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Review

Biopotency role of culinary spices and herbs and their chemical constituents in health and commonly used spices in Nigerian dishes and snacks

Abdullahi Mann

Department of Science Laboratory Technology, Federal Polytechnic, Bida, P. M. B. 55, Bida, Niger State, Nigeria. E-mail: abdumann@yahoo.com. Tel: 080342956556.

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This review paper summarizes the current scientific publications of researches concerning the potential health benefits of herbs and spices; it also highlights some commonly used spices in Nigerian dishes and snacks, major useful compounds of these herbs and spices and the need for value addition and product development.

Keyword: Biopotency, culinary spices, snacks.

INTRODUCTION

The Emperor Charlemagne in the 9th century described an herb as a friend of physicians and the praise of cooks. Over time, it has come to be understood that biopotency role is the capacity of a chemical substance such as a hormone or vitamin to function in a biological system, while culinary is the art of cooking. The words 'herb' and 'spice' are often used interchangeably. Generally, the leaf of a plant used in cooking may be referred to as a culinary herb, and any other part of the plant, often dried, as a spice. Spices can be the buds (cloves), bark (cinnamon), rhizomes or roots (ginger), berries (pepper), aromatic seeds (cumin) and even the stigma of a flower. Many of the aromatic seeds called spices are actually gathered from herbal plants when they have finished flowering.

A familiar example is coriander; the leaves being referred to as an herb, however the dried seeds are always referred to as a spice. The stem and roots of coriander which are used in cooking, and bulb of onions and garlic are vegetable materials tended to be classified along with herbs, as they are often used fresh and applied in a similar way to cooking. Beginners in the field of science may be wondering of what relevance is chemistry to certain professions such as catering programmes. This is because chemistry is an experimental or practically oriented science, which deals with nature and properties of matter and the changes or transformation nature undergoes under different conditions.

Chemistry provides reasonable explanations for various phenomena in the human environment. Foods particularly its constituents are made up of chemical substances. Therefore, the role of phytochemists is to identify, isolate, and elucidate the structures of the compounds present in these culinary herbs and spices and also to determine the mechanism of their action in human systems. The preparation of many Nigerian dishes involves a lot of herbs and spices. Therefore, the nature of the chemical constituents in these herbs and spices need to be known since they are capable of interacting with a living tissue or system as nutritional supplements.

SOME COMMONLY USED SPICES IN NIGERIAN DISHES AND SNACKS

Some Nigerian dishes and snacks are jollof rice, miyan-kuka, miyan-kubewa, kunun-zaki, kunun-tsamiya, kunun-gyada, fura, gboruagi, nakiya, dakuwa, kulikuli and kudo (Alabi, 2007). The preparation of these local dishes (soups) and snacks traditionally required kayan yaji (culinary spices) which consist of ingredients such as albasa (onion, bulb); aleyaho (spinach, leaf); Ayoyo (leaf); kuka (baobab, fruit); bakin ganye (seed); borkono (chilli, fruit); chitta (ginger, rhizome); dadawa (locust beans, seed); fasakwari (bark); kabewa (okro, fruit); kanufari (clove, buds); nutmeg (aril/seed kernel); tafarnuwa (Garlic, bulb); tsamiya (tamarind, fruit); tumatir(tomato, fruit); Kimba (fruit); shuwaka (bitter leaf, leaf); ugu (fluted pumpkin, seed/leaf); Zabibi (turmeric, rhizome); zoborodo (calyx) and zogale (leaf) (Alabi, 2007).

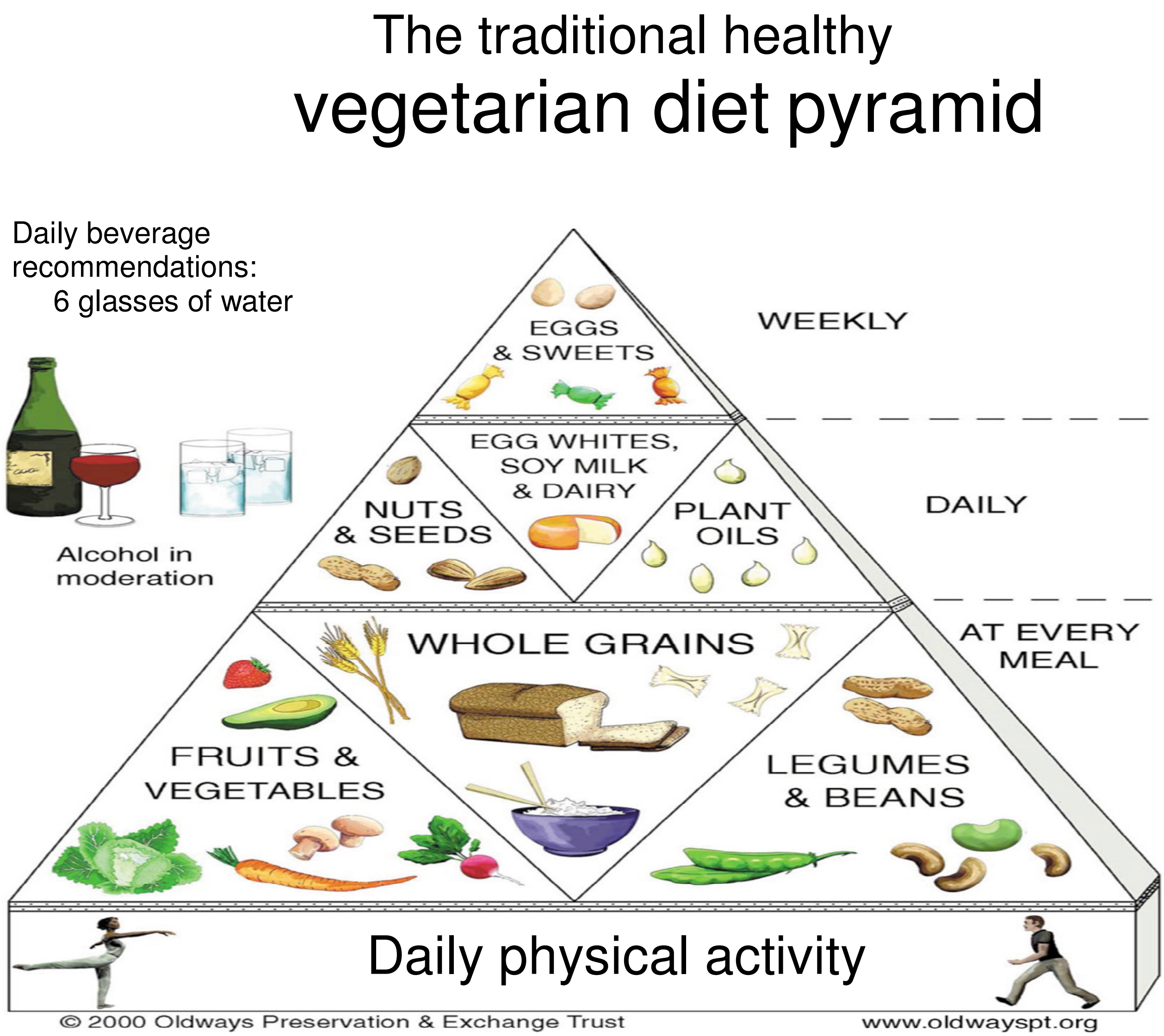


Figure 1. The traditional healthy vegetarian diet pyramid.

