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

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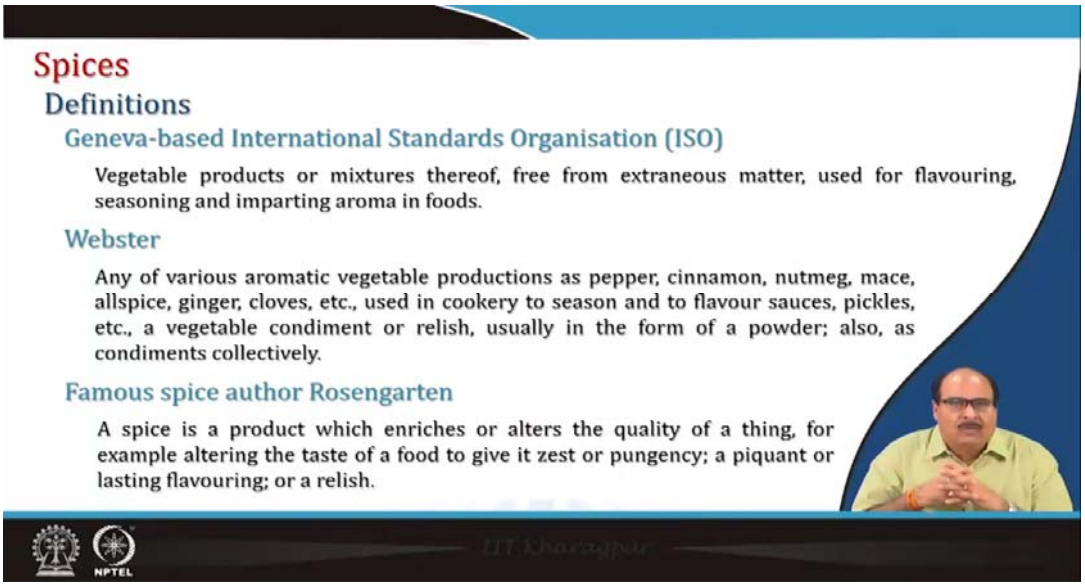
Lecture – 04
Indian Spices

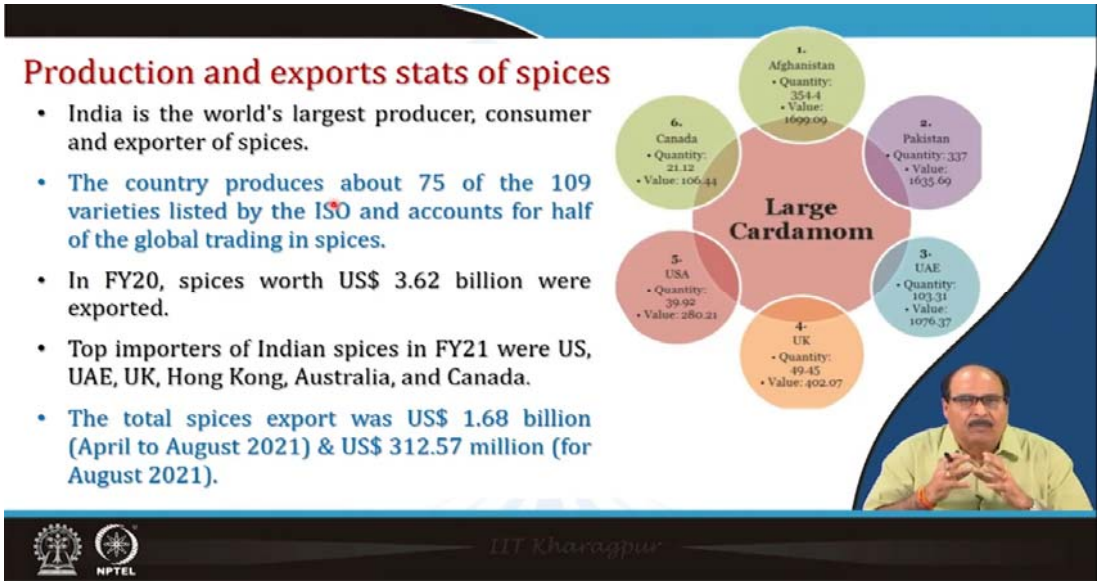
This topics covered in the lecture are classification of indian spices, their composition, sensory attributes, antimicrobial potential, antioxidants, bioactives, and health value along with some important features of natural colours, flavouring compounds, and lastly infestation and quality losses associated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



Spices

Definitions

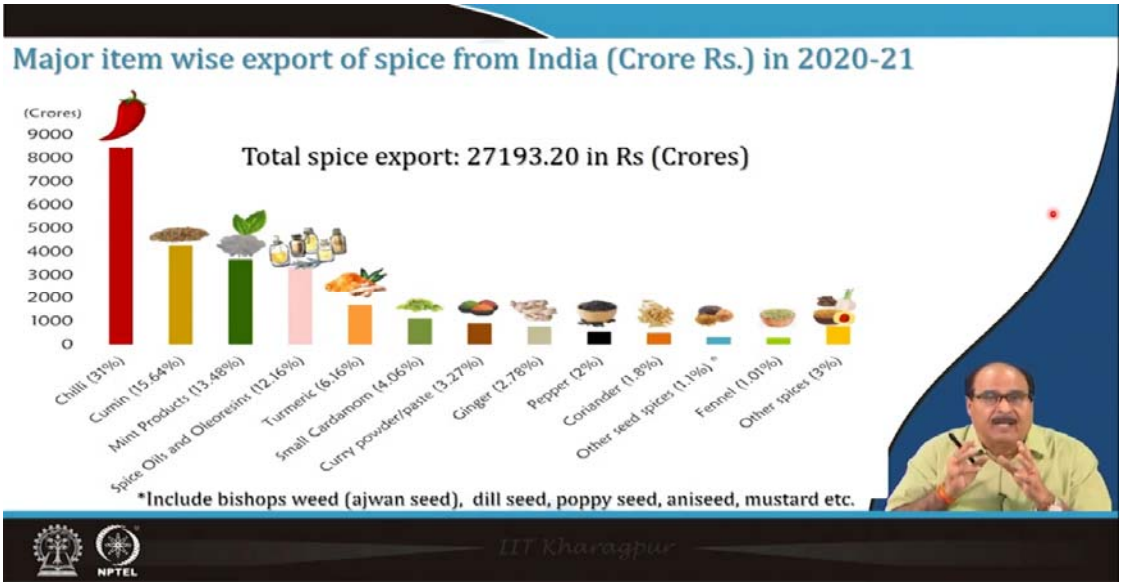
The Geneva based international standards organization (ISO) defines the spices as vegetable products or mixture thereof, which are free from extraneous matter, used for flavoring, seasoning and imparting aroma in foods. According to the Webster, any of the various aromatic vegetable production as paper, 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.



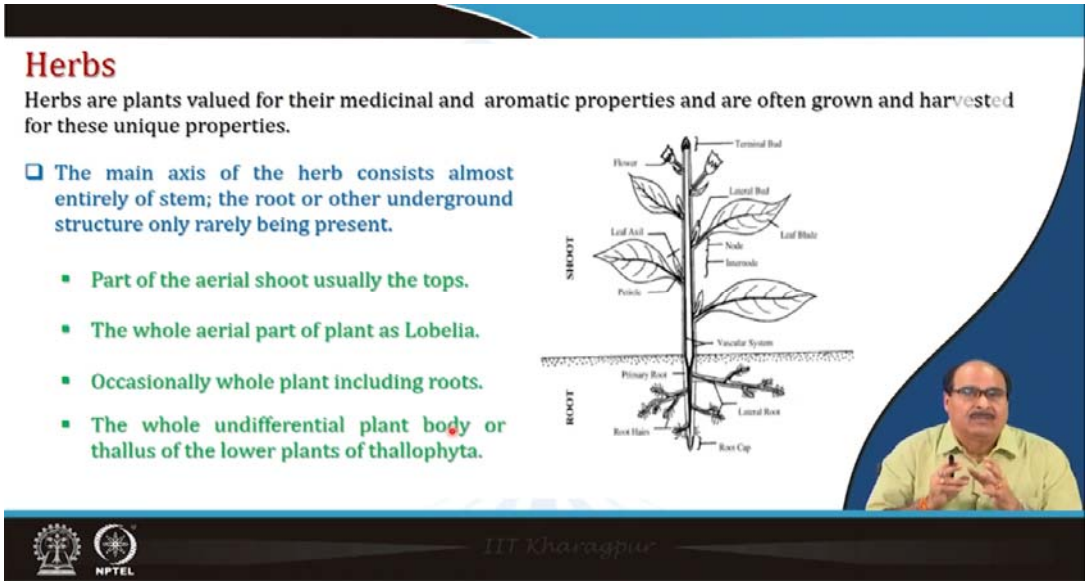
Production and exports stats of spices

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.

