


Review Article
ADVANCE REVIEW ON NUTRITIONAL PHYTOCHEMICAL, PHARMACOLOGICAL AND ANTIMICROBIAL PROPERTIES OF CHILI
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ABSTRACT

India is the world's largest producer, consumer and exporter of chili peppers. It is one of the important commercial crops and a major constituent of Indian diet. It has green color and attain red color on ripening. Chili peppers produces alkaloid compound, capsaicinoids, responsible for the hotness. Chili also contain carotenoids, phenols, foliates and oxidative product which show many biological activities in the human body. It is a good source of minerals like iron, magnesium and potassium, vitamins like A, C, B, E and P and dietary fibers. The nutrient values of Chili depend upon the variety and their stages of maturity. Chili has nutritional values, antimicrobial and pharmacological properties. Chili have many biochemical and pharmacological properties like antioxidants, anti-inflammatory, antiallergenic and anti-carcinogenic. Chili is used in the pharmaceutical industry because of its pharmacological properties. Chili plays important role to increase immunity, anti-ulcer, analgesic, anti-inflammatory, and anti-hemorrhoid agent. The extracts of Chilli are used to alleviating the pain of arthritis, headaches, burns and neuralgia. It have the power to boost immune system and lower cholesterol, effective in heart disorders. This is the advance study to made a review of chili focusing mainly on its nutritional phytochemical, pharmacological and antimicrobial and clinical uses.

KEYWORDS: Chilli, *Capsicum*, Capsaicin, Pharmacology.

INTRODUCTION

Chili pepper, one of the most important commercial crops of India. It is grown almost throughout the country accounts 25% of the world production^[1]. There are more than 400 varieties of chilli available all over the world, different varieties and stages of maturity also have great influence on their pungency, size, shape and colors^[2,3]. Chili pepper is the first in Asia and the fourth important vegetable crops of the world. The world production approximately 122.34 million tons of fresh chili and 2.8 tons of dry Chilli^[4]. Chili pepper is a very remunerative spice crop of the Indian subcontinent and occupies an area of about 0.81 million hectare^[5]. *Capsicum* is a genus of plant under the family of *Solanaceae*, and has variety of names according to their size, location and type. Chili pepper is the third most important crop of family sloanaceae after potato and tomato. Most commonly used names are chili, bell, red, green or just called as pepper, having high content of vitamin C and total soluble phenolics than other vegetables^[6,7]. *Capsicum*, is the only crop that produce alkaloid compound called capsaicinoids, responsible for the hot test. Capsaicinoids are important constituent effective for neurology used in the pharmaceutical industry^[8]. Peppers contain carotenoids, Vitamin C, phenols, vitamin C, foliates and oxidation product (dehydroascorbic acid), has many biological activities in the human body due to its antioxidant properties. ^[9-11]The nutrient values of peppers depend upon the variety and their stages of maturity^[12]. Peppers have many biochemical and pharmacological properties like antioxidants, anti-inflammatory, antiallergenic and anti-carcinogenic activities^[13,14]. In addition, peppers also

contributed antimicrobial property^[15]. The pungency (hotness) of the chill is present in the inner membrane placenta of the chili and is measure in Scoville scale. The different varieties of chili belonging to the common of species: *Capsicum annum*, *Capsicum frutescens*, *Capsicum*, *Capsicum pubescens*, *Capsicum baccatum*.

Kingdom- Plant, Division- Magnoliophyta, Class- Magnoliopsida, Order- Solanale, Family- Solanaceae, Genus- *Capsicum*. *Capsicum* are herbaceous or semi-woody annuals or perennial plant. The leaves are dark green on the upper surface and pale green on the lower surface. The flowers are small, white and borne singly or in clusters of 2 or 3 in the axils of the leaves. The fruits are of different shapes and sizes depend upon the variety of plant. Botanically Chili pepper is known as *Capsicum frutescens.capsicum annum*. The world's hottest chili "*Naga Jolokia*" is cultivated in Tezpur, Assam. It is generally recommended that 4-8 weeks old seedlings are transplanted when they are about 15-24 cm in height. Flowering takes place 45 to 60 days after transplanting. Yield continues for about 3 months depending upon environmental conditions. The studies show that both growth and yield of Chillies are influenced by different aged chilli seedlings ^[16]. Chili grows best at 20–30°C and growth and yields suffer when temperatures exceed 30°C or drops below 15°C. Chili prefers warm and humid climate. According to Ayurveda, Chilli has many medicinal properties such as stimulating good digestion, natural pain killer to relieve pains. The extracts of chili peppers are used for alleviating the pain of arthritis, headaches, burns

and neuralgia. It is also claimed that they have the power to boost immune system and lower cholesterol.