Some of the herbs include *Afromomum danielli*; baobab (*Adasonia digitata*); basil (*Ocimum basilicum*); black pepper (*Piper nigrum*); celery leaf (*Apium graveolens*); clove (*Syzygium aromaticum*); cumin (*Cuminum cyminum*); curry leaf (*Murraya koenigii*); fluted pumpkin (*Telfaria occidentalis*); garlic (*Allium sativum*); ginger (*Zingiber officinale*); nutmeg (*Myristica fragans*); onion (*Allium cepa*); chilli (*Capsicum frutescens*); red pepper (*Capsicum annum*); star anise (*Illicium verum*); tomato *(Lycopersicum esculentum*); turmeric (*Curcuma longa*); bitter leaf (*Vernonia amygdalina*); spinach (*Amaranthus hybridus*); *Piper* guineese; *Xylopia aethiopica*; *Zanthoxylum zanthoxyloxides*; *Moringa oleifera*; *Hibiscus sabdarifa*; Okro (*Hibiscus esculenta*) and (*Corchorous olitorus*). These culinary herbs and/or spices show high potential as functional ingredients in traditional snacks (Cooking secret. org/herbs-spices/spice- producing- areas).

HERBS AND SPICES AS INTEGRAL PART OF BOTH CULINARY AND MEDICINAL PREPARATIONS

Herbs and spices have a long history of both culinary and medicinal uses (Tapsell et al., 2006). Herbs and spices are integral part of the daily diet. Herbs and spices could be regarded as one of the first real 'functional foods' but have largely become forgotten foods in the modern westernized diet. Herbs and spices can add variety, flavour, colour and aroma to the everyday diets whilst contributing a wide range of both nutrients (Murphy et al., 1978) and bioactives that may contribute to improved health (Kitts, 1994). Herbs and spices may act synergistically to enhance the health-related properties of other foods (Thimayamma et al., 1983).

Food and medicine are closely related (Etkin, 1996) and commonly used vege-tables are considered as foods

(Figure 1) due to their high content of valuable nutrients (Etkin and Ross, 1982). Herbs and spices are added to traditional dishes and snacks to beneficially improve the health status of the consumer without detrimental effect on the flavour and taste. Flavours and seasonings are important considerations for snacks (Williams, 1999) and herbs could be used as both flavouring (Williams, 1999; Nordmark, 1999) and functional ingredients (Pszczola, 1999) in snack products. Moreover, the pharmacological properties of traditional herbs have been well documented (Farnsworth and Bunyapraphatara, 1992; Primary Health Care, 1998).

Since prehistoric times, herbs have been the basis for nearly all medicinal therapy until synthetic drugs were developed in the 19th Century. Today, herbs are still found in 40% of prescription drugs. Culinary herbs also have been grown and used for their ability to enhance and complement the flavours of a wide variety of foods. The majority of herbs and spices constitute important bioactive secondary metabolites which possess versatile pharmacological and medicinal properties.

Herbs and spices, as plant products, can add substantial variety to the nutrients and bioactives available in the diet. Herbs have been widely used as culinary herbs and have been known as medicinal plants in traditional medicine. Dietary spices influence various systems in the body such as gastrointestinal, cardiovascular, reproductive and nervous systems resulting in diverse metabolic and physiologic actions (Kochhar, 2008). Using the tools and techniques of contemporary physiology, researchers are now elucidating mechanisms justifying the traditional use of dietary spices as appetite enhancers, digestives, carminatives, antiflatulents, secretagogues, as well as in both diarrhoea and constipation (Clair, 1961; Farnsworth, 1985; Pruthi, 1976).

Dietary spices may influence gastric emptying, gastrointestinal motility, secretion of gastric acid as well as intestinal bicarbonate, bilopancreatic secretions, absorptive processes and bacterial microflora (Kang et al., 1988; Newberne, 1988; Udupihille, 1993). Many of the commonly consumed foods, herbs, and spices contain phytoestrogens and phytoprogestins that act as agonists and antagonists' *in vivo* (Zava et al., 1998). Over 150 herbs traditionally used for treating a variety of heath problems were extracted and tested for their relative capacity to compete with estradiol and progesterone binding to intracellular receptors for progesterone (PR) and estradiol (ER) in intact human breast cancer cells (Zava et al., 1998).

The six highest ER-binding herbs that were commonly consumed were soy, licorice, red clover, thyme, turmeric, hops and verbena. The six highest PR-binding herbs and spices commonly consumed were turmeric, thyme and red clover (Zava et al., 1998). The global spice trade in 2004 consisted of 1.547 million, valued at US$ 2.97 billion (Parthasarthy et al., 2008). Therefore, using herbs as functional ingredients to improve the health benefits of snacks is an interesting alternative.

Any good snack should be convenient to consume, inexpensive, nutritious, low in fat, and have long shelf life.

Culinary benefits of herbs and spices

There are a number of potential culinary benefits of herbs and spices:

The health promoting effect of vegetables and fruits (Craig, 1999) is thought to relate not only to the general nutritional profile of this food group which are high in dietary fibre, low in fat and salt, low energy density and high in vitamins A, C and foliate, but in addition, wide range of non-nutrient bioactives and phytochemicals such as flavonoids and other phenolics are also found in herbs and spices. It has been proposed that the additive and synergistic effects of the complex mixture of phytochemicals in fruits and vegetables, herbs and spices are largely responsible for their health benefits (Craig, 1999). Wild vegetables have been reported to contain comparatively high amounts of Vitamins A and C and other antioxidant micronutrients (Szeto et al., 2002), promote good health by assisting in preventing cancer and high blood pressure, stimulating the immune system, improving drug metabolism (Van't et al., 2000), and tissue regeneration (Rayner, 1998).

