USAGE OF INDIAN CULINARY SPICES AS A PROMISING NUTRACEUTICAL AND FUNCTIONAL FOOD

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Abstract

Introduction: Indian spices are rightly regarded as Treasures of Indian Kitchens. Many spices contain high levels of antioxidants that help to counteract the effect of damaging free radicals thereby playing an important role in therapeutics and alternative medicine. These also experience well-established reputation for their nutraceutical and functional food efficacy. Moreover, these are well known for their pharmacological and prebiotic properties. Indian hotel industry also efficiently uses these natural aromatic and stimulating components for gaining tasty food.

Objectives:

- To assess antioxidant capacity of Indian culinary spices to combat ageing
- To ascertain nutraceutical efficacy of these spices
- To highlight usage of selected spices as functional food

Methodology: Extracts of seventeen Indian culinary spices were prepared by steam distillation process and assessed for their antioxidant activity on copper induced in vitro protein oxidation. An extensive survey was conducted on usage of selected spices as remedy to fight against disorders.

Results/Findings: Maximum inhibition was exhibited by extracts of mustard, cumin, turmeric, fennel, coriander and mint. Turmeric, fennel and mint extracts were able to inhibit in vitro oxidation process completely even at 50 percent dilution indicating the presence of strong antioxidants. A range of 30-35 percent inhibitory ratio was noted with cardamom, cinnamon, curry leaves, bay leaves, fenugreek seeds, nutmeg and black pepper. Diluted extracts of nutmeg and black pepper were ineffective to prevent oxidation of BSA. Very low inhibitory ratio was noticed in ginger and onion extracts. Nil protection against oxidative damage was shown on inclusion of cardamom, nutmeg, clove and garlic.

Conclusion/Recommendations: Further research is needed on determination of correlation between antioxidant capacity and chemical composition of bioactive compounds in spice extracts. Therapeutic potential of these spices may further be explored and exploited to develop new formulations in order to crack their utility as a nutraceutical.

Keywords: antioxidants, nutraceutical, functional food, spices, therapeutic

Introduction

Spices, the predominant flavoring, coloring and aromatic agents in foods and beverages, are now gaining importance for their diversified uses. The nutritional, anti-oxidant, anti-microbial and medicinal properties of spices have far-reaching implications. In the present scenario, the anti-diabetic, anti-hypercholesterolemic, anti-carcinogenic, anti-inflammatory effects of spices have paramount importance, as the key health issues of mankind nowadays are diabetes, cardio-vascular diseases, arthritis and cancer.

Spices or their active principles could be used as possible ameliorative or preventive agents for these health disorders. Extensive studies on animal models carried out indicate that spices could be consumed at higher dietary levels without any adverse effects on growth, organ weights, food efficiency ratio and blood constituents. Curcumin, the coloring pigment present in turmeric, capsaicin, the pungent principle in red pepper, allicin, the active principle in garlic, 6-gingerol, the pungent principle in ginger, saponin and fiber present in fenugreek are immensely valuable in health care with their multiple physiological effects. India, the land of spices, could exploit the fast growing nutraceutical sector with her high intrinsic quality spices. The scope of spices like turmeric, ginger, fenugreek, garlic and red pepper in the nutraceutical industry with their possible role in the control/prevention of important health disorders are being explored. (M.R. Shylaja and K.V. Peter)

Spices and aromatic herbs have been used since antiquity as preservatives, colorants, and flavor enhancers. Spices, which have long been the basis of traditional medicine in many countries, have also been the subject of study, particularly by the chemical, pharmaceutical, and food industries, because of their potential use for improving health. Both in vitro and in vivo studies have demonstrated how these substances act as antioxidants, digestive stimulants, and hypolipidemics and show antibacterial, anti-inflammatory, antiviral, and anticancerigenic activities. These beneficial physiological effects may also have possible preventative applications in a variety of pathologies.

Spices are esoteric food adjuncts that have been used as flavoring and coloring agents, and as preservatives for thousands of years. Spices have also been recognized to possess medicinal properties and their use in traditional systems of medicine has been on record for a long time. With the advancement in the technology of spices and on knowledge of the chemistry and pharmacology of their active principles, their health benefit effects were investigated more thoroughly in recent decades. Many health promoting attributes of these common food adjuncts have been recognized in the past few decades by pioneering experimental research involving both animal studies and human trials. These studies documented digestive stimulant action, hypolipidemic effect, antidiabetic influence, antilithogenic property, antioxidant potential, anti-inflammatory property, antimutagenic, and anticarcinogenic potential of spices. Among these, the hypocholesterolemic and antioxidant properties of a few specific spices have far-reaching nutraceutical value. These beneficial physiological effects also have the potential of possible therapeutic application in a variety of disease conditions. (Krishnapura Srinivasan, 2005)

Oxidation may be defined as a process which involves the addition of oxygen (O_2) or any other electronegative element or as a process which involves the removal of hydrogen (H_2) or any other electropositive element. Oxidation is literally *decay*. It is a natural process that occurs around us all the time. Oxidation provided energy needed for life yet within our bodies the process is a two – edged sword. Unfortunately, a small number of oxygen molecules we breathe are converted within our bodies to unstable free radicals. This oxidative reaction plays a crucial role in the formation of human disorders like cancer, emphysema, cirrhosis, atherosclerosis and arthritis which are all correlated with oxidative damage (Halliwell B. et. al., 1996).