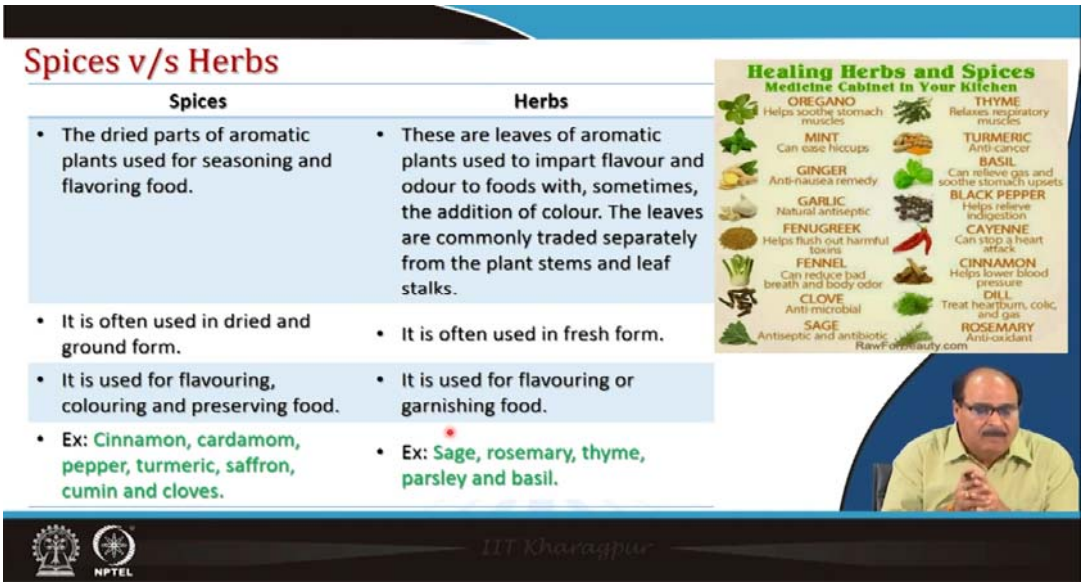


India is known as the hub of spices. From the data of major item wise export of spice from India, in 2021 (value in the terms of crore rupees), it can be clearly observed that chilli contributed the highest (31%) followed by cumin, mint products, spice oils and oleorisins and small cardamom, ginger,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

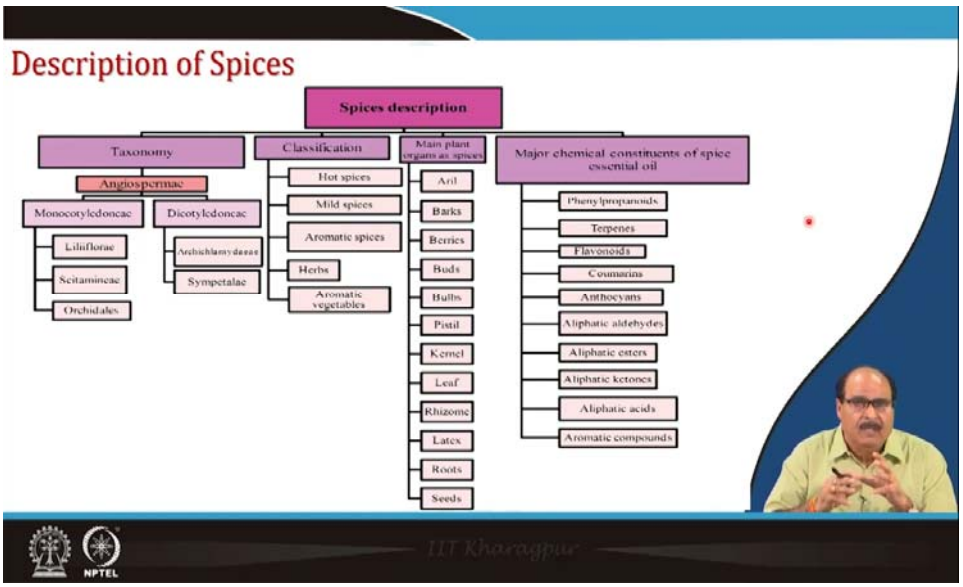


Difference between spicesand herbs

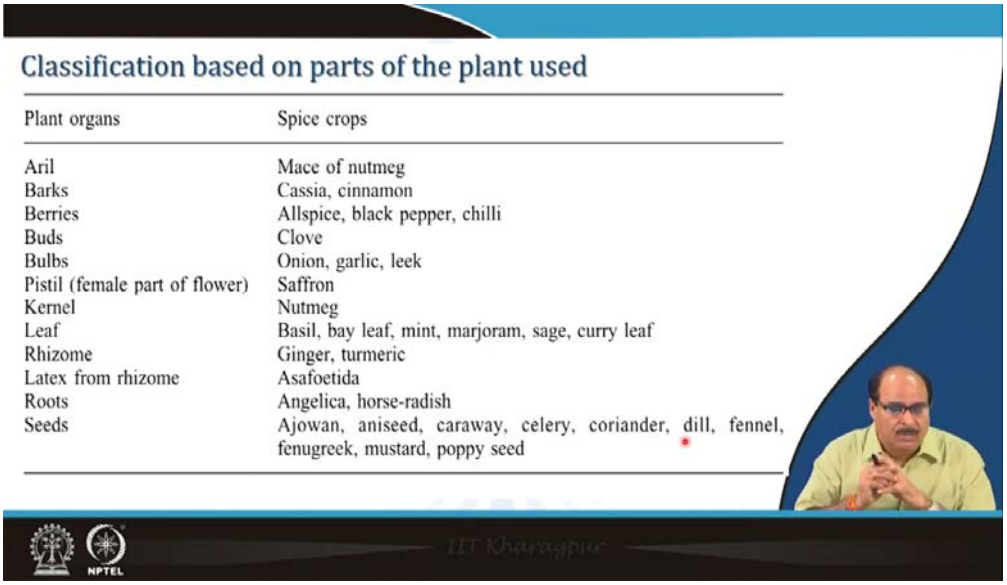
Spices are generally dried parts of the aromatic plants used for seasoning and flavoring food, whereas the herbs are generally leaves are the aromatic plants which are used to impart flavor and odour to foods, with sometimes the addition of color. The leaves are commonly traded separately from the plant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

ground form. Herbs are generally used in fresh form. Spices is 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 example of the herbs.

