

Post Harvest Operations and Processing Fruits, Vegetables, Spices and Plantation Crop Products

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Lecture – 04 Indian Spices

This topics covered in the lecture are classification of indian spices, their composition, sensory attributes, antimicrobial potential, antioxidants, bioactives, and health value along with some important features of natural colours, flavouring compounds, and lastly infestation and quality losses associated with spices.

Concepts Covered

- Classification, composition, sensory attributes
- Antimicrobial potential, antioxidants, bioactives, health value
- Natural colours, flavours
- Infestation and quality losses



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Spices

Definitions

Geneva-based International Standards Organisation (ISO)

Vegetable products or mixtures thereof, free from extraneous matter, used for flavouring, seasoning and imparting aroma in foods.

Webster

Any of various aromatic vegetable productions as pepper, cinnamon, nutmeg, mace, allspice, ginger, cloves, etc., used in cookery to season and to flavour sauces, pickles, etc., a vegetable condiment or relish, usually in the form of a powder; also, as condiments collectively.

Famous spice author Rosengarten

A spice is a product which enriches or alters the quality of a thing, for example altering the taste of a food to give it zest or pungency; a piquant or lasting flavouring; or a relish.

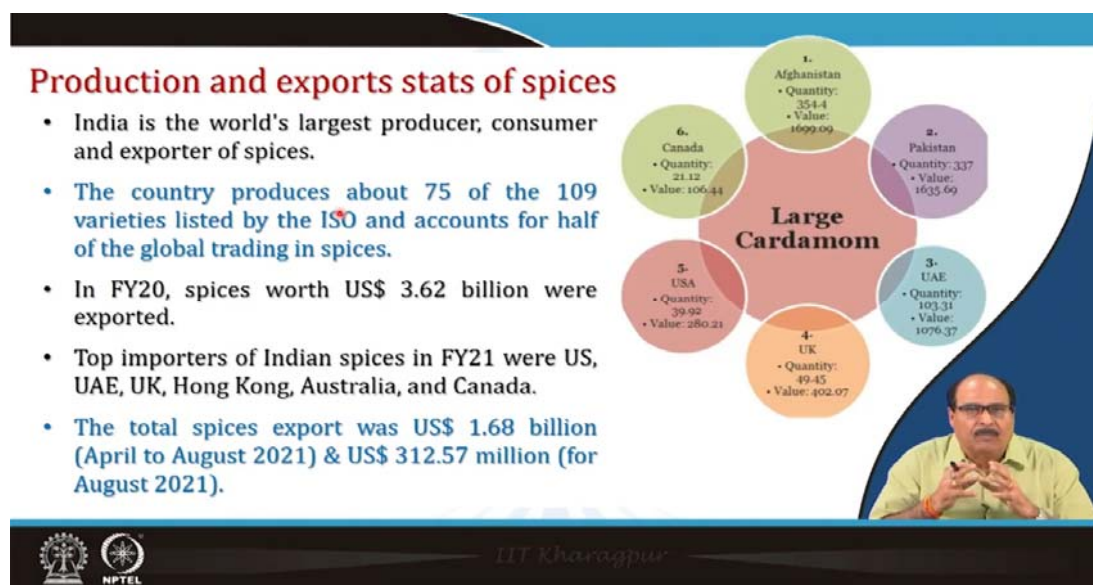


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Spices

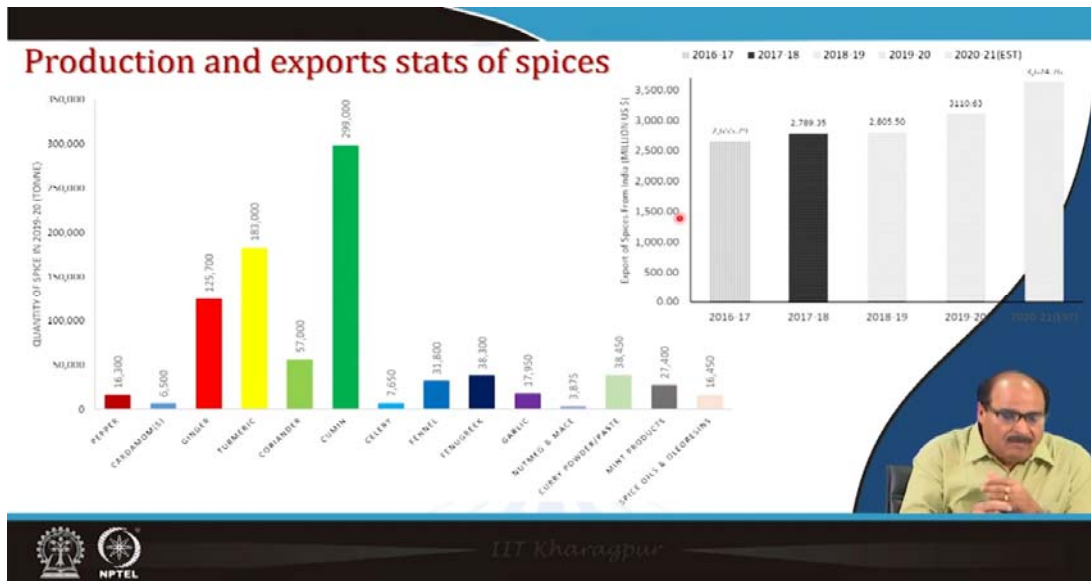
Definitions

The Geneva based international standards organization (ISO) defines the spices as vegetable products or mixture thereof, which are free from extraneous matter, used for flavoring, seasoning and imparting aroma in foods. According to the Webster, any of the various aromatic vegetable production as paper, cinnamon, nutmeg, mace, allspice, ginger, cloves, etc., which are used in cookery to season and to flavor sauces, pickles, etc. as a vegetable condiments or relish, usually in the form of a powder, or also as condiments collectively. Famous spice author Rosengarten has described the spice as a product which enhances or alters the quality of a thing, for example, altering the taste of a food to give it zest or pungency, a piquant or lasting flavoring or a relish.