Vitamins & Minerals

According to the National Institute of Nutrition, Hyderabad^[17] Chili peppers are the good source of vitamins and minerals. Chili peppers have many components for which it is considered as a food. Fresh Chili

peppers are rich in vitamin C, Vitamin C stimulates immune system and heal cellular damage. Dried chillies are very high in vitamin A. Red chillies are the great source of β -carotene. On drying, Chili loses most of its vitamin C and increases vitamin A content by 100 times. Vitamin A is a powerful anti-oxidant and anti-inflammatory agent.

Table 1: Constituents of Chili [per100g]

Parameters	Chillies Dry	Chillies Green
Moisture	10.000 gm	85.700 gm
Protein	15.000 gm	2.900 gm
Fat	6.200 gm	0.600 gm
Minerals	6.100 gm	1.000 gm
Fibre	30.200 gm	6.800 gm
Carbohydrates	31.600 gm	3.000 gm
Energy	246.000 K cal	29.000K.gm
Calcium	160.000 mg	30.000 mg
Phosphorus	370.000 mg	80.000 mg
Iron	2.300 mg	4.400 mg
Carotene	345.000 μ g	175.000 μ g
Thiamine	0.930 mg	0.190 mg
Riboflavin	0.430 mg	0.300 mg
Niacin	9.500 mg	0.900 mg
Vitamin C	50.000 mg	111.000 mg
Sodium	14.000 mg	-
Potassium	530.000 mg	-
Phytin Phosphorus	71.000 mg	7.000 mg
Magnesium	--	272.000 mg
Copper	--	1.400 mg
Manganese	--	1.380 mg
Molybdenum	--	0.070 mg
Zinc	--	1.780 mg

Source: National Institute of Nutrition, Hyderabad (2012)

Chili peppers are rich in vitamins A and C content, 6 times more than an orange fruit. Chili pepper also contains vitamins B2, B6, Riboflavin, niacin, folate and vitamin E. High content of Vitamin C prevents respiratory infections and strengthens the immune system. Vitamin A is needed for good vision and healthy immunity. On drying, vitamin A content of chili peppers increases 100 times. Studies show that antibacterial action of chili pepper prevents stomach ulcers by killing ulcers-causing bacteria. Chili has a very beneficial effect on the circulatory system as it counteracts cholesterol build-up and reduces platelet aggregation, thus reducing the risk of heart attacks and strokes. Chili pepper is a good source of potassium, manganese, iron and magnesium as well as a macro nutrient: $\frac{1}{2}$ cup of chili pepper contains 1.5 g protein, 7.1 g carbohydrates and 1.1 g fiber.

Chemical Constituents

Chili pepper comprises of number of chemical such as capsaicoids, flavonoids, carotenoids, steroids, steroidal glycosids, polyphenol and macronutrients.

Capsaicinoids

Chili pepper contains five compounds, which are collectively known as capsaicinoids. These compounds are produced as secondary metabolites by chili peppers. These are named as capsaicin, dihydrocapsaicin, nordihydrocapsaicin, homocapsaicin and homohydrocapsaicin, nornordihydrocapsaicin^[18]. Chemically, these are acid amides of vanillylamine with C9-C12 branched fatty acid chain. Their molecules structure differ only in the saturation of the acyl group^[19,20]. Capsaicinoids are synthesized and accumulated in the epidermal tissue of the placenta of chili pepper^[21]. Capsaicin and dihydrocapsaicin together constitute more than 80% of total capsaicinoids content of Chili pepper^[22]. The capsaicinoids are mainly

