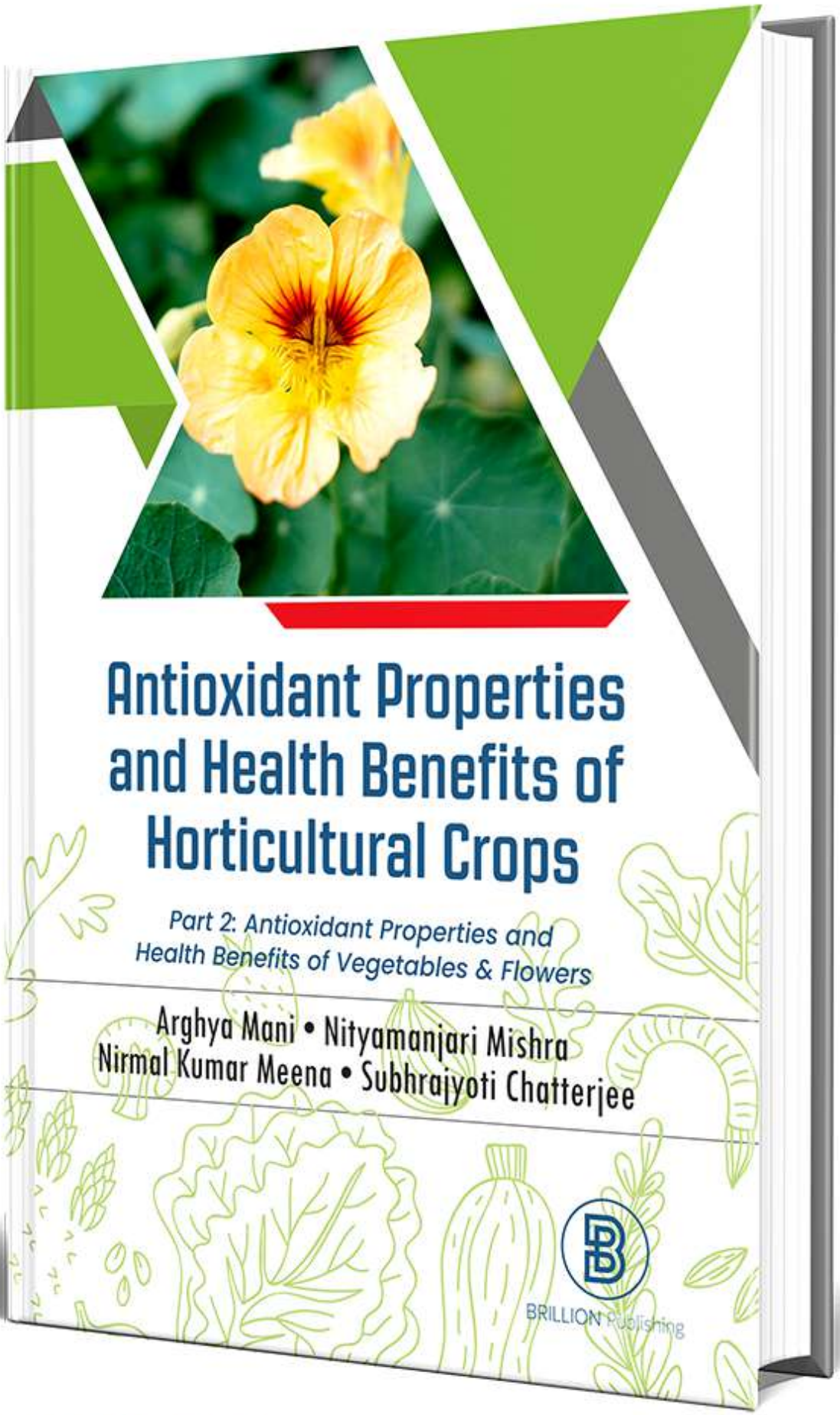

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ANTIOXIDANT PROPERTIES AND HEALTH BENEFITS OF HORTICULTURAL CROPS

ANTIOXIDANT PROPERTIES AND HEALTH BENEFITS OF HORTICULTURAL CROPS

Part 2: Antioxidant Properties and Health Benefits of Vegetables & Flowers

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FOREWORD

Fruits and vegetables are reported to have health-improving benefits, hence known as protective foods and they contain different kinds of antioxidants Some fruits and vegetables like citrus fruits (orange, grapefruit, lime, lemon), grapes, pomegranates, apples, dates, green and yellow vegetables, cabbage, strawberries, carrots, dark leafy greens, and banana are widely known to be rich in natural antioxidant contents.

An antioxidant can be defined as a substance which significantly delays or prevents oxidation of oxidizable substrate when present at low concentration. Antioxidants are broadly divided in to two groups namely natural enzymatic antioxidants and non-enzymatic antioxidants. Superoxide dismutase, catalases are natural enzymatic antioxidants and located mostly in peroxisomes. Fruits and vegetables are very good source of natural antioxidants like carotenoids, vitamins, phenolic compounds, flavonoids, dietary glutathione and endogenous metabolites which act as free radical scavengers, singlet and triplet oxygen quenchers, enzyme inhibitors, peroxide decomposers and synergists. Antioxidants exert both additive and synergistic effects in reducing the risk of oxidative damages to cells. Hence, consuming fruits and vegetables can be the most easy and healthy way of reducing the risk of many chronic diseases like cardio- and cerebrovascular, ocular and neurological diseases, strokes, cancer, diabetes, hypertension and blood-related diseases.

The compilation of nutritional and antioxidant properties of various fruits and vegetable crops in the book entitled "**Antioxidant Properties and Health Benefits of Horticultural Crops**" is highly informative and useful for the researchers, teachers, students and extension personnel to take up further scientific research and development. This book would enlighten the readers about the healing power of nature to attract them more towards the plant grown foods rather than choosing the processed food. I am glad and appreciate the endeavours of all the Authors and Editors for bringing and this book encompassing with all these aspects.

Date: 28 January, 2022

Bhubaneswar

(P.N. Jagdev)

Preface

Antioxidants are known to significantly delays or prevents oxidation of oxidizable substrate when present at low concentration as compared to that of an oxidizable substrate. Fruits and vegetables are very natural source of natural antioxidants which consist of many different desirable components. These antioxidants are carotenoids, vitamins, phenolic compounds, flavonoids, dietary glutathione and endogenous metabolites. Carotenoids are found mainly in yellow, orange and red fruits and vegetables. Large amounts of α- and β-carotene are found in carrots, pumpkins, mangoes and peaches; the greatest amounts of lycopene are accumulated in tomatoes, while green leafy vegetables are a good source of lutein and zeaxanthin. Polyphenolic compounds, which include flavonoids, phenolic acids, lignans and stilbenes, are found in many fruits, vegetables, coffee, tea, herbs and spices and chlorophylls found in leafy green vegetables. This book provides in-depth information about the antioxidant properties of different fruits and vegetables including inflorescence, flowers and flower buds (broccoli, cauliflower, cabbage), bulb, stem and stalk (onion, celery, asparagus, celery), leafy vegetables, fruit and seed (peppers, squash, tomato, eggplant, green beans), roots and tubers (red beet, carrots, radish), and fruits, such as citrus (orange, lemon, grapefruit), berries (blackberry, strawberry, lingonberry, bayberry, blueberry), melons (pumpkin, watermelon), and many more. Each chapter, contributed by experts in the field of Horticulture, also discussed the factors that influencing antioxidant content, such as genotype, environmental variation and agronomic conditions. This also contains detailed information on nutritional and anti-nutritional compositions of fruits and vegetables., antioxidant properties of a range of fruits and vegetables. Fruits and vegetables provide an abundant and cheap source of fibre, antioxidants, several vitamins and minerals and thus increasingly recognized as essential component for food and nutritional security. This book discusses the nutritional properties, antioxidant potential and health benefits of fruits and vegetables in human health. Nutritional composition and antioxidant

