

A review article on *Capsicum Chinense*

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Abstract

Chilli peppers are one of the few horticulture items that are as widely available as they are. Numerous cuisines from all over the world make use of this fruit in their preparations. When it comes to the family of plants known as Solanaceae, the chilli pepper belongs to the genus known as *Capsicum*. This fruit has a variety of nutritionally important components, including carbohydrates, fibre, proteins, and lipids, among others. The chilli pepper has a greater number of compounds that have the ability to have an influence on biological processes. There have been a number of studies conducted in recent years that have demonstrated that several varieties of chilli include phenolic compounds, carotenoids, and capsaicinoids, all of which are known to possess biological activity. Polyphenols are among the bioactive chemicals that have been the subject of the greatest investigation among these others. Polyphenols have the capacity to reduce blood sugar levels, combat inflammation, and bring down blood pressure, which are three of the most significant bioactivities connected with each of these compounds. This work provides a comprehensive analysis of the bioactivities that are associated with the capsaicinoids and polyphenols found in a variety of chilli products, both in vitro and in vivo. When it comes to the creation of functional meals or components, these particulars are helpful.

Keywords: Chili, Pharmacological Activity, Nutrients, Phytochemical

Introduction

The Indian market for chillies, which are both a spice and a vegetable crop (*Capsicum annum* L.), has a significant volume of untapped potential for expansion., India cultivates more than 1.4 million hectares of fresh and dry chilli fruits[1]. This contributes to the country's total production of 18.8 MT of chilli, which makes it one of the most highly valued fruits and vegetables on a worldwide scale. As a result of its colour, heat, pungent taste, and aroma, chillies are utilised as spices and culinary complements in a wide variety of national cuisines, the quantity of vitamins A, C, and E that chillies contain might vary depending on the cultivar the chilli is grown from. When it came to preparing chillis, a wide range of techniques were utilised, such as fresh, canned, pickled, frozen, fermented, dehydrated, or powdered forms. In addition to its abundance of antioxidants and anti-cancer components, capsaicin's effectiveness in relieving muscular pain has contributed to its increased relevance[2][3]. Recent scientific findings on its medicinal applications have also contributed to its enhanced significance[4][5]. King Chilli, also known as "Bhut Jolokia," is one of the most fiery types of chilli, It is indigenous to the northeastern region of India and is commonly referred to by its common name. The Defence Research Laboratory in Tezpur, which is located in the state of Assam in India, has determined that the king chilli is the chilli that is the hottest in the entire globe[6]. In addition, it has a Scoville heat unit (SHU) of 100,130,4 and is therefore the hottest chilli. According to studies, the quantity of capsaicin found in king chilli fruits is substantially higher than that found in other varieties of chilli fruits.[7] According to research conducted by, the region's high foothill climate and ample nitrogen make it an ideal location for cultivating a broad variety of capsicum crops, including king chilli beans. states that the monsoon season, which is characterized by high levels of humidity, is the optimal time to produce the crop[8][9]. A direct outcome of the strong aroma and high degree of heat that the king chilli possesses is the enormous potential that it possesses both locally and globally, the production of king chilli is supposed to increase on a yearly basis in the northeastern area of India, there is a significant demand for the fragrant green king chilli, the market price of green King Chilli (bhut jolokia) is higher during its off season, but it remains at a reasonable price throughout its season (300–400 per kilogramme)[10][11] There is a significant amount of green chilli that never makes it out of the field because there is not enough processing and preservation equipment. It is highly challenging to extend the shelf life of green king chilli once it has been harvested because of the fast deterioration of its shelf life that occurs during storage, shipping, and marketing[12]. There is a requirement that green peppers be consumed when they are still fresh in order for them to be relished in India[13]. The majority of retail establishments, including supermarkets, do not put into practice the most effective methods for handling and storing pepper, which results in a reduction in the pepper's freshness and a shorter shelf life. Modified environment packaging (MAP), on the other hand, has the potential to enhance the quality of fresh king chilli and extend its shelf life simultaneously[14].