Ageing appears to be in good part due to oxidants produced as byproducts of normal metabolism. Free radicals punch holes into our body's cellular membranes, damaging DNA, the genetic material within. Free radicals can even oxidise essential thiol groups of enzymes and proteins rendering them inactive. Hydrogen peroxide formed at in vivo high oxygen pressure can also cause damage.

Biomolecules inevitably get damaged by these processes. As we get older, lesions accumulate until we might have a few million lesions per cell. The body repairs much of the damage caused by oxidation. Our bodies have numerous ways of defending against damage caused by oxidation and repairing the lesions; glutathione protection, protection by enzymes such as catalase, glutathione peroxidase, glutathione reductase, superoxide dismutase, metal ions and antioxidants. However, the unrepaired damage can build up and over time may contribute to several diseases including cancer, cardiovascular or heart disease and cataracts. Antioxidants can prevent and reverse the harmful effects of oxidation. Thus the onset of disease caused by oxidation can be delayed or prevented. Antioxidants cannot delay ageing in healthy older people.

But they do help to minimize the damage made by several diseases especially those associated with old age e.g. cancer, neurological diseases, cardiovascular diseases, complications of diabetes etc.

Vitamin B, C and flavonoids are water soluble and work within the cells, watery interiors by protecting the aqueous parts of our cells and tissues while vitamin E is fat soluble and protects the lipid portions, especially cellular membranes that surround cells; in addition it improves immune function in older people and reduces the risk of some age related conditions, including heart diseases, some forms of cancer etc. Use of antioxidant rich spices for their medicinal values is attracting great attraction. Various spices used in Indian foods such as turmeric, cumin, fenugreek, mint, clove, ginger etc. are also documented for their medicinal properties. Some of them are reported to have flavonoids, fat-soluble and water-soluble vitamins also. The present investigations were undertaken to explore the possibility of medicinal uses of the common spices for their antioxidant properties.

The main objectives of the study were:

- To assess antioxidant capacity of Indian culinary spices to combat ageing
- To ascertain nutraceutical efficacy of these spices
- To highlight usage of selected spices as functional food

Review of Literature

Reactive oxygen species (ROS) are highly reactive and potentially damaging chemical species (Frankel and Meyer, 2000, Carpenter et. al., 2007, Suk Kim et. al., 2011). Free radicals can also cause lipid peroxidation in foods, which leads to their deterioration. Oxidized polyunsaturated fatty acids may induce aging and carcinogenesis. When produced in excess, ROSs can cause tissue injury. However, tissue injury can itself cause ROS generation. The oxidative damages caused by ROS Oxidative stress is one of the major etiological factors for diseases like Cataract, Cancer, Heart ailments, Arthritis, Alzheimer's disease, nutritional deficiencies, bacterial, viral infections (Halliwell B., 1996). Antioxidants can prevent the oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidative chain reactions (Tachakittirungrod et. al., 2007). Spices are strong source of natural antioxidants which known to protect tissues / cells from oxidative stress, which is generally considered to be a cause of mutation and leads to cancer (Ringman et al., 2005).

Spices and herbs are recognized as sources of natural antioxidants and thus play an important role in the chemoprevention of diseases and ageing (Nooman A., 2008). A large number of medicinal plants and their purified constituents have shown beneficial therapeutic potentials. Various herbs and spices have been reported to exhibit antioxidant activity, including Ocimum sanctum, Piper cubeba Linn., Allium sativum Linn., Terminalia bellerica, Camellia sinensis Linn., Zingiber officinale Roscoe and several Indian and Chinese plants. The majority of the antioxidant activity is due to the flavones, isoflavones, flavonoids, anthocyanin, coumarin lignans, catechins and isocatechins (Aqil F et. al., 2006). Antioxidant-based drug formulations are used for the prevention and treatment of complex diseases like atherosclerosis, stroke, diabetes, Alzheimer's disease and cancer (Devasagayam T. P. A. et. al, 2004). Generally, Spices, like turmeric, fenugreek, mustard, ginger, etc. may offer many health benefits and have been proven to counteract oxidative stress in vitro and in vivo (Tachakittirungrod et. al., 2007). Most of these spices have been intensely studied only for their components like phenolic compounds, beta carotene, curcuminoids and flavonoids (Manda and Adams, 2010, Suk Kim et. al., 2011), but when these so called active components are subjected to thermal stability tests, it is observed that, their antioxidant ability is considerably reduced.