properties of fruits and vegetables provides an overview of the nutritional and anti-nutritional composition, antioxidant potential, and health benefits of a wide range of commonly consumed fruits and vegetables. The book presents a comprehensive overview on a variety of topics, including fruits, such as Mango, banana, citrus (orange, lemon, grapefruit), berries (blackberry, strawberry, lingonberry, bayberry, blueberry) and vegetables such as melons (pumpkin, watermelon), flower buds (broccoli, cauliflower, cabbage), bulb, stem and stalk (onion, celery, asparagus, celery), leaves (watercress, lettuce, spinach), fruit and seed (peppers, squash, tomato, eggplant, green beans), roots and tubers (red beet, carrots, radish), and many more Underutilized crops. A diet based on the consumption of fresh fruits and vegetable has been associated with health protection and longevity, due to their nutraceutical value. Additionally, fruits and vegetables supply dietary fiber, and fiber intake is linked to lower incidence of cardiovascular disease and obesity. Fruits and vegetables also supply vitamins and minerals to the diet and are sources of phytochemicals that function as antioxidants, phytoestrogens, and anti-inflammatory agents and through other protective mechanisms. Differences among fruits and vegetables in nutrient composition are detailed. The antioxidant compounds such as vitamin C (ascorbic acid), vitamin E (tocopherol), carotenoids, flavonoids as well as phenolic acids, indeed, able to neutralize reactive oxygen species (ROS) and, for this reason, are worldwide recognized as beneficial for preventing human diseases among which cancer and cardiovascular pathologies. Each chapter, contributed by an international level expert in the field also discusses the factors influencing antioxidant content such as genotype, environmental variation and agronomic conditions. Keeping all these in mind the manuscript "Antioxidant Properties and Health Benefits of Horticultural Crops – Part 1 & Part 2" has been prepared as a reference for all concerned with details and elaborative antioxidant properties and health benefits of different vegetables. Humble effort has been made to ensure that the information collected from various sources such as individuals, institutions, organizations, reviews and research publications are accurate. However, we have put our best efforts in preparing this book but if any error or whatsoever has been skipped out, we will welcome the suggestions of the readers by core from our heart in making the book further more informative. We hope that this book will be extremely useful for the students, teachers, researchers and various institutions.

Editors

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Chapter 3

Antioxidant Properties and Health Benefits of Chilli and Capsicum

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Abstract

The genus *Capsicum* possesses a great diversity in flavour, colour, shape, size along with several biochemical compounds. Besides their direct culinary uses, peppers are also used for colouring, flavouring, preserving, nutraceutical, and medicinal purposes. Several species in this genus and varieties are pungent exclusively due to presence of capscicin and dihydrocapsaicin. Wide range of phytochemicals, such as capsaicinoids, phenolics, ascorbic acid, and carotenoids are present in it and thus making it highly nutritional. Capsicum is a potent reducing agent and possesses a strong capacity to scavenge free radicals (Niki, 1991), particularly during oxidative stress. The whole fruit, seeds and the processed products of it are also having antioxidant property. It is known to reduce the risk of many degenerative diseases. In this context, an overview of the botanical description, biological properties, bioactive compounds, health benefit of pepper is presented.

Key words: capsicum, nutrition, phytochemicals, antioxidant, health benefit.

Introduction:

Peppers (*Capsicum sp*.) are one of the most common and widely used condiments throughout the world. It belongs to family Solanaceae that comprises 90 genera and 2000 species. This plant family is native to the Americas and includes vegetables such as pepper, tomato, and potato. This *Capsicum* genus possesses a great diversity in flavour, colour, shape, size along with several biochemical compounds. Peppers are generally consumed fresh as vegetables or processed for use as spice and other products. Capsicum is widely used to cure several diseases from time immemorial. Due to a number of phytochemical compounds present in it, it is also having antioxidant properties. It may also be used as ornamental plants or as a source of extracts for use in various pharmaceutical or cosmetic products.

History:

The Andean Region of South America is the centre of origin of pepper. Peru has the highest diversity of cultivated chilli peppers in the world (van Zonneveld *et al.*, 2015), while Bolivia is the centre of origin for several cultivated and wild pepper varieties. However, the origin of domesticated chilli peppers (*Capsicum annuum*) is believed to be in Mexico (Kraft *et al.*, 2014). Hot chilli and sweet peppers (*Capsicum annuum* var. *annuum*) have originated from the wild and weedy species *C. annuum* var. *minimum* distributed from southern United States to northern South America (Swarup, 2006). Chilli is believed to be as old as 7000 B.C. used in Mexico as spice long before agriculture was started there by man and were cultivated from 3500 B.C. According to another group of scientists, the primary centre of origin of chilli is southern to Central America and secondary centre is Guatemala.

According to Swarup (2006), the archaeological excavation in Peru proved the cultivation of *C. baccatum* was as early as 2000 B.C. and the species *C. baccatum* var. *baccatum* has been regarded as wild progenitor of the cultivated species *C. baccatum* var. *pendulum* of South America. The species, *C. frutescens* is widespread as a wild, weedy or semi-domesticated plant in lowland tropical America including Mexico, central South America and low- land South America. *C. frutescens* is also closely related to *C. chinense* which was distributed in tropical America. It has been considered that, the species*, C. chinense* was originated from wild type of *C*. *frutescens* because of no existence of wild *C. chinense*. The species, *C. pubescens* was domesticated and cultivated in the highlands of Andes, later in Mexico and Central America and it has also no wild ancestral type. It differs morphologically from other cultivated species. However, close relationship of *C. pubescens* has been found with *C. eximium*, *C. cardenasii* and *C. tovari.* Domestication syndrome of chilli and pepper was the size and shape of the fruit and also fruit setting habit, from erect to pendent. It also turned into self pollinated due to inserted stigma unlike the exerted stigma found in wild types.

Distribution:

Chilli was brought to the rest of the world by Christopher Columbus after the discovery of America. On his return, Columbus brought pepper to Spain in 1493. Later, it moved to northern England in 1548 and central Europe in 16th century. However, Europeans started to consume chilli when Christopher Columbus and his crew reached the Caribbean, they were the first Europeans to encounter Capsicum. They called them 'peppers' because, like black pepper of the genus Piper known in Europe, they have a spicy, hot taste unlike other foods (Bosland and Votava, 2000). He took chile pepper back to Spain where it became a very famous spice.