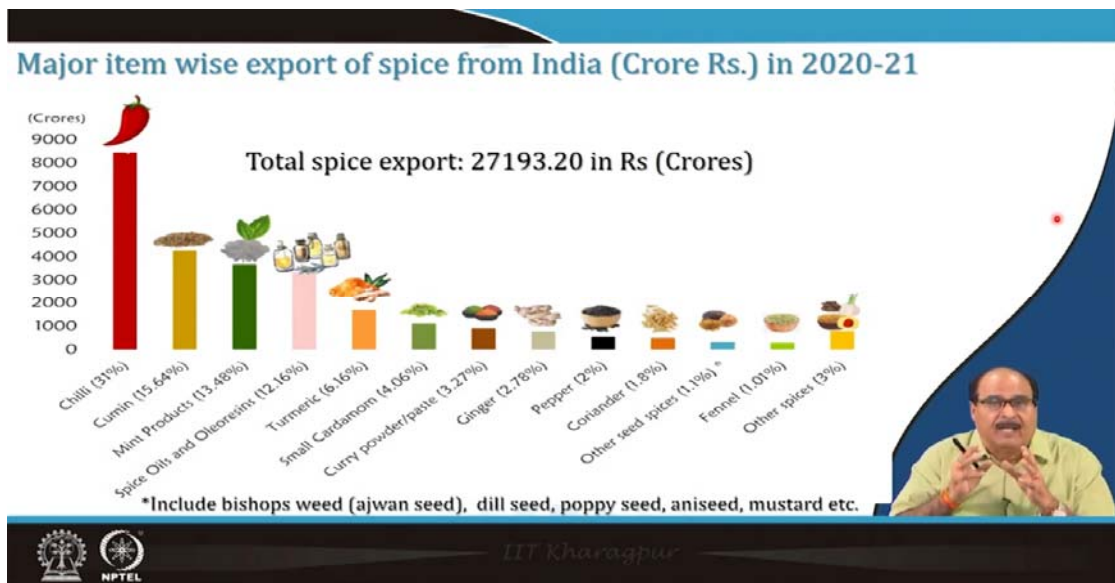


Production and exports stats of spices

India is the world's largest producer, consumer and exporter of spices. The country produces about 75 of the 109 varieties listed by the ISO and it accounts for half of the global trading in spices. In the year 2020, spices worth US dollar 3.62 billion were exported from India. Top importers of Indian spices in the financial year 21 were USA, UAE, UK, Hong Kong, Australia and Canada. The major countries, which imported large cardamom from India include Afghanistan, Pakistan, United Arab Emirates, UK, USA and Canada. The exported value of total spices was US dollar 1.68 billion from April to August 2021 and in the August 2021 alone, it was to the tune of US dollar 312.57 million.



This figure shows the production and export states of spices in terms of quantity of spice produced (in tons) in the year 2019 in India. The cumin was the highest in India with 2,99,000 tons production followed by turmeric and then ginger in 2019-20. The export value of spices from India (in million US dollar) has also shown a progressive increase from 2016-17 to 2020-21.



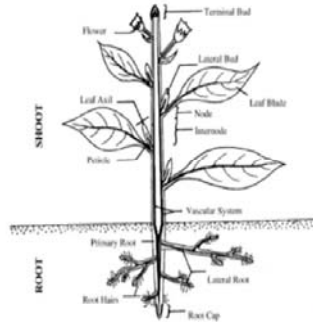
India is known as the hub of spices. From the data of major item wise export of spice from India, in 2021 (value in the terms of crore rupees), it can be clearly observed that chilli contributed the highest (31%) followed by cumin, mint products, spice oils and oleorisins and small cardamom, ginger, curry powder, pepper, and coriander.

Herbs

Herbs are plants valued for their medicinal and aromatic properties and are often grown and harvested for these unique properties.

□ The main axis of the herb consists almost entirely of stem; the root or other underground structure only rarely being present.

- Part of the aerial shoot usually the tops.
- The whole aerial part of plant as Lobelia.
- Occasionally whole plant including roots.
- The whole undifferentiated plant body or thallus of the lower plants of thallophyta.



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Herbs

Herbs are plants valued for their medicinal and aromatic properties and are often grown and harvested for these unique properties. The main axis of the herb consists almost entirely of the stem, the root or other underground structures only being present. It includes part of the aerial shoot, usually the tops; the whole aerial part of the plant as Lobelia; occasionally whole plant including roots. The whole undifferentiated plant body or thallus of the lower plants of thallophyta.

Spices v/s Herbs

Spices	Herbs
<ul style="list-style-type: none"> • The dried parts of aromatic plants used for seasoning and flavoring food. 	<ul style="list-style-type: none"> • These are leaves of aromatic plants used to impart flavour and odour to foods with, sometimes, the addition of colour. The leaves are commonly traded separately from the plant stems and leaf stalks.
<ul style="list-style-type: none"> • It is often used in dried and ground form. 	<ul style="list-style-type: none"> • It is often used in fresh form.
<ul style="list-style-type: none"> • It is used for flavouring, colouring and preserving food. 	<ul style="list-style-type: none"> • It is used for flavouring or garnishing food.
<ul style="list-style-type: none"> • Ex: Cinnamon, cardamom, pepper, turmeric, saffron, cumin and cloves. 	<ul style="list-style-type: none"> • Ex: Sage, rosemary, thyme, parsley and basil.



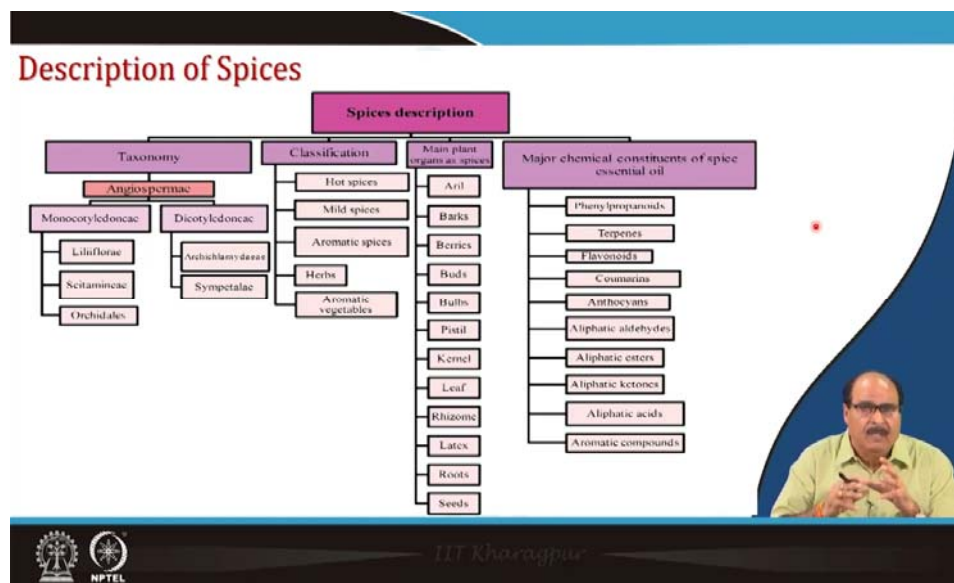
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Difference between spices and herbs

Spices are generally dried parts of the aromatic plants used for seasoning and flavoring food, whereas the herbs are generally leaves of the aromatic plants which are used to impart flavor and odour to foods, with sometimes the addition of color. The leaves are commonly traded separately from the plant stems and leaves are leaf stalks. Spices are often used in dried and

ground form. Herbs are generally used in fresh form. Spices are used for flavoring, coloring and preserving food items. Herbs are generally used for flavoring or garnishing a food. Common examples of spices include cinnamon, cardamom, pepper, turmeric, saffron, cumin and cloves. Sage, rosemary, thyme, parsley and basil are some of the examples of the herbs.


So, these herbs and spices, as shown in this figure, these are the medicine cabinet in the kitchen. For example, oregano helps soothe stomach muscles. Ginger has anti-nausea remedy. Garlic is a naturally known since ages, as antiseptic agent. Fenugreek helps flush out harmful toxins. Cinnamon helps lower blood pressure. Black pepper helps relieve indigestion. So, all these herbs and spices, they are the basket, that is the medicine cabinet, they have very important health value and health property.



