CHAPTER 1

Introduction

1.1 Aim, Objective and Scope of the Thesis

The thesis is an attempt to apply spectroscopic methods to investigate a few natural products having both adverse and beneficial effects on the human body. The natural products selected for this study are chilli and its seeds (Capsicum annum L.), turmeric (Curcuma longa L.), and black pepper (Piper nigrum L.). The selected spectroscopic methods are X-ray fluorescence (XRF), visible emission, atomic absorption (AAS), Fourier transform infrared (FT-IR), Fourier transform Raman (FT-Raman) and fluorescence spectroscopy. Through XRF, AAS and visible emission spectroscopy, the elemental analyses of the samples have been done. FT-IR and FT-Raman spectroscopic methods which provide complete information about the functional groups (bonding type between elements) of the samples, are used for qualitative structural information. The static fluorescence method has been used for getting large scale molecular information. The thesis has two main objectives: first, to provide a satisfactory spectroscopic characterisation of the samples, and second, to substantiate popular beliefs regarding the use of the samples for medicinal and nutritional purposes as well as different scientific reports on these items. The results presented in this thesis can be used as a biodiversity database as well as in quality control of the samples.
It is to be mentioned here that although a lot of studies have been carried out on these samples, these are not informative from the structural and constituents point of view. Studies are mainly related to some investigations of the samples’ affect on the human body, use of the samples for the treatment of different diseases and comparisons of their affects on the human body with popular existing medicines. Further, a survey of literature indicates that studies on the molecular structure of the samples and also on their composition through spectroscopic methods are almost negligible.

1.2 Chilli and its seeds (*Capsicum annum* L.)

Chilli is a fruit of a plant from the genus *Capsicum*. The *capsicum* species are herbs or shrubs that can grow up to a metre tall. There are many kinds of fruits:

1. The long or chilli pepper is either green or red and grows up to 7-15 cm long,
2. The bell or sweet pepper is puffed up, round, or oval,
3. The cherry pepper is cherry shaped and can be red, yellow or purple.

The chilli pepper is an important spice of high commercial and medicinal value due to its antioxidant, anti-cancerous and many other properties. It occupies an important place in the history of human culture in many countries. The plant can be used to relieve uterine pain associated with childbirth [1]. The leaves of chilli peppers are used to cure toothache. The fruits are used to stimulate gastric activities and increase blood circulation [2]. It is also a stimulant, carminative, used locally for neuralgia and for rheumatism [3]. It is well-known that the fiery taste of chillies is due to the active constituent *capsaicin* (*C<sub>9</sub>H<sub>14</sub>O<sub>2</sub>). Some other chemical constituents of chilli pepper are solandine, solanine, solasidine, scopoletin, chlorogenic acid, alanine, amyrin, caffeic acid, camphor, carvone, cinnamon, citric acid, linalool, linoleic acid, oleic, piperine, vitamin B1, B3, C, E, oleoresin etc [4]. Chilli peppers originated in the Americas, and
their cultivations have grown up around the world, because they are widely used as food and in medicines. Chilli peppers have been a part of the human diet in the Americas since at least 7500 BC. The archaeological evidence at sites located in southwestern Ecuador shows that chilli peppers were domesticated more than 6000 years ago [5], and is one of the first cultivated crops in the Americas.