The spread of chilli peppers to Asia occurred through its introduction by Portuguese traders, who were aware of its trade value and resemblance to the spiciness of black pepper, promoted its commerce in the Asian spice trade routes (Bosland, 1998). It was introduced in India by the Portuguese towards the end of the 15th century (Raj *et al.*, 2007). Chilli also became extremely popular in India after it was first brought to India by Vasco-da-Gama. Chilli found its way in ayurveda, the traditional Indian medical system with medicinal properties such as stimulating good digestion and endorphins, a natural pain killer to relieve pains. In 21st century Asian cuisine, chilli peppers are commonly used across diverse regions.

Area and production:

Today, it is unimaginable to think of Indian food item without the hot spice, chilli. Peppers cover 1.93 million ha of crop-growing surface area. As a spice and vegetables, the world's pepper production has gone from over 12 million tons in 1993 to more than 31 million tons in 2013 over the past 20 years (FAO, 2013). India has become world's one of the largest producers and exporters of chilli, exporting to USA, Canada, UK, Saudi Arabia, Singapore, Malaysia, Germany and many countries across the world. China is the largest pepper producer (almost 16 million tons) and is followed by Mexico (2.3 million), Turkey (2.2 million), and Indonesia (1.8 million). It contributes 25% of world's total production of chilli and India is dominating international chilli market. Some of the hottest chillies are also cultivated in India. The states, Andhra Pradesh, Maharashtra, Karnataka, Gujarat, Tamil Nadu and Orissa are overshadowing Indian chilli market. According to the UN Food and Agriculture Organization, in the year 2016, 34.5 million tonnes of green chilli peppers and 3.9 million tonnes of dried chilli peppers were produced worldwide. China was the world's largest producer of green chillis, providing half of the global total. Global production of dried chilli peppers was about one ninth of fresh production, led by India with 36% of the world total.

Botanical description

Chilli and peppers belong to family Solanaceae, genus *Capsicum*, botanical name *Capsicum annuum* L. Genus *Capsicum* is divided into three sections by Hunziker

(1956) - Monotypic *Tubocapsicum*, *Pseudoacnistus* and *Capsicum*. Section Capsicum includes 22 wild species and five domesticated species. All the species in Capsicum having chromosome no. n=12 except *C. ciliatum* and *C. scolnikianum* having n=13.

According to the book, Species Plantarum, 1753, two species of capsicum was documented. Furthermore, another three species were recorded in 1797. Linnaeus documented *C. anomalum*, *C. pubescence* Ruiz and Pavan, *C pendulum* Wild, *C frutescence* l. and *C. annuum* L. There are five domesticated species namely, *C. annuum* L., *C. baccatum* L., *C. chinense* Jacq., *C. frutescence* L., *C. pubescence* Ruiz and Pavan. However, *C. annuum* is the most important species around the world including all commercially sweet peppers and spice types. The domesticated *Capsicum spp*. can be grouped into 2 groups depending upon the cross compatibility, i.e. the white flowered which includes *C. annuum*, *C. chinense*, *C. frutescens* (*C. annuum* group) and *C. baccatum* var. *baccatum* and *C. baccatum* var *pendulum* (*C. baccatum* group); ii. The purple flowered comprising *C. pubescens*, *C. eximium* and *C. cardenasii*.

Description of species:

C. annuum:

This species is the most common and extensively cultivated among the five domesticated capsicum species. The species encompasses a wide variety of shapes and sizes of peppers, both mild and hot, such as bell peppers, jalapeños, New Mexico chile, and cayenne peppers. This species is annual and herbaceous in nature. Both diploidy and polyploidy can be seen in *C. annuum*. Leaves are small and narrow, flowers are small, solitary, pendulous and with white or purple corolla. Fruit is having lower pungency (0.1%). Zhigila *et al.* (2014) described fruit morphology of five varieties of *C. annuum*. A common grouping of cultivar groups for *C. annuum* is as follows:

- abbreviatum; fruits ovate, wrinkled, fruit colour red or yellow, small, trilocular, 2-5 cm long; also called wrinkled pepper;
- acuminatum; fruits slender, curved, up to 11 cm long, mild to extremely pungent; also named chilli;
- cerasiforme; fruits globose with firm flesh, up to 2.5 cm in diameter, mild to pungent, red, yellow or purple; also called cherry pepper or bird's eye pepper;
- conoides; fruits subconical, up to 3 cm long, very pungent; also called cone pepper;
- fasciculatum; fruits clustered, erect, up to 7.5 cm long, very pungent; also called cluster pepper;
- grossum: fruits large with basal depression, inflated, red, orange, yellow, or purple, flesh thick and mild; also called sweet pepper or paprika;

- longum; fruits drooping, up to 30 cm long, mild or pungent, red, yellow or whitish; also called long pepper.

C. baccatum:

The species is one the most important species of capsicum and having white or cream coloured flower and typically having a green or golden coloured corolla. The fruit tends to be very pungent, and registers 30,000 to 50,000 on the Scoville Heat Unit scale. Fruits are having variety of shapes and sizes, typically hang down. The flowers are protogynous, but readily self pollinate. In the field, high rates of outcrossing (up to 90%) can occur with insect pollination. This species possesses powdery mildew and anthracnose fruit rot resistance genes.

C. chinense

This is the most variable among the domesticate species and widely spread within Latin America. *C. chinense* varieties are well known for their unique flavours and many have exceptional heat. The hottest peppers in the world are members of this species, with Scoville Heat Unit scores of over 2 million (Guinness World Records, 2016). It is believed that *C. frutescens* is the ancestor to the *C. chinense* species (*Russo, 2012*). Within *C. chinense*, the appearance and characteristics of the plants can vary greatly. Varieties such as the well-known 'Habanero' grow to form small, compact perennial bushes about 0.5 metres in height. The flowers, as with most *Capsicum* species, are small and white with five petals, the fruit varies greatly in colour and shape, with red, orange, and yellow being the most common mature colours, but colours such as brown and purple are also known (Smith, 1950).

C. frutescence L.:

C. frutescens is annual, biennial or short-lived perennial shrub. Flowers are having greenish white or greenish yellow coloured corolla, cluster bearing and erect. Flowers are either insect or self-pollinated. The plant berries typically grow erect; ellipsoid-conical to lanceoloid shaped. They are usually very small and pungent, growing 1-2 cm long and 0.3-0.7 cm in diameter. Fruit typically grows a pale yellow and matures to a bright red, but can also be other colours. *C. frutescens* has a smaller variety of shapes compared to other *Capsicum* species. *C. frutescens* has been bred to produce ornamental strains because of its large quantities of erect peppers growing in colourful ripening patterns (Carvalho, 2014).