3.1 Methodology

The selected spices were procured from the local market, identified and authenticated at Department of Botany, Kurukshetra University, Kurukshetra.

3.1.1 Chemicals Used

1. Bovine Serum Albumin (BSA) fraction V
2. Copper Chloride
3. 5,5 – Dithiobis 2-nitrobenzoic acid (DTNB)
4. Ethylenediaminetetraacetic acid disodium salt (EDTA)
5. Phosphate buffer
    i) Monobasic sodium phosphate ($Na_2HPO_4.2H_2O$)
    ii) Dibasic sodium phosphate ($NaH_2PO_4.2H_2O$)
6. Tris (hydroxymethyl) aminomethane buffer
7. Urea

All the above mentioned chemicals were of analytical grade and obtained from Hi-Media Laboratories Limited, Mumbai (India) or Sisco Research Laboratories.

3.1.2 Extraction

The seeds were dried at 60^0C in hot air oven till constant weight was attained. Finely powdered spices seeds were extracted with 80 percent methanol (1g/10ml) in a shaker at room temperature for 4 hours. Residue was again extracted with 80 percent methanol for 2 hours. Collected extracts were filtered through double layered muslin followed by centrifugation at 5000rpm for 5 minutes in order to get clear supernatant. Extracts were concentrated in a vacuum evaporator and stored at -20^0 C for further use. The extracts were diluted appropriately for various experiments.

3.1.2.1 Calculations

Inhibitory ratio of each extract was calculated by comparing the total oxidation taking place in absence of any spice extract i.e. control to the sulphydryl groups which could be saved due to the presence of extracts of some spices in the reaction mixture. Following equation was used to evaluate percent inhibitory ratio of each extract:

$$\text{Inhibitory Ratio (\%)} = \frac{\begin{pmatrix} \text{Cystein SH residue} & \text{Cystein SH residue} \\ \text{in presence of test sample} - & \text{in absence of test sample} \end{pmatrix}}{\begin{pmatrix} \text{Cystein SH residue} & \text{Cystein SH residue} \\ \text{before incubation} \quad - & \text{in absence of test sample} \end{pmatrix}} X\ 100$$

For every experiment, the following assays were done:

1. $\text{Buffer} + \text{CuCl2} + \text{BSA} \xrightarrow[\text{for 2 hrs.}]{\text{Incubated}} \underset{\text{(in buffer)}}{\text{EDTA}} + \underset{\text{(in buffer)}}{\text{Urea}} + \text{DTNB} \rightarrow \text{Read at 412nm say O.D.} = c$

2. $\text{Buffer} + \text{CuCl2} \xrightarrow[\text{for 2 hrs.}]{\text{Incubated}} \underset{\text{(in buffer)}}{\text{EDTA}} + \text{Urea} + \text{BSA} + \underset{\text{(in buffer)}}{\text{DTNB}} \rightarrow \text{Read at 412nm say O. D.} = a$

3. $\text{Buffer} + \text{CuCl2} + \text{BSA} + \text{Extract} \xrightarrow[\text{for 2 hrs.}]{\text{Incubated}} \underset{\text{(in buffer)}}{\text{EDTA}} + \underset{\text{(in buffer)}}{\text{Urea}} + \text{DTNB} \rightarrow \text{Read at 412nm against blank}$

a-c = Total $CuCl_2$ induced oxidation of BSA taking place in 2 hours at 37^0 C

b = Sulphydryl groups present when spice extract is included in the assay mixture

b-c = Sulphydryl groups saved due to inhibitory effect of the spice on BSA oxidation

Therefore,

$$\textbf{\textit{Inhibitory Ratio}}\ (\%) = \frac{\mathbf{b - c}}{\mathbf{a - c}}\mathbf{X\ 100}$$

3.2 Survey

Continuous field surveys were conducted for 2 years to the selected 328 households of Kurukshetra for data collection on regular basis. Various formal as well as informal discussions were conducted with the knowledgeable persons of the families like housewives, old ladies etc. (n= 483) to extract the true information. A semi-structured questionnaire was administered to know the usage, culinary function and remedial function of various commonly used spices during illness or disorders. The data collected has been presented in the form of a table for better presentation and comparison.

4. Results and Discussion

Spices, being agricultural commodities, are prone to spoilage by insect or microbial attack. Hence, the spice oils or oleoresins, which contain all the active principles of spices are extracted and marketed. Spice oils are obtained by the steam distillation of ground spices. Oleoresins are obtained by the solvent extraction of ground spices. The spice oils (extracts) prepared by steam distillation were used for the present studies.

