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Capsicum: Chemistry and Medicinal Properties of Indigenous Indian Varieties

Mithun Rudrapal and Khomendra Kumar Sarwa

Abstract

Capsicum pods (or chili pepper) constitute the world's second most consumed vegetable crop and spice after tomato in our daily culinary practice. Five indigenous species that are widely domesticated in various parts of India include *Capsicum annuum* L., *Capsicum chinense* Jacq., *Capsicum frutescens* L., *Capsicum baccatum* L., and *Capsicum pubescens* L. The chili pods of *C. chinense* Jacq (locally known as *Bhut Jolokia* in the Assam state of India) was officially recognized as the world's hottest *Capsicum* variety according to the Guinness Book of World Records. Capsaicinoids, a group of chemical principles present in matured *capsicum* pods, are responsible for the pungency as well as pharmacological/medicinal properties of capsicum. Some important capsaicinoids include capsaicin, followed by dihydrocapsaicin, nordihydrocapsaicin, homodihydrocapsaicin, and homocapsaicin. Traditional practices of capsicum pods of *Bhut Jolokia* have been well documented for the management of various human disorders/ailments, particularly in the north-eastern region of India. In modern medicine, *Bhut Jolokia* pods have been used in the treatment of arthritis, gastritis, toothache, and musculoskeletal and neuropathic pain including other pharmacological disorders and microbial infections. Capsaicinoids have been reported to exhibit a diverse range of biological effectiveness such as antioxidant, analgesic, and anti-inflammatory, anticarcinogenic effects.

Keywords: *capsicum*, capsaicinoids, capsaicin, *Bhut Jolokia*, *Dhan Jolokia*, indigenous, Indian varieties, pungency, traditional uses, medicinal properties

1. Introduction

Capsicum (also called as Peeper or Chili pepper) is an important vegetable crop widely cultivated in tropical and subtropical regions of the world. This spice crop has been well known since past 9500 years. *Capsicum* pods or chili pepper constitute the world's second most consumed vegetable crop and spice after tomato in our daily culinary practice [1].

India is the largest producer, consumer, and exporter of *Capsicum* in the world. It contributes about 36% to global production of *Capsicum* and exports about 20% of its total production [2]. The production of *Capsicum* in India is dominated by the state of Andhra Pradesh, which contributes 53% of the total production followed by Karnataka (9%), Odisha (6%), West Bengal (6%), Maharashtra (5%), and Madhya Pradesh (4%). *Capsicum* is also cultivated in other parts of India including the north-eastern states [3].

Several indigenous varieties of *Capsicum* are known to be cultivated in the north-eastern region of India. Some of such indigenous varieties have been well documented to be the hottest *Capsicum* varieties in the world [4]. These indigenous varieties are popularly known by different local names among various communities of the north-eastern states of India. These are namely, *Bih Jolokia* (*Bih* means poi-son, *Jolokia* means pepper), *Bhut Jolokia* (*Bhut* means ghost) in Assamese language, *Oo-Morok* (*Oo* means Tree, *Morok* means Chili) in Manipuri language, and *Naga Jolokia* (or *Naga Morich*) in Nagamese language and *Raja Chili* (King of Chili). The word *Jolokia* usually refers to the vernacular name of *Capsicum* pod or chili pepper in Assamese language of India [5–7].

2. Indigenous *Capsicum* varieties of India

The plant of *Capsicum* belongs to the genus *Capsicum*, which is a member of the family Solanaceae [8]. The genus *Capsicum* has approximately 27 species, out of which 5 species are widely domesticated in various parts of India. These are namely, *Capsicum annuum* L., *Capsicum chinense* Jacq., *Capsicum frutescens* L., *Capsicum baccatum* L., and *Capsicum pubescens* L. [9]. The images of indigenous *Capsicum* varieties of India are presented in **Figure 1**.

Capsicum annuum is the most cultivated species across different parts of India. *Capsicum chinense* and *Capsicum frutescens* are also the most common cultivated species, particularly in the north-eastern region of India. Other three species including *Capsicum baccatum* and *Capsicum pubescens* are also found to be cultivated in the north-eastern states of India [10]. **Table 1** describes five indigenous *Capsicum* varieties of India.