GEOGRAPHICAL DISTRIBUTION

The Indian market for chillies, which are both a spice and a vegetable crop (*Capsicum annum* L.), has a significant volume of untapped potential for expansion India cultivates more than 1.4 million hectares of fresh and dry chilli fruits[15]. This contributes to the country's total production of 18.8 MT of chilli, which makes it one of the most highly valued fruits and vegetables on a worldwide scale. As a result of its colour, heat, pungent taste, and aroma, chillies are utilised as spices and culinary complements in a wide variety of national cuisines., the quantity of vitamins A, C, and E that chillies contain might vary depending on the cultivar the chilli is grown.[16]. When it came to preparing chillis, a wide range of techniques were utilised, such as fresh, canned, pickled, frozen, fermented, dehydrated, or powdered forms. In addition to its abundance of antioxidants and anti-cancer components, capsaicin's effectiveness in relieving muscular pain has contributed to its increased relevance [17]. Recent scientific findings on its medicinal applications have also contributed to its enhanced significance. King Chilli, also known as "Bhut Jolokia," is one of the most fiery types of chilli. It is indigenous to the northeastern region of India and is commonly referred to by its common name[18]. The Defence Research Laboratory in Tezpur, which is located in the state of Assam in India, has determined that the king chilli is the chilli that is the hottest in the entire globe. In addition, it has a Scoville heat unit (SHU) of 100,130,4 and is therefore the hottest chilli, the quantity of capsaicin found in king chilli fruits is substantially higher than that found in other varieties of chilli fruits. According to research conducted by the region's high foothill climate and ample nitrogen make it an ideal location for cultivating a broad variety of capsicum crops, including king chilli beans. It states that the monsoon season, which is characterized by high levels of humidity, is the optimal time to produce the crop. A direct outcome of the strong aroma and high degree of heat that the king chilli possesses is the enormous potential that it possesses both locally and globally, the production of king chilli is supposed to increase on a yearly basis in the northeastern area of India[19]. There is a significant demand for the fragrant green king chilli, the market price of green King Chilli (bhut jolokia) is higher during its off season, but it remains at a reasonable price throughout its season (300–400 per kilogramme)[20]. There is a significant amount of green chilli that never makes it out of the field because there is not enough processing and preservation equipment. It is highly challenging to extend the shelf life of green king chilli once it has been harvested because of the fast deterioration of its shelf life that occurs during storage, shipping, and marketing[21]. The majority of retail establishments, including supermarkets, do not put into practice the most effective methods for handling and storing pepper, which results in a reduction in the pepper's freshness and a shorter shelf life. Modified environment packaging (MAP), on the other hand, has the potential to enhance the quality of fresh king chilli and extend its shelf life simultaneously[22].

BOTANICAL DISTRIBUTION

The capsicum plant, also known as *Capsicum annum* L., is an example of a delicate perennial subshrub. Its stem is densely branched, and it is a perennial. This plant reaches its maximum potential when it reaches a height of up to 1.5 metres.[23]. When the fruit is ready to be consumed, it is typically green in colour; but, due to a lack of chlorophyll, it may be white. A solitary white flower is the source of its development[24]. In spite of the fact that specific varieties might transform into brown, purple, peach, or orange when they are ripe, the most typical transformation that mature fruits undergo is the colouring of red[25]. Despite the fact that this plant is typically grown as an annual in regions with a milder climate, it is most successful in situations that are hot and dry. Herbs, subshrubs, trees, vines, or annuals or perennials with a short life cycle, frequently with a thick lignified xylopodium, hairless or sparsely to densely coated in hair, with trichomes that are simple, branched, eglandular or glandular, and uniseriate are examples of plants that fall into this category[26]. Young stems are angled, herbaceous, sometimes weak and fragile, and occasionally somewhat scrambling. Meanwhile, older stems are woody at the base and may have fissured bark and lenticels. Young stems are slanted and herbaceous[27]. The blades of sympodial units can be simple or whole, they can be concolorous or discolorous, they can be glabrous or densely pubescent, and they can have simple or branching uniseriate trichomes that are either eglandular or glandular[28]. Sympodial units can have two sets of leaves or just one set of leaves. The leaves typically have a geminate pattern. In a typical situation, the petioles are fully grown. The flowers are arranged in clusters of one to twenty or more blooms in inflorescences that are either solitary or paired; branching inflorescences are only seen seldom. Because they are axillary, the inflorescences are frequently unbranched. The magnificent actinomorphic blooms have five merous petals, with domesticated varieties having four to eight merous petals[29]. Depending on the situation, the pedicels may be erect, slightly spread, or slightly curved. Additionally, the end of the pedicles may be geniculate or nongeniculate[30]. The calyx is often truncate, entire, round, or five-angled in form, and it can have anywhere from three to ten appendages. It is quite uncommon for the corolla to be entirely greenish-white or predominantly purple. The corolla can be stellate, rotate-stellate, campanulate, or campanulate-urceolate[31]. It can be white, yellow, violet, or fuchsia in colour. Additionally, it may contain spots that are maroon, purple, or greenish-yellow on the interior. Anthesis is characterized by the lobes spreading out or reflexing, and the presence of an inter petal membrane is generally present. In domesticated species, there can be as many as eight stamens, but even in wild species, there are only five stamens, and they are almost always equally distributed[32]. In order to form a staminal plaque that is united to the base of the corolla, the filaments acquire a hairy appearance and become more expansive at the base. A pair of brief lateral auricles may be found on each plaque. A dome-shaped or ovoid form is characteristic of the anthers, which might be yellow, cream, blue, or purple in colour[33]. They are thought to be connivent before to anthesis; however, after they have reached maturity, they are often free and can be dehiscent through longitudinal slits. Under most situations, gynoecium is bicarpellate; but, under exceptional circumstances, it can be three- or even four-carpellate.