4.1 Effects of the extracts of various spices on in vitro Protein Oxidation

In the preliminary experiment, the extracts of the selected spices were used as such. 100µl of the extract was added to the reaction mixture and the results were observed in terms of inhibition of protein oxidation induced by copper. Data in Table 1 shows that total sulphydryl groups in the BSA taken for assay recorded optical density of 0.590 after reaction with DTNB. But after incubating with $CuCl_2$ for two hours, sulphydryl groups left unoxidised recorded 0.162 at 412nm after reaction with DTNB.

$$\text{O.D. of Buffer} + CuCl_2 \longrightarrow \text{EDTA} + \text{Urea} + \text{BSA} + \text{DTNB} = a = 0.590$$

(in buffer)

$$\text{O.D. of Assay Buffer} + CuCl_2 + \text{BSA} = 0.162$$

Presence of extracts of mustard, cumin, turmeric, fennel, coriander and mint had offered an inhibitory effect on decrease in optical density i.e. oxidation of sulphydryl groups to the extent of 80 percent to 100 percent. There was no oxidation of BSA when turmeric, fennel and mint extracts were included in assay mixture along with copper indicating strong antioxidant activity of these extracts. Presence of mustard, cumin and coriander extracts in assay mixture saved about 80 percent of sulphydryl groups from oxidation as compared to control. However, extracts of cinnamon, black pepper, fenugreek, ginger, bay leaves and curry leaves could inhibit copper induced in vitro BSA oxidation by 27-40 percent when included in assay mixture, whereas inclusion of onion extract had marginal effect of 22.3 percent only. Oxidation of BSA was not affected by green cardamom, nutmeg, clove and garlic extracts.

Table 1: Effect of Inclusion of various Spice Extracts on Copper Induced *in vitro* Protein Oxidation

S.No.	Spice	O.D. at 412 nm (b)	Percent Inhibition (%)
1	Bay leaves	0.302	32.8
2	Black pepper	0.287	29.2
3	Green Cardamom	0.165	Nil
4	Cinnamon	0.317	36.2
5	Coriander	0.525	84.9
6	Clove	0.160	Nil
7	Cumin	0.506	80.2
8	Curry leaves	0.299	31.7
9	Fennel	0.598	100.0
10	Fenugreek	0.305	33.5
11	Garlic	0.163	Nil
12	Ginger	0.276	28.5
13	Mint	0.591	100.0
14	Mustard	0.509	81.3
15	Nutmeg	0.168	Nil
16	Onion	0.231	22.3
17	Turmeric	0.594	100.0

4.2 Effect of varying Concentrations of Spice Extracts on Inhibitory Ratio

In the subsequent experiments to observe the effect of varying concentrations of the extracts on inhibitory ratio, the extracts were diluted with 50mM Tris HCl buffer pH 7.4 Varying volumes of original extracts in 100µl of the diluted extract were included in assay mixture to observe the effect of varying volume of extracts in assay mixture on inhibitory ratio.

Inclusion of lower concentration of coriander had shown little inhibition of protein oxidation (Figure 1). The inhibitory effect was noticeable only at higher concentrations indicating that in coriander extract, antioxidant property is present in very low concentration but is strong enough to produce about 85 percent inhibition at 100µL.

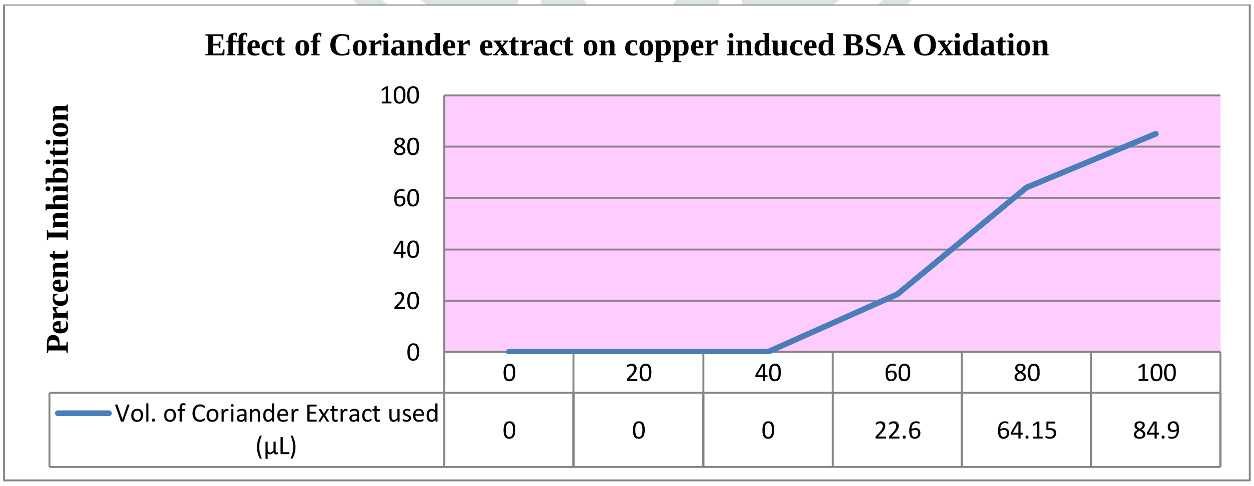

Fig.1 Effect of Coriander extract on Protein Oxidative Modification induced by Copper