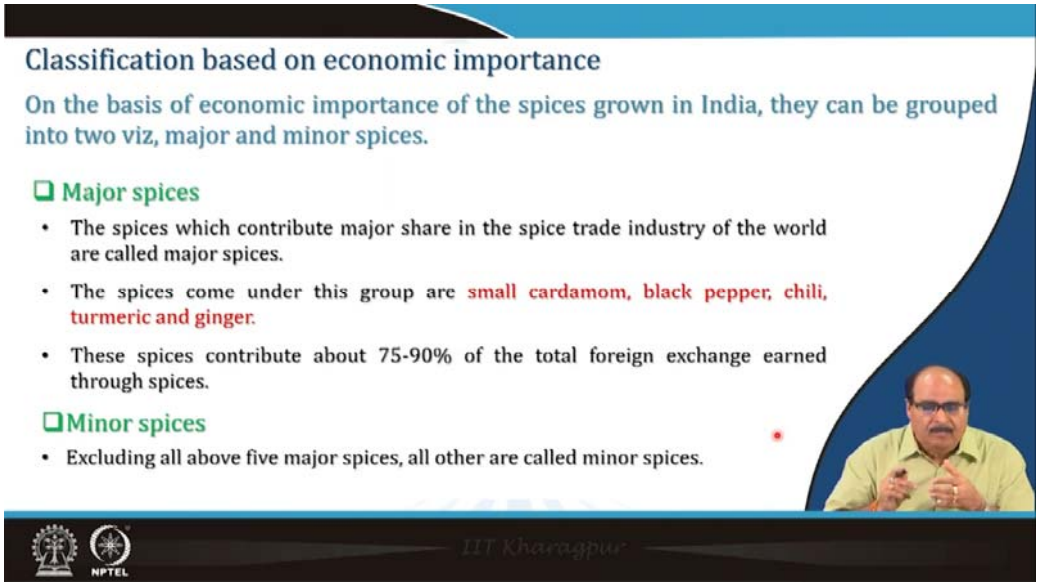
So, these herbs and spices, as shown in this figure, these are the medicine cabinet in the kitchen. For example, oregano helps soothe stomach muscles. Ginger has anti-nausea remedy. Garlic is a naturally known since ages, as antiseptic agent. Fenugreek helps flush out harmful toxins. Cinnamon helps lower 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 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, anthocyans, aliphatic aldehydes, esters, ketones, acids, and aromatic compounds. These compounds of spices and herbs confer various health benefits.

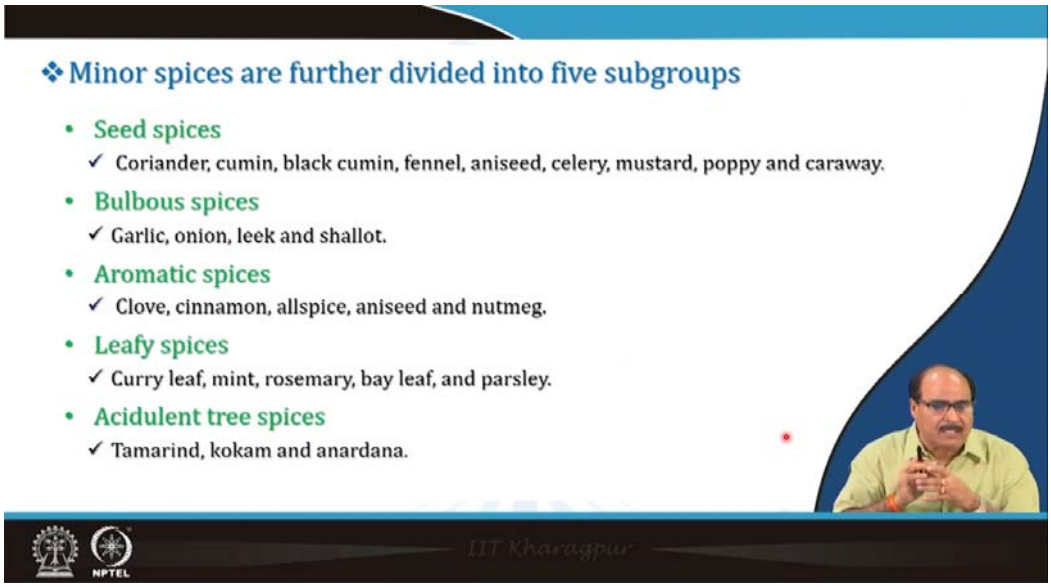


In details, classification of the spice based on the part of the plant used are as: aril (e.g. mace of nutmeg), barks (e.g. cassia or cinnamon), berries (e.g. black pepper, chilli), buds (e.g. clove), pistil (e.g. saffron), kernel (e.g. nutmeg), leaf (e.g. basil, mint, marjoram, sage, curry leaf), rhizome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

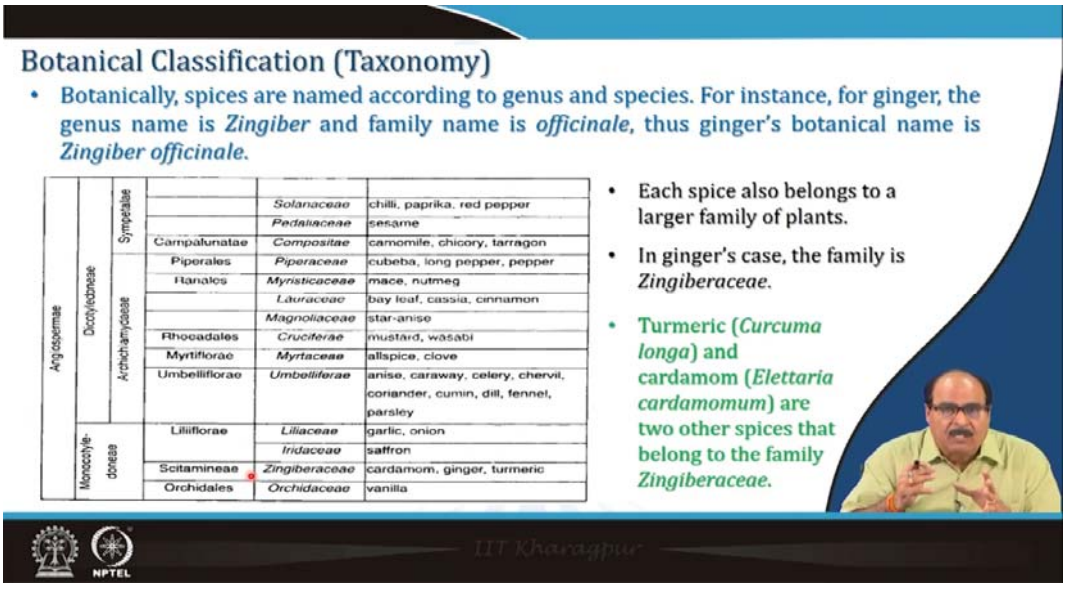


The all spices are also classified on the bases of their economic importance. Under this category, spices are grouped into two major categories i.e. major and minor spices. Major spices are those which contribute major share in the spice trade industry of the world. These major spices, they include five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

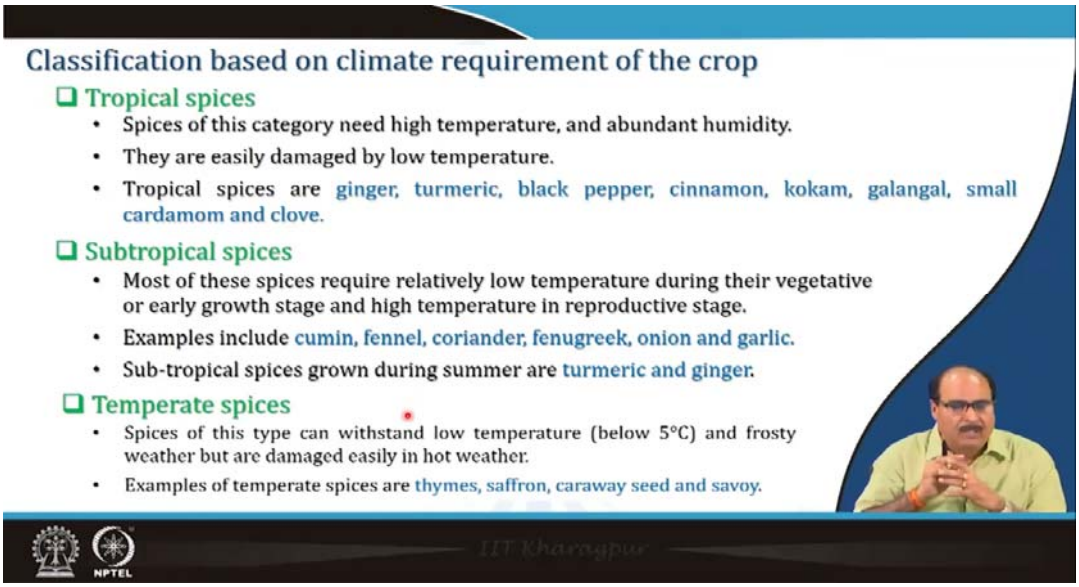


These minor spices are further grouped into five sub groups like seed spices (e.g. coriander, cumin seed, black cumin, fennel, aniseeds, celery, mustard, poppy, caraway), bulbous spices (e.g. garlic, onion, leek and shallot), aromatic spices (e.g. clove, cinnamon, allspice, aniseed and nutmeg), leafy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