capsaicin content provide pungency to chili pepper. Biosynthesis of capsaicin depends on the gene *AT3*^[23]. The quantities of capsaicinoids and capsaicin in Chili pepper varies according to soil and climatic condition. Capsaicin (Trans-8-methyl-*N*-vanillyl-6- none amide) is a crystalline, lipophilic, colorless and odorless alkaloid with the molecular formula $C_{18}H_{27}NO_3$. Its molecular weight is 305.40 g/mol, and it is fat-, alcohol- and oil-soluble. Capsaicinoids are synthesized naturally in the placenta of chili fruits from enzymatic condensation of vanillylamine and different-sized fatty acid chains which are elongated by a fatty acid synthase. Capsaicinoids are important for food and pharmaceutical industries. Number of studies are available on chemical, enzymatic synthesis and tissue culture of chili pepper^[24,25] Capsaicinoids have a wide variety of biological and physiological activities which can performed different functions such as antioxidants, anticarcinogenics, promotion of energy metabolism and suppression of fat accumulation and anti-inflammatories^[26]. Due to the irritation the use of these molecules are limited.

Amino acids

Tryptophan, lysine and phenylalanine are the essential amino acid for the human being that cannot be synthesized therefore must be supplied in diet. These amino acids are present in chili pepper.

Carotenoids and Flavonoids

Chili pepper are rich in carotenoids. These carotenoids are alpha carotene, beta lutein and zeaxanthin.^[18] The carotenoids have strong antioxidant properties that protect against cancer. Red chillies are a good source of beta-carotene. A single pod contains a full day's supply of beta-carotene which makes the chilli an invaluable food to fight against cancer and heart disease. Total flavonoids present in green chili are 83.5 mg/kg of dry Weight. They include myrecetin, luteolin, both flavones and flavonone glycoside conjugates.^[27]

STEROIDS AND STEROIDAL GLYCOSIDES

Chili pepper has lanostenol and lanostenol as steroids. Capsicosides A, D and proto-dega Lactotignin are steroidal glycosides present in Green Chilli.^[18]

PHARMACOLOGICAL PROPERTIES

Chili pepper may prevent cancer, heart disease, stroke, blood clots, obesity, high blood pressure, high cholesterol, bronchitis, emphysema, coughs and colds and stomach ulcer. Chilies are also said to be good for kidneys, spleen, pancreas, lungs and heart. About 12% of chilli is comprised of capsaicin used as medicinal compound. Although the precise role of capsaicin is not fully understood, current evidence suggests that capsaicin relieves neuralgia pain by depleting and preventing accumulation of substance P (Principal chemo mediator) in peripheral sensory neurons. Substance P is thought to be the principal chemo mediator of pain impulses from the periphery to the central nervous system. Initial release of substance P from sensory neurons is believed to be responsible for burning sensations experienced by some individuals.

Natural Pain Killer

Capsaicin, the active ingredient of green chili, acts as a selective agonist for the transient receptor potential vanilloid selective agonist for the ingredient receptor potential vanilloid (TRPVI) receptor present on afferent neurons^[18]. These receptor are found to be responsible for analgesic effect. Capsaicin is recognized as a treatment for osteo-arthritic pain^[28]. Capsaicin can be applied as cream or plaster, helps in reducing back pain^[29]. Capsaicin also has benefits in headaches, including migraine headaches^[30]. It can also be used to treat the pain associated with cancer^[31]. Those effects depend on the chronic activation of something called the transient receptor potential vanilloid 1 (TRPV1) channel found in the lining of blood vessels. Activation of the channel leads to an increase in production of nitric oxide, a gaseous molecule known to protect blood vessels against inflammation and dysfunction, Zhu explained. Capsaicin (an active ingredient in many commercial pain medications) is a natural painkiller that provides pain relief from arthritis and diabetes, and can alleviate headache, and joint pain. Capsaicin blocks substance P, part of the body's pain-and inflammation chemistry.

