

Module-06: Chemical composition of spices and condiments

Spices

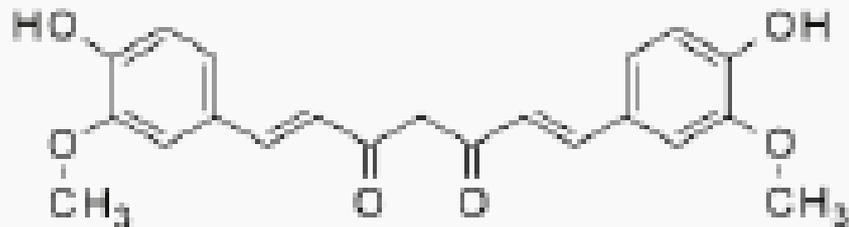
Turmeric

- Turmeric is an antioxidant phytochemical known as a polyphenol and has the chemical composition of $C_{21}H_{20}O_6$.
- It contains a mixture of phenolic compounds called curcumin about 5%, and related compounds called curcuminoids, and a volatile oil about 5% with turmerone and zingiberene; cineole and other monoterpenes; starch; protein; and high amounts of vitamin A and other vitamins like vitamin C and E, several carotenoids, curcumin.

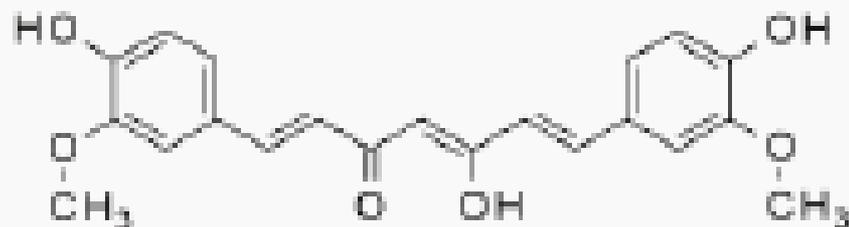
Functions:

- Curcumin is one of the antioxidants.
- Cineole stimulates central nervous system and is antiseptic.
- Essential oil has stimulating effects on the gallbladder and also stimulates the liver to produce more bile and regulate its viscosity.

- Curcumin exists in two forms, keto and enol.
- Keto form is preferred in solid phase while enol form in solution and is a PH indicator as it turns yellow in acidic solution and bright red in basic solution.



Curcumin keto form



Curcumin enol form

Coriander

Leaves and seeds contain many essential volatile oils such as borneol, linalool, cineole, cymene, terpineol, dipentene, phellandrene, pinene and terpinolene. In addition to this they are also rich in numerous anti-oxidant polyphenolic flavonoids such as quercetin, kaempferol, rhamnetin and epigenin.

Fruits contain 0.2–2.6% volatile oil. The major component of the oil is *d*-linalool (coriandrol), which is present in 55–74%. Other compounds present in the oil include decyl aldehyde, borneol, geraniol, geranyl acetate, camphor, carvone, anethole, caryophyllene oxide, elemol, and monoterpene hydrocarbons (mainly γ -terpinene, and α - and β -pinene, *d*-limonene, *p*-cymene, β -phellandrene and camphene).

Other constituents present in fruits include up to 26% fats made up of glycerides (primarily of oleic, petroselinic and linolenic acids), a small amount of unsaponifiable matter (containing β -sitosterol, δ -sitosterol, triacontane, triacontanol, tricosanol, etc.); proteins (11–17%); about 1.0% starch and 20% sugars; coumarins; flavonoid glycosides, and rutin.

Leaves contain less volatile oil than fruits; about 5% fats; about 22% proteins; sugars; coumarins and flavonoid glycosides similar to those in fruits; vitamin C; and others. The volatile oil contains mainly decyl and nonyl aldehydes, and linalool, among others. The herb is a good source of minerals like potassium, calcium, manganese, iron, and magnesium. It is also rich in many vital vitamins, including folic-acid, riboflavin, niacin, vitamin-A, beta carotene.