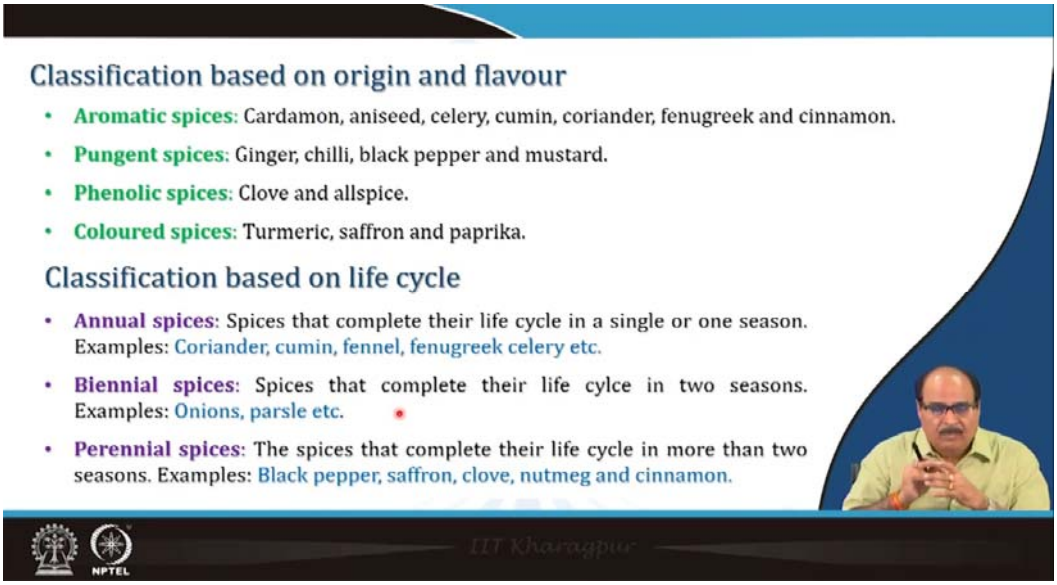
Botanically, spices are named according to genus and species. For instance, for ginger, the genus name is *Zingiber* and family name is *officinale*, thus ginger's botanical name is *Zingiber officinale*. Each spice also belongs to a larger family of plants. In ginger's case, the family is Zingiberaceae.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



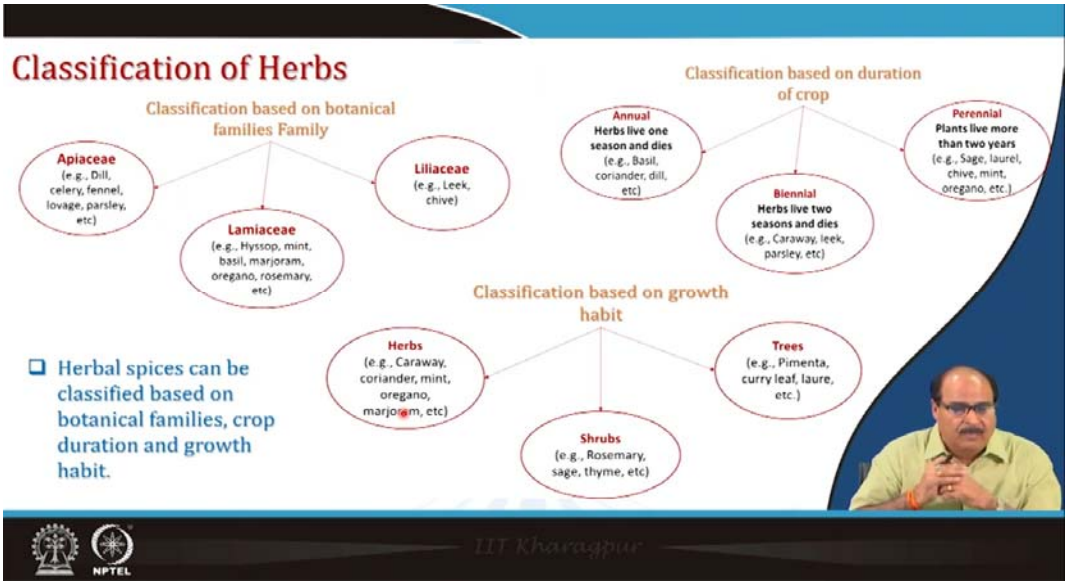
Based on climate requirement, spices are grouped into three categories i.e. tropical, subtropical, and temperate spices. Tropical spices need high temperature and abundant humidity. They are easily damaged by low temperature. The examples of this group of spice include ginger, turmeric, black pepper, 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 ^{o}C and frosty weather but are damaged easily in hot weather. Examples of this category of spices are thymes, saffron, caraway, seed and savoy.



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).



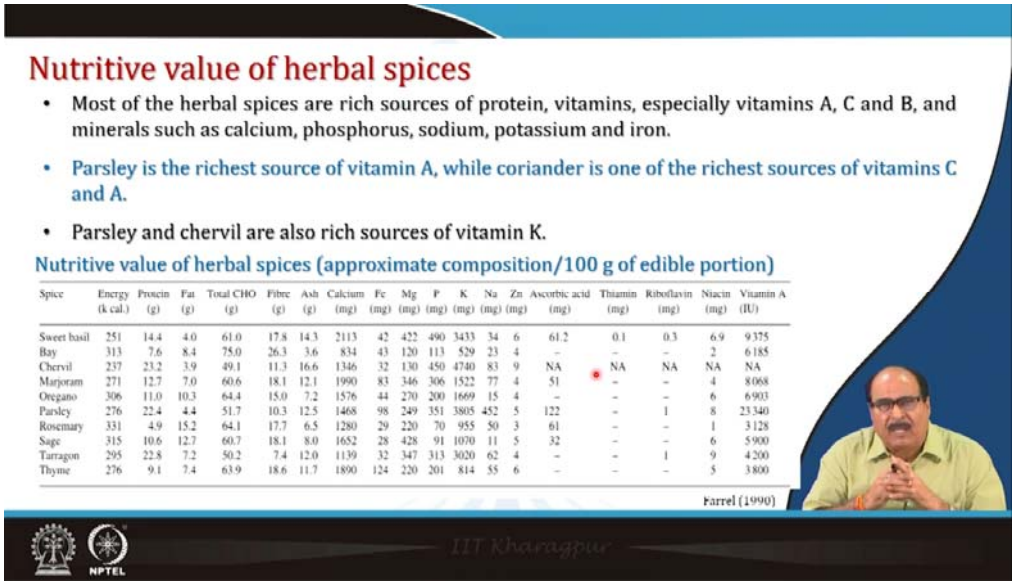
Generally, herbs are classified based on the botanical families, crop duration and growth habit. Under the category of botanical family that is they are classified as apiaciae, lamiaceae. The examples of apiaceae include celery, fennel, parsley. Lamiaceae includes hoyssop, mint,

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 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.