Species of Capsicum	
	
C. annuum flower	***C. annuum fruit***
	
C. chinense flower	***C. chinense fruit***
	
C. baccatum flower	***C. baccatum var. pendulum cv. 'Bishops Crown'***
	
C. frutescence flower	***C. frutescence fruit***

C. pubescence flower

C. pubescence fruit

C. pubescence

The species name, 'pubescens', means hairy, the hairiness of the leaves, along with the black seeds, distinguish this species from others. *Capsicum pubescens* grow as a shrub, but sometimes as climbing plants. They grow up to 4 m woody plants relatively quickly, and may live up to 15 years. The leaves have leaf blade ovate to 5-12 cm long, 2.5 to 4 cm wide, tapering at the top and the base is wedge-shaped. The flowers appear singly or in pairs (rarely up to four) on the shoots. This species is the blue-violet-coloured petals, brighter in the centre. The anthers are partly purple, partly white. The calyx has five triangular pointed teeth, which have in the fruit a length of about 1 mm.

C. praetermissum

This species differentiates from the other species in that it is semi-domesticated, endemic from the South East of Brazil and represents a transition between the groups of purple and white flowers. The species are predominantly diploids (2n=24), present an extraordinary diversity in the fruit's morphology, colour, size and flavour (from sweet to spicy) and are widely used as either vegetables or spices (Bosland and Votava, 2012).

Table 1: Morphological characteristics of different capsicum species and their wild relatives (Deshpande, 2001)

Species	Wild/ cultivated	Calyx teeth	corolla	Flowers/ nodes	Seeds
C. annuum var. *annuum*	Cultivated	Present	White large	1	Yellow smooth
C. annuum var. *aviculare*	Wild progenitor	absent	White small	1 (3-4)	Yellow smooth
C. baccatum var. *pendulum*	Cultivated	Present	White with yellow or green spot	1	Yellow smooth

Species	Wild/ cultivated	Calyx teeth	corolla	Flowers/ nodes	Seeds
C. baccatum var. *baccatum*	Wild progenitor	Present	White with yellow or green spot	2-3	Yellow smooth
C chinense	Cultivated	absent	Dull white	2-3	Yellow smooth
C. frutescens	Cultivated	Present	Greenish white	2-3	Yellow smooth
C. pubescens	Cultivated	absent	Purple	1 (2-3)	Rough
C. cardenasii	Wild progenitor	absent	Purple campanulus	2-3	Yellow smooth
C. eximium	Wild progenitor	absent	Magenta to white with green or yellow spot	2-3	Yellow smooth

Horticultural classification:

Smith *et al.* (1987) classified chilli cultivars based on the fruit shape, colour and uses.

I. Fruit large, smooth, thick fleshed

A. Bell group: Fruit large, 7.5-12.5 cm long blocky blunt, 3-4 lobed, square to rectangular or tapering in longitudinal section, colour usually green when immature, red at maturity, mostly non pungent although few pungent forms are known.

i. Non-pungent: a. Green turning red (or rarely orange yellow) when ripe ('California Wonder', 'Yolo Wonder'); b. yellow, turning red when ripe ('Golden Bell', 'Roumanian')

B. Pimento group: fruit heart shaped but pointed, 3.7-12.5 cm long, smooth thick walled, non pungent ('Pimento', 'Pimento Perfection')

II. Fruit broad, smooth, thin walled

A. Ancho group: fruit 10-15 cm long, heart shaped but pointed, somewhat flattened, sweet to mildly pungent.

i.. Dark green turning red at maturity (Mexican Chilli, 'Ancho')

ii.. turning brown at maturity ('Mulato')

III. Pods long, slender

A. Anahem chilli group (long green-long red chilli): Fruit medium to dark green, smooth, 12.5-20 cm × 3.2-5 cm tapering to point, flesh medium thick, moderately pungent to sweet. e.g. i. Moderately pungent ('Sandia'), ii. Mildly pungent ('Mild California'), iii. Slightly pungent ('Mild California'), iv. Non-pungent ('Paprika')

B. Cayenne group: fruit slender, 2.5-25 cm × 1.9-2.5 cm, medium green, characteristically wrinkled and irregular in shape, thin walled and highly pungent.

1. Mature red fruit ('Cubanclle', 'Cuban')

IV. Fruit elongated to 7.5 cm long, green when immture

A. Jalapeno group: fruit 3.75-5 cm wide, 5-7.5 cm long, rounded, cylindrical shaped, thick walled, dark green smooth ('Jalapno', 'Mild Jalapeno')

B. Serrano group: fruit slender, cylindrical, often slightly constricted, near middle, tapering to abrupt point, highly pungent 1.25 cm × 5-6.25 cm ('Serrano')

C. Small hot group: fruit slender, medium to thin walled, < 7.5 m long, highly pungent ('Red Chilli', 'Japanese Chilli')

V. Fruit small to 5 cm, globular to oblate thick fleshed;

A. Cherry group: i. Non-pungent ('Sweet Cherry'), ii. Pungent ('Large Red Cherry', 'Small Red Cherry')

VI. Fruit yellow when immature

A. small wax group: fruit 7.5 cm or less in length; i. Pungent ('Floral Gem'), ii. Non-pungent ('Sweet Tam')

B. long wax group: fruit 8.8 cm or more in length, pointed or blunt

i. Pungent ('Hungerian Yellow Wax'), ii. Non-pungent ('Sweet Banana', 'Hungerian Sweet Wax')

VII. Fruit slender, yellow turning red at maturity, 2.5-3.75 cm long, highly pungent of the species, *C. frutescens.*

Nutritional benefits of the crop:

Green chilli (*Capsicum annuum* L. var. *longum*) is a source of vitamins and minerals. It is reported that it contains moderate to high levels of neutral phenolics or flavonoids, phytochemicals that are important antioxidant components of a plant- based diet. Among the phytochemicals, the most important natural antioxidants present in green chilli are vitamin C, the most abundant water soluble antioxidant (Frei *et al.*, 1989); carotenoids; and phenols. These compounds are reported to possess biochemical and pharmacological effects including antioxidation, anti-inflamation, and anti-allergy (Havesten, 1983; Rice-Evans *et al.*, 1995) and may reduce the risk of degenerative diseases (Hasler, 1998; Hertog *et al.*, 1992; Lee *et al.*, 1995).

The antioxidant and antioxidative enzyme present in green chilli build shield against harmful reactive oxygen species and free radicals. Depending upon the quality of the antioxidant present, the quality of green chilli varies.

Table 2: Nutritional composition of *Capsicum* spp. fruit (per 100 g of edible portion) (Fathima, 2015).