As far as the description of spices is concerned, they are described in terms of their taxonomy i.e. monocotyledoneae, dicotyledonac. They are also classified according to the nature of the spices like hot spice, mild spice, aromatic spice, herbs or aromatic vegetables. These are classified as the parts of the plants used as a spice like arils, barks, buds, pistil, leaf, kernel, etc. The figure also shows the major chemical constituents of spice essential oil. So, these spice essential oils can have various useful chemical compounds, like phenylpropadnoids, terpenes, flavonoids, coumarins, anthocyanins, aliphatic aldehydes, esters, ketones, acids, and aromatic compounds. These compounds of spices and herbs confer various health benefits.

Classification based on parts of the plant used

Plant organs	Spice crops
Aril	Mace of nutmeg
Barks	Cassia, cinnamon
Berries	Allspice, black pepper, chilli
Buds	Clove
Bulbs	Onion, garlic, leek
Pistil (female part of flower)	Saffron
Kernel	Nutmeg
Leaf	Basil, bay leaf, mint, marjoram, sage, curry leaf
Rhizome	Ginger, turmeric
Latex from rhizome	Asafoetida
Roots	Angelica, horse-radish
Seeds	Ajowan, aniseed, caraway, celery, coriander, dill, fennel, fenugreek, mustard, poppy seed



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In details, classification of the spice based on the part of the plant used are as: aril (e.g. mace of nutmeg), barks (e.g. cassia or cinnamon), berries (e.g. black pepper, chilli), buds (e.g. clove), pistil (e.g. saffron), kernel (e.g. nutmeg), leaf (e.g. basil, mint, marjoram, sage, curry leaf), rhizome (e.g. ginger, turmeric), and seeds (e.g. ajowan, aniseed, caraway, celery, coriander, dill, fennel).

Classification based on economic importance


On the basis of economic importance of the spices grown in India, they can be grouped into two viz, major and minor spices.

Major spices

- The spices which contribute major share in the spice trade industry of the world are called major spices.
- The spices come under this group are **small cardamom, black pepper, chili, turmeric and ginger.**
- These spices contribute about 75-90% of the total foreign exchange earned through spices.

Minor spices

- Excluding all above five major spices, all other are called minor spices.




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The all spices are also classified on the bases of their economic importance. Under this category, spices are grouped into two major categories i.e. major and minor spices. Major spices are those which contribute major share in the spice trade industry of the world. These major spices, they include five spices like small cardamom, black pepper, chili, turmeric and ginger.

These spices contribute about 75 to 90% of the total foreign exchange earned through the spices. So, there are five spices included in the category of major spices of the India. Excluding these five all other spices, rests are coming under the minor spices category.

❖ **Minor spices are further divided into five subgroups**

- **Seed spices**
 - ✓ Coriander, cumin, black cumin, fennel, aniseed, celery, mustard, poppy and caraway.
- **Bulbous spices**
 - ✓ Garlic, onion, leek and shallot.
- **Aromatic spices**
 - ✓ Clove, cinnamon, allspice, aniseed and nutmeg.
- **Leafy spices**
 - ✓ Curry leaf, mint, rosemary, bay leaf, and parsley.
- **Acidulent tree spices**
 - ✓ Tamarind, kokam and anardana.



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These minor spices are further grouped into five sub groups like seed spices (e.g. coriander, cumin seed, black cumin, fennel, aniseeds, celery, mustard, poppy, caraway), bulbous spices (e.g. garlic, onion, leek and shallot), aromatic spices (e.g. clove, cinnamon, allspice, aniseed and nutmeg), leafy spices (e.g. curry leaf, mint, rosemary, bay leaf and parsley), and acidulent tree spices (e.g. tamarind, kokam, anardana).

Botanical Classification (Taxonomy)

- Botanically, spices are named according to genus and species. For instance, for ginger, the genus name is *Zingiber* and family name is *officinale*, thus ginger's botanical name is *Zingiber officinale*.

Angiospermata	Dicotyledonae	Sympeplaleae	<i>Solanaceae</i>	chilli, paprika, red pepper			
			<i>Pedaliaceae</i>	sesame			
			<i>Campanulatae</i>	<i>Compositae</i>	camomile, chicory, tarragon		
			<i>Piperales</i>	<i>Piperaceae</i>	cubebs, long pepper, pepper		
			<i>Ranales</i>	<i>Myrsinaceae</i>	mace, nutmeg		
				<i>Lauraceae</i>	bay leaf, cassia, cinnamon		
				<i>Magnoliaceae</i>	star-anise		
			<i>Rhododales</i>	<i>Cruciferae</i>	mustard, wasabi		
			<i>Myrtiflorae</i>	<i>Myrtaceae</i>	allspice, clove		
			<i>Umbelliflorae</i>	<i>Umbelliferae</i>	anise, caraway, celery, chervil, coriander, cumin, dill, fennel, parsley		
			Monocotyledoneae		<i>Liliiflorae</i>	<i>Liliaceae</i>	garlic, onion
						<i>Iridaceae</i>	saffron
					<i>Scitamineae</i>	<i>Zingiberaceae</i>	cardamom, ginger, turmeric
					<i>Orchidales</i>	<i>Orchidaceae</i>	vanilla

- Each spice also belongs to a larger family of plants.
- In ginger's case, the family is *Zingiberaceae*.
- **Turmeric (*Curcuma longa*) and cardamom (*Elettaria cardamomum*) are two other spices that belong to the family *Zingiberaceae*.**




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Botanically, spices are named according to genus and species. For instance, for ginger, the genus name is *Zingiber* and family name is *officinale*, thus ginger's botanical name is *Zingiber officinale*. Each spice also belongs to a larger family of plants. In ginger's case, the family is *Zingiberaceae*. Turmeric (*Curcuma longa*) and cardamom (*Elettaria cardamomum*)

are two other spices that belong to the family Zingiberaceae. In the table, the botanical name including family, genus of certain or major spices that is grown in the country, in the two groups i.e. monocotyledoneae or dicotyledoneae.

Classification based on climate requirement of the crop

- ❑ **Tropical spices**
 - Spices of this category need high temperature, and abundant humidity.
 - They are easily damaged by low temperature.
 - Tropical spices are ginger, turmeric, black pepper, cinnamon, kokam, galangal, small cardamom and clove.
- ❑ **Subtropical spices**
 - Most of these spices require relatively low temperature during their vegetative or early growth stage and high temperature in reproductive stage.
 - Examples include cumin, fennel, coriander, fenugreek, onion and garlic.
 - Sub-tropical spices grown during summer are turmeric and ginger.
- ❑ **Temperate spices**
 - Spices of this type can withstand low temperature (below 5°C) and frosty weather but are damaged easily in hot weather.
 - Examples of temperate spices are thymes, saffron, caraway seed and savoy.



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Based on climate requirement, spices are grouped into three categories i.e. tropical, subtropical, and temperate spices. Tropical spices need high temperature and abundant humidity. They are easily damaged by low temperature. The examples of this group of spice include ginger, turmeric, black pepper, cinnamon, kokam, galangal, small cardamom and clove.

Sub tropical spices are those that require relatively low temperature during their vegetative or early growth stages and high temperature in their reproductive stage. Examples of this category include cumin, fennel, coriander, fenugreek, onion and garlic. Subtropical spices grown during summer are turmeric and ginger. Temperate spices can withstand low temperature i.e. below 5 °C and frosty weather but are damaged easily in hot weather. Examples of this category of spices are thymes, saffron, caraway, seed and savoy.