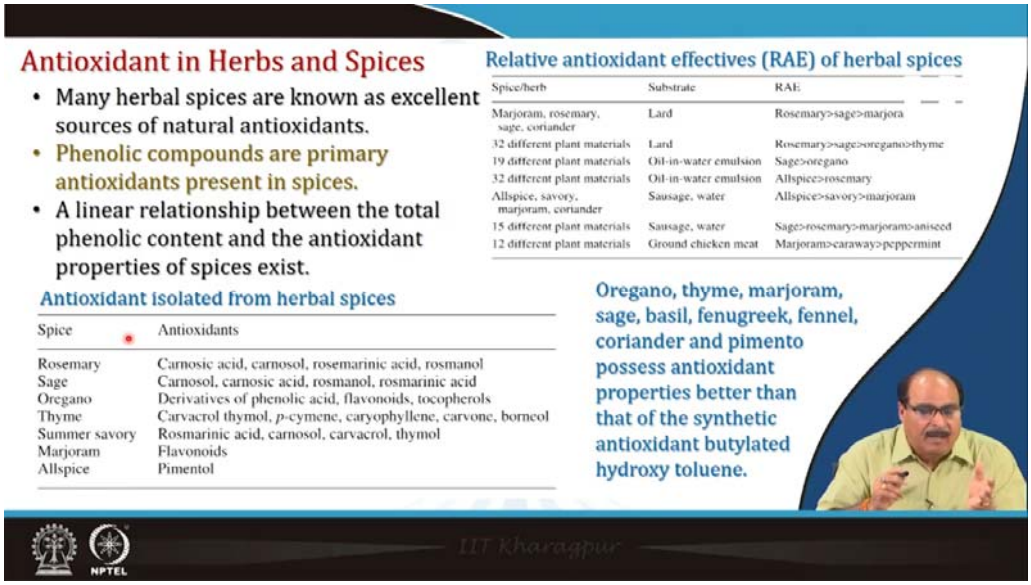
Spice	Energy (k cal.)	Protein (g)	Fat (g)	Total CHO (g)	Fibre (g)	Ash (g)	Calcium (mg)	Fe (mg)	Mg (mg)	P (mg)	K (mg)	Na (mg)	Zn (mg)	Ascorbic acid (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin A (IU)
Sweet basil	251	14.4	4.0	61.0	17.8	14.3	2113	42	422	490	3433	34	6	61.2	0.1	0.3	6.9	9375
Bay	313	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

Nutritive value of herbal spices

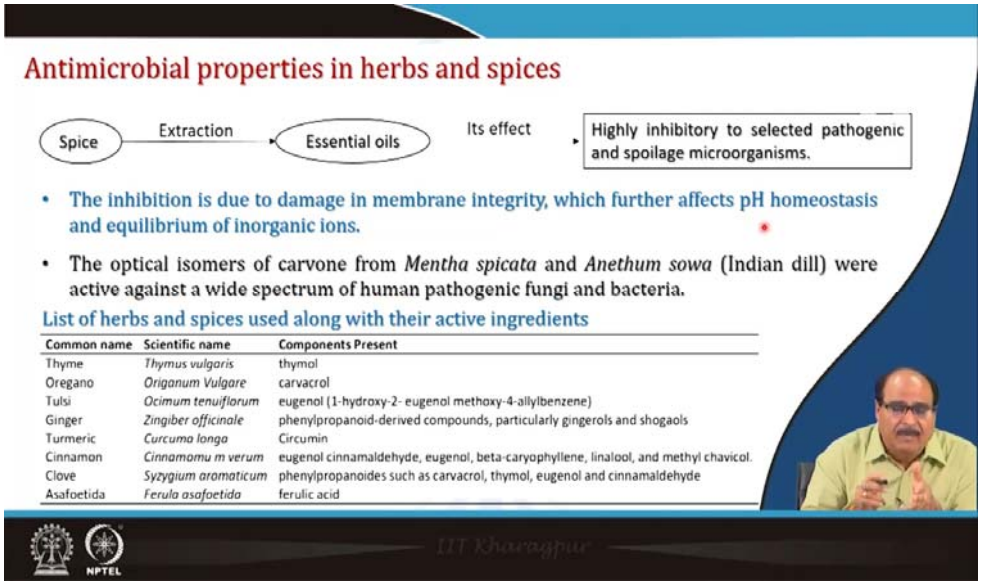
Most of the herbal spices are rich sources of protein, vitamin, especially vitamin A, C and B, and minerals such as calcium, phosphorus, sodium, potassium and iron. Parsley is the richest source of vitamin A, while coriander is one of the richest sources of vitamins C and A. Parsley and chervil are also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

The table represents the nutritive value of herbal spices in terms of approximate compositionper 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.

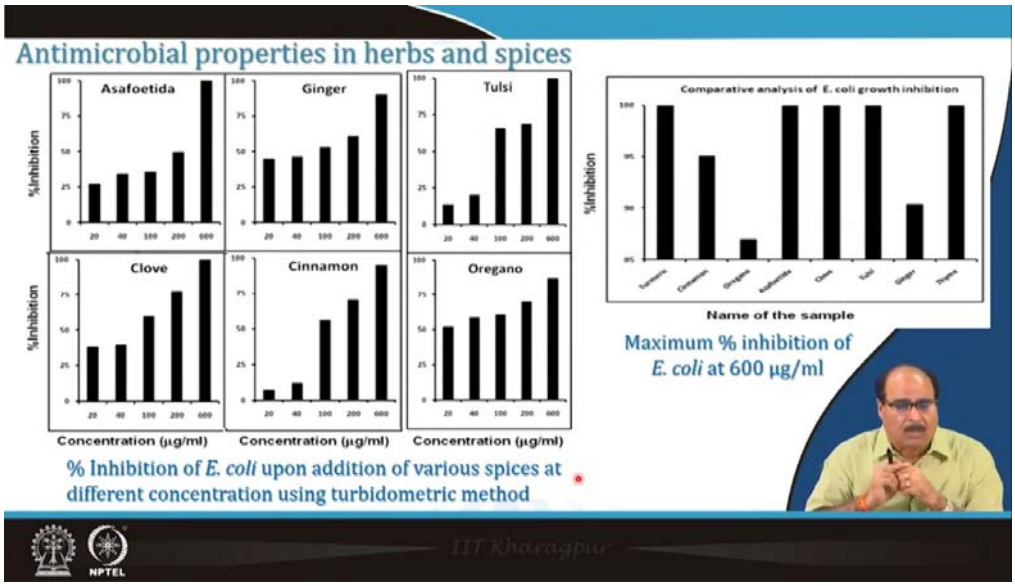


Similarly, many herbal spices are known as excellent sources of natural antioxidants. Phenolic compounds are primarily antioxidants present in spices. There is a linear relationship between the total phenolic content and the antioxidant properties of the spices. This table enlists the antioxidant isolated from herbal spices such as carnosic acid, carnosol, rosemarinic 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.

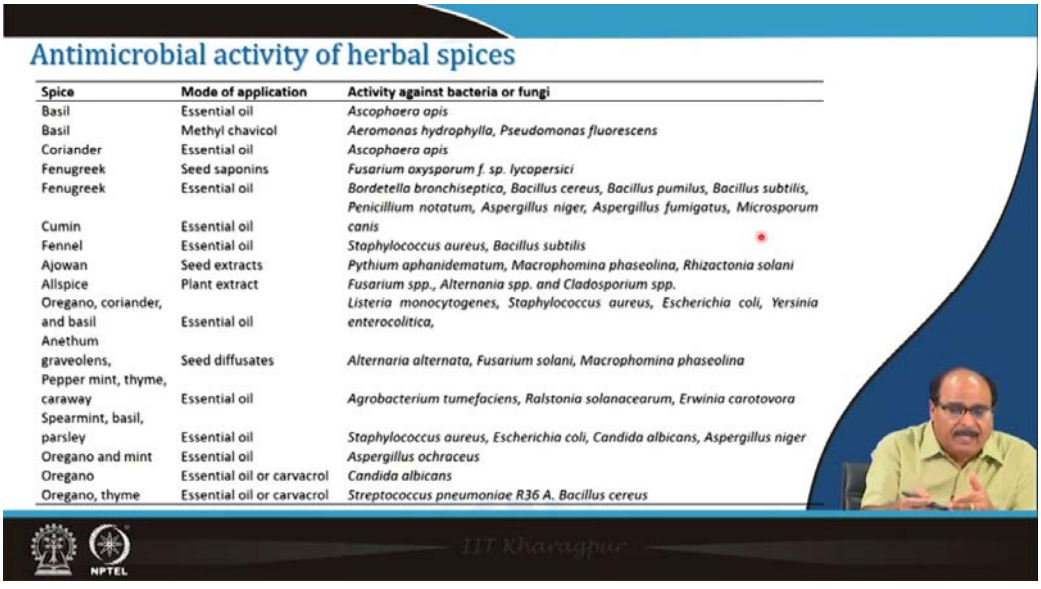


These spices contain essential oils. So, using appropriate extraction method, these essential oils are extracted and are used as an antimicrobial. They are highly inhibitory to selected

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.