Continuous acceleration in percent inhibition was observed in case of cumin (Figure 2).Cumin extract at very low volume of 20µL had shown 29.19 percent inhibition of protein oxidation, which increased almost linearly upto 80.29 percent at 100µL. These results denote an appreciable volume dependent activity of cumin extract on protein oxidation.

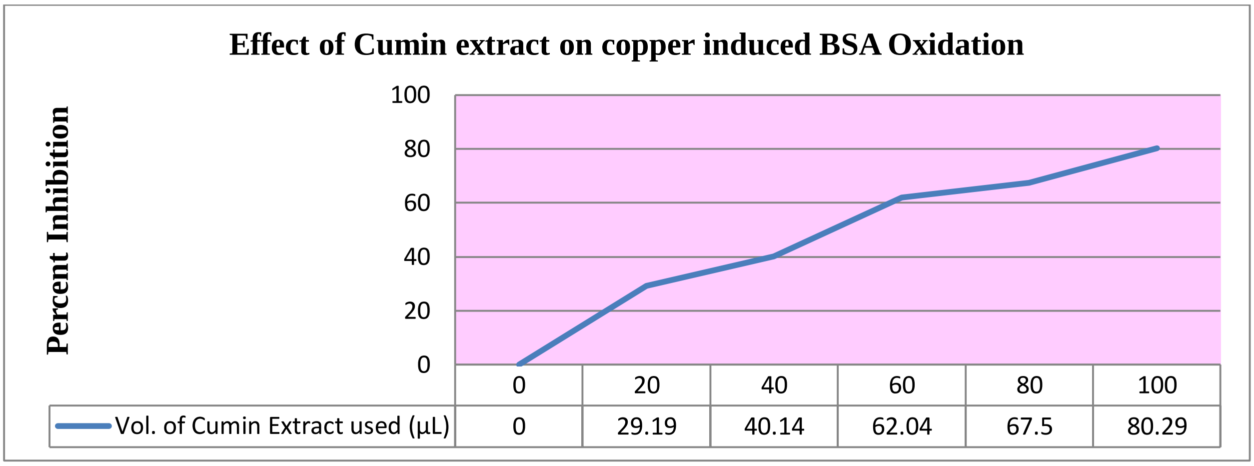

Fig.2 Effect of Cumin extract on copper induced BSA Oxidation in vitro

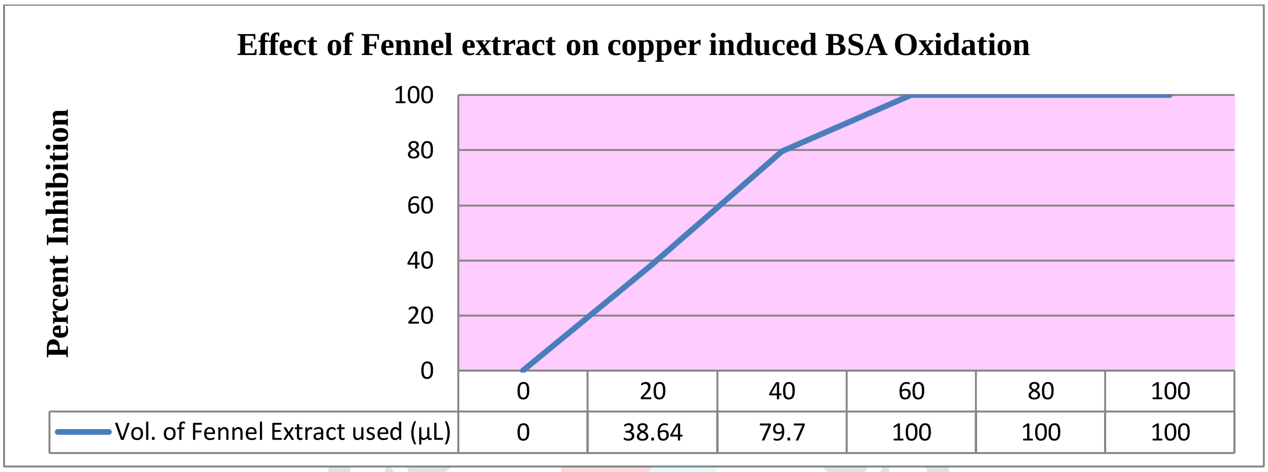

Fig.3 Effect of Fennel extract on copper induced BSA oxidative modification in vitro

Results observed in presence of fennel extract (Figure 3) highlight the two fold increase in percent inhibition when volume of extract was increased from 20µL to 40µL. The inhibition achieved was 100 percent for higher additions of amount of extract. This indicates that fennel extract has powerful antioxidant property for in vitro protein oxidation.