Pharmacological aspects

Recent advances in our understanding at the cellular and molecular levels of carcinogenesis have led to the development of a promising new strategy for cancer prevention called chemoprevention. It is defined as the use of specific chemical substances – natural or synthetic, or their mixtures to suppress, retard or reverse the process of carcinogenesis. It is one of the novel approaches of controlling cancer alternative to therapy (Stoner and Mukhtar, 1995; Bush et al., 2001; Jung et al., 2005). Tamarind is used traditionally as an astringent antiflammatory and antidiuretic agent, a laxative, carminative and digestive agent (Sudjaroen et al., 2005; Siddhuraju, 2007).

Antioxidant capacity

One of the benefits of culinary herbs and spices are primarily due to their antioxidant properties. Free radical and related species are generated in the body as a result of metabolic reactions. Accumulation of free radicals causes damages in living systems resulting in oxidative stress. The free-radical scavengers (antioxidants) have potential to prevent, delay or ameliorate many of human chronic and ageing diseases such as cancer, diabetes, heart disease, stroke, malaria and rheumatoid arthritis. Free radical scavenging is an important mechanism for the inhibition of lipid peroxidation, and can be a good marker for antioxidant activity; results indicate that the addition of some spices and herbs to food products can prevent their oxidative deterioration in foods (Mariutti et al., 2008). The multiple roles of traditional vegetables as both food and medicinal sources have been widely documented (Lee et al., 2003; Ogle et al., 2003; Adebooye and Opabode, 2004; Ayodele, 2005). Several studies have demonstrated that some edible plants or vegetable diets possess substantial antioxidant properties (Aliyu et al., 2008; Szeto et al., 2002).

Antioxidant activity studies of Nigerian spices implicate the total phenolic contents for its activity (Olukemi et al., 2005). Polyphenols, phenolic compounds, flavonoids, and terpenes are well known for their antioxidant activity (Chu et al., 2002; Ninfali et al., 2005; Sun et al., 2002). Phenolic compounds from edible plants are the main antioxidants in the human diet (Halvorsen et al., 2002). There is growing interest in the antioxidant and anti-inflammatory capacities of these compounds relative to prevention or treatment of chronic diseases that involve inflammation (Jensen, 2006). For example, dietary phenolics have been related to reduced risk of cancer (Dashwood, 2007), cardiovascular disease (Visioli and Hagen, 2007) and diabetes (Banini et al., 2006). The antioxidant properties of herbs and spices are of particular interest in view of the impact of oxidative modification of low density lipoprotein cholesterol in the development of atherosclerosis. Consuming a half to one clove of garlic (or equivalent) daily may have a cholesterol-lowering effect of up to 9%. The garlic extract has been associated with anticlotting (*in-vivo* studies), as well as modest reductions in blood pressure (an approximate 5.5% decrease in systolic blood pressure).

Food synergy

There is some evidence of a synergistic effect of the antioxidant capacity of herbs and spices when added to other foods (Bijlani, 1974). Substitution of just 3 g of a mixed salad comprised of a 2:1 mix of tomato (124 g) and lettuce (76 g) with 3 g of fresh marjoram (1.5%w/w) raised the antioxidant capacity (ORAC value) of the salad from about 1400 µmol TE/200 g to well over 4000 µmol TE/200 g (285% increase). This compared to an expected rise to just over 2200 µmol TE (157% increase) based on the antioxidant capacity of the individual components. When lemon balm was substituted in the same manner, the antioxidant capacity increased from about 1400 µmol TE/200 g to just over 2000 µmol TE/200 g (46% increase) compared to an expected rise to about 1500 µmol TE/200 g (7% increase).

Antimicrobial activity

There are many phytochemicals such as carotenoids, phenolics and organosulphur compounds, which possess bioactivity beyond antioxidation. For example, diallyl sulphides in garlic are associated with reductions in total cholesterol, LDL cholesterol and triglycerides, while geraniol, and other monoterpenes, exhibit antiproliferative properties in human colon cancer cell lines (Willett, 1994). Clove bud oil has various biological activities, such as antibacterial, antifungal, antioxidant and insecticidal properties.

The high level of eugenol present in the essential oil impacts strong biological and antimicrobial activity (Raghavenra et al., 2006). Curry leaves have been studied for their antifungal activity (Dwivedi et al., 2002; Ray and Strivastava, 2006).

A range of bioactive substances in herbs and spices have been studied (Kitts, 1994), but the challenge lies in integrating this knowledge to ascertain whether any effects can be observed in humans, and within defined cuisines.

Flavour enhancer

One of the major barriers to increasing the consumption of vegetables is taste (Cox et al., 1998). The addition of herbs and spices to other vegetables, salads or even fruits, can help overcome this obstacle. Herbs and spices can be used with other vegetables and fruits or with other foods, to replace other less desirable taste promoters such as salt, sugar and fat.

Visual and olfactory stimulation

Herbs and spices can add to the visual and olfactory attractiveness of a range of foods adding both colour and an attractive aroma to a range of otherwise brand foods. Certain phytochemicals give fruits and vegetables, herbs and spices their colours and also indicate their unique physiological roles. Colours have been used to promote food choices and contrasting colours have been shown to be one of the key factors in food selection (Drewnowski, 1996). A method for selecting fruits and vegetables based on colours keyed to the content of phytochemicals is a way of translating the science of phytochemical nutrition into dietary guidelines for the public (Heber and Bowerman, 2001).

Convenience

Herbs and spices are convenient to use in everyday cooking, available all year round in either fresh or dried forms; inexpensive, varied and highly palatable. Herbs and spices not only provide variety, flavour, colour and aroma to the everyday diet but can reduce the need to use other less healthy flavourings such as salt, fat or sugar.

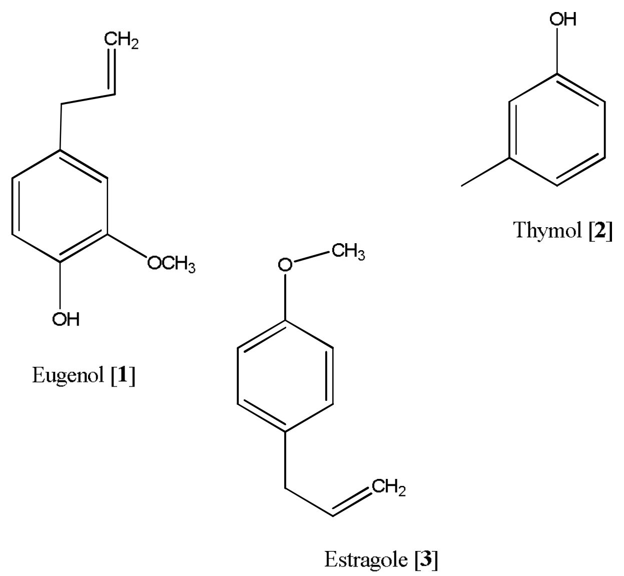


Figure 2. Active compounds in basil.

