordihydrocapsaicin, homocapsaicin and homodihydrocapsaicin are considered minor capsaicinoids because of their relative low abundance in most natural products.

Capsaicin ($C_{18}H_{27}NO_3$)is a powerful and stable alkaloid that can be detected by human taste buds in solutions of ten parts per million.

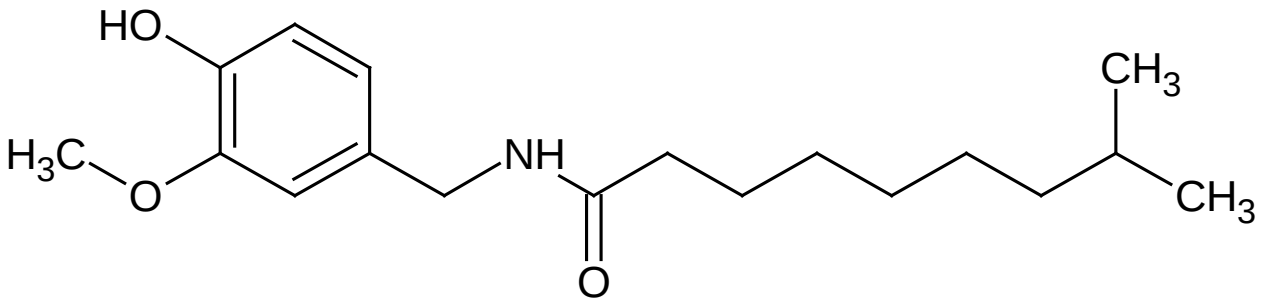
The capsaicinoids present in the capsicum fruit are predominantly capsaicin and dihydrocapsaicin, making up 80 to 90%. Dihydrocapsaicin accounts for about 22% of the total capsaicinoids mixture and has about the same pungency as capsaicin.

Pungency of Chilli is expressed as Scoville Heat units.

Pure Capsaicin rates over 15,000,000 Scoville Units! The "Red Savina" Habanero has been tested at over 577,000 Scoville units



Capsaicin



Dihydro Capsaicin

Chilli Type	Scoville Heat Units (SHU)
Bell/Sweet	0-100
New Mexican	500-1000
Espanola	1,000-15,00
Ancho & Pasilla	1,000-2,000
Cascabel & Cherry	1,000-2,500
Jalapeno & Mirasol	2,500-5,000
Scotch Bonnet & Thai	100,000-350,000
Habanero	200,000-350,000
Nagarhari(Assam)	855,000

Curry leaf *Murraya koenigii*

Terpenes are the main constituents of the volatile essential oil of M. koenigii, leaves of which are used for curry flavouring.

Oil produce less than 4% of other components, with 8 monoterpene hydrocarbons (about 16%) and 17 sesquiterpene hydrocarbons (about 80%).

The major constituents responsible for aroma are β-caryophyllene, β-gurjunene, β-elemene, β-phellandrene and β-thujene

The volatile oils from the leaves of six species of the genus Murraya have been studied by GC-MS and about 60 monoterpene and sesquiterpenes components were identified.

carbazole alkaloids

First discovery of carbazoles from plant sources, girinimbine, was reported in *M. Koenigii*

Murrayanine.
mahanimbine, girinimbine and two new carbazole alkaloids isomahanimbine and koenimbidine from the leaves and roots of curry leaf plant

C_{23}-carbazole alkaloid mahanimbinol, was isolated from the stem of the Indian curry leaf plant *Murraya koenigii*.

Problem –where we need support

Incorporation of functional foods rich in bioactive compounds, such as phenolics, carotenoids, proteins, carbohydrates, lipids, saponins, acids, amino acids, vitamins, pre- and probiotics, bioactive peptides etc., with anti-oxidative, anti-inflammatory and anti-angiogenic beneficial properties into our diet may have physiological benefits that reduce the risks of diseases and have health-promoting properties.

The use of nutraceuticals for targeting early stages of chronic angiogenic diseases to prevent pathological conditions and hypoxia-induced angiogenesis would be a valuable concept in the diet-health relationship.

- **The effectiveness of nutraceutical products depends on its bioavailability, a formidable challenge, since only a small proportion of molecules remain available following oral administration, due to insufficient gastric residence time, low permeability and/or solubility within the gut, instability under food processing conditions (temperature, oxygen, light) or in the gastro-intestinal (GI) tract (pH, enzymes, presence of other nutrients), all of which limit the activity.**

- Thus these molecules must be delivered in the active molecular form to the physiological target.
- ENCAPSULATION & TARGETED DELIVERY OF THE MOLECULE are promising methods by which we can approach the problem.

Encapsulation of spice phytochemicals

- **Establish the dose-response relationship of spice bioactive compounds, since most of these products have potentially beneficial as well as toxic effects.**
- **Deduce the kinetics of these compounds or its metabolites *in vitro* and *in vivo*.**
- **Develop nutraceutical delivery systems encapsulated in micro-, or nanoparticles, which can be used in food applications that require compounds generally recognized as safe (GRAS).**
- .

•Characterize the physicochemical properties of the encapsulated single or combinations of (+ the bioavailability enhancer piperine for instance) spice phytochemicals: particle size, encapsulation efficiency, release properties, compatibility with the phytochemical being delivered, etc.

Applications of micro/ nano-scale particles for drug delivery in therapeutic systems, designed for intelligent, modulated – slow release or stable, and selective delivery of drugs to specific areas in the body in order to maximize drug action and minimize toxicity.

Goal
To exploit the nutraceutical potential of spice bioactive molecules by developing druggable molecules.

Other areas where we need collaboration

Development of diagnostic microarray for detection of plant pathogens

Development of LFD (Lateral Flow Device) based diagnostics

Training on next generation sequencing for whole genome sequencing,

Transcription sequencing and metagenomics

Training in Bio informatic tools for analysis of next generation sequencing data

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THANK YOU