An increase in percent inhibition of in vitro protein oxidation with increase in volume had been observed in case of extract of mint. Addition of 40, 60 and 100 µl of extract to the assay mixture had registered inhibition of 59.9, 75 and 100 percent respectively (Figure 4). The results indicate that extract as low as 20µl is having antioxidant property enough to reduce protein oxidation by about 50 percent. This property increased linearly with volume.

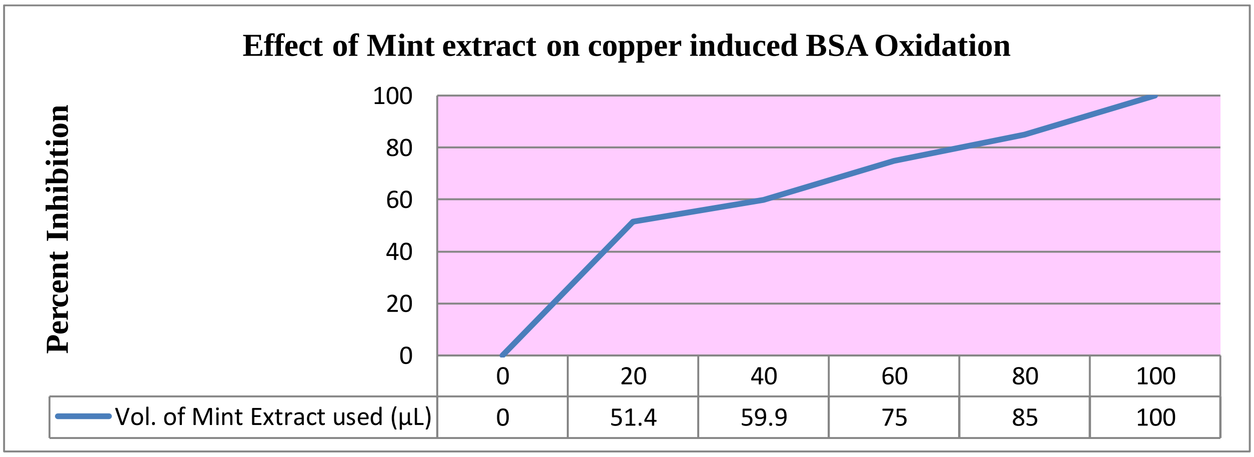

Fig.4 Effect of Mint extract on in vitro BSA oxidation

Results of effect of varying volume of extract of mustard on percent inhibition of protein oxidation are shown in Figure 5. It has been observed that protein oxidation was considerably reduced even when the amount of extract included in assay mixture was just 20µL. A sharp inhibition of about 45 percent was observed with 20-40 µL of mustard extract in the assay mixture. Inclusion of 100 µL of this extract had reduced the copper induced BSA protein oxidation by 81.13 percent.