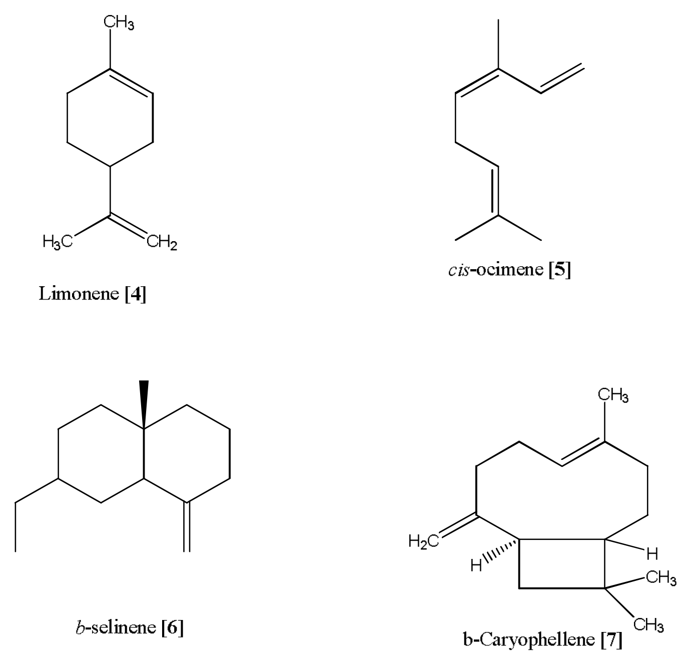


Figure 3. Volatile oils constituents present in celery leaves.

Bioenhancer

Piperine (1-piperoyl piperidine) in black pepper is shown to possess bioavailability–enhancing activity with various structural and therapeutically diverse drugs. This property of piperine may be attributed to increased absorption, which may be due to alteration in membrane lipid dynamics and a change in the conformation of enzymes in the intestine (Khajuria et al., 2002).

Remedy for bird flu

Star anise is the industrial source of shikimic acid, a primary ingredient used to create the anti flu drug, Tami flu, which is regarded as the most promising drug to mitigate the severity of the bird flu H_5N_1 strain of virus (Goodman, 2005). Tami flu is the only drug available which may reduce the severity of bird flu (also known as avian flu).

MAJOR COMPOUNDS IN CULINARY HERBS AND SPICES

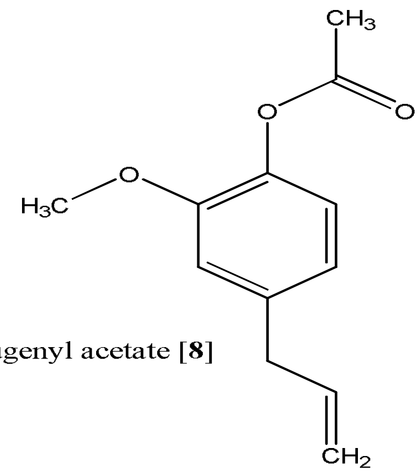
Many culinary spices (for example, clove, garlic, ginger, onion, mustard, pepper and turmeric) have their bioactive constituents' characterized (Achinewhu et al., 1995). Bioactive compounds confer protection against cardio-vascular and cancer diseases. Spices impact aroma, colour and taste to food preparations and sometimes mask undesirable odours. Volatile oils give the aroma, and oleoresins impact the taste. Aromatic compounds play significant role in the production of flavourants, which are used in the food industry to flavour, improve and increase the appeal of their products. These compounds are classified by functional groups, for example alcohols, aldehydes, amines, esters, ethers, ketones, thiols, etc. In spices, the volatile oils constituent these components (Zachariah, 1995; Menon, 2000). Several active ingredients of spices including capsaicin (red pepper) piperine (black pepper), curcumin (turmeric), eugenic acid (clove), ferulic acid (turmeric) and myristic acid (mace, amla) have been reported to influence lipid metabolism predominantly by mobilization of fatty acids (Srinivasan and Satyanarayana, 1987).

Basil (Ocimum basilicum)

Preliminary studies on basil have shown that its leaf and seed may help people with type 2 diabetes to control their blood sugar levels (Agrawal et al., 1996; Rai et al., 1997). Active compounds in holy basil are terpenoids, particularly eugenol, thymol, and estragole (Figure 2) (de Vasconcelos et al., 1999).

Celery leaf (Apium graveolens)

The effect of polyacetylenes in celery leaves towards human cancer cells and their human bioavailability to reduce tumour formation in a mammalian *in vivo* model indicates that they may also provide benefits for health (Christensen and Brandt, 2006). Limonene (40.5%), β–selinene (16.3%), *cis*-ocimene (12.5%) and β–caryophyllene (10.5%) (Figure 3) are some of the volatile oils constituents present in celery leaves found in Nigeria (Ehiabhi et al., 2003).



Eugenyl acetate [8]

Figure 4. Constituent of clove oil.

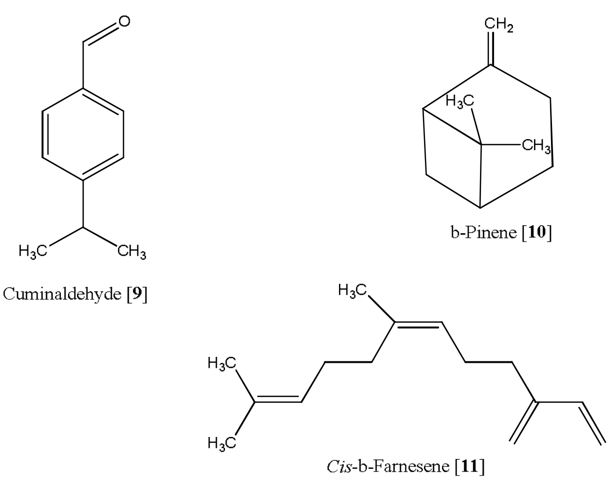


Figure 5. Constituent of cumum.

Clove (Syzygium aromaticum)

Cloves (Syn. *Eugenia aromaticus*) are actually the dried buds of the clove tree. The minor constituents like methyl amyl ketone, methyl salicylate, etc. are responsible for the characteristic pleasant odour of cloves. There are three constituents of clove oil namely eugenol (70 to 80%), β-caryophyllene (5 to 12%) and eugenyl acetate (15%), which together make up 99% of the oil. Cloves also contain flavonoids, galloyltannins, phenolic acids and triterpenes (Figure 4).

Cumin (Cuminum cyminum)

Among the seeds spices, cumin fruits have a distinctive bitter flavour and strong, warm aroma due to their abundant essential oil content. Of this, cuminaldehyde (40 to 65%) is the major constituent and important aroma compound and its bitterness is ascribed to it. The characteristic flavour of cumin is due to the presence of monoterpenes such as α-pinene and *cis*-β-farnesene (Figure 5).