Glabrous, subglobose to ovoid in form (occasionally ellipsoid), and with an annular nectary at its base, the ovary is a structure that is characterized by its ovaries. A straight or slightly curved form, cylindrical or clavate in shape, glabrous, and frequently protruding beyond the anthers are the characteristics typical of the styles. It is possible for stigmas to be long, medium, or short in length. They can also be globose or discoid in form, occasionally considerably bilobed, and sometimes delicately papillate. They are subglobose or ellipsoid in shape and can be any shade of yellow, brown, or blackish-yellow [34]. The seeds are often shaped like a C or a D, and their seed coats are smooth, reticulate, or mildly tuberculate. The number of stone cells that should be present should not exceed six, if there are any at all [35]. In contrast to embryos, which are often imbricate but can sometimes be annular or coiled, endosperm is abundant, solid, and white. Many chromosomes are present equals A plant or subshrub that is exceedingly varied, often planted as an annual, and with a height of between 0.5 and 1.5 metres, standing erect, and having plenty of branches[36]. A powerful root system that has a large number of lateral branches. It is possible for the stems to be subterete or irregularly angular, to have a diameter of up to one centimetre, to have several branches, and to have a hue that can range from green to brown-green[36]. There are specks of a purple colouring that may be seen close to the nodes. In addition to being subglabrous, the leaf blades are oval in shape, light to dark green in colour, and can measure up to 10(-16) cm x 5(-8) cm. Petioles are simple and alternate, and their length can vary widely from one plant to the next. In most cases, the blooms are produced in a single cluster and are arranged in a terminal position. The pedicel can be as long as three centimetres in the flower and as long as eight centimetres in the fruit[37]. There are typically five teeth that are visible on the calyx, which has a cup-like form, is persistent, and becomes bigger within the fruit. A white corolla with five or seven lobes that rotate from campanulate to rotate is the characteristic of this flower[38]. The stamens range in colour from a light blue to a purple hue and have five or seven stamens. The style is filiform, the stigma is capitate, and the ovary takes the form of a 2(-4)-locular structure[39]. The fruit is a berry that does not include pulp and can vary in size, shape, colour, and the degree of spiciness it possesses. While it is juvenile, it can be green, yellow, cream, or purple in colour; when it is ripe, it can be red, orange, yellow, or brown in colour. It is typically more or less conical in shape and can grow up to 30 centimetres in length[40]. This seed features an orbicular form, is flattened, and measures between three and four and a half millimetres in diameter. It has a thickness of around one millimetre. This plant may grow to a height of 0.3 to 1.2 metres and a width of 15 to 30 centimetres[41]. It is classified as either a herb or a small shrub. With a roughly oval shape and smooth margins, its glossy leaves may grow to be up to 7.5 centimetres in length[42]. When the leaves of certain types reach maturity, they take on a dark purple or perhaps a black coloration altogether. Each of the five-petalled flowers can be a variety of colours, including white, greenish purple, lavender, or even a star shape[43]. Berry-like in appearance, the fruits come in a broad range of sizes and shapes, and they are really just fruits. Contrary to bell peppers, which are large, spherical, and wrinkled, cayenne peppers are elongated and thin. This is to highlight the contrast between the two types of peppers. Depending on the type, the colour of the fruit can change from green to red to yellow to orange to even black as it ripens.