Classification based on origin and flavour

- **Aromatic spices:** Cardamon, aniseed, celery, cumin, coriander, fenugreek and cinnamon.
- **Pungent spices:** Ginger, chilli, black pepper and mustard.
- **Phenolic spices:** Clove and allspice.
- **Coloured spices:** Turmeric, saffron and paprika.

Classification based on life cycle

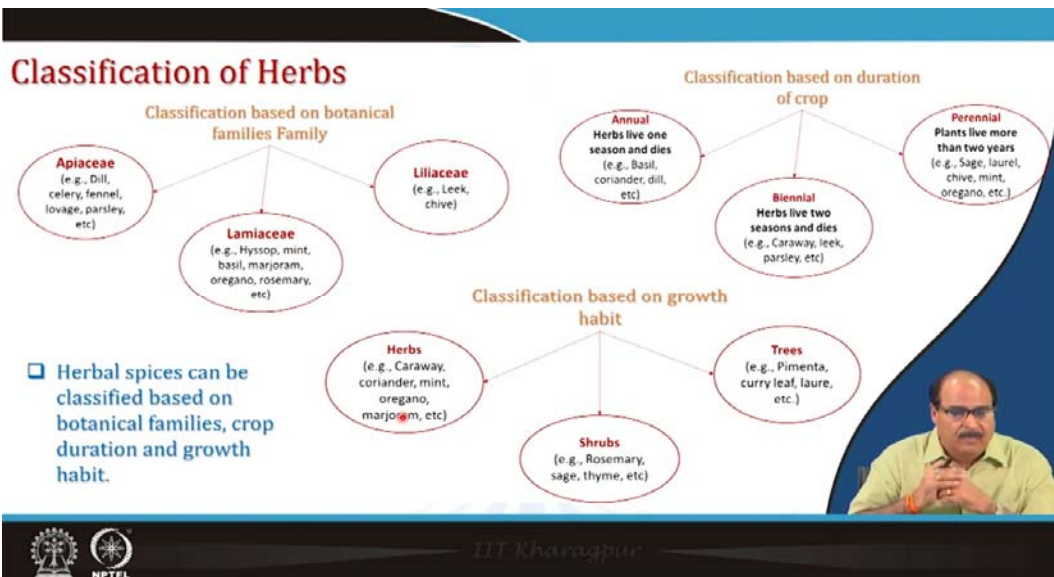
- **Annual spices:** Spices that complete their life cycle in a single or one season. Examples: Coriander, cumin, fennel, fenugreek celery etc.
- **Biennial spices:** Spices that complete their life cycle in two seasons. Examples: Onions, parsley etc.
- **Perennial spices:** The spices that complete their life cycle in more than two seasons. Examples: Black pepper, saffron, clove, nutmeg and cinnamon.



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Spices are also classified on the basis of their origin and flavour such as aromatic spices like cardamom, aniseeds, celery, cumin, etc., pungent spices like ginger, chili, black pepper, mustard, phenolic spices like cloves and allspice, and colored spices like turmeric, saffron and paprika. The spices are also classified based on their life cycle, which include annual spices, biennial spices or perennial spices.

Annual spices complete their life cycle in a single or one season. Example: coriander, cumin, fennel, fenugreek, celery, etc. Biennial spices complete their life cycle in two seasons (e.g. onions and parsley). Perennial spices complete their life cycle in more than two seasons (e.g. black pepper, saffron, clove, nutmeg, and cinnamon).



Generally, herbs are classified based on the botanical families, crop duration and growth habit. Under the category of botanical family that is they are classified as apiaciae, lamiaceae. The examples of apiaceae include celery, fennel, parsley. Lamiaceae includes hoysop, mint,

basil, marjoram, and liliaceae include leek, chive. Under the annual category, the crops include basil, coriander, dill; biennial herbs which leave two seasons and die after that such as caraway, leek, parsley; and perennial herbs live more than two seasons like sage, laurel, chive and mint. Classification based on the growth habit includes herbs, shrubs and trees. Herbs include caraway, coriander, mint, oregano, marjoram, etc. Shrubs include rosemary, sage, thyme. And trees include pimenta, curry leaf, laure, etc.

Compounds responsible for flavour in herbal spices

Spice	Major component	Others
All spice	Eugenol	Cineol, phellandrene, caryophyllene
Basil, sweet	D-Linalool	Methyl chavicol, eugeneol and cineole
Bay (laurel) leaves	Cineole	L-Linalool, eugenol, methyl eugenol, geraniol, geranyl and eugenyl esters, L- α -terpineol, α -pinene and β -phellandrene
Caraway	Carvone	D-Limonene, carveol, D-dihydrocarveol, L-neodihydro carveol
Celery	D-Limonene	Selinene, sesquiterpene alcohol, sedanolide
Coriander	D-Linalool	D- α -pinene, β -pinene, α and γ -terpinene, gerciniol, borneol, <i>p</i> -cymene
Dill	Carvone	Dihydrocarvone, D-Limonene, α -phellandrene, α -pinene and dipentene
Fennel	Anethole	Fenchine, α -pinene, camphene, D- α -phellandrene, dipentene, methyl chavicol and <i>p</i> -hydroxyphenyl acetone
Marjoram	Carvacrol	D-Linalool, eugenol, chavicol, methyl chavicol, D-terpineol and caryophyllene limonene, cineol
Mint (peppermint)	Menthol	Menthone, menthyl acetate, β -pinene, α -pinene, sabinene acetate
Mint (spearmint)	L-Carvone	Terpene, carveol, dihydrocarveol acetate
Oregano	Thymol	Carvacrol, α -pinene, cineole, linalyl acetate, linalool, dipentene, <i>p</i> -cymene and β -caryophyllene
Parsley	Apiole	Myristicin, α -pinene
Rosemary	Cineole	Borneol, linalool, eucalyptol, camphor, bornyl acetate, α -pinene, camphene, sabinene, phellandrene, α -terpinene
Sage	Thujone	Borneol, cineole, bornylesters, α -pinene, salvene, D-camphor phellandrene, acimene
Tarragon	Methyl chavicol	L-Pinitol, α -benzopyrene and eugenol
Thyme	Thymol	Carvacrol, linalool, L-borneol, geraniol, amyl alcohol, β -pinene, camphene, <i>p</i> -cymene, caryophyllene, 1,8-cineole

Compounds responsible for flavor in herbal spices

This table gives the various major compounds which contribute to the flavor of the spices, herbs and spices or herbal spice. For example, in all spices the major flavoring compound is eugenol, and other compounds such as cineol, phellandrene or caryophyllene, etc. In basil, the major compound contributing to the flavor is D-linalool, and minor compounds include methyl chavicol, eugenol, cineole, etc. Similarly, in the coriander, D-linalool is the major compound. In marjoram carvacrol is the major compound and D-linalool, eugenol, chavicol, methyl chavicol, D-terpineol are the minor compounds. In rosemary, cineole is the major compound which contributes to its flavor. Borneol, linalool, eucalyptol, camphor, bornyl acetate, alpha pinene are the minor compound.

So, researchers have analyzed that there are many compounds i.e. chemical compounds, organic compounds, aerobic compounds, which together constitute or contribute collectively to the specific peculiar flavor of that particular product.