In response to the burn, our brain secretes endorphins, the body's natural pain relievers (their pain-relieving effect is similar to that of morphine) and uplifting chemicals. Medically, it is one of the most powerful local pain relievers available and is regularly used to treat the pain of arthritis, shingles, toothache and surgery scars. Ointments and lotions with capsaicin are also used as an external remedy for nerve pain and itching. Capsaicin acts as TRPVI receptors. This receptors is a nonselective, ligand operated cationic channel located primarily in the small fibers of nociceptive neurons. It is also broadly distributed in tissue of the brain, bladder kidneys intestines keratinocytes of epidermis, glial cells, liver and polymorph nuclear granuloocytes, mast cells, and macrophage. This channel can be regulated and activated by endogenously released endovanilloids and diverse exogenous stimuli including chemical agonists as capsaicin, olvanil and resiniferatoxin, identified as TRPVI agonists. The TRPVI contains a heat - sensitive subunit responsible for the burning sensation caused by capsaicin to TRPVI increase intracellular calcium, triggering release of neuropeptides such as substance P and the calcium gene - related peptide (CGRP)^[32]. Contact between capsaicin and sensory neurons produce a localized heat sensation. Topically, it acts primarily on sensory -C fibers to cause depletion of substance P from the nerve terminals^[33]. This mechanism has served as a base for studies of the structure -activity relationship, which are aimed at development of new synthetic ligands for the TRPVI. Capsaicin's effects in the nervous system are not exclusively analgesic. Capsaicin also promotes the release of somatostatin, CGRP and endotheline.^[34]

Immunity Booster

Chili pepper contains high amounts of beta - carotene vitamin A and vitamin C, Which help in building immune system of the body. Its active ingredient capsaicin also boosts the defense mechanism of the body.^[35]

Cardiovascular

Chili pepper (*capsicum frutescens*) reduces blood cholesterol, triglyceride levels platelet aggregation^[35]. Thus, it lowers the risk of heart attack, stroke and pulmonary embolism. Chili pepper prevents the deposition of fats along blood vessel walls caused by free radicals, which the first step in the development of atherosclerosis^[36]. It lower blood pressure and heart rate^[37]. Capsaicin can reduce the incidence of cardiovascular diseases by inhibition of platelet aggregation and the activity of clotting factors. Capsaicin can pass through plasma membrane of platelets and thus alter membrane fluidity^[38,39]. It has been reported that capsaicinoids have potential beneficial effects on the cardiovascular system to treat various cardiovascular threats in human beings that include coronary heart disease, myocardial infarction, hypertension and atherosclerosis^[38]. Studies report that capsaicin has been able to increase the resistance of LDL to oxidation y delaying the initiation of oxidation and slowing the rate of oxidation. Consumption of chilli regularly for 4 weeks can increase the resistance of serum lipoproteins to oxidation in adult men and women^[38,36]. Polyphenol obtained from Chili pepper showed anti-oxidant and vasodilator effects^[40].

Anti-inflammatory agent

Capsaicin is a potent inhibitor of substance P, is a neuropeptide associated with inflammatory processes^[41]. It reduces the inflammation by stimulating the blood flow of that area. Capsaicin reduced paw inflammation in animals and delayed the onset of arthritis^[42]. Chili pepper also protects lung tissues owing to its anti-inflammatory action.

Gastro Protective Agent

Chili pepper provides protection against developing stomach ulcer by killing ingested bacteria. Chili increase the secretion of mucus and protective buffer solution in stomach^[42]. Capsaicin possesses antibacterial property particularly against the bacteria *H. Pyroli*, a causative agent of stomach ulcer^[43]. The studies have shown that capsaicin sensitive sensory nerves are involved in a local defense mechanism against gastric ulcer. Capsaicin-sensitive sensory nerves are also present in gastrointestinal system which plays a crucial role in maintenance of gastrointestinal mucosa integrity against injurious interventions. Capsaicin sensitive sensory nerve get stimulation by chili at low concentration^[44]. Capsaicinoids exert either beneficial or detrimental effects on gastrointestinal mucosa depending on the dose and/or duration of drug treatment^[38].

Anti-rhinitis

Sinus passage opens by releasing allergens from the nose, eating chilli enhances nasal secretion, provide relief from congested nose. It is also an ingredient of nasal sprays effective in relieving allergies and sinus problem like allergic rhinitis^[45]. As it possesses anti-inflammatory activity.