However, on average, the hue of the fruit is green. Cultivars and varieties are often classified based on characteristics of the fruit, such as its size, shape, colour, flavour, and pungent quality. This is because the different forms of the fruit are easily able to cross-pollinate with one another[44]. Cayenne pepper, also known as capsicum, gets its name from the Greek word for "to bite," which describes the fruits and seeds of the plant, which are known for their hot and pungent properties[45]. When it comes to preparing Indian cuisine, green chilies are an absolute must. Peppers belonging to the genus *C. annum* L. are responsible for the production of the great majority of chilli peppers. Over time, the hairy stems of the shrub, annual, or perennial plant will finally fall off. The plant can grow to a height of 20–80 centimetres. The leaf stem of solitary or paired leaves is between 4 and 7 centimetres in length, and the leaf blade is either oblong-ovate, ovate, or ovate-lance-shaped, measuring between 4 and 13 centimetres in length and 1.5 to 4 centimetres in width[46]. The leaf blade also has a narrowing base, an entire edge, a short tapering or pointy tip, and finally no hairs at all. The inflorescences can be either solitary or clustered, and they include a small number of flowers. One to two centimetres of the flower stalks and their tips are twisted. The sepal cup form is 2-4 x 3 mm and is wavy. The diameter of the white blossoms is around one centimetre, and the length of the purple anthers is approximately one and a half to two millimetres. There are a variety of shapes and colours that the fruits of the capsicum plant can take, including orange, yellow, or purple. The majority of chilli peppers have a red flesh coloured inside[47]. Hot peppers, also known as *Capsicum annum* L., are classified as annual herbaceous plants; nevertheless, they are actually perennial woody perennials[48]. The widespread assumption is that it was the first crop to be domesticated in the Americas where it was grown. However, the height of the plant can range anywhere from two to four feet, depending on the species. The leaves are typically glabrous, simple, and flat [49]. They are also entire. Generally speaking, you will see a single, creamy-white flower with seeds that are straw-colored inside [50].

Pharmacological Activity

Among the many pharmacological actions documented for capsaicin, a compound found in capsicum species, are the following potential therapeutic uses:

Pain management:

To a large extent throughout history, capsaicin has been utilised in the practice of folk medicine, often on the basis of the idea that. An example of this would be the use of a chemical that gives rise to searing pain in order to alleviate other types of scorching pain.[51]. The first formal study from the Western world on the analgesic properties of topical capsaicin was published in 1850, and it recommended that an alcoholic hot pepper extract may be used as a remedy to ease burning or itching in the hands and feet. Topical drugs containing capsaicin are now available in a number of countries for the purpose of alleviating neuropathic and musculoskeletal pain. These medications typically have doses that range from 0.025 to 0.1% by weight.

It is not uncommon to find these products available without a prescription. The outcomes of clinical trials conducted on these medications for the treatment of a wide range of pain disorders, including post-herpetic neuralgia (PHN), diabetic neuropathy, and chronic musculoskeletal pain, have shown contradictory results. Typical dosage regimens consist of applying the product to the skin three to five times per day for a period of two to six weeks.^{3, 4} It is likely that patients are not obedient enough to use low-concentration capsaicin-based solutions as prescribed, which can lead to contamination of their clothing, bedding, contact lenses, and other personal possessions. This is one of the probable explanations for the limited efficacy of these products. It is also possible for patients to suffer burning sensations with each treatment.

Anti inflammatory activity:

As a result of extracts from their leaves, peduncles, and stems, plants that are grown in Yucatán, Mexico on black and red soils have been shown to exhibit anti-inflammatory properties *in vivo* and antioxidant activity *in vitro*. There are a variety of extraction methods and soil types, each of which has its own unique impacts and degrees of activity. Through the use of supercritical fluid, the compounds that had anti-inflammatory effects were in fact successfully extracted. Maceration and Soxhlet techniques yielded the greatest results for the extraction of antioxidant compounds and polyphenols from plant stems that were cultivated on red soil. This was proved by the fact that the most active sample was obtained from the plant stems. Catechuic acid was the chemical that was found in the greatest quantity. In conclusion, the findings brought to light the relevance of selecting the appropriate extraction process in order to get compounds that may be utilized in a variety of contexts.

Anticancer activity:

We found that acetonitrile extract significantly decreased cell viability when applied to HepG2 cells. The capsaicinoids found in the extract worked in a dose-dependent way to drastically reduce output. The results of the current study indicate that capsaicinoids extracted in acetonitrile have anticancer properties and show promise as a treatment for this disease.

Gastrointestinal Activity:

The active components of dietary spices have multiple positive effects on the gastrointestinal system. These effects include influencing gastric emptying, stimulating gastrointestinal defence and absorption, and stimulating secretions from the pancreas, the intestines, the liver, and the salivary glands. Chilli, or *Capsicum annum* (Solanaceae), is a spice with a long history of usage in traditional Indian medicine for a wide range of medical conditions. It is well-documented that capsaicin and chilli have therapeutic potential; but, in many physiological contexts, they have opposite effects. Various gastrointestinal complaints, including dyspepsia, appetite loss, gastric ulcer, gastroesophageal reflux disease, and more, have traditionally been treated with chilli in traditional medicine.