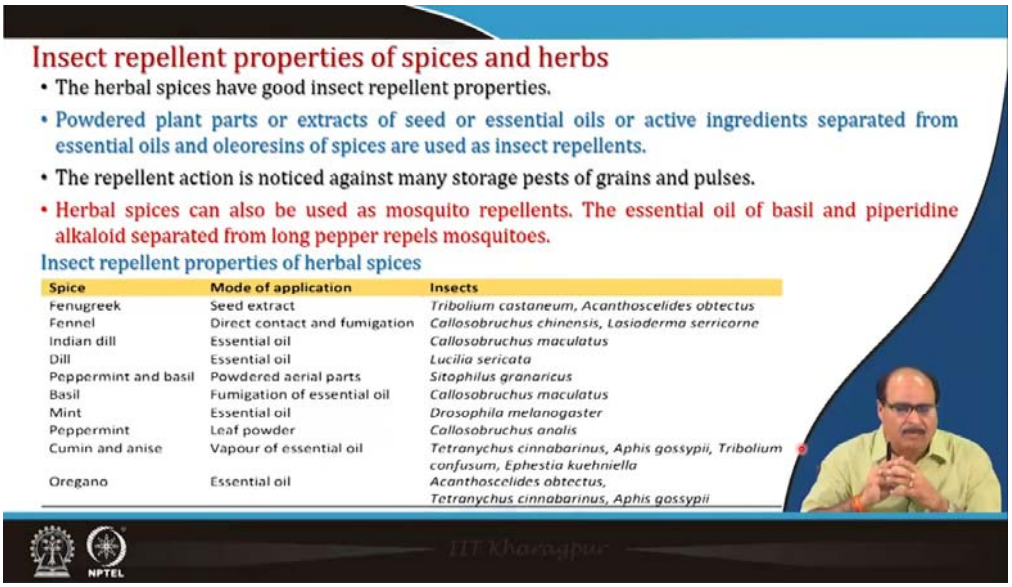


This slide gives a comparison of different spices like asafoetida, ginger, tulsi, clove, cinnamon and oregano with their effectiveness on the inhibition of the *E. coli* at different concentrations. It can be clearly observed that the percentage inhibition increases with increasing the concentrations.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

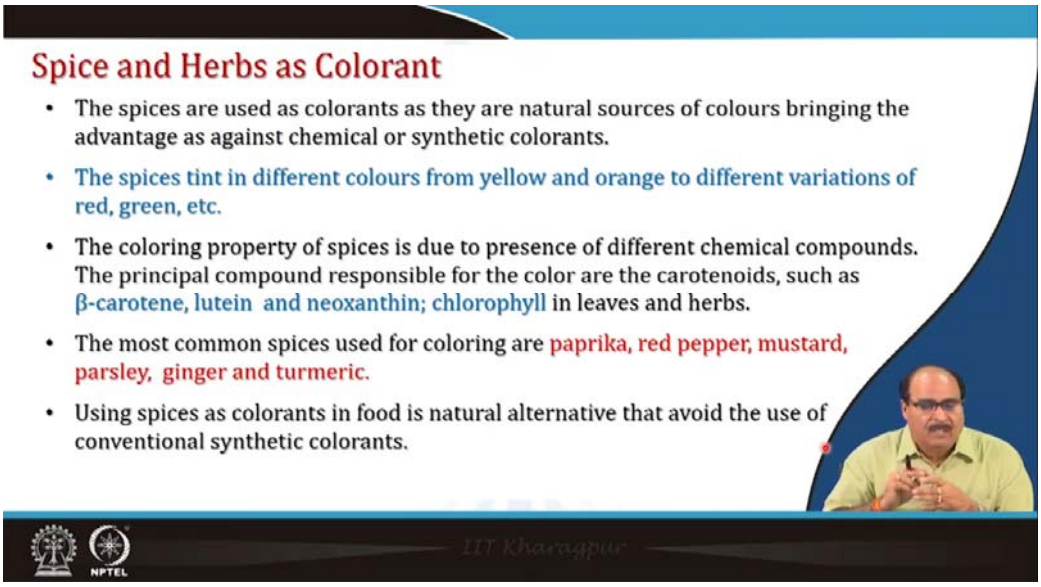


Spice	Mode of application	Activity against bacteria or fungi
Basil	Essential oil	*Ascophaera apis*
Basil	Methyl chavicol	*Aeromonas hydrophylla, Pseudomonas fluorescens*
Coriander	Essential oil	*Ascophaera apis*
Fenugreek	Seed saponins	*Fusarium oxysporum f. sp. lycopersici*
Fenugreek	Essential oil	*Bordetella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

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*.

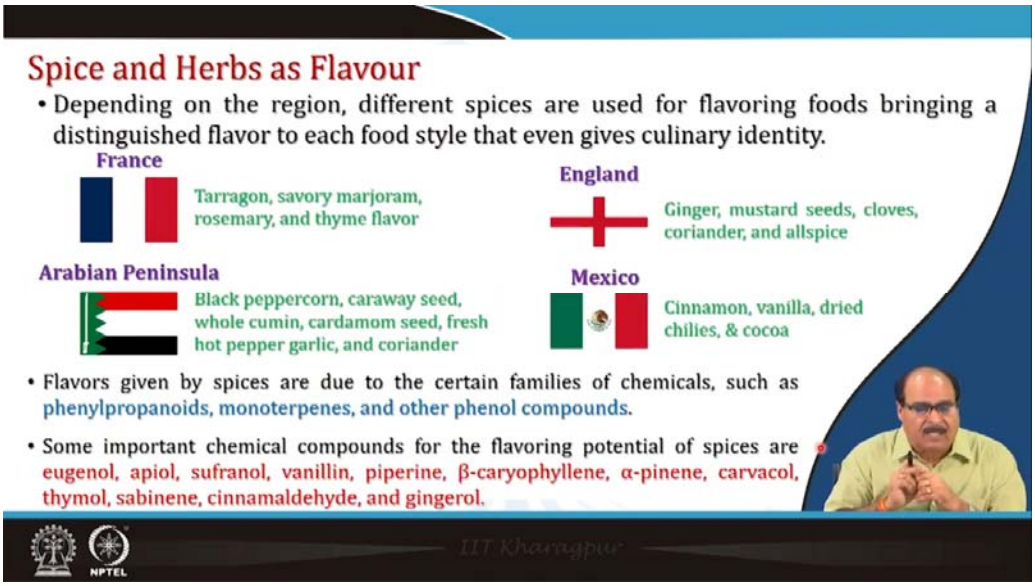


The herbal spices have good insect repellent properties. Powdered plant parts or extracts of seed or essential oils or active ingredients separated from the essential oils and oleoresins of spices are used as insect repellents. The repellent action is noticed against many storage pests of grains and 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*.



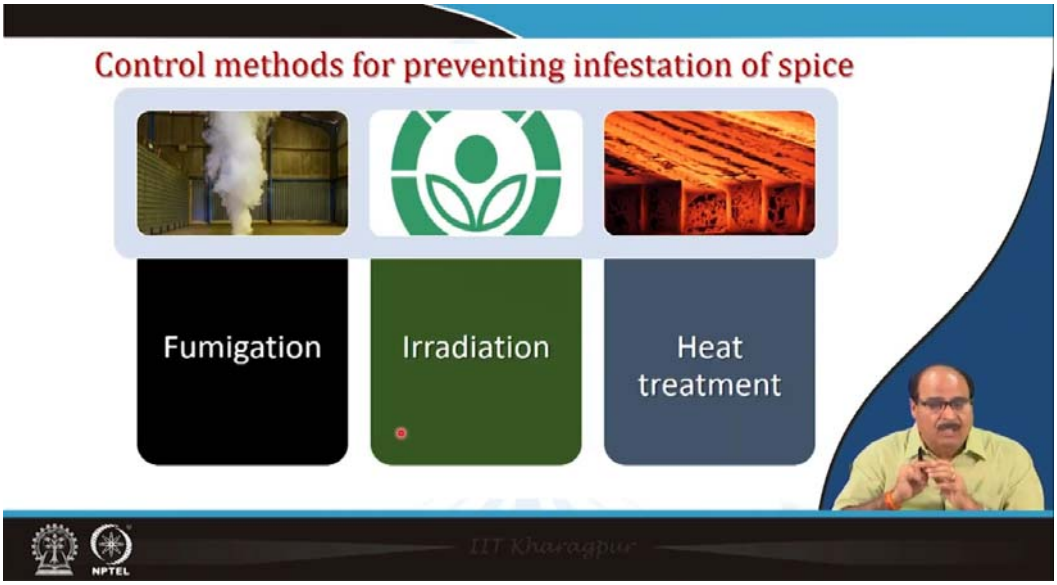
Then spices and herbs are used as colorants. The spices are the natural sources of colors bringing the advantage as against chemical or synthetic colorants. Spices tint in different

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.