Nutrient[a]	Spices, pepper, red or cayenne[b]	Peppers, sweet, green, raw[c]	Peppers, hot chilli, green, raw[d]	Peppers, sweet yellow, raw[e]
Water (g)	8.05	93.89	87.74	92.02
Protein (g)	12.01	0.86	2.00	1.00
Energy (kcal)	318	20	40	27
Carbohydrate (g)	56.63	4.64	9.46	6.32
Calcium (mg)	148	10	18	11
Phosphorus (mg)	293	20	46	24
Selenium (µg)	8.8	0.0	0.5	0.3
Iron (mg)	7.80	0.34	1.20	4
Sodium (mg)	30	3	7	2
Copper (mg)	0.373	0.066	0.30	0.107
Potassium (mg)	2014	175	340	212
Fatty acids, total saturated (g)	3.260	0.058	0.021	0.031
Fatty acids, total monounsaturated (g)	2.750	0.008	0.011	
Total lipids (fat) (g)	17.27	0.17	0.20	0.21
Ash (g)	6.04	0.43	0.60	0.45
Niacin (mg)	8.701	0.480	0.950	0.890
Vitamin C, total ascorbic (mg)	76.4	80.4	242.5	183.5
Thiamin (mg)	0.328	0.047	0.090	0.028
Vitamin B-6 (mg)	2.450	0.224	0.278	0.168
Carotene, beta (mg)	21.84	0.208	0.671	0.120
Cryptoxanthin, beta (mg)	6.252	0.007	0.050	

[a]Composition data obtained from the National Nutrient Database for Standard Reference Release 28, USDA Food Composition database (https://ndb.nal.usda.gov/ndb/; accesed 18/11/2017);

[b]Scientific name: *C. frutescens* or *C. annuum.*

[c]Scientific name: *C. annuum.*

[d]Scientific name: *C. frutescens.*

Vitamins

Capsicum is good source of several vitamins like vitamin E, vitamin C, vitamin A, and vitamin B complex and minerals such as thiamine, folate, molybdenum,

manganese, potassium, calcium, iron, polyphenols (mainly luteolin), flavonoids, and quercetin. Carotenoids in Capsicum include β-carotene and a number of xanthophylls including lutein, zeaxanthin, violaxanthin, cucurbitaxanthin A, and β-cryptoxanthin. Among them, only β-carotene and β-cryptoxanthin possess provitamin A activity and the oxidative cleavage of these compounds yields retinal. β-carotene contents vary within varieties of peppers. Red chilli peppers are high in beta carotene, which body converts into vitamin A. Vitamin A content and its accumulation increases with fruit maturity. A family of B vitamins is available in *Capsicum sp*., among them B_6 plays a role in energy metabolism. Chilli peppers are very high in this powerful antioxidant, which is important for wound healing and immune function. Vitamin C is involved in synthesis of collagen tissue, metal ion metabolism, antihistamine reactions, and enhancement of immune system (Combs, 1992). It is a potent reducing agent and possesses a strong capacity to scavenge free radicals (Niki, 1991), particularly during oxidative stress.

Vitamin K_1

Vitamin K is also known as phylloquinone and this vitamin is essential for blood clotting and healthy bones and kidneys. This vitamin is also available in *Capsicum sp*. in significant amount.

Potassium

An essential dietary mineral that serves a variety of functions, potassium may reduce risk of heart disease when consumed in adequate amounts. Regular consumption of capsicum and chilli can be helpful for heart patients.

Copper

The average value of copper is found in Peppers, hot chili, green, canned, pods, excluding seeds, solids and liquids which in 100g contains 0.101 mg of Copper. Copper is an essential trace element, important for strong bones and healthy neurons.

Carotenoids:

Carotenoids are important component or antioxidant property of pepper. The types and levels of carotenoids differ between different varieties, agronomic practices and environmental conditions. Yellow-orange colours of chilli pepper fruits are mainly due to the accumulation of α- and β-carotene, zeaxanthin, lutein and β- cryptoxanthin. Carotenoids such as capsanthin, capsorubin and capsanthin-5, 6-epoxide confer the red colours. Chromoplasts are the sites of carotenoid pigment synthesis and storage. According to the most accepted theory, the synthesis of carotenoids in chilli peppers is controlled by three loci: c1, c2 and y. Several enzymes participating in carotenoid biosynthesis in chilli pepper fruits have been isolated and characterized and the corresponding gene sequences have been reported. Carotenoids act as antioxidants

and immune enhancers and may afford protection against various types of cancer, coronary heart diseases, advanced age-related macular degeneration, and cataracts (Ziegler *et al.*, 1986; Bradley and Shinton, 1998; Feskanich *et al.*, 2000). Flavonoid intake is shown to reduce cancer risk (Yoshida *et al.*, 1990).

Carotenoids serve as powerful antioxidants and have provitamin-A activities. More than 30 different carotenoid pigments have been identified in pepper fruit. Some cultivars of hot pepper have as much as 12 mg/ kg total carotenoids, while in others, its level is undetectable. The main carotenoids responsible for the red colour of pepper fruits are the three xanthophylls unique to *Capsicum*, that is, capsanthin, capsorubin, and capsanthin 5,6-epoxide.

The main carotenoid in red chilli peppers is capsanthin. It is constituted up to 50% of the total carotenoid content. This compound is responsible for their red colour. It also possesses antioxidant property. The major carotenoid antioxidant in yellow chili peppers is violaxanthin**,** accounts for 37- 68% of the total carotenoid content in chilli. Letuin is found abundantly in green (immature) chilli peppers, lutein's levels decrease with maturation. High consumption of lutein is helpful for eye. During maturation, lutein levels decline and levels of β-carotene, β-cryptoxanthin, and zeaxanthin increase. At the breaking stage of fruit development, the red carotenoids, capsanthin and capsorubin, are produced. Capsanthin levels continue to increase as fruit ripen composing between 37% and 80% of total carotenoid content. Red peppers also contain lycopene, which has many health beneficial attributes. Besides being rich in phytochemicals, peppers provide dietary fiber.

Capsaicin

The major phytochemicals present in hot peppers are capsaicinoids. Capsaicin is an alkaloid with a phenyl-propanoid nature which has given rise to a family of capsaicinoids composed of at least 22 primary compounds. Out of them, capsaicin and dihydrocapsaicin contribute to about 90-95% of total capsaicinoids present in most hot pepper varieties (Ishikawa, 2003; Reyes-Escogido *et al.* 2011). These compounds are mainly localized in the epidermal vacuoles of the placenta and the septum from fruits, and they can be separated and identified through the use of high-performance liquid chromatography associated with electrospray ionization mass spectrometry (HPLC- ESI/MS). Capsaicin is the main bioactive plant compound in chilli peppers, responsible for their unique, pungent taste and has been used as an anti-inflammatory and anti-allergic agent. The degree of pungency is characterized in terms of Scoville heat units (SHU) measured based on the concentrations of capsaicinoid compounds within the fruit. SHU scale measures the number of times the extract is diluted to make pungency undetectable in sugar water (Scoville, 1912). The compound can directly scavenge various free radicals (Kogure *et al.*, 2002). Pun1 gene is responsible for the key regulatory factor in the capscicinoid pathway and controls the accumulation of

capscicin (Stewart *et al.*, 2007; Reddy *et al.*, 2014). Besides this, the concentration is dependent on the maturity times and agronomic practices also.

Three structural characteristic features make capsaicin one of the most pungent compounds known: the vanillyl group, the acid-amide linkage, and the alkyl side-chain. Any alteration in one of these groups supposes a decrease in pungency. The capsaicinoid burning sensation is produced by binding to vanilloid receptors VR-1, responsible for pain perception (Xavier and Galvez, 2016). A sensation of heat and pain is felt by the binding of the capsaicinoids to receptors in mouth and throat resulting in sensing 'heat'. It also serves as a natural defense against herbivory. Birds are not affected by these compounds. Though, domestication and consequent breeding have resulted in reduction of pungency and capsaicinoid content of some peppers especially in bell peppers. Capsaicinoid content is a major quality factor in spice peppers (chilli, tabasco, and paprika). There is a direct correlation between total capsaicinoid levels and pungency (as measured in SHU, which is a subjective organoleptic measure and chilli hotness, is now determined by high-performance liquid chromatography). Capsaicin and dihydrocapsaicin are undetectable in sweet pepper varieties, but significant amounts of these compounds are present in chilli and paprika types (Padmanabhan *et al.*, 2016).