Nutritive value of herbal spices

- Most of the herbal spices are rich sources of protein, vitamins, especially vitamins A, C and B, and minerals such as calcium, phosphorus, sodium, potassium and iron.
- Parsley is the richest source of vitamin A, while coriander is one of the richest sources of vitamins C and A.
- Parsley and chervil are also rich sources of vitamin K.

Nutritive value of herbal spices (approximate composition/100 g of edible portion)

Spice	Energy (kcal)	Protein (g)	Fat (g)	Total CHO (g)	Fibre (g)	Ash (g)	Calcium (mg)	Fe (mg)	Mg (mg)	P (mg)	K (mg)	Na (mg)	Zn (mg)	Ascorbic acid (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin A (IU)
Sweet basil	251	14.4	4.0	61.0	17.8	14.3	2113	42	422	490	3433	34	6	61.2	0.1	0.3	6.9	9375
Bay	313	7.6	8.4	75.0	26.3	3.6	834	43	120	113	529	23	4	-	-	-	2	6185
Chervil	237	23.2	3.9	49.1	11.3	16.6	1346	32	130	450	4740	83	9	NA	NA	NA	NA	NA
Marjoram	271	12.7	7.0	60.6	18.1	12.1	1990	83	346	306	1522	77	4	51	-	-	4	8068
Oregano	306	11.0	10.3	64.4	15.0	7.2	1576	44	270	200	1669	15	4	-	-	-	6	6903
Parsley	276	22.4	4.4	51.7	10.3	12.5	1468	98	249	351	3805	452	5	122	-	1	8	23340
Rosemary	331	4.9	15.2	64.1	17.7	6.5	1280	29	220	70	955	50	3	61	-	-	1	3128
Sage	315	10.6	12.7	60.7	18.1	8.0	1652	28	428	91	1070	11	5	32	-	-	6	5900
Tarragon	295	22.8	7.2	50.2	7.4	12.0	1139	32	347	313	3020	62	4	-	-	1	9	4200
Thyme	276	9.1	7.4	63.9	18.6	11.7	1890	124	220	201	814	55	6	-	-	-	5	3800

Farrel (1990)



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Nutritive value of herbal spices

Most of the herbal spices are rich sources of protein, vitamin, especially vitamin A, C and B, and minerals such as calcium, phosphorus, sodium, potassium and iron. Parsley is the richest source of vitamin A, while coriander is one of the richest sources of vitamins C and A. Parsley and chervil are also rich sources of vitamin K.

The table represents the nutritive value of herbal spices in terms of approximate composition per 100 g of edible portion. As shown in the table, oregano contains 11% protein that is equivalent to wheat, 10.3% fat, and 306 kcal per 100 gram of the edible portion. Similarly, marjoram contains around 13% protein, 7% fat. It provides 271 Calories per 100 gram. Bay contains around 7.6% protein, 8.4% fat in addition to the various micro and micronutrients and it provides 313 kcal heat energy per 100 gram.

Although these spices have good nutritional value including good sources of protein, fats, carbohydrate and energy value, but these spices they are not consumed as a source of nutrients, as a source of protein, fat or energy in the body. The major reason behind that these spices contain various aromatic compounds, flavoring compounds, coloring compounds and majority of those compounds have pungent taste having a strong flavor. They also possess aromatic and antibacterial properties. So, because of this flavor they cannot be used as staple food. These spices therefore are not considered as a source of nutrients in our diet, rather they are used as a source of flavoring, coloring or boosting antimicrobial properties, and improving the health value of the food.

Antioxidant in Herbs and Spices

- Many herbal spices are known as excellent sources of natural antioxidants.
- Phenolic compounds are primary antioxidants present in spices.
- A linear relationship between the total phenolic content and the antioxidant properties of spices exist.

Antioxidant isolated from herbal spices

Spice	Antioxidants
Rosemary	Carnosic acid, carnosol, rosmarinic acid, rosmanol
Sage	Carnosol, carnosic acid, rosmanol, rosmarinic acid
Oregano	Derivatives of phenolic acid, flavonoids, tocopherols
Thyme	Carvacrol thymol, <i>p</i> -cymene, caryophyllene, carvone, borneol
Summer savory	Rosmarinic acid, carnosol, carvacrol, thymol
Marjoram	Flavonoids
Allspice	Pimentol

Relative antioxidant effectiveness (RAE) of herbal spices

Spice/herb	Substrate	RAE
Marjoram, rosemary, sage, coriander	Lard	Rosemary>sage>marjora
32 different plant materials	Lard	Rosemary>sage>oregano>thyme
19 different plant materials	Oil-in-water emulsion	Sage>oregano
32 different plant materials	Oil-in-water emulsion	Allspice>rosemary
Allspice, savory, marjoram, coriander	Sausage, water	Allspice>savory>marjoram
15 different plant materials	Sausage, water	Sage>rosemary>marjoram>aniseed
12 different plant materials	Ground chicken meat	Marjoram>caraway>peppermint

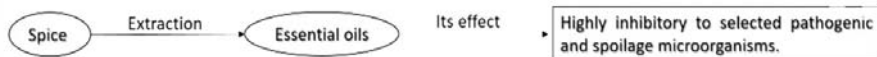
Oregano, thyme, marjoram, sage, basil, fenugreek, fennel, coriander and pimento possess antioxidant properties better than that of the synthetic antioxidant butylated hydroxy toluene.



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Similarly, many herbal spices are known as excellent sources of natural antioxidants. Phenolic compounds are primarily antioxidants present in spices. There is a linear relationship between the total phenolic content and the antioxidant properties of the spices. This table enlists the antioxidant isolated from herbal spices such as carnosic acid, carnosol, rosmarinic acid, and rosmanol contribute to the antioxidant potential of rosemary. Similarly, in oregano, the antioxidant potential is contributed by the derivatives of phenolic acids, flavonoids, and tocopherols. Also, in the table (on the right-hand side top) represents the relative antioxidant effectiveness of the herbal spices. And it was their antioxidant effectiveness, how effective they are as antioxidants. Oregano, thyme, marjoram, sage, basil, fenugreek, fennel, coriander and pimento possess antioxidant properties better than that of the synthetic antioxidant, butylated hydroxyl toluene.

Antimicrobial properties in herbs and spices



- The inhibition is due to damage in membrane integrity, which further affects pH homeostasis and equilibrium of inorganic ions.
- The optical isomers of carvone from *Mentha spicata* and *Anethum sowa* (Indian dill) were active against a wide spectrum of human pathogenic fungi and bacteria.