Anti-Obesity

Chili pepper is a thermogenic agent. It increase the process of heat production. Oxygen consumption is also enhanced after eating chili pepper. Obesity cause

metabolic deregulation, hyperglycemia, hyperlipidemia, insulin resistant diabetes and fatty liver disease^[46]. In obese people, diet containing chilli pepper significantly lowers the amount of insulin required to reduce blood sugar levels. Furthermore, it reduce LDL cholesterol levels and thus, helps in reducing weight. The antiobesity effect of capsaicin showed that thermogenesis and lipid metabolism related proteins were markedly altered upon capsaicin treatment. The non-pungent CH-19 sweet pepper is responsible for weight loss. Studies reveal that body temperature and oxygen consumption increase with a single dose of CH-19 sweet pepper and regular intake of it can promote reduction of body weight and oxidation of body fat.^[38,36]

Enhancement of Insulin Sensitivity

Chili pepper contains antioxidants, vitamin C and carotenoids which are thought to be useful in insulin regulation.^[18] Vitamin C decrease the chronic inflammation in the body by combating free radicals, which are precursor of diabetes.^[47]

Anti Cancer

According to American institute for Cancer Research noted that Chili pepper is a promising anticancer agent. Capsaicin profound anti proliferate effect on human prostate cancer cell in culture. The underlying mechanism of action for the anticancer effect of chili appears to be related to i) Triggered suicide of primary types of prostate cancer cell lines ii) Retarded expression of prostate – specific antigen (PSA) iii) Inhibition of PSA transcription resulting in rapid fall of PSA levels^[48]. iv) Disruption of mitochondria of the cells a study was conducted on mice, they were given capsaicin in the diet for 16 months. They had a reduced appetite, and their tumor rates were generally lower, particularly liver cancer^[49]. Another research showed that orally administered capsaicin reduce pancreatic tumors in mice^[8]. It was also observed that Capsaicin may alter the way of cancer-causing chemicals^[50]. The cytochromes (live enzyme) may increase the cancer-causing properties of certain chemicals like vinyl carbonate, aflatoxin, several nitrosamines enzyme and benzopyrine. Capsaicin inhibits these enzymes (cytochromes) and prevent from cancer^[51]. Various study report that Capsaicin represses the growth of various malignant cell lines by induction of cycle arrest, apoptosis, dihydrocapsaicin was reported to induce the autophagy in HCT116 human colon cancer cells and also by the inhibition of cellular metabolic activation^[38,52,53]. It has also been found that capsaicin was able to block breast cancer cell migration and kill prostate cancer cells^[54, 55]. The metabolites of capsaicin (such as the reactive phenoxy radicals) can even attack the DNA and trigger the mutagenicity and malignant transformation^[38,56].

Anti-epileptic: Animal studies provide evidence for the antiepileptic potential of Chili pepper^[57].

Inhibition of Bacterial Growth: It was reported that capsaicin showed an in vitro growth inhibition against MtzR and MtzS strains. The capsaicin could be a useful treatment for antibiotic resistant strains and for those who do not want to take synthetic antibiotics^[58]. According to the U.S Food and Drug and Administration (FDA), there are

several food-borne pathogens that are of concern and harmful to the general public particularly harmful to pregnant women. The well-known foodborne pathogens are *Bacillus cereus*, *Bacillus subtilis*, *Enterobacter aerogenes* and *Pseudomonas aeruginosa*^[59]. Capsaicin having the properties to kill these food borne pathogens.

CONCLUSION

Chili pepper is an important integral of Indian food. A small Chili pepper fruit provides lots of vitamins: A, C, B2, B6, E and minerals. *Capsicum*, is the only crop that produce alkaloid compound, responsible for hotness. Capsaicinoids are important constituent effective for neurology, used in the pharmaceutical industry. Chili pepper has pharmacological properties such as anticancer, anti-inflammatory, antioxidant, antihemorrhoidal, anti-obesity, gastro protective, antipyretic, analgesic and provide relief from rhinitis sinusitis, migraine, diabetes and arthritis. The small amount of chili in our daily diet provide plenty of health benefits.

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