There are over 200 known components in chilli, and some of these active ingredients have several positive effects on gastrointestinal disorders, including preventing ulcers, cancers, and gastrointestinal infections; regulating secretions and absorptions; and alleviating symptoms of gastroesophageal reflux disease (GERD). While chilli and its active ingredients show promise as gastroprotective agents, further research is needed to establish safe dosages. The phytochemistry and gastrointestinal advantages of chilli and its active components are summarized in this article.

Antibacterial activity:

The purpose of this research was to identify the impact of *Capsicum chinense* extracts at varying concentrations on two specific types of bacteria: *Staphylococcus aureus* and *Escherichia coli*. When tested against the test bacterium, the extracts showed promise. When tested against *Staphylococcus aureus*, the extract from *Capsicum chinense* var. Noga Bhut was more effective than that from var. Roja Bhut. Antibacterial activity against *Escherichia coli* was found to be greater in the extract from *Capsicum chinense* var. Roja Bhut compared to the one from *Capsicum chinense* var. Noga Bhut. A 75% extract of *Capsicum chinense* variety CA1 showed a 12 mm zone of inhibition against *Escherichia coli*, indicating higher antibacterial activity. The greatest 11 mm zone against *Staphylococcus aureus* was demonstrated by the 75% extract of *Capsicum chinense* variety CC2. Antibacterial activity was enhanced in extracts from increasing concentration percentages.

Cardiovascular activity:

It has been demonstrated that the grade of ripeness, harvest time (PTD), and the relationship between the two have a substantial influence on almost all of the polyphenols that were examined. During the days of harvest, the concentration of some polyphenols, such as gallic and protocatechuic acid, increased. However, the concentration of the majority of polyphenols, including as catechin, chlorogenic acid, vanillic acid, and ellagic acid, decreased. Chlorogenic acid (79.97 ± 2.02 mg/100 g) and catechin (355.30 ± 5.81 mg/100 g) were the polyphenols that had the highest concentration values with respect to ripe Habanero peppers that were harvested at 160 PTD. When it came to the antioxidant activity testing, only catechin and vanillic acid exhibited an acceptable fit ($R^2 > 0.7$) in both the immature and mature Habanero peppers. This was the case for all of the polyphenols that were examined. This tendency was also observed when the total polyphenols were taken into consideration. According to the linear correlation analysis, the amount of polyphenols present has a substantial impact on the antioxidant activity. Catechin, which is the primary polyphenol found in Habanero peppers, is the polyphenol that has the most significant influence on antioxidant activity. Catechin has a strong linear correlation with antioxidant activity. As a result, this offers evidence that the antioxidant activity of fruits containing *Capsicum chinense* decreases with harvest time, along with the content of the principal polyphenols. On the basis of the findings, it is possible to draw the conclusion that the peppers that were harvested at 160 PTD have the greatest total polyphenol content and antioxidant activity in comparison to the other three dates that were examined.

Because of the high polyphenol content of habanero peppers, the functional food business has a financial interest in these peppers. With this knowledge, we are able to determine the optimal time to harvest these peppers.

Anti-diabetic activity:

In ObD mice, treatment with RPSE did not result in any changes to the body weight, accumulation of fat, or injury to the liver. It is interesting to note that supplementation with RPSE improved the indicators of glycemic control, such as insulin, HbA1c, and fasting glucose levels. A reduction in pro-inflammatory cytokines and triglycerides in the blood was also seen after treatment with RPSE. In addition, the OGTT found that RPSE enhanced insulin sensitivity and glucose uptake during the course of the study. Through the process of transcriptional downregulation, RPSE supplementation was able to decrease the expression of gluconeogenic genes and proteins in the liver, including PEPCK and GP6Pase. As the underlying mechanism of the RPSE-induced anti-diabetic action, it was discovered that an elevated phosphorylation of FOXO1 and AMPK was responsible for the impact. These findings imply that RPSE improved glycemic control in ObD mice by decreasing hepatic gluconeogenesis through the activation of FOXO1 and AMPK. This was accomplished by inhibiting hepatic protein synthesis.

Conclusion

Bhut jolokia, also known as *Capsicum Chinense* Jacq, has a high capsaicinoid content, which makes it an excellent candidate for future exploitation. This is especially true when taking into account the significance of capsaicin in terms of both health and illness, as well as its financial implications in the culinary and pharmaceutical industries. Therefore, further research is required to determine the extent of this fruit's toxicity and to determine how it might be utilised in the field of medicine.

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