Sinapic acid

This is also known as sinapinic acid and has a variety of potential health benefits. It is generally accepted that substances which are able to donate hydrogen or an electron to 2,2-diphenyl-1-picrylhydrazyl ($DPPH^{\cdot}$), a synthetic nitrogen-centered stable radical, can be considered as antioxidants and therefore radical scavengers. At a concentration of 20 μM, sinapic acid was able to inhibit 33.2% of the $DPPH^{\cdot}$ radical, which was comparable to the scavenging activity of caffeic acid (49.6%) and α-tocopherol (41.8%), and close to the activity of butylated hydroxytoluene (BHT) (29.2%) (Kikuzaki *et al.*, 2002). Similarly to sinapic acid, ferulic acid is an antioxidant that may help protect against various chronic diseases.

Flavonoids

Though the pericarp, flesh, and seed of pepper contain flavonoids, pepper is not considered to be a rich source of flavonoids. Flavones and flavonol aglycones constitute the most prevalent flavonoid groups in pepper. Quercetin and luteolin are the prevalent flavonoids in peppers. Luteolin and its derivatives form the primary flavones, while quercetin and its derivatives are the primary flavonol aglycones. Quercetin is the major flavonoid in chilli pepper. Quercetin derivatives also dominate in green pepper. Other flavones identified in pepper include apigenin, O-glycosyl flavones, and C-glycosyl flavone. Several studies also reported that total flavonoid content and the levels of individual flavonoids decline with fruit maturity. Studies also

found that coloured peppers generally had higher quercetin and luteolin contents (red peppers had higher contents than yellow and orange peppers).

Moreover, the metalloenzyme, superoxide dismutase, which is universally present in all plants and imparts defense against oxidative stress, converts superoxide radical anion into hydrogen peroxide. In addition, catalase (CAT) and a variety of peroxidases (POD) catalyze the breakdown of hydrogen peroxide (Asada, 1994). The pepper oil separated by vacuum has major chemicals such as trans-b-ocimene, linalool, 2-methoxy-3-isobutylpyrazine, limonene, hex-cis-3-enol, and methyl salicylate (Idress *et al.*, 2020). Moreover, chilli pepper showed many biologic activities including antioxidant, antimicrobial, antiplatelet, antiobesity, and anti-inflammatory. The chemical constituents vary depending on the type of species or cultivar, environmental condition as well as agronomic practices.

Antioxidant property of the crop:

Leaves:

Thai pepper leaves are a good source of vitamin A, vitamin B, and antioxidants. They also contain a small amount of capsaicin. In China, pepper leaves have been used for mouthwashes and are used topically to help reduce symptoms of muscle soreness. The juice of the leaves is also used in Javanese traditional medicine as an anti-inflammatory to help reduce skin irritation after child birth. Today, Thai pepper leaves can be found in fresh markets in Asia, Southeast Asia, South and Central America, and Africa.

Flowers:

The hypolipidemic effect of hydroalcoholic extract of flowers from *C. annuum* was examined through the evaluation of inhibition of pancreatic lipase by Marrelli *et al.* (2016). In this study, phytochemical analysis of flowers exhibited that total phenolic and flavonoid content in the extract was 128.7 ± 4.5 mg chlorogenic acid equivalent/g of crude extract and 17.66 ± 0.11 mg of quercetin equivalent/g of crude extract, respectively. The extract inhibited pancreatic lipase with IC_{50} value equal to 3.54 ± 0.18 mg/ml. It also inhibited lipid peroxidation with IC50 value of 27.61 ± 2.25 µg/ml after 30 min of incubation and 41.69 ± 1.13 µg/ml after 60 min of incubation. The IC_{50} value of radical scavenging activity was 51.90 ± 2.03 µg/ml. The extract was also able to inhibit NO production (IC_{50} = of 264.3 ± 7.98 µg/ml) without showing any cytotoxic effect.

Fruit:

In addition to a rich source of vitamin C, vitamin A (β-carotene and provitamin A), vitamin B_2 (riboflavin), B_3 (niacin), E, K and B_6, peppers and chillies are also constituted by carotenoids and flavonoids. Carotenoids are responsible for the pigmentation of

fruits and flavonoids, which may function as antioxidant activity, anti-inflammatory, anti-cancerous, anti-allergic, anti-hemorrhagic, and these phytochemicals are ultimately enhances nutritional value and quality of food.

Almost all *Capsicum* sp. possess antioxidant activity. Fruit extracts of different genotypes of Capsicum (*C. annuum*, *C. baccatum*, *C. chinense*, *C. frutescens* and *C. praetermissum*) were investigated by Bertao *et al.* (2016) for total phenolics, flavonoids, capsaicinoids contents and antioxidant activity. According to their study, *C. praetermissum* showed the highest total antioxidant activity and the highest concentrations of phenolic compounds and flavonoids. For *C. annuum* and *C. frutescens* the antioxidant activity was significant and the levels of phenolic compounds and flavonoids intermediate, while *C. baccatum* demonstrated the lowest antioxidant activity independent of significant levels of these compounds. *C. chinense* showed the lowest level of total phenols and flavonoids despite expressive antioxidant activity. The determination of capsaicinoid content revealed higher levels of capsaicin and dihydrocapsaicin for extracts of *C. praetermissum*, intermediate levels to *C. baccatum*, *C. chinense* and *C. frutescens*, whereas, the *C. annuum* showed the lowest levels of capsaicinoids, typical of these ornamental genotype. The extracts of *C. praetermissum* and *C. baccatum* exhibited low cytotoxic potential compared to other genotypes. The genotoxic potential was variable between analyzed genotypes, with *C. praetermissum* presenting the lowest rates. All species showed a dose-effect relationship dependent of extract concentration. The results of the present study indicated that *Capsicum* genotypes demonstrated a very high diversity of bioactive compounds that can be explored as agents in the control of complex biological processes related to human nutrition and health.

Among the four different fruit colour (green, red, orange, yellow), the antioxidant property also differs. Red and orange bell peppers had significantly higher levels of total phenolic content (TPC) than yellow or green bell peppers. Orange bell pepper exhibited the highest level of radical scavenging activity and total antioxidant activity, while green bell pepper exhibited the highest superoxide dismutase-like activity. The difference in antioxidant activities may depend on the kinds of antioxidant compounds related to the colour of the pepper. It was found a significant negative correlation between TPC and radical scavenging activity inhibiting capacity $(IC)_{50}$, and a significant positive corretation between TPC and total antioxidant activity. All extracts of bell pepper inhibited H_2O_2-induced and 4-hydroxy-2-nonenal-induced DNA damage in human leukocytes and showed potential toxicity on HT-29 cells. These findings suggest that the 4 different coloured bell peppers may be useful as antioxidants and cancer prevention in food (Park *et al.*, 2012).