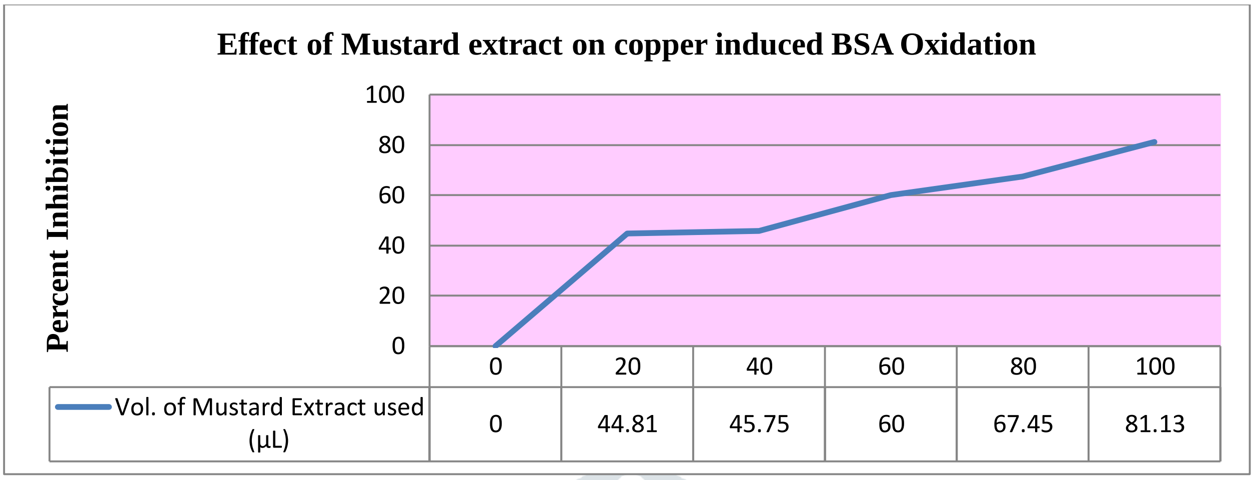

Fig.5 Effect of Mustard extract on copper induced BSA oxidation

The results in figure 6 show that presence of turmeric extract in the assay mixture had exerted a strong inhibitory effect on copper induced protein oxidation. Sulphydryl group oxidation was inhibited upto 27.8 percent by inclusion of 20µl of the extract in the assay mixture. An increase in the volume of extract had further increased the inhibition sharply and almost 100 percent inhibition was there in presence of 60µL or more of the extract. Complete inhibition of oxidative modification of BSA protein by turmeric has underlined its importance as an effective antioxidant.

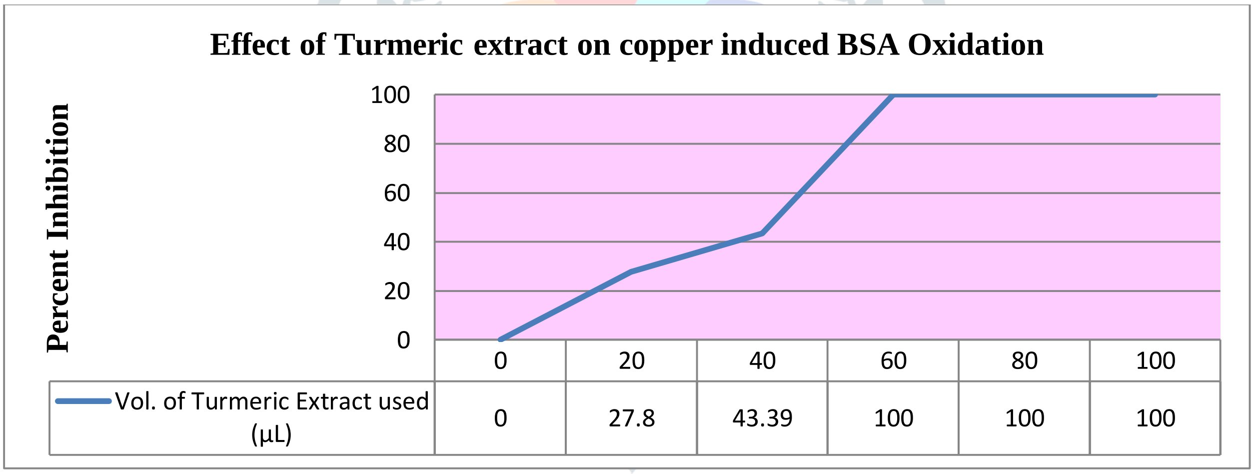

Fig.6 Effect of Turmeric extract on copper induced BSA oxidative modification in vitro

Mustard and cumin had shown similar increase in inhibition and similar maximum inhibitory ratio. Antioxidant principle in turmeric, fennel and mint seems to be most efficient with 100 percent inhibition, whereas antioxidants in fennel, coriander and mint seem to be more effective even at low concentrations. Antioxidant principles present in extracts of cinnamon, curry leaves, bay leaves, fenugreek seeds, nutmeg and black pepper seem to be comparatively less efficient since 30 to 35 percent inhibition observed with 60 µL extract was not further enhanced with volume. Lower concentrations of extractable antioxidants may be responsible for negligible inhibition with lower volume of extracts of pepper and ginger; which increases with increase in volume. Ginger and onion had exhibited very low inhibitory ratio. Green cardamom, nutmeg, clove and garlic had no steam extractable antioxidant to inhibit copper induced protein oxidation. Isolation of different antioxidant principles from these spices can be done to explore their medicinal uses.

4.3 Demographic Profile of Respondents

Table 2 depicts the demographic profile of the respondents. The characteristics include age, qualification and occupational status of the housewives and the old ladies like mother-in laws, grandmothers etc.

Table 2: Demographic Profile of Respondents

Parameter	Frequency (N = 319)	Percentage (%)
Age		
20 to 35 years	n = 45	14.1
36 to 50 years	n = 183	57.4
51 to 65 years	n = 91	28.5
Educational Qualification		
Primary	n = 27	8.5
Middle	n = 42	13.2
Matric	n = 85	26.6
Senior Secondary	n = 64	20.1
Graduate	n = 62	19.4
Post Graduate	n = 39	12.2
Occupational Status		
Housewife	n = 152	47.6
Self Employed	n = 93	29.2
Salaried	n = 74	23.2

Data regarding the culinary as well as therapeutic usage of commonly used spices was collected from the respondents by administering a semi-structured questionnaire. In case of less educated subjects and old ladies, questions were asked verbally to help them fill the questionnaire during informal visits to their households. The collected information about the therapeutic usage of the selected spices has been summarized in Table 3.