Antibacterial effect of chilli was observed by Takashi et al. in mice fed with a diet containing 2% red pepper [6]. Antioxidant compounds and their antioxidant activity in four different coloured (green, yellow, orange, and red) sweet bell peppers were investigated by Sun et al. [7]. Ascorbic acid, capsaicin, and total phenolic compounds found in chilli contributed to its antioxidant activities. The total phenolics content of green, yellow, orange, and red peppers were 2.4, 3.3, 3.4, and 4.2 μmol catechin equivalent/g fresh weight, respectively. The red pepper had significantly higher total phenolics content than the green pepper. Among the four different coloured peppers, red pepper contained a higher level of β-carotene, capsanthin, quercetin, and luteolin. The yellow pepper had the lowest β-carotene content, while the green one had undetectable capsanthin and the lowest content of luteolin. The free radical scavenging abilities of peppers were lowest in the green pepper but not significantly different from the other three peppers. All four coloured peppers exhibited significant abilities in preventing the oxidation of cholesterol during heating. However, these four peppers did not show significant differences in their abilities in preventing cholesterol oxidation [7]. Rabbits fed with 1% red pepper powder for 12 weeks showed reduced blood plasma cholesterol ester transfer protein activity. The total cholesterol, triglyceride, LDL-C, VLDL-C, and VLDL-TG levels and the atherogenic index were all decreased by using the red pepper group, whereas the HDL-C level was found to be higher after the use of red pepper [8].
Research done so far on the diet of human being reveals that after adding chilli to foods, the oxidation of LDL or bad cholesterol become high, which ultimately minimises the development of major risk for cardiovascular disease [9]. Researchers are suspecting that the hot-tasting component of chilli peppers, i.e the capsaicin, may be carcinogenic. A population-based case-control study conducted by Carnillo et al. in Mexico City during 1989–1990 examined the relationship between chilli pepper consumption and gastric cancer risk. They concluded that the chilli pepper consumption may be considered as a strong risk factor for gastric cancer, and proposed further studies to test their hypothesis [10]. Further it has also been reported that Aflatoxins and N-nitroso compounds, which are carcinogenic, are frequently found in chilli powder [11, 12]. Researchers have used capsaicin from chillies to kill nerve cells in the pancreases (gland lying across the posterior wall of the abdomen) of mice with Type 1 diabetes, thus allowing the insulin producing cells to start producing insulin again [13]. It has also been found that the amount of insulin required in order to minimise blood sugar after having a meal can be reduced if the meal contains chilli pepper [14]. Several studies found that capsaicin could have an anti-ulcer protective effect on stomachs infected with Helicobacter pylori by affecting the chemicals, the stomach secretes in response to infection [15-17]. By combining an anesthetic with capsaicin, researchers can block pain in rat paws without causing temporary paralysis. This anesthetic may sometime allow patients to be conscious during surgery. It may also lead to the development of more effective treatment of chronic pain [18, 19]. Considering the consumption of capsaicin as a food additive and its current medicinal application for human beings, correct evaluation and precise assessment of any harmful effects of this compound are essential from the view point of public health issues. Numerous investigations have
been conducted to determine the adverse and favourable effects of capsaicin and chilli peppers, but results are found discordant. Further, investigations done so far focused on the peppers which contain the fruit as a whole: skin as well as the seeds, but no work has been done specifically on the seeds of the crop.

1.3 Turmeric (*Curcuma longa* L.)

Turmeric with the botanical name *Curcuma longa* L. belongs to the family Zingiberaceae and has been attributed a number of medicinal properties in the traditional system of medicine for treating several common ailments [20-23]. It belongs to the genus *Curcuma*, which consists of several plant species with underground rhizomes and roots. About 40 species of the genus are indigenous to India, indicating the Indian origin [24]. Originally, it had been used as a food additive to improve the palatability, storage and preservation of food. The spice is cultivated in warm, rainy regions like India, China, Indonesia, Jamaica and Peru [25]. It is estimated officially that about 80% of the world production of turmeric is from India alone.

The use of turmeric dates back nearly 4000 years to the Vedic culture in India, where it was used as a culinary spice and had some religious significance. The name is derived from the Latin term *terra merita*, meaning 'meritorious earth', referring to the colour of ground turmeric, which resembles a mineral pigment. In many languages, turmeric is named simply as 'yellow root'. Turmeric is an erect perennial herb with thick and fleshy rhizomes and leaves in sheaths, characteristic of the family Zingiberaceae. The plant reaches a height of about 1 metre. Leaves are alternate, obliquely erect or subsessile. The underground rhizome consists of two distinct parts: the egg-shaped primary or mother rhizome, which is an extension of the stem, and the long cylindrical, multibranched secondary rhizomes, growing downward from the
primary rhizomes. Rhizomes are of orange-brown, pale yellow or reddish-yellow in colour.

In India and Nepal, turmeric rhizomes, popularly known as ‘Haldi’ rhizomes, are used as a household remedy [26]. Turmeric has been used internally as a stomachic, tonic and blood purifier and externally in the prevention and treatment of skin diseases [27]. It is also effective against biliary disorders, cough, anorexia, diabetic wounds, rheumatism and sinusitis [28]. Turmeric is used widely as a food colourant and is one of the principal ingredients in curry powder. In the food industry, turmeric powder is used in mustard paste, curry powder, etc. In Asian countries, dry or fresh turmeric, as well as ground turmeric, are used for vegetable and meat dishes and soup-like dishes [25]