Curry leaf (*Murraya koenigii*)

The curry leaf plant is highly valued for its characteristic aroma and medicinal value (Philip, 1981). A number of leaf essential oil constituents and carbazole, murrayacine and koenigine alkaloids have been extracted from this plant (Mallavarapu et al., 1999). There are a large number of oxygenated mono and sesquiterpenes present, for example, *cis*-ocimene (34.1%), β-caryophyllene (9.5%), α-pinene (19.1%), δ-terpenene (6.7%) and β-phellandrene (Figure 6) which appear to be responsible for the intense odour associated with the stalk and flower parts of curry leaves (Onayade and Adebayo, 2000). Both *Murraya koenigii* and *Brassica juncea* showed significant hypoglycemic action in experimental rats (Khan et al., 1996).

Garlic (Allium sativum)

The therapeutic effects of garlic as hypolipidemic, anti-thrombotic, anti-hypertensive, anti-hyperglycemic, anti-hypercholesterolemic and immuno-modulatory have been reported (Krishnaraj, 1997; Block, 1998). The bioactive components responsible for the health benefits of garlic are assumed to be allylic sulfur compounds. The use of herbs and spices to displace fats and salt in the diet may reduce cardiovascular risk but the most convincing studies is that of a specific herb or spice and cardio-vascular disease related to garlic. Garlic is commonly used for the reduction of cholesterol and cardiovascular risk. Consumption of garlic or garlic oil has been associated with a reduction in total cholesterol, low-density lipoprotein (LDL) cholesterol and triglyceride levels. An intake of between one-half and one clove of garlic per day may reduce the total cholesterol by 9%. Garlic extracts have been shown to have anti-clotting properties (Gottlieb, 1982), and to cause modest reductions in blood pressure (approximately 5.5% decrease in systolic pressure) (Balentine et al., 1999). The effectiveness is associated with the active substances in garlic such as Allicin and other breakdown products (Koch and Lawson, 1996). Allicin (Figure 7) has also been isolated and identified as the component responsible for the remarkable antibacterial activity of garlic (Block, 1985; Lawson, 1996).

Therapeutic application of allicin as antifungal agent (Yamada and Azuma, 1997), antiparasitic (Mirelman et al., 1987), antiviral agents (Tsai et al., 1985) and other antibiotic effects (Chowdhury et al., 1991) have been

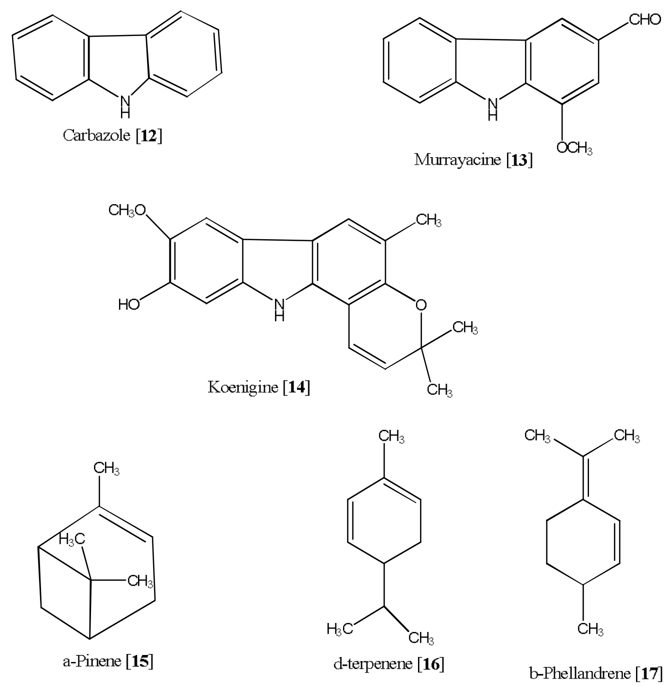


Figure 6. Constituents of curry leaf.

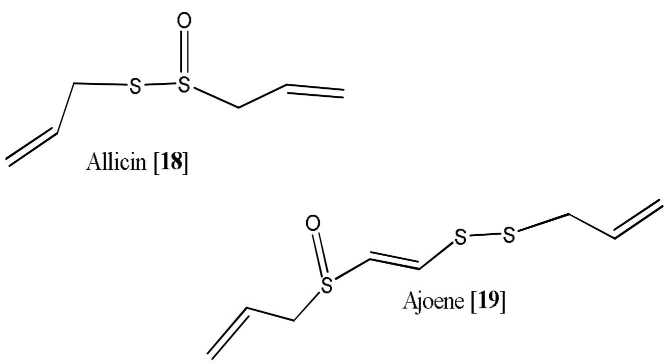


Figure 7. Constituents of garlic.

shown. Inhibition of certain thiol-containing enzymes in the microorganisms by the rapid reaction of thiosulphinates with thiol groups was assumed to be the main mechanism involved in the antibiotic effect (Cavallito et al., 1944). Allicin and ajoene (Figure 7), the major sulfur components of garlic were shown to inhibit inducible nitric oxide syntheses by reducing the protein and mRNA and thus to promote vasodialation. The diallyl-trisulfide rich oil prevents blood coagulation even in diabetes (Chan et al., 2007; Milner, 2001; Ohaeri and Adoga, 2006). *In vitro* and rodent cancer models have shown that diallyl sulphide, a compound in garlic, is effective in the detoxification of carcinogens (Surh and Lee, 1995) through its effects on phase I and phase II enzymes.

Ginger (Zingiber officinale)

Ginger (family: Zingiberaceae) has many therapeutic attributes such as antimicrobial, antithrombotic, antiinflammatory and anticancer activity. Ginger has also demonstrated to be antimutagenic, inducers of detoxification, and preventers of DNA damage *in vitro* (Ackermann et al., 2001; Ohaeri and Adoga, 2006). Ginger has been shown to reduce nausea and vomiting during pregnancy (Southgate, 1993). Ginger is a mixture of over several hundred known constituents, including gingerols, shagaols, β-carotene, caffeic acid, curcumin, salicylate and capsaicin (Schulick, 1996). 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 (Purseglove et al., 1981) 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 (Figure 8) (Wohlmuth et al., 2006).