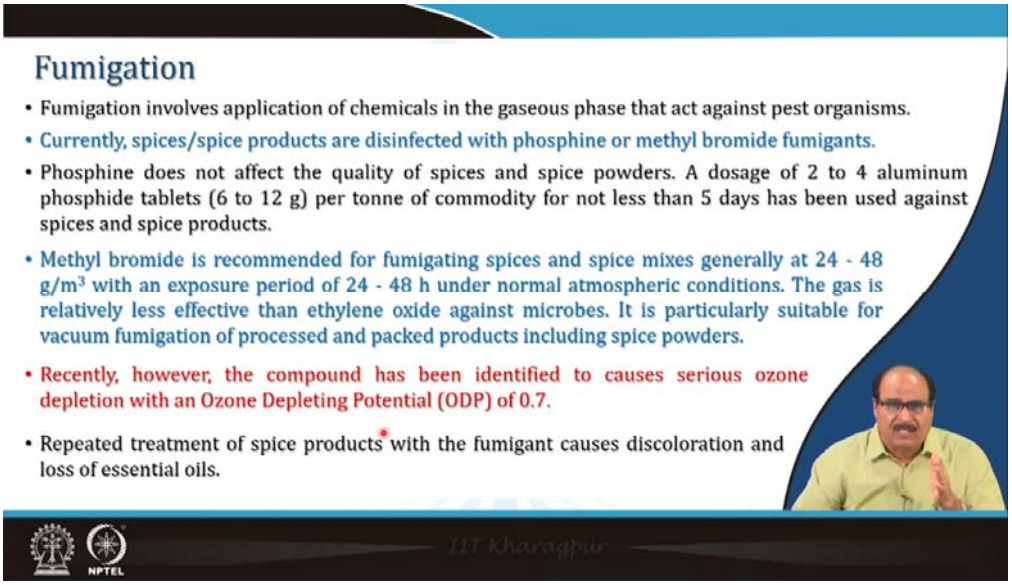


Depending upon the region, different spices are used for flavoring foods, bringing a distinguished flavor to each food style that even gives culinary identity. For example in France, they use a specific type of flavor like savory marjoram, rosemary, and thyme etc. Similarly, in England, they use ginger, 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, peperine.

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.

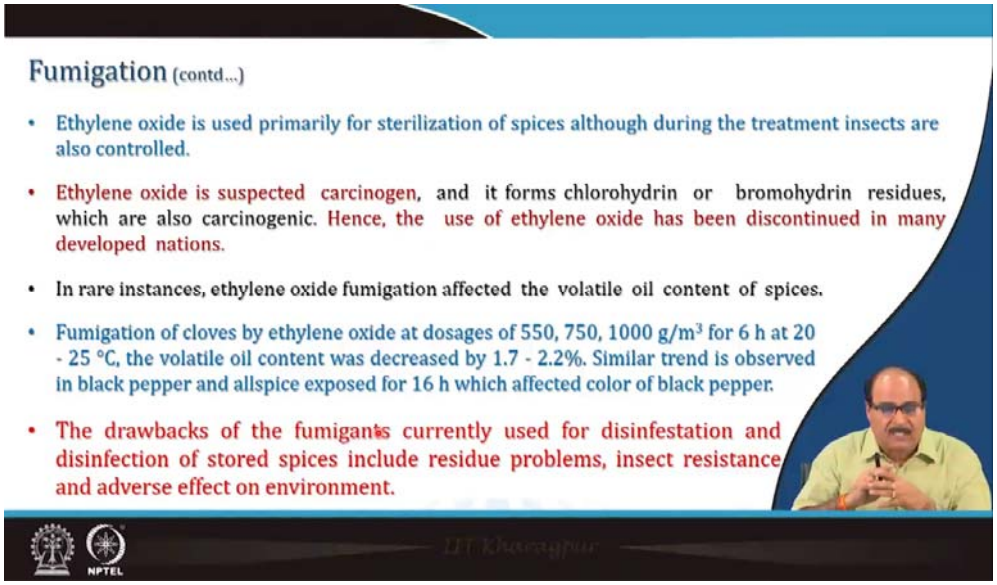


The insect infestation is one of the major problem in the spices. So, the fumigation, irradiation or heat treatments can be generally used for preventing the infestation.



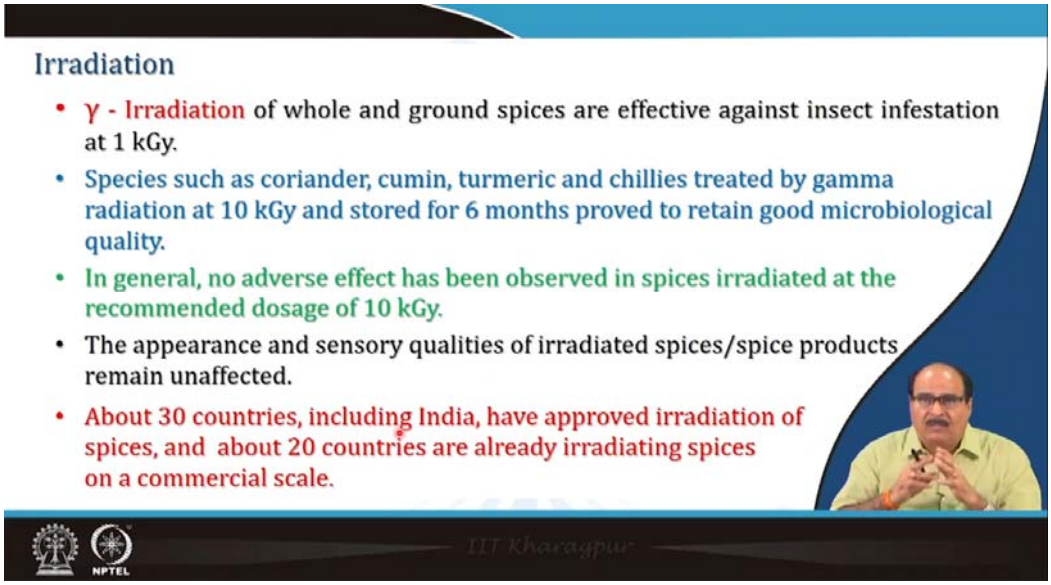
Fumigation involves the application of various chemicals in the gaseous phases that act against pest organisms. Currently, spices or spice products are disinfected with phosphine or methyl bromide fumigants. Methyl bromide is recommended for fumigating spice and spice mixes, generally, at 24 to 48 gram 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.