List of herbs and spices used along with their active ingredients

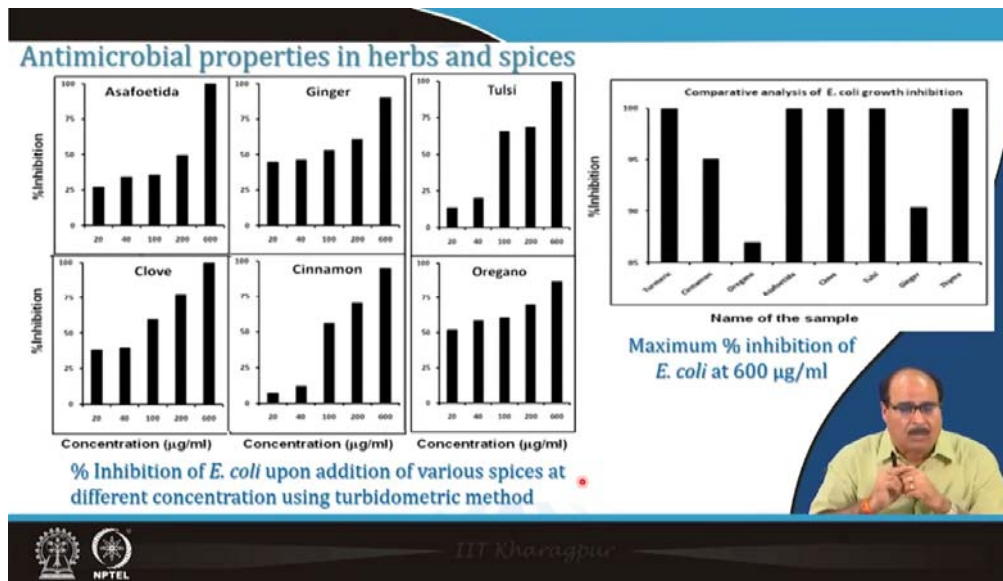
Common name	Scientific name	Components Present
Thyme	<i>Thymus vulgaris</i>	thymol
Oregano	<i>Origanum Vulgare</i>	carvacrol
Tulsi	<i>Ocimum tenuiflorum</i>	eugenol (1-hydroxy-2- eugenol methoxy-4-allylbenzene)
Ginger	<i>Zingiber officinale</i>	phenylpropanoid-derived compounds, particularly gingerols and shogaols
Turmeric	<i>Curcuma longa</i>	Circumin
Cinnamon	<i>Cinnamomu m verum</i>	eugenol cinnamaldehyde, eugenol, beta-caryophyllene, linalool, and methyl chavicol.
Clove	<i>Syzygium aromaticum</i>	phenylpropanoides such as carvacrol, thymol, eugenol and cinnamaldehyde
Asafoetida	<i>Ferula asafoetida</i>	ferulic acid



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These spices contain essential oils. So, using appropriate extraction method, these essential oils are extracted and are used as an antimicrobial. They are highly inhibitory to selected

pathogenic and spoilage microorganisms. The inhibition of the microbial growth due to spices essential oil is attributed to the damage in membrane integrity which further affects the pH homeostasis and equilibrium of inorganic ions. The optical isomers of carvone from *Mentha*, *Spicata* and *Anethum sowa* (Indian dill) were active against the wide spectrum of human pathogen fungi and bacteria. The table enlists the herbs and spices used along with their active ingredients. For example, in oregano, the compound present is carvacrol, curcumin in turmeric, phenylpropanoides such as carvacrol, thymol, and eugenol in clove. These are the major source of the antimicrobial property of spices.



This slide gives a comparison of different spices like asafoetida, ginger, tulsi, clove, cinnamon and oregano with their effectiveness on the inhibition of the *E. coli* at different concentrations. It can be clearly observed that the percentage inhibition increases with increasing the concentrations. As shown in figure, at 600 µg/ml of turmeric, asafoetida, clove, tulsi and thyme lead to around 100% inhibition of the *E. coli*.

Antimicrobial activity of herbal spices

Spice	Mode of application	Activity against bacteria or fungi
Basil	Essential oil	<i>Ascophaera apis</i>
Basil	Methyl chavicol	<i>Aeromonas hydrophyla</i> , <i>Pseudomonas fluorescens</i>
Coriander	Essential oil	<i>Ascophaera apis</i>
Fenugreek	Seed saponins	<i>Fusarium oxysporum f. sp. lycopersici</i>
Fenugreek	Essential oil	<i>Bordetella bronchiseptica</i> , <i>Bacillus cereus</i> , <i>Bacillus subtilis</i> , <i>Penicillium notatum</i> , <i>Aspergillus niger</i> , <i>Aspergillus fumigatus</i> , <i>Microsporium canis</i>
Cumin	Essential oil	<i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i>
Fennel	Essential oil	<i>Pythium aphanidematum</i> , <i>Macrophomina phaseolina</i> , <i>Rhizactonia solani</i>
Ajowan	Seed extracts	<i>Fusarium spp.</i> , <i>Alternaria spp.</i> and <i>Cladosporium spp.</i>
Allspice	Plant extract	<i>Listeria monocytogenes</i> , <i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Yersinia enterocolitica</i> ,
Oregano, coriander, and basil	Essential oil	
Anethum graveolens,	Seed diffusates	<i>Alternaria alternata</i> , <i>Fusarium solani</i> , <i>Macrophomina phaseolina</i>
Pepper mint, thyme, caraway	Essential oil	<i>Agrobacterium tumefaciens</i> , <i>Ralstonia solanacearum</i> , <i>Erwinia carotovora</i>
Spearmint, basil, parsley	Essential oil	<i>Staphylococcus aureus</i> , <i>Escherichia coli</i> , <i>Candida albicans</i> , <i>Aspergillus niger</i>
Oregano and mint	Essential oil	<i>Aspergillus ochraceus</i>
Oregano	Essential oil or carvacrol	<i>Candida albicans</i>
Oregano, thyme	Essential oil or carvacrol	<i>Streptococcus pneumoniae</i> R36 A, <i>Bacillus cereus</i>


The table represents the antimicrobial activity of herbal spices. For example, fennel is an essential oil and is effective against *Staphylococcus aureus*, *Bacillus subtilis* and the oregano and mint, are the essential oils which are effective against *Aspergillus ochraeus*.


Insect repellent properties of spices and herbs

- The herbal spices have good insect repellent properties.
- Powdered plant parts or extracts of seed or essential oils or active ingredients separated from essential oils and oleoresins of spices are used as insect repellents.
- The repellent action is noticed against many storage pests of grains and pulses.
- Herbal spices can also be used as mosquito repellents. The essential oil of basil and piperidine alkaloid separated from long pepper repels mosquitoes.

Insect repellent properties of herbal spices

Spice	Mode of application	Insects
Fenugreek	Seed extract	<i>Tribolium castaneum</i> , <i>Acanthoscelides obtectus</i>
Fennel	Direct contact and fumigation	<i>Callosobruchus chinensis</i> , <i>Lasioderma serricornis</i>
Indian dill	Essential oil	<i>Callosobruchus maculatus</i>
Dill	Essential oil	<i>Lucilia sericata</i>
Peppermint and basil	Powdered aerial parts	<i>Sitophilus granarius</i>
Basil	Fumigation of essential oil	<i>Callosobruchus maculatus</i>
Mint	Essential oil	<i>Drosophila melanogaster</i>
Peppermint	Leaf powder	<i>Callosobruchus analis</i>
Cumin and anise	Vapour of essential oil	<i>Tetranychus cinnabarinus</i> , <i>Aphis gossypii</i> , <i>Tribolium confusum</i> , <i>Ephesthia kuehniella</i>
Oregano	Essential oil	<i>Acanthoscelides obtectus</i> , <i>Tetranychus cinnabarinus</i> , <i>Aphis gossypii</i>






Dr. Khuram

The herbal spices have good insect repellent properties. Powdered plant parts or extracts of seed or essential oils or active ingredients separated from the essential oils and oleoresins of spices are used as insect repellents. The repellent action is noticed against many storage pests of grains and pulses. Herbal spices can also be used as mosquito repellent. The essential oil of basil and piperidine alkaloid separated from long pepper repels mosquito. This table shows insect repellent properties of spices, mode of application. For example, fenugreek as seed extract is applied and repels the *Tribolium castaneum*.