Ginger is a major tranquilizer, carminative, and an antihypertensive agent due to its gingerol. It is used as a spice as well as an important medicinal product. Ginger is also produced in Nigeria. Ginger has been suggested for potential utility in treating peptic ulceration due to its action as a thromboxane synthetic inhibitor (Schulick, 1996). Synergy is implicated in the antiulcer effect as a result of an experiment where the extract was fractionated and assayed, and particularly, the high activity (97.7% inhibition at 125 ppm) found to occur in a fraction that contained α-zingiberene, p sesquiphellandrene, bisabolene and *ar*-curcumene (Beckstrom-Sternberg and Duke, 1994). Several controlled clinical trials suggest that ginger root can relieve symptoms of motion sickness by a mechanism of action that differs from that of antihistamines. The responsible constituents are believed to be gingerols and shagaols (Phillips et al., 1993).

Ginger root is a putative agent for preventing ageing dependent penile vascular changes and impotence (Tajuddin et al., 2003).

Nutmeg (Myristica fragans)

Nutmeg is used to treat complaints of the digestive tract, such as stomach cramps and diarrhea, as well as catarrh of the respiratory tract. The extracts of nutmeg were found to stimulate the mounting behaviour of male mice, and also to significantly increase their mating performance devoid of any conspicuous general short

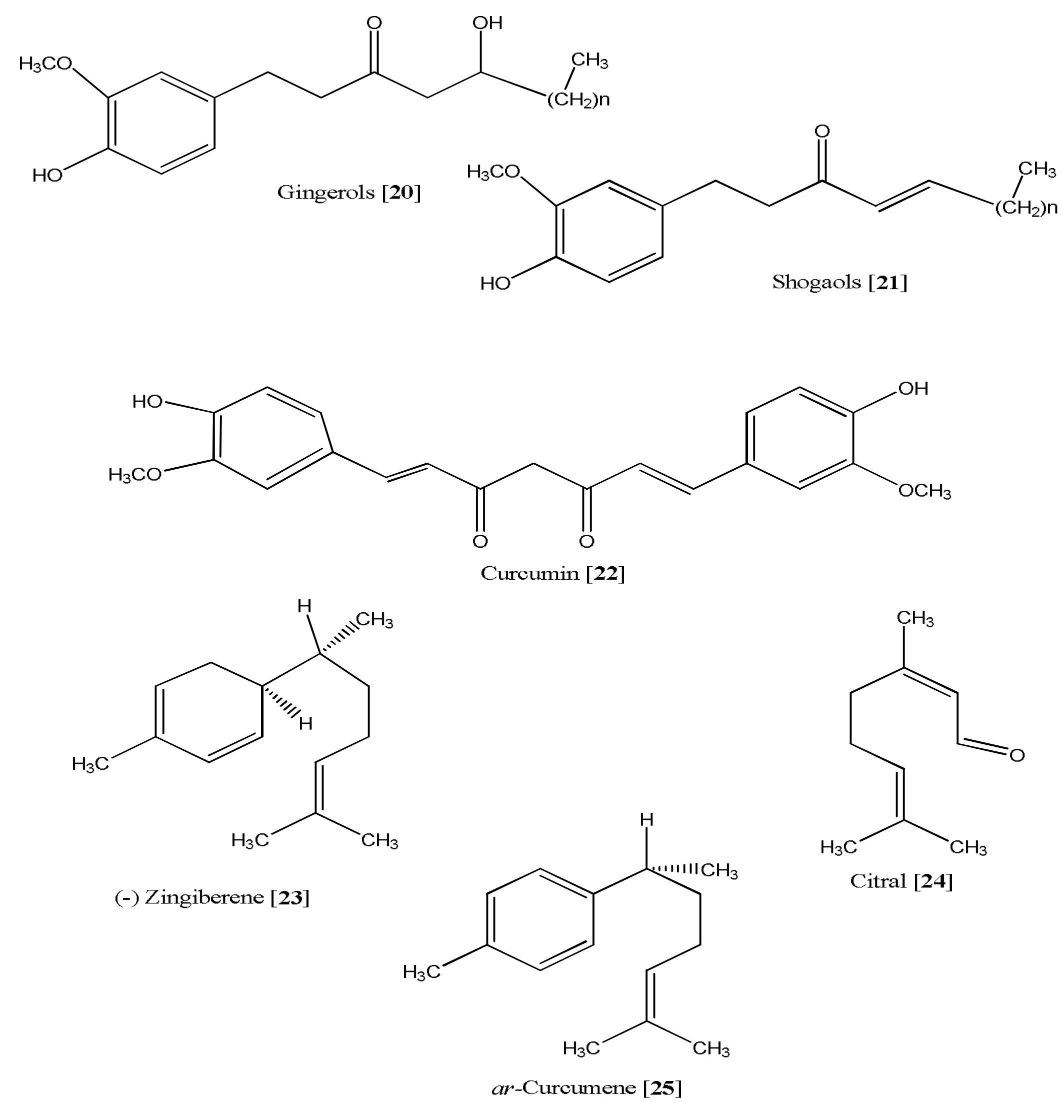


Figure 8. Constituents of ginger.

term toxicity (Tajuddin et al., 2003). Nutmeg oil possesses strong antibacterial, antifungal, anti-inflammatory and insecticidal properties due to the presence of sabinen, β- and α-pinenes (Figures 6 and 7), eugenol, isoeugenol, methyl engenol, safrol, neolignan, myristicin, elemicin, and linalool (Figure 9). Myristicin isolated from the nut impacts hallucinogenic properties and it is reported to be an effective insecticide, while the lignin types of the constituents are anticarcinogenic (Narasimhan and Dhake, 2006).

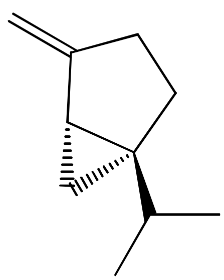
Onion (Allium cepa)

Onion and its juice may be used to treat appetite loss, prevention of age-related changes in blood vessels (arteriosclerosis), minor digestive disturbances and other traditional uses such as colds, cough, asthmas and diabetes (van Wyk and Wink, 2005). Onions undergo enzymatic breakdown of sulphur-containing substances due to damages of tissue to give pungent volatiles that cause weeping (van Wyk, 2005). The pharmacological activity as well as the pungent smell are due to several sulphur-containing compounds – mainly sulphoxides such as trans-5-(1-propenyl)-L-(+)-cysteine sulphoxide) and cepaenes (α-sulphinyl-disulphides) (Figure 10) (van Wyk and Wink, 2005)).