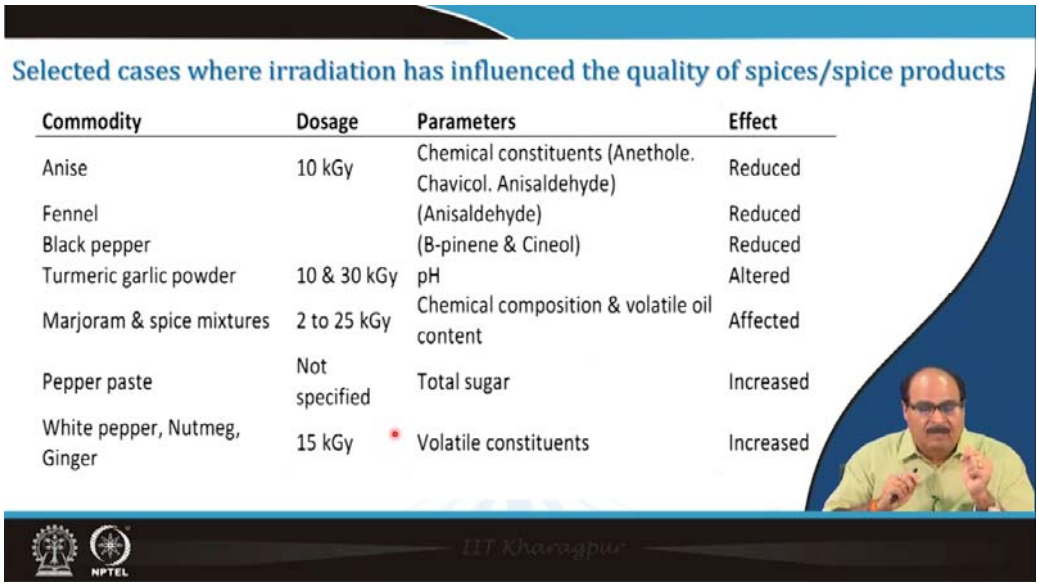


Ethylene oxide is suspected carcinogen and it forms chlorohydrin or bromohydrin residues, which are also carcinogenic. Hence, the use of ethylene oxide has been discontinued in many

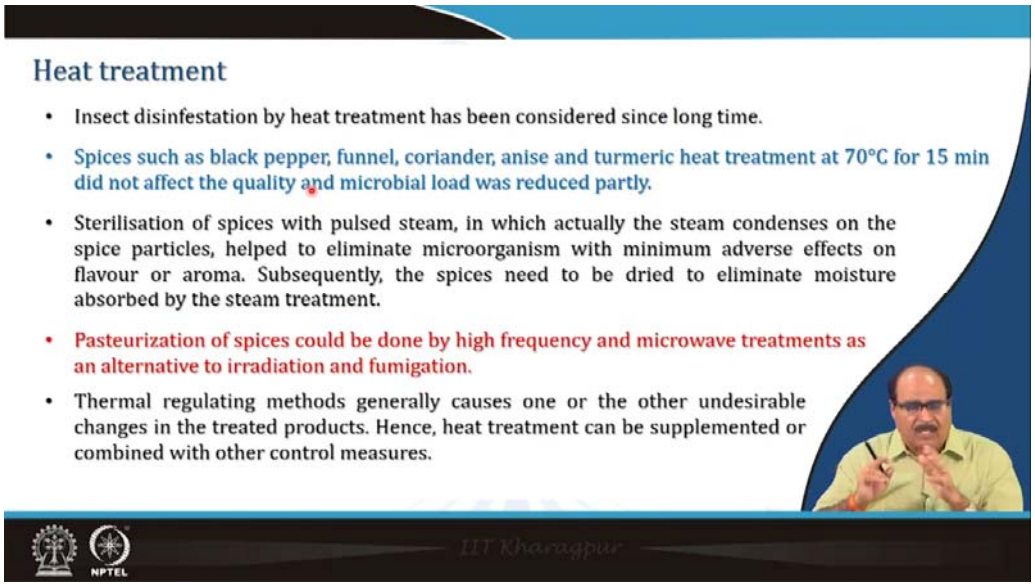
developed countries. Fumigation of cloves by ethylene oxide at doses recommended in various regulatory agencies i.e. 550, 750, 1000 gram per cubic meter for 6 hours at 25 ^{o}C. It was found that the volatile oil content was decreased by 1.7 to 2.2%. So, the drawbacks of the fumigants currently used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



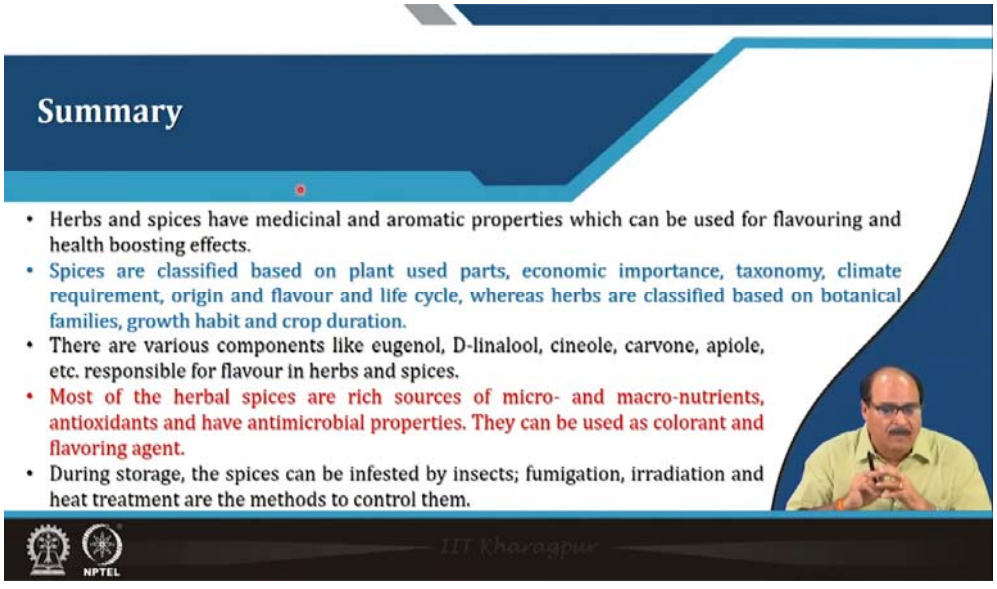
Gamma-irradiation of whole and ground spices are effective against insect infestation at 1 kGy. Spices such as coriander, cumin, turmeric, and chilies are treated by gamma radiation by 10 kGy and stored for 6 months are proved to retain good microbiological quality. In general, there is no adverse effect has been observed in spices irradiated at the recommended dosage of 10 kGy. The appearance and sensory qualities of irradiated spices and 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.



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.

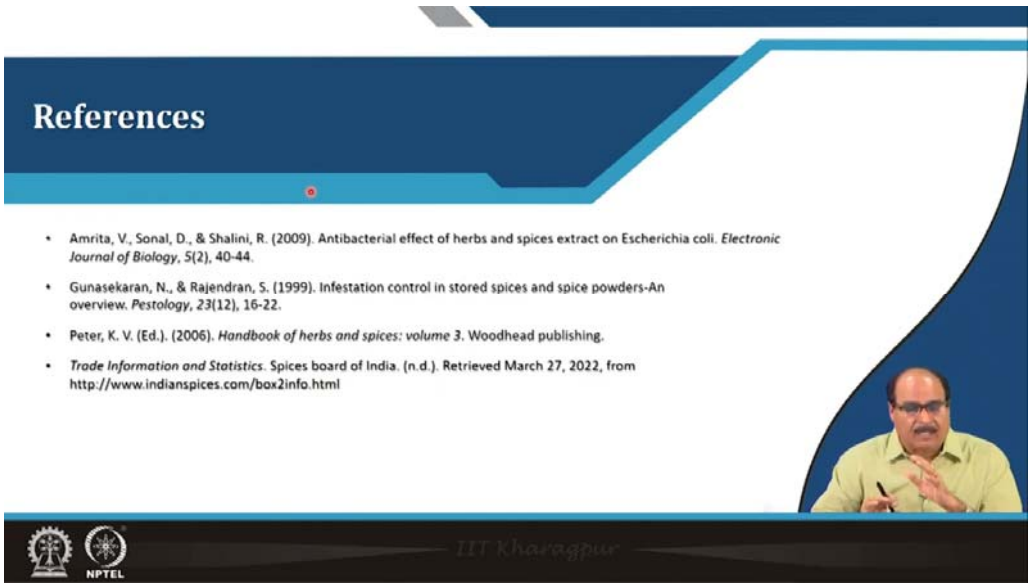


Heat treatment is another insect infestation has been considered since long time. Spices such as black pepper, fennel, coriander, anise, turmeric, they are heat treated at 70 ^{o}C for about 15 min and did not affect the quality and microbial load was reduced partly. Sterilization of spices with pulsed 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 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.



These are the references for further study. Thank you.