Spice and Herbs as Colorant

- The spices are used as colorants as they are natural sources of colours bringing the advantage as against chemical or synthetic colorants.
- The spices tint in different colours from yellow and orange to different variations of red, green, etc.
- The coloring property of spices is due to presence of different chemical compounds. The principal compound responsible for the color are the carotenoids, such as β -carotene, lutein and neoxanthin; chlorophyll in leaves and herbs.
- The most common spices used for coloring are paprika, red pepper, mustard, parsley, ginger and turmeric.
- Using spices as colorants in food is natural alternative that avoid the use of conventional synthetic colorants.








Dr. Khuram

Then spices and herbs are used as colorants. The spices are the natural sources of colors bringing the advantage as against chemical or synthetic colorants. Spices tint in different


colors from yellow and orange to different variations of red, green, etc. The coloring property of spices is due to the presence of various chemical compounds. The principal compound responsible for the color include beta-carotene, lutein, neoxanthin, chlorophyll, etc. in the leaves and herbs. The most common spices which are used as coloring materials are paprika, red pepper, mustard, parsley, ginger, and turmeric. So, using spices as colorants in the food is natural alternative to avoid the use of conventional synthetic colorants.

Spice and Herbs as Flavour

- Depending on the region, different spices are used for flavoring foods bringing a distinguished flavor to each food style that even gives culinary identity.

<p>France</p>  <p>Tarragon, savory marjoram, rosemary, and thyme flavor</p>	<p>England</p>  <p>Ginger, mustard seeds, cloves, coriander, and allspice</p>
<p>Arabian Peninsula</p>  <p>Black peppercorn, caraway seed, whole cumin, cardamom seed, fresh hot pepper garlic, and coriander</p>	<p>Mexico</p>  <p>Cinnamon, vanilla, dried chilies, & cocoa</p>

- Flavors given by spices are due to the certain families of chemicals, such as phenylpropanoids, monoterpenes, and other phenol compounds.
- Some important chemical compounds for the flavoring potential of spices are eugenol, apiol, sufranol, vanillin, piperine, β -caryophyllene, α -pinene, carvacol, thymol, sabinene, cinnamaldehyde, and gingerol.



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Depending upon the region, different spices are used for flavoring foods, bringing a distinguished flavor to each food style that even gives culinary identity. For example in France, they use a specific type of flavor like savory marjoram, rosemary, and thyme etc. Similarly, in England, they use ginger, mustard seed. In Mexico, cinnamon, vanilla, and in Arabian Peninsula, they use black peppercorn, caraway seed, whole cumins. Flavor given by the spices are due to presence of certain families of chemicals like phenylpropanoids, monoterpenes and other phenolic compounds. Some important chemical compounds that are present in the spices which have good flavoring potential include eugenol, apiol, sufranol, vanillin, piperine.

Infestation and Quality Losses

- During storage, spices and spice products are attacked by beetle and moth pests among which the spice beetle, *Stegobium paniceum* L. and the cigarette beetle, *Lasioderma serricorne* F. are predominant.
- In dry products when insect infestation is high there will be heating and moisture condensation which is conducive for spoilage by microorganisms.

Insect pests of stored spices and spice products

Insect

Lasioderma serricorne
Stegobium paniceum
Tribolium castaneum
Tribolium confusum
Trogoderma granarium
Tenebroides mauritanicus
Arneceus fasciculatus
Rhyzopertha dominion
Carpophilus obsoletus
Cryptolestes sp.
Cryptoblabes gnidiella
Sitophilus oryzae Moths
Sitotroga cerealella
Ephesia cautella
Corcyra cephalonica

Commodity

Coriander and its products, Turmeric, Ginger, Chillies, Cardamom, Garlic bulb.
 Turmeric, Chillies, Coriander, Ginger, Cardamom, Chillies, Turmeric.
 Chillies.
 Coriander and its products.
 Chillies, Ginger, Turmeric, Cardamom.
 Ginger, Turmeric, Cardamom, Chillies, Turmeric.
 Coriander, Ginger.
 Garlic bulb, Turmeric.
 Turmeric, Garlic bulb.
 Garlic bulb.
 Turmeric.
 Chillies.
 Chillies, Turmeric.
 Turmeric.



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During storage, spices and spice products are attacked by beetle and moth pests, which the spice beetle, *Stegobium paniceum* L. and the cigarette beetle, *Lasioderma serricorne* F. are predominant. So, in dry products when the insect infestation is high, there will be heating and moisture condensation, which is conducive for the spoilage by microorganisms. So, insect pests of stored spices and spice products are provided in this table. For example, *Lasioderma serricorne* is the common pest in coriander and its products, turmeric, ginger, etc.

Control methods for preventing infestation of spice



Fumigation



Irradiation



Heat treatment



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The insect infestation is one of the major problem in the spices. So, the fumigation, irradiation or heat treatments can be generally used for preventing the infestation.

Fumigation

- Fumigation involves application of chemicals in the gaseous phase that act against pest organisms.
- Currently, spices/spice products are disinfected with phosphine or methyl bromide fumigants.
- Phosphine does not affect the quality of spices and spice powders. A dosage of 2 to 4 aluminum phosphide tablets (6 to 12 g) per tonne of commodity for not less than 5 days has been used against spices and spice products.
- Methyl bromide is recommended for fumigating spices and spice mixes generally at 24 - 48 g/m³ with an exposure period of 24 - 48 h under normal atmospheric conditions. The gas is relatively less effective than ethylene oxide against microbes. It is particularly suitable for vacuum fumigation of processed and packed products including spice powders.
- Recently, however, the compound has been identified to causes serious ozone depletion with an Ozone Depleting Potential (ODP) of 0.7.
- Repeated treatment of spice products with the fumigant causes discoloration and loss of essential oils.



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Fumigation involves the application of various chemicals in the gaseous phases that act against pest organisms. Currently, spices or spice products are disinfected with phosphine or methyl bromide fumigants. Methyl bromide is recommended for fumigating spice and spice mixes, generally, at 24 to 48 gram per cubic meter with an exposure period of 24 to 48 hour under normal atmospheric conditions.

The gas is relatively less effective than ethylene oxide against microbes. It is particularly suitable for vacuum fumigation of processed and packaged products including spice powders. Recently, however the compound has been identified to cause serious ozone depletion with an ozone depleting potential of about 0.7. So, repeated treatment of spice products with fumigant causes discoloration and loss of some essential oils.

Fumigation (contd...)

- Ethylene oxide is used primarily for sterilization of spices although during the treatment insects are also controlled.
- Ethylene oxide is suspected carcinogen, and it forms chlorohydrin or bromohydrin residues, which are also carcinogenic. Hence, the use of ethylene oxide has been discontinued in many developed nations.
- In rare instances, ethylene oxide fumigation affected the volatile oil content of spices.
- Fumigation of cloves by ethylene oxide at dosages of 550, 750, 1000 g/m³ for 6 h at 20 - 25 °C, the volatile oil content was decreased by 1.7 - 2.2%. Similar trend is observed in black pepper and allspice exposed for 16 h which affected color of black pepper.
- The drawbacks of the fumigants currently used for disinfestation and disinfection of stored spices include residue problems, insect resistance and adverse effect on environment.