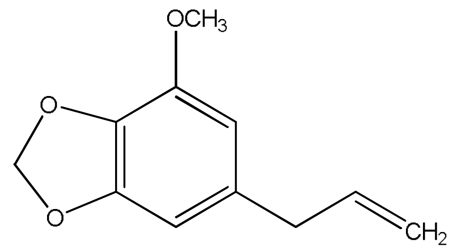
Pepper

Black pepper (Piper nigrum)

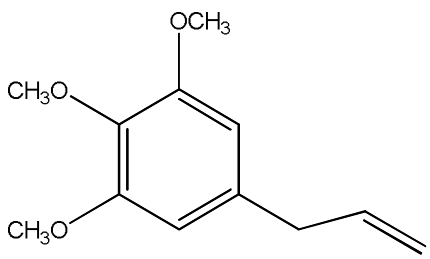
Black pepper oil contains β and α-pinenes, δ-limonene



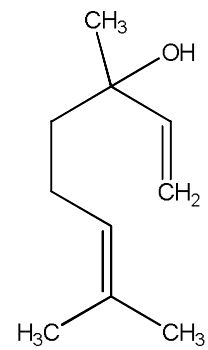
Sabinen [**26**]



Myristicin [**27**]

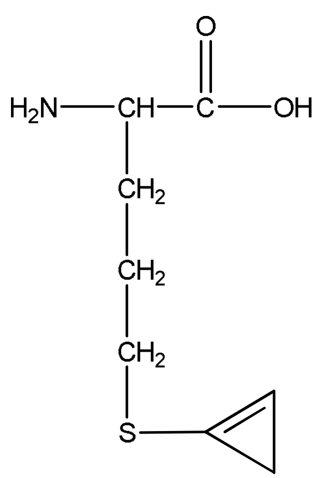


Elemicin [**28**]

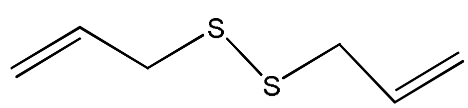


Linalool [**29**]

Figure 9. Constituents of nutmeg.



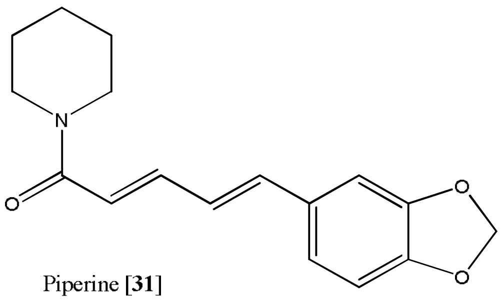
trans-5-(1-propenyl)-L-(+)-cysteine sulphoxide) [**29**]



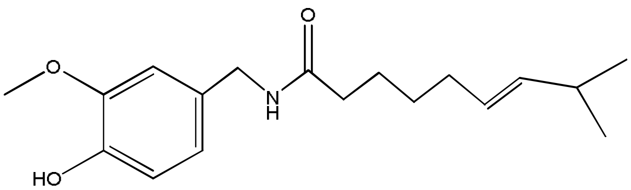
a-sulphinyl-disulphide [**30**]

Figure 10. Constituents of onion.

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 (Lewis et al., 1969). The major compounds in the fresh pepper are trans – linalool oxide and α-terpineol. Pepper has long been recognized as a carminative, (a substance that helps prevent the formation of intestinal gas), a property likely due to its beneficial effect of stimulating gastric acid secretion by piperine (Figure 11) , an alkaloid found in pepper (Ononiwu et al., 2002). Other researchers have shown that pepper demonstrated impressive antioxidant (Karthikeyan and Rani, 2003;



Piperine [31]



Capasaicin [32]

Figure 11. Constituents of pepper.

Vijayakumar et al., 2004; D'Souza et al., 2004) and anti-inflammatory effects (Mujumdar et al., 1990; Pratibha et al., 2004). Chilli causes dyspepsia in patients with or without ulcer, and patients with ulcer are often advised to avoid its use (Desai et al., 1977). Clinical data suggest that chilli ingestion may have a beneficial effect on human peptic ulcer disease (Desai et al., 1977).

The protective effect of capsicum could involve vanilloid receptors because resiniferatoxin an ultrapotent analogue of capsaicin also displays antiulcer activity and both capsaicin (Figure 11) and resiniferatoxin act on vanilloid (capsaicin) receptors. Piperine, piperyline and piperamine; the pungent alkaloid present in *Piper nigrum* Linn, and *P. longum* Linn enhanced the bioavailability of various structurally and therapeutically diverse drugs (Khajuria et al., 1998). The sharp smell is due to the essential oil, which contains mainly sabinen, piperine, phellandrene, linalool and limonene.

Chilli pepper (Capsicum frutescens)

Chilli pepper hot spices may interact with epithelial cells of the gastrointestinal tract to modulate their transport properties (Jensen-Jarolim et al., 1998). It contains piperine and capsaicin (Figure 11). Several pharmacological effects of capsaicin transiently reduced resistance and piperine increased resistance, making them candidates for causing the effects seen with crude spice extract (Khajuria et al., 1998). Both black and red pepper may induce epigastric pain by removing the stomach's hydrophobic lining and activating intramucosal pain receptors (Bhatia, 2000). Chilli being rich in phenolic compounds would be expected to bind iron in the intestine and inhibit its absorption in humans. Capsaicin affected carbohydrate absorptive ability of duodenal epithelial cells but lipid absorption was not affected (Kawada et al., 1986; Srinivasan and Satyanarayana, 1987). Capsaicin in skin creams is effective in the treatment of various kinds of pain.

Red pepper (Capsicum annuum)

Red pepper (*Capsicum annuum*) Linn (family: Solanaceae) produces capsain and capsaicin, used as spice and medicine (Columbus, 1987). Capsaicin, the pungent active principle of red chilli has been shown to cause gastric mucosal oedema and hyperemia and decrease in the gastric acid output (Desai et al., 1977; Nopanitaya, 1973). Capsaicin helps the metabolism of epoxide aromatic hydrocarbons, which interferes with their ability of bind to DNA (causing mutations) (Suzuki and Iwai, 1984).

Star anise (Illicium verum)

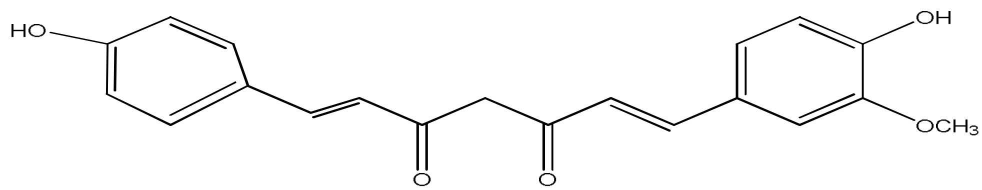
In star anise, the presence of a prenyl moiety in the phenylpropanoids plays an important role in antitumour–promoting activity. Hence, the prenylated phenylpropanoids might be valuable as a potential cancer chemopreventative agent (Padmashree et al., 2007).