Nutrient value per 100 g

Energy	23 Kcal
Carbohydrates	3.67 g
Protein	2.13 g
Total Fat	0.52 g
Cholesterol	0 mg
Dietary Fibre	2.80 g
Folates	62 µg
Niacin	1.114 mg
Pantothenic acid	0.570 mg
Pyridoxine	0.149 mg
Riboflavin	0.162 mg
Thiamine	0.067 mg
Vitamin C	27 mg
Vitamin E	2.50 mg
Vitamin K	310 mcg
Sodium	46 mg
Potassium	521 mg
Calcium	67 mg
Iron	1.77 mg
Magnesium	26 mg
Phosphorus	48 mg
Selenium	0.9 mg
Zinc	0.50 mg
Carotene-α	36 µg
Carotene-β	3930 µg
Crypto-xanthin-β	202 µg
Lutein-zeaxanthin	865 µg

Fennel

- The main chemical components of fennel oil are β -pinene, myrcene, fenchone, trans-anethole, methyl chavicol, limonene, 1, 8-cineole and anisic aldehyde.
- Fruits contain 1.5–8.6% volatile oil; 9–28% fixed oil composed primarily of petroselinic acid (60–75%), oleic acid, and linoleic acid with a relatively high concentration of tocopherols; flavonoids (mainly quercetin-3-glucuronide, rutin, isoquercitrin, and quercetin-3-arabinoside); protein (16–20%); sugars; vitamins; minerals; and others. Low concentrations of polyacetylenes were recently detected in the root. An antimicrobial phenyl propanoid was also isolated from the stem.
- The volatile oil contains mostly *trans*-anethole (72–74%), with lesser amounts of fenchone (11–16%), estragole (methyl chavicol, 3–5%), limonene, camphene, and α -pinene. Other compounds present include monoterpene hydrocarbons (β -pinene; α -thujene, α -fenchene, 3-carene, sabinene, α -phellandrene, myrcene, α - and β -terpinene, terpinolene, and *p*-cymene), fenchyl alcohol.

Chemical category of fresh fennel:

Chemical category	Composition (%)
<i>Monoterpene: Hydrocarbons</i>	17.6
Ketones	5.0
Esters	0.6
<i>Phenols & PhenolEthers</i>	72.7
<i>Sesquiterpene:Hydrocarbons</i>	0.1
<i>Unknown</i>	1.3
Total identified	97.3

Essential oil composition of fennel plant

Compound	Composition %
α -pinene	4.2
β -myrcene	1.1
α -phellandrene	10.8
Limonene	2.1
Fenchone	5.3
Isoanethole	17.3
<i>trans</i> -anethole	51.9
Monoterpene hydrocarbons	18.2
Oxygenated monoterpenes	5.3
Phenyl propanoids:	69.2
Yield (% v/w)	0.30
Ratio(iso/trans)	0.34

Twenty four constituents are present in fennel which constitute **97.0%** of the **total essential oil** components. Phenol ethers is the main chemical category (72.7%) followed by monoterpene hydrocarbons (17.6%). The major essential oil constituents are *trans*-anethole (55.5%) followed by isoanethole (17.2%), α -phellandrene (10.3%), fenchone (5.0%) and α -pinene (3.4%).

Fenugreek

Fenugreek contains simple alkaloids consisting mainly of trigonelline (up to 0.13%), choline (0.05%), gentianine, and carpaine. Other constituents include:

1. Saponins that yield on hydrolysis 0.6–1.7% steroid.
2. Flavonoids, including vitexin.
3. Fixed oils (5–8%), which on extraction with fat solvents yield an extract with a strong odour.
4. Considerable amount of mucilage, which appears to be mostly a galactomannan and is probably responsible for swelling of the seed in water.
5. Protein (23–25%), which is low in S-amino acids but high in lysine and tryptophan.
6. Free amino acids, including (2S, 3R, 4R)-4-hydroxyisoleucine, histidine, lysine, and arginine.
7. Vitamins, especially A, B1, and C.
8. Minerals (especially calcium and iron).
9. Volatile components (more than 50), which include *n*-alkanes, Sesquiterpene, and oxygenated compounds.

Parameters	Value
Moisture	13.700gm
Protein	26.200gm
Fat	5.800 gm
Minerals	3.000gm
Fibre	7.200gm
Carbohydrates	44.100gm
Energy	333.000 K cal
Calcium	160.000 mg
Phosphorus	370.000mg
Iron	6.500 mg
Carotene	96.000µg
Thiamine	0.340 mg
Riboflavin	0.290 mg
Niacin	1.100 mg
Folic Acid (Free)	14.500 µg
Folic Acid (Total)	84.000 µg
Choline	1161.000 mg
Magnesium	124.000 mg
Sodium	19.000 mg
Potassium	530.000 mg
Copper	0.710 mg
Manganese	1.030 mg
Zinc	3.080 mg
Chromium	0.064 mg
Phytin Phosphorus	151.000 mg

Garlic

- Garlic contains more than 200 chemical compounds. Some of the important ones include: volatile oil (0.1–0.36%) with sulphur-containing compounds: (allicin, alliin, and ajoene), protein (16.8%) and enzymes: (allinase, peroxidase and myrosinase). Allicin is what gives garlic its antibiotic properties and is responsible for its strong odour. Garlic also contains citral, geraniol, linalool, A phellandrene and B phellandrene.
- *Vitamin and Mineral Content:* B-vitamins especially B1, vitamin C, vitamin A, flavonoids, ascorbic acid, thiamine, riboflavin, niacin phosphorous, potassium, sulphur, selenium, calcium, magnesium, germanium, sodium, iron, manganese and trace iodine. Seventeen amino acids are found in garlic, including eight essential ones.