Table 3: Active Ingredient and Functional Properties of the selected Spices

Spice	Active Ingredient(s)	Functional Properties
Bay Leaves	**α-pinene, β-pinene, Myrcene, Limonene, Linalool, Neral, Methyl Chavicol, α-Terpineol, Eugenol, Geranyl Acetate**	• **Anti inflammatory properties** • **Anti diabetic** • **Anti cancer properties**
Black pepper	**Piperine**	• **Anti tumour properties** • **Anti bacterial properties** • **Anti pyretic properties** • **Digestive stimulant** • **Antioxidant**
Cardamom	**Alpha-terpinyl acetate, Cineole, Linalyl acetate, Limonene, Linalool, Limonene, Terpinolene and Myrcene**	• **Antioxidant** • **Anti inflammatory properties** • **Anti bacterial properties** • **Diuretic**
Cinnamon	**Cinnamaldehyde**	• **Carminative properties** • **Anti fungal properties** • **Anti viral properties** • **Anti diabetic**
Coriander	**Citronelol**	• **Anti diabetic**

		• Antioxidant • Anti inflammatory properties
Clove	Eugenol	• Antioxidant • Anti carcinogenic properties • Anti microbial properties
Cumin	Cuminaldehyde, Pyrazines	• Detoxifying properties • Anti ageing
Curry leaves	Glycosides, Carbazole alkaloids, Koenigin, Girinimbin, Iso-mahanimbin, Koenine, Koenidine and Koenimbine	• Anti bacterial properties • Anti diabetic • Anti stress
Fennel	Alpha pinene, beta myrcene, beta pinene, Anethole, Fenchone, Estragole	• Antioxidant properties • Anti microbial properties • Detoxifying properties
Fenugreek	Saponins, 4-hydroxyisoleucine, Trigonelline, Galactomannan, Trigoneosides	• Anti ageing properties • Anti diabetic • Anti cancer properties
Garlic	Allicin	• Anti carcinogenic properties • Antibiotic properties • Anti hypertensive properties • Cholesterol lowering properties • Anti thrombotic properties • Anti diabetic properties
Ginger	Gingerol	• Anti oxidative properties • Anti inflammatory properties • Anti diabetic properties • Cholesterol lowering properties • Anti cancer properties
Mint	Menthol, Menthone	• Anti oxidant properties • Mouth freshening properties • Anti congestion properties
Mustard	Glucosinolates like Sinigrin, Myrosin and Sinalbin	• Anti cancer properties • Anti bacterial properties • Healing properties • Cholesterol lowering properties
Nutmeg	Eugenol, Myristicin	• Anti cancer properties • Anti diabetic properties • Anti arthritis properties
Onion	Quercetin	• Anti tumour properties • Anti oxidant properties • Anti inflammatory properties • Anti diabetic properties
Turmeric	Curcumin	• Anti inflammatory properties • Antioxidant properties • Anti carcinogenic properties

Conclusion

The expansion of nutraceutical industry is far beyond those of food and pharmaceutical industries. The customers' perception of therapeutic and curative effects of neutraceuticals will highlight their future demand. Although nutraceuticals have significant promise in the promotion of human health and disease prevention, health professional, nutritionists and regulatory toxicologist should strategically work together to plan appropriate regulation to provide the ultimate health and therapeutic benefit to mankind. The interaction of nutraceuticals with food and drugs is another area, which should be taken into consideration. Food based approaches for enhancing the intake of spices and phyto-chemicals can offer an avenue to greatly impact the onset and progression of chronic diseases, oxidant stress and ageing. Although the chemo- preventive approach is a recognized strategy, public health action should be directed at increasing the consumption of spices which possess a package of protective phyto-nutrients.

The tested spices were found to be rich in antioxidant sources. Maximum inhibition was observed with the extracts of mustard, cumin, turmeric, fennel, coriander and mint. Turmeric, fennel and mint inhibited the in vitro oxidation process completely even at 50 percent dilution indicating the presence of strong antioxidants in the extracts of these spices. Inhibitory ratio observed with cinnamon, curry leaves, bay leaves, fenugreek seeds and black pepper was 30-35 percent. Diluted extracts of cinnamon and black pepper were ineffective to prevent oxidation of BSA in the assay. Ginger and onion had exhibited very low inhibitory ratio. Inclusion of green cardamom, nutmeg, clove and garlic had not shown any protection against oxidation suggesting the absence of antioxidants or inefficiency of steam distillation process in extraction of antioxidant principles from these spices. However, all of the studied spices are known to exert several beneficial physiological effects on human body as indicated by the findings of the survey conducted for their medicinal uses. Dietary spices were found to influence various systems in the body such as gastrointestinal, cardiovascular, nervous and reproductive resulting in diverse metabolic and physiologic actions.

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