Seeds

Capsicum seeds are packed with nutrients like vitamin C, vitamin B6, vitamin A, iron, copper, potassium, niacin, dietary fibre, folate etc. Chilli seeds are known to

lower cholesterol levels as they contain a substance known as phytosterol that acts as a good fat for our body. These phytosterol, β-carotene, and β-cryptoxanthin present in it imparts antioxidant property of seeds. It boosts immunity by eliminating free radicals and helps to stay fit.

Anti-oxidant property of processed products

Powder:

Processed chilli is an alternative to make sure people can still consume chilli when the price of fresh chilli is expensive. One technique for extending the shelf life of chilli is processed into chilli powder. This process also functions as preservative because in powder, the water content of chilli decreases, thereby reducing the level of food damage. However, the drying process during chilli powder manufacture causes a decrease in the quality and nutrition of chilli powder (Sharma *et al.*, 2015). In the production process of chilli powder, soaking in a chemical solution such as sodium metabisulfite, citric acid, and ascorbic acid can maintain the quality of chilli powder is normally applied (Wiriya *et al.*, 2009). Immersion with sodium metabisulfite 0.3% and citric acid 1% can improve the quality of dried chilli in terms of colour, total carotene, total phenol including antioxidant activity, and total ascorbic extract (Chaethong and Pongsawatmanit, 2015). These chemicals have disadvantages due its relatively expensive price, and not readily found and moreover people tend to prefer things that are natural. The best test results have a chemical characteristic (colour value, total colour value, capsaicin content, total phenol, total flavonoids, vitamin C levels, and antioxidant activity IC_{50}) which are not different from control. Soaking with lime 15% solution has the same effect as soaking with synthetic chemical substances in maintaining physical and chemical characteristics of chilli powder (Kusnadi *et al.*, 2020).

Pepper Sauce:

The antioxidant potential for chilli sauce was considerable and is probably due to the synergistic contribution of the bioactive compounds present in the sauce constituents. The *C. frutescens* hot sauce is presented as an alternative for the use of bioactive compounds that may have antioxidant potential and may contribute to the prevention of the negative effects of free radicals (Pereira *et al.*, 2016). According to their study, the concentration of pepper *Capsicum frutescens*, with treatment ratios (fruit: water: vinegar: salt) being maintained at three treatment (T), T1 (0.5: 1: 0.5: 0.33), T2 (1: 1: 0.5: 0.33), and T3 (2: 1: 0.5: 0.33). By the DPPH method, the values found for EC_{50} (g g DPPH−1) from 3726.9 to 5425.9 for the alcoholic extract were the most significant. Antioxidant compounds present in pepper sauce may have a greater chemical affinity for the ethanol used in the extraction, than with water, which explains the greater antioxidant activity in this extract. The content of total phenols did not vary between the three treatments. While the content of carotenoids found was significantly different in the treatment with lower content of the fruit *in natura*, when compared to the treatment with higher content (44.02 and 56.09 μg of β-carotene/ 100 g, respectively) and the content of ascorbic acid varied between 10.95 and 21.59 mg/100 g. Therefore, the pepper sauce was presented as an alternative to the consumption of bioactive compounds that may have antioxidant potential.

Roasting:

The effect of roasting on the nutritional content was investigated by Hamed *et al.*, 2019. Among the cultivars tested, the levels of capsaicin ranged from 0 to 3636 μg/g in the mature green stage and from 0 to 4820 μg/g in the red/yellow stage. The concentration of dihydrocapsaicin ranged from 0 to 2148 μg/g in the mature green stage and from 0 to 2162 μg/g in the red/yellow stage. The levels of capsaicinoid compounds in mature green and red/yellow stages were either reduced or increased after roasting depending on the cultivar. The ranges of total phenolic and total flavonoids compounds were 2096 to 7689, and 204 to 962 μg/g, respectively, in the green and red/yellow mature stage pods. Ascorbic acid levels in the peppers ranged from 223 to 1025 mg/ 100 g Dry Weight (DW). Both raw and roasted peppers possessed strong antioxidant activity as determined by 2,2-diphenyl-1-picrylhydrazyl) reagent (DPPH, 61–87%) and 2,20-azino-bis (3-ethylbenzthiazoline-6-sulphonic acid) (ABTS, 73–159 μg/g) assays. Ascorbic acid and antioxidant activity decreased after roasting

in the mature green and red stages, whereas total phenolics and flavonoids increased except in the mature green stage of 'Sweet Delilah' and yellow stage of 'Canrio'as used in the study.

Chilli extracts:

Potentials of extracts from chilli and pepper to scavenge free radicals and exhibit antioxidant activities have also been reported. These can be exploited in preserving processed foods or to prevent the rancidity of oils and at the same time get the benefits of medicinal properties of these spices. These spices are routinely used in Asian diets as food adjuncts.

Health benefits:

Besides their direct culinary uses, peppers are also used for nutraceutical, and medicinal purposes. Mother tincture is prepared from the ripe, dried fruit. In homeopathy capsicum is also used to cure patients.

Green chilli:

Green chillies, when taken along with food, stimulate our taste buds of tongue and thereby, increase flow of saliva which contains amylase enzyme and thus it helps in the digestion of starchy or cereal foods into easily assimilable sugar, glucose. When taken fresh with salads, they, being rich in vitamins A and C, serve as a good vitamin supplement in addition to their being an appetizer. Thus green chillies are more nutritious than ripe, dried chillies or chilli powder, as most of the vitamins are lost during drying. Chillies also act as detoxifier by removing the waste products from our body and increase the blood supply to the tissues. Chillies stimulate the release of endorphins that are known as natural pain killers.

Red chilli:

The benefits of spices and their bioactive compounds have since been suggested by various *in-vitro*, *in-vivo* and experimental models. Pungent spices, for example chilli peppers, increase lipid catabolism in different organs and tissues (Lee *et al.*, 2011; Zhu *et al.*, 2011), which could protect against hypercholesterolemia and obesity, reducing the risks of hypertension, type 2 diabetes, and atherosclerotic cardiovascular disease. The anti-microbial activity of spices, as highlighted by inhibitory effects against *Helicobacter pylori* and other bacteria and fungi (Bergonzalli *et al.*, 2003; Lai and Roy 2004; Liu, 1996), may alter the gut microbiota and influence various metabolic diseases (Qin *et al.*, 2012). Many spices possess antioxidant (Halvorsen *et al.*, 2006) and anti-inflammatory effects (Chen *et al.*, 2001), and could serve to prevent and mitigate various chronic diseases.

Total mortality for participants who consumed hot red chilli peppers was 21.6% compared to 33.6% for those who did not (absolute risk reduction of 12%;

relative risk of 0.64). Consumption of hot red chilli peppers was associated with a 13% reduction in the instantaneous hazard of death. Similar, but statistically non-significant trends were seen for deaths from vascular disease, but not from other causes. In this large population-based prospective study, the consumption of hot red chilli pepper was associated with reduced mortality. Hot red chilli peppers may be a beneficial component of the diet (Chopan and Littenberg, 2017).