Tamarind (Tamarindus indica)

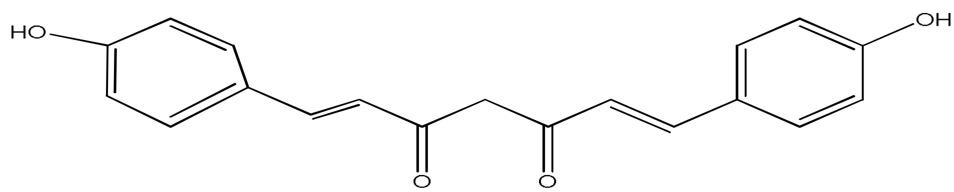
It has numerous traditional uses such as the treatment of liver and bile disorders. The fruit pulp is used as drinks and it is rich in pectin, monosaccharides and organic acids.

Turmeric (Curcuma longa)

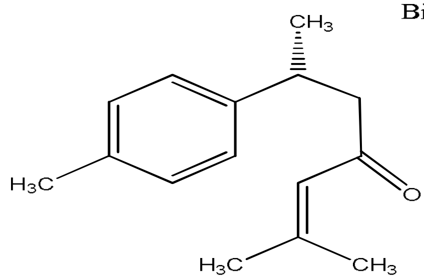
Turmeric is the dried rhizome of plant *Curcuma longa* and apart from its culinary appeal and common use as a spice, it is well known for its medicinal properties in Egyptian and Indian culture for more than 6000 year. It is used for the healing of peptic ulcer and for its carminative effects (van Wyk and Wink, 2005). Curcumin (1, 7-bis (4-hydroxy-3-methoxy phenyl)-1-6-hepatadine-3-5-dione), demethoxycurcumin and bisdemethoxycurcumin (Figure 12) are members of curcuminoid family; represents one of the yellow pigments isolated from turmeric. Other compounds are bisabolane, guaiane, α- and β– turmerone, curlone and zingiberene. Its immunomodulatory properties including anti-oxidant, anti-inflammatory and anti-tumor properties are well documented (Govindrajan, 1980). The curcumin reduces nitric oxide(NO) and exerts beneficial effects in experimental colitis, therefore



Demethoxycurcumin [33]



Bisdemethoxycurcumin [34]



Turmerone [35]

Figure 12. Constituents of star anise.

inflammatory bowl diseases (IBD) due to the oxidative and nitrosative stresses are treated by this yellow pigment (Platel and Srinivasan, 1996). The immuno-nutritional ability of curcumin has demonstrated its active role in the treatment of the allergic (Govindrajan, 1980). The powder form is used in various dishes.

Turmeric contains essential oils, fatty oils and 2 to 5% curcuminoids. Certain varieties contain up to 9% curcuminoids. It has all proximate principles such as carbohydrates, proteins and fats and provides all nutrients in small quantities. Turmeric is fairly rich in omega-3 fatty acids. Curcuminoids are polyphenolic compounds with a β-diketone moiety. The 3 types of curcuminoids, namely Curcumin I, II and III, differ with regard to their hydroxyl and methyl groups. Current efforts in research are focused on evidence-based science to determine the functional benefits of their bioactive compounds. Whole turmeric or the extracted curcuminoids appear to be active in many disease processes with specific reference to chronic ailments such as cardiovascular, degenerative, infective and inflammatory disorders as well as cancers. Embelic acid and turmeric are potential hypolipidemic and hypocholesterolemic agents (Dixit et al., 1988). The chemopreventive and bioprotectant property of curcumin in turmeric increases cancer cells' sensitivity to certain drugs commonly used to combat cancer, rendering chemotherapy more effective. It also possesses strong antimicrobial and antioxidant activity (Lim et al., 2001) and inhibits HIV-1 integrase (Li et al., 1993).

Curcumin and capsaicin altered bile salt secretion to make it less lithogenic and also lowered cholesterol levels, without any significant effect on fat absorption (Dixit et al., 1988). Capsaicin acted as a lipotrope, preventing triglyceride accumulation and increasing preferential utilization of fats (Dixit et al., 1988). It also stimulated lipid mobilization and lowered perirenal adipose tissue weight and serum triglycerides in fat fed rats (Dixit et al., 1988). Curcumin, eugenol and ferulic acid reduced fatty acid biosynthesis in rat liver and increased skeletal muscle lipoprotein lipase activity (Srinivasan and Satyanarayana, 1987).

VALUE ADDITION AND NEW PRODUCT DEVELOPMENT

Basic qualities such as aroma flavour, pungency, colour, etc must be conserved for a value added product and this has to start at the farm – level. The first spice oil and oleoresin industry was started in 1930 in India at Calicut by a private entrepreneur. Extracts of ginger were manufactured during 2nd world war. The major oils were from black pepper, chilli seed, capsicum, clove, nutmeg, mace, cassia, galagal, juniper and peppermint (Guenther, 1950). Pepper oil, ginger oil, celery seed oil, and peppermint were the major oils exported from India. Oleoresins exported are black pepper, chillies, capsicum, ginger, turmeric, white pepper, coriander, cumin, celery, fennel, mustard seed, garlic, clove, nutmeg, tamarind, rosemary and curry powder oleoresins. Green tea extract (*Camellia sinensis*) was given a qualified licence by FDA for cancer prevention due to (-)-epigallocatechin gallate presence.

CONCLUSION

Spices produce vast and diverse assortment of organic compounds, the great majority of which do not appear to participate directly in growth and development. These substances, traditionally referred to as secondary metabolites, assume great significance. Even though these chemical structures are perceived generally as biologically insignificant, several researches have shown their usefulness in human health concerns. Secondary metabolites in spices and herbs have been a fertile ground for chemical investigation for decades, driving the frontiers of chemical knowledge forward. In recent years, there has been an emphasis on secondary metabolites in relation to dietary components, which may have a considerable impact on human health. Reports from studies on animals models and *in vitro* system, leads us to direct future research perspectives in this area. The action of spices on reproductive functions as well as their potential role as regulators of fertility and/or conception also is an area holding great future promise. Synergy is an important concept in spice physiology and has a pharmacokinetic basis. Components of whole spices which are not active themselves can act to improve the stability, solubility, bioavailability or half life of the active components. Hence, a particular chemical might in pure form have only a fraction of the pharmacological activity that it has in its plant matrix thus suggesting that measuring an individual's food intake and assessing individual variation in disposition, bioavailability, and metabolism of micronutrients might allow for more accurate and individualized nutritional approaches for dietary prescription.

Dietary modifications will only work if they are in consonance with individual preferences, culture values and philosophical orientations toward health and disease. This presentation will be useful to plant breeders, nutritionists, other researchers, and the general public who are interested in the antioxidant potentials of various herbs and spices as culinary supplements.

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