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Ethylene oxide is suspected carcinogen and it forms chlorohydrin or bromohydrin residues, which are also carcinogenic. Hence, the use of ethylene oxide has been discontinued in many

developed countries. Fumigation of cloves by ethylene oxide at doses recommended in various regulatory agencies i.e. 550, 750, 1000 gram per cubic meter for 6 hours at 25 °C. It was found that the volatile oil content was decreased by 1.7 to 2.2%. So, the drawbacks of the fumigants currently used for disinfestation and disinfection of stored spice include residue problems, insect resistance and adverse effect on the environment.

Irradiation

- **γ - Irradiation** of whole and ground spices are effective against insect infestation at 1 kGy.
- Species such as coriander, cumin, turmeric and chillies treated by gamma radiation at 10 kGy and stored for 6 months proved to retain good microbiological quality.
- In general, no adverse effect has been observed in spices irradiated at the recommended dosage of 10 kGy.
- The appearance and sensory qualities of irradiated spices/spice products remain unaffected.
- About 30 countries, including India, have approved irradiation of spices, and about 20 countries are already irradiating spices on a commercial scale.








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Selected cases where irradiation has influenced the quality of spices/spice products

Commodity	Dosage	Parameters	Effect
Anise	10 kGy	Chemical constituents (Anethole, Chavicol, Anisaldehyde)	Reduced
Fennel		(Anisaldehyde)	Reduced
Black pepper		(B-pinene & Cineol)	Reduced
Turmeric garlic powder	10 & 30 kGy	pH	Altered
Marjoram & spice mixtures	2 to 25 kGy	Chemical composition & volatile oil content	Affected
Pepper paste	Not specified	Total sugar	Increased
White pepper, Nutmeg, Ginger	15 kGy	• Volatile constituents	Increased






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The table shows the selected cases where irradiation has influenced the quality of the spices and spices products with the commodity, their dosage level and the parameters with the effect. For example in the case of turmeric, garlic powder, the required dose level is 10 and 30 kGy which alters the pH.

Heat treatment

- Insect disinfection by heat treatment has been considered since long time.
- Spices such as black pepper, fennel, coriander, anise and turmeric heat treatment at 70°C for 15 min did not affect the quality and microbial load was reduced partly.
- Sterilization of spices with pulsed steam, in which actually the steam condenses on the spice particles, helped to eliminate microorganism with minimum adverse effects on flavour or aroma. Subsequently, the spices need to be dried to eliminate moisture absorbed by the steam treatment.
- Pasteurization of spices could be done by high frequency and microwave treatments as an alternative to irradiation and fumigation.
- Thermal regulating methods generally causes one or the other undesirable changes in the treated products. Hence, heat treatment can be supplemented or combined with other control measures.




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Heat treatment is another insect infestation has been considered since long time. Spices such as black pepper, fennel, coriander, anise, turmeric, they are heat treated at 70 °C for about 15 min and did not affect the quality and microbial load was reduced partly. Sterilization of spices with pulsed steam, in which actually the steam condenses on the spice particles help to eliminate microorganism with minimum adverse effect on flavor or aroma. Pasteurization of spice could be done by high frequency and microwave treatments as an alternative to irradiation and fumigation. Thermal regulating methods generally causes one or the other undesirable changes in the treated products. Hence, the heat treatment can be supplemented or combined with other control measures.

Summary

- Herbs and spices have medicinal and aromatic properties which can be used for flavouring and health boosting effects.
- Spices are classified based on plant used parts, economic importance, taxonomy, climate requirement, origin and flavour and life cycle, whereas herbs are classified based on botanical families, growth habit and crop duration.
- There are various components like eugenol, D-linalool, cineole, carvone, apiole, etc. responsible for flavour in herbs and spices.
- Most of the herbal spices are rich sources of micro- and macro-nutrients, antioxidants and have antimicrobial properties. They can be used as colorant and flavoring agent.
- During storage, the spices can be infested by insects; fumigation, irradiation and heat treatment are the methods to control them.

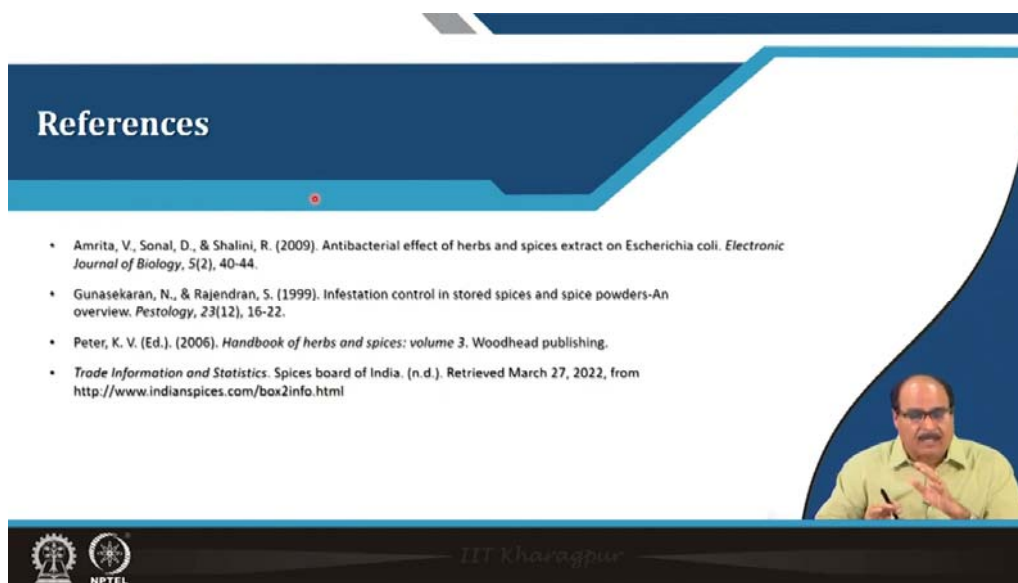


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Summary

Herbs and spices have medicinal and aromatic properties which can be used for flavoring and health boosting effects. Spices are classified based on the plant used parts, economic importance, taxonomy, climate requirement, origin and flavor and life cycle, whereas the herbs are classified based on botanical families, growth habit and crop duration. There are various compounds like eugenol, D-linalool, cineole, carvone, apiole, etc., which are responsible for flavor in the herbs and spices. Most of the herbal spices are rich sources of micro and macronutrients, antioxidants and have antimicrobial properties. They can be used as colorant and flavoring agents. During storage, the spices can be infested by insects; fumigation, irradiation and heat treatment are the methods to control them.



References

- Amrita, V., Sonal, D., & Shalini, R. (2009). Antibacterial effect of herbs and spices extract on *Escherichia coli*. *Electronic Journal of Biology*, 5(2), 40-44.
- Gunasekaran, N., & Rajendran, S. (1999). Infestation control in stored spices and spice powders-An overview. *Pestology*, 23(12), 16-22.
- Peter, K. V. (Ed.). (2006). *Handbook of herbs and spices: volume 3*. Woodhead publishing.
- *Trade Information and Statistics*. Spices board of India. (n.d.). Retrieved March 27, 2022, from <http://www.indianspices.com/box2info.html>

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These are the references for further study. Thank you.