Anti-cancerous

According to the latest findings of the Adyar Cancer Research Institute, Madras, the common green chillies (*C. annuum*) have been found to be the most fertile source for the enzyme, L-asparaginase which has an anti-tumour element. It is used in the treatment of acute lymphocytic Leukemia, a type of cancer and it is claimed that this enzyme produces a rapid fall in the lymphoblast count and is thus very useful in averting crisis. Thus, the enzyme is useful temporarily just to overcome a crisis to give physician more time to switch over to other drugs. It may also be clarified that the effect of the enzyme cannot be obtained by just eating green chillies. Thus, the enzyme has to be isolated from chillies and then administered. However, the content in green chilli is governed by cultivar, management practices, and local environmental conditions (Mahendran and Bandara, 2000; Panchal *et al.*, 2001). Moreover, it has been noted that the vitamin C, β-carotene and folic acid found in chilli reduces the risk of colon cancer.

Fight inflammation and relief pain

Capscicin present in chilli is being considered as an effective treatment of sensory nerve fibre disorders, including pain associated with osteoarthritis, psoriasis, and diabetic neuropathy. The purified form capsaicin has been found to relieve pain by reducing substance P, which is found at nerve endings and is involved in transmitting neuralgic and arthritic pain signals to the brain. Though, pain relief is not instantaneous after application as it cures depletion of cumulative substance P over a period of weeks with full entire.

Cardiovascular benefits

A supplementation with capsaicin may improve physical activities, including grid, strength and endurance performance by increasing live glycogen content. Capsaicinoids but not capsinoids may decrease the total plasma cholesterol, reduce the formation of atherosclerotic plaque and relax the aortic artery increasing the fecal excretion of acidic sterols in hamsters fed with diets containing capsaicinoids. Moreover, it may modulate plasma lipids and possess beneficial vascular activity (Huang *et al.*, 2014). Phytosterols present in seeds remove plaque in the blood vessels, prevent the absorption of blood cholesterol in the intestine, and thus lowers cholesterol level in blood.

Red chilli peppers, such as 'cayenne', have been shown to reduce blood cholesterol, triglyceride levels, and platelet aggregation, while increasing the body's ability to dissolve fibrin, a substance integral to the formation of blood clots. Potassium combined with folate in pepper can reduce chances of heart disease. Moreover, potassium can help relax blood vessels, thus making blood flow much easier in body. Chilli peppers also contain riboflavin (Vit- B_2) and niacin (Vit- B_3). Niacin is responsible for maintaining healthy cholesterol levels and in turn, lowers the risk for heart disease. Chilli peppers can also protect fats in blood against free radicals. It has been found that, cultures using hot pepper liberally have a much lower rate of heart attack, stroke and pulmonary embolism.

Clear congestion

Capsaicin not only reduces pain, but its peppery heat also stimulates secretions that help clear mucus from your stuffed up nose or congested lungs. Capscicin contained nasal spray help to relief from nasal congestion or allergies as it has anti-bacterial property to fight against chronic sinus infection.

Boost immunity

The bright colour of red chilli peppers signals its high content of β-carotene or pro-vitamin A, often called the anti-infection vitamin. Vitamin A is essential for healthy mucous membranes, the nasal passages, lungs, intestinal tract and urinary tract and serves as the body's first line of defence against invading pathogens. Vitamin A is a key compound in maintaining a healthy respiratory, intestinal, and urinary system. Also, vitamin A and vitamin C in the chilli peppers are vital in building up immunity against infections and illnesses.

Vision

Capsicum is incredibly beneficial for vision health. The high carotenoid compounds especially lutein and zeaxanthin content, protect retina from oxidative damage. It also helps eyes from mascular degenerations.

Anaemia

Anaemia is a condition that usually results because of low iron in the body. A characteristic of the condition is that it reduces the amount of oxygen in your blood. As a result, most people with anaemia, feel sluggish and tired without a clear reason. Capsicum is very high in vitamin C and is moderately high in iron. The combination of these two vitamins and minerals allow iron to absorb more effectively and thus help to recover from anaemia.

Lose weight

The efficacy of these bioactive compounds in weight loss is not conclusive. In fact, no solid evidence shows that capsaicin ingestion provokes weight loss, but there is a positive correlation between capsaicin and a decrease in weight re-gain (Srinivasan, 2016). Mean short-term studies have demonstrated an increase in diet-induced thermogenesis and a decrease in the respiratory quotient immediately after a meal in which capsaicin was supplemented (Yoshioka *et al.*, 1995). Both capsaicin and capsaicinoids are capable of increasing the whole-body energy expenditure and reduce the body fat *via* brown adipose tissue stimulation through the specific receptor TRPV1, increasing the stamina consumption and decreasing body fat modestly but consistently (Saito and Yoneshiro, 2013). Besides other factors, the *trans* differentiation of mesenchymal stem cells into adipocytes is an added detrimental factor that may cause the intensification of obesity. Ibrahim *et al.* (2015) reported that, Capsaicin potentially inhibits the adipogenic differentiation of mesenchymal stem cells via many different pathways (anti-proliferative, apoptotic and cell cycle arrest) through the stimulation of reactive oxygen species (ROS) and reactive nitrogen species (RNS) production. Thus, capsaicin not only suppresses the maturation of pre-adipocytes into adipocytes but also inhibits the differentiation of mesenchymal stem cells into adipocytes.

Eradicate gastrointestinal disorders

The tannins present in capsicum perform the role of an astringent and treat inflammation and other problems of the gastrointestinal track such as dysentery, diarrhoea and other microbial disorders. It also acts as an agent of gastric mucus formation ensuring peptic ulcers not to develop. Its analgesic and antiseptic properties help in treating food poisoning. It reduces cramps and alleviates stomach spasms and pain. It also helps repair the damaged tissues in the stomach and the gastro-intestinal tract.

Alleviates menopausal symptoms

Owing to the presence of flavonoid in them, capsicums have been instrumental in reducing symptoms associated with menopause in women.

Overcome skin problems

Owing for their antioxidant property, capsicum is well known as anti-ageing supplement. This antioxidant acts on cell tissues leaving with improved skin appearance.

Gestational diabetes

Red and green capsicum enables insulin production thus, levelling the blood-glucose level in the body. So, capsicum is highly efficient in preventing type II diabetes. Green capsicum in particular has rich hypoglycaemic benefits.

Anti-bacterial

Capsicum seed are known to have anti-bacterial properties and is used for treating with skin problems. In addition to their use in cuisines, chilli peppers have been explored for their antimicrobial and antifungal properties. It also acts as natural antimicrobials, and is used to control for a number of microorganism-control issues in food items.

Conclusion

The both fresh and processed products of *Capsicum* sp. have significant nutritional importance along with radical scavenging property. Though nutritional benefit of pepper varies in between the cultivars, environment and agronomic practices, still peppers have taken an important position in health issues. So, promoting the cultivation of nutritionally rich cultivars is necessary. It can be a great opportunity for processing sectors also. Its nutritional benefit is also being exploited in medicinal purpose from time immemorial. Promoting the certified organic chilli and pepper is an another emerging sector, which will provide fresh and high nutritional rich produces to the consumers and also bring forth better economy to the farmers.

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