Parameters	Value
Moisture	62.000 gm
Protein	6.300 gm
Fat	0.100 gm
Minerals	1.000 gm
Fibre	0.800 gm
Carbohydrates	29.800 gm
Energy	145.000 K cal
Calcium	30.000 mg
Phosphorus	310.000 mg
Iron	1.200 mg
Thiamine	0.060 mg
Riboflavin	0.230 mg
Niacin	0.400 mg
Vitamin C	13.000 mg
Magnesium	71.000 mg
Copper	0.630 mg
Manganese	0.860 mg
Zinc	1.930 mg
Chromium	0.020 mg

Clove

- Cloves are actually the dried buds of the clove tree. The minor constituents like methyl amyl ketone, methyl salicylate, are responsible for the characteristic pleasant odour of cloves. Clove oil is comprised of many different compounds, with the primary component being eugenol (49–87%), β -caryophyllene (4–21%), and eugenyl acetate (0.5–21%). Smaller amounts of β -humulene, methyl eugenol are also present, as well as trace amounts (<1%) of 25–35 other constituents. Cloves also contain flavonoids, galloyltannins, phenolic acids and tri-terpenes.
- Several factors govern the relative quantities of the different constituents in clove oil, including plant genetics, climate, soil and cultivation techniques, the part of the plant extracted, and the extraction method.

Cumin

- Among the spices cumin is having highest antioxidant activity and these antioxidants also act as preservatives by preventing or slowing the spoilage of food.
- Among the seed spices, cumin fruits have a distinctive bitter flavour and strong, warm aroma due to their abundant essential oil content. Cumin-aldehyde (40 to 65%) is the major constituent and important aroma compound. The characteristic flavour of cumin is due to the presence of monoterpenes such as α -pinene and *cis*- β -farnesene.

Parameters	Value
Moisture	11.900 gm
Protein	18.700 gm
Fat	15.000 gm
Minerals	5.800 gm
Fibre	12.000 gm
Carbohydrates	36.600 gm
Energy	356.000 K cal
Calcium	1080.000 mg
Phosphorus	511.000 mg
Iron	11.700 mg
Carotene	522.000 µg
Thiamine	0.550 mg
Riboflavin	0.360 mg
Niacin	2.600 mg
Vitamin C	3.000 mg
Choline	1065.000 mg
Magnesium	475.000 mg
Sodium	126.000 mg
Potassium	980.000 mg
Copper	0.710 mg
Manganese	1.020 mg
Zinc	2.660 mg
Phytin Phosphorus	153.000 mg

Capsicum

- Capsaicin and dihydrocapsaicin are the main capsaicinoid in chilli pepper while nordihydrocapsaicin, homodihydrocapsaicin and homocapsaicin are the minor capsaicinoids.
- Capsaicin is synthesized in interocular septum of chilli pepper and is made from vanillylamine and 8-methyl-6-nonenoyl CoA.

Pepper

Pepper gets its spicy heat mostly from the piperine compound, which is found both in the outer fruit and in the seed. Black pepper contains between 4.6% and 9.7% piperine while white pepper contains slightly more than that. Black pepper contains 2–4% volatile oil and 5–9% piperine, piperidine, piperettine, and a few minor alkaloids (piperidine, piperolein A, piperolein B, piperanine, etc.). Piperine and piperanine are the known pungent principles. Black pepper oil contains β and α -pinenes, δ -limonene and β -caryophyllene as major components. Caryophyllene is the substance with sweet floral odours, whereas oils with high pinene content give turpentine like off-odours. The major compounds in the fresh pepper are trans – linalool oxide and α -terpineol.

Black pepper is also reported to contain flavonol glycosides (especially those of kaempferol, rhamnetin, and quercetin) in considerable concentration, as well as sterols (stigmastane-3, 6-dione and stigmast-4-ene-3, 6-dione) and polysaccharides.