It has long been used in both Ayurvedic and Chinese medicine as an anti-inflammatory medicine, to treat digestive disorders and liver problems, and for the treatment of skin diseases and wound healing. Epidemiological observations suggest that turmeric consumption may reduce certain forms of cancer and render other protective biological effects in human, which is attributed to its constituent – curcumin [29]. Thus, it is used effectively as anti-inflammatory, antiangiogermic, antioxidant, anticancerous etc. In particular, these compounds block several enzymes required for the growth of tumours and may therefore have a role to play in future cancer treatments. As a treatment, it also has some enticing attributes. Curcumin is a non-toxic, highly promising natural antioxidant compound having a wide spectrum of biological functions. It is expected that in the near future, curcumin may find application as a novel drug to control various diseases, including inflammatory disorders, carcinogenesis and oxidative stress-induced pathogenesis. New research also suggests that turmeric may play a vital role in fighting HIV/AIDS, particularly HIV Type 1. With the support
of nanotechnology, the therapeutic effect of turmeric can be enhanced. In future, the therapy can be used for curing various diseases. Not only does turmeric slow cancer growth, it has also been found to correct the cystic fibrosis defect in mice, to help prevent the onset of alcoholic liver disease and may slow down other serious brain diseases like multiple sclerosis and Alzheimer’s disease.

1.4 Black Pepper (*Piper nigrum* L.):

Black pepper (*Piper nigrum* L) belongs to the family Piperaceae. The word ‘pepper’ is derived from the Sanskrit *pippali*. It is cultivated for its fruit, which is usually dried and used as a spice and seasoning. The same fruit is also used to produce white pepper and green pepper. Black pepper is native to South India, where it is cultivated extensively, and also to some other tropical regions. The fruit, known as peppercorn when dried, is a small drupe, 5 mm in diameter, dark red when fully mature, containing a single seed. Dried ground pepper and its variants are some of the most common spices in European cuisine, having been known and prized since antiquity for both its flavour and its use as a medicine. The spiciness of black pepper is due to the chemical *piperine*. Ground black peppercorn, usually referred to simply as ‘pepper’, may be found on nearly every dinner table around the world, often alongside table salt. Black pepper, also nicknamed as ‘black gold’ and the ‘king of spices’, is one of the most important and widely consumed spice in the world. Compared with many other spices, properly dried black pepper (moisture content 8 – 10%) can be stored in airtight containers for many years without losing its taste and aroma.

Black pepper oil can be used to help in the treatment of pain relief, rheumatism, chills, flu, colds, exhaustion, muscular aches, physical and emotional coldness, fevers, as a nerve tonic and to increase circulation. Furthermore, it increases the flow of saliva,
stimulates appetite, encourages peristalsis, tones the colon muscles and is a general digestive tonic [31]. Black pepper has multiple uses in the processed food industry, in kitchens, in perfumery, in traditional medicine and even in beauty care. Pepper is valued for its pungency and flavour, which is attributed by the alkaloid piperine and the volatile oil [32]. The pungency of black pepper has been the subject of chemical investigations since the early 19th century. In 1819, Oersted isolated piperine, the most abundant alkaloid in pepper, as a yellow crystalline substance and its structure was later identified as the trans form of piperoyl piperidine [33]. The pungent dark oily resin obtained after removal of piperine from the oleoresin was named as chavicine [34]. Chavicine was claimed to possess a far greater bite on the tongue than crystalline piperine, but later workers demonstrated that piperine in solution was very pungent.

The therapeutic properties of black pepper oil include analgesic, antiseptic, antispasmodic, antitoxic, aphrodisiac, diaphoretic, digestive, diuretic, febrifuge, laxative, rubefacient and tonic (especially of the spleen). As a natural medicinal agent, black pepper in tea has been credited for relieving arthritis, nausea, fever, migraine headaches, poor digestion, strep throat and even coma. It has also been used for non-medical applications, as an insecticide. Of course, black pepper is a favourite spice of cooks because of its dark colour and pungent aroma and flavour. Pepper and pepper-containing preparations are used for the treatment of intermittent fever, neuritis, cold, pains and diseases of the throat. In Chinese medicine, pepper is used for the treatment of malaria. There is also report about the antioxidant potential of black pepper essential oil and oleoresin extracted by supercritical carbon dioxide extraction [35].
References:


35. Tipsrisukond N, Fernando LN & Clarke AD (1998). Antioxidant effects of essential oil and oleoresin of black pepper from supercritical carbon dioxide
extractions in ground pork *Journal of Agricultural and Food Chemistry* 46 (10) 4329–4333.