White pepper contains little volatile oil but has the same pungent principles and alkaloids as black pepper. Both also contain about 11% protein, 65% carbohydrates, lipids, crude fibre, and others. Pepper oil contains a complex mixture of monoterpenes (70–80%), Sesquiterpene (20–30%), and small amounts of oxygenated compounds, with no pungent principles present. Major monoterpenes include α -thujene, α -pinene, camphene, sabinene, β -pinene, myrcene, 3-carene, limonene, and β -phellandrene. Sesquiterpenes include β -caryophyllene (major component), β -bisabolene, β -farnesene, curcumene, humulene, β -selinene, α -selinene, β -elemene; α -cubebene, α -copaene, and sesquisabinene. Oxygenated components include linalool, l-terpinen-4-ol, myristicin, β -pinone etc.

Curry Leaf

The curry leaf plant is highly valued for its characteristic aroma and medicinal value. A number of leaf essential oil constituents and alkaloids have been extracted from this plant. There are a large number of oxygenated mono and Sesquiterpene present, for example, *cis*-ocimene (34.1%), β -caryophyllene (9.5%), α -pinene (19.1%), δ -terpenene (6.7%) and β - phellandrene which appear to be responsible for the intense odour associated with the stalk and flower parts of curry leaves.

Parameters	Value
Moisture	63.800 gm
Protein	6.100 gm
Fat	1.000 gm
Minerals	4.000 gm
Fibre	6.400 gm
Carbohydrates	18.700 gm
Energy	108.000 K cal
Calcium	830.000 mg
Phosphorus	57.000 mg
Iron	0.930 mg
Carotene	7560.000 µg
Thiamine	0.080 mg
Riboflavin	0.210 mg
Niacin	2.300 mg
Folic Acid (Free)	23.500 µg
Folic Acid (Total)	93.900 µg
Vitamin C	4.000 mg
Magnesium	44.000 mg
Copper	0.100 mg
Manganese	0.150 mg
Zinc	0.200 mg
Chromium	0.006 mg
S	81.000 mg
Cl	198.000 mg
Oxalic Acid	132.000 mg
Phytin Phosphorus	35.000 mg

Ginger

Ginger owes its characteristic organoleptic properties to two classes of constituents. The aroma of ginger are due to the constituents of its steam-volatile oil which are mainly Sesquiterpene hydrocarbons, monoterpene hydrocarbons and oxygenated monoterpenes while its pungency is due to the non-steam-volatile components also known as the gingerols. The major Sesquiterpene hydrocarbon constituent of ginger oil is α -zingiberene. Certain ginger oil has a reputation for possessing a particular 'lemony' aroma, due to its high content of the isomers, neral, and geranial often collectively referred to as citral. The antioxidant components analysed were polyphenols, vitamin C, β carotene, flavonoids and tannins.

6.1.11.1. Nutritional composition of ginger (per 100g)

Constituent	Value
Moisture	15.02
Ash	3.85 g
Protein	5.087 g
Fat	3.72 g
Calcium	88.4 mg
Phosphorous	174 mg
Insoluble fibre	23.5 %
Iron	8.0 mg
Soluble fibre	25.5 %
Zinc	0.92 mg
Carbohydrate	38.35 g
Copper	0.545 mg
Vitamin C	9.33 mg
Manganese	9.13 mg
Total carotenoids	79 mg
Chromium	70 μ g

Cardamom

The main chemical components of cardamom oil are α -pinene, β pinene, sabinene, myrcene, β -phellandrene, limonene, methyl eugenol and trans-nerolidol. It contains 2.8–6.2% volatile oil, 10% protein, 1–10% fixed oil, up to 50% starch, manganese, and iron, among others. The volatile oil is composed mainly of α -terpinyl acetate and 1,8-cineole, each of which may be present at concentrations of up to 50% or more; lesser components include limonene, sabinene, linalool, linalyl acetate, α -pinene, α -terpineol, camphene, myrcene, 1,4-cineole, borneol, etc. Acid constituents of the oil include acetic, butyric, decanoic, dodecanoic, citronellic, geranic, hexanoic, heptanoic, nerylic, and perillic acids. The fixed oil mainly consists of waxes containing *n*-alkanes and sterols.

Parameters	Value
Moisture	20.000 gm
Protein	10.200 gm
Fat	2.200 gm
Minerals	5.400 gm
Fibre	20.100 gm
Carbohydrates	42.100 gm
Energy	229.000 kcal
Calcium	130.000 mg
Phosphorus	160.000 mg
Iron	4.600 mg
Thiamine	0.220 mg
Riboflavin	0.170 mg
Niacin	0.800 mg
Choline	1550.000 mg
Magnesium	173.000 mg

Condiments

- Vinegar
- Sauce
- Olive oil
- Mustard
- Table salt
- Ketchup
- Tamarind