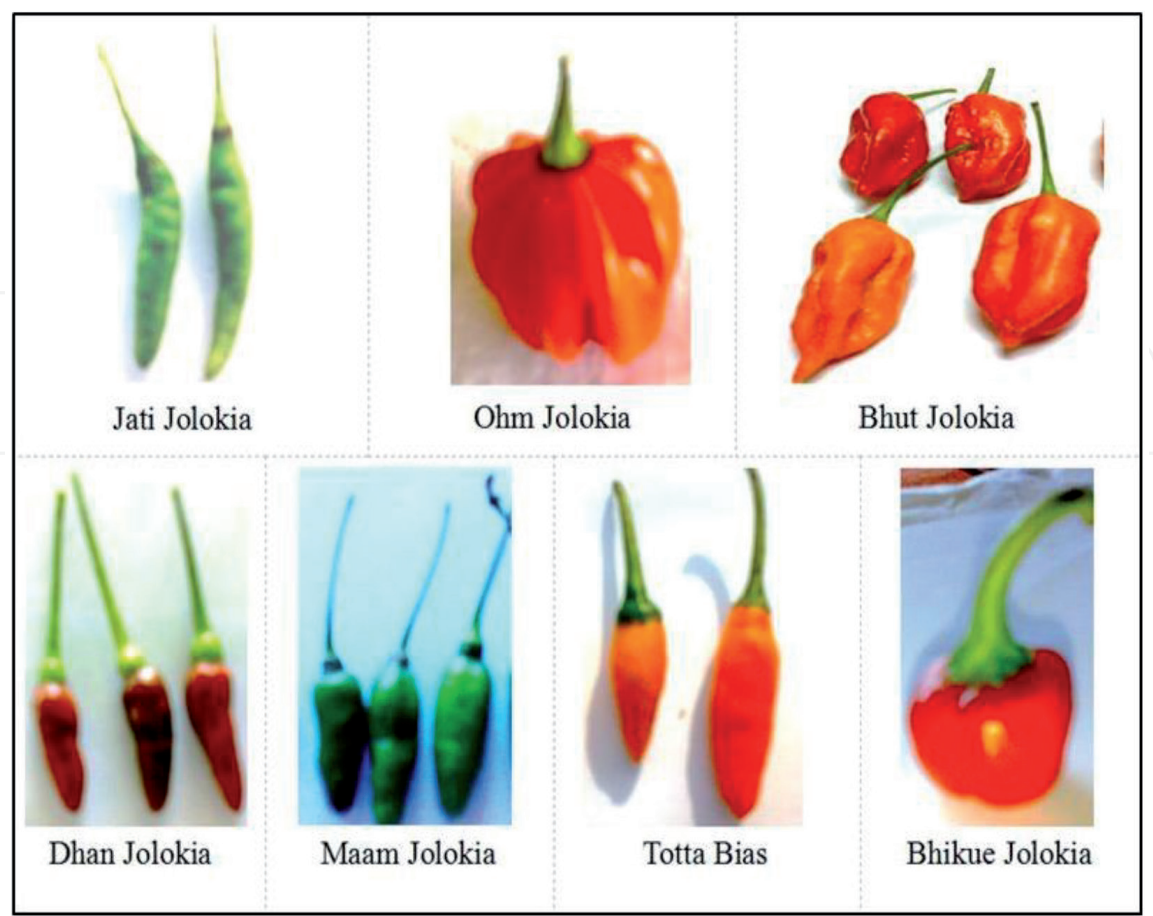


Figure 1.
Photographs showing indigenous *Capsicum* varieties of India.

Species/botanical name	<i>Capsicum</i> variety/ vernacular name	Description
<i>Capsicum annum</i>	Jati Jolokia	Elongated, 2.5–3.0 cm long, width 0.8–1.0 cm, smooth surface, light red, characteristic odor
<i>Capsicum chinense</i>	Bhut Jolokia	Elongated, 5.0–7.0 cm long, 2.5–3.0 cm width, undulating rough surface, dark red, characteristic aroma
<i>Capsicum frutescens</i>	Dhan Jolokia	Tiny in size, elongated, 1.0–1.5 cm long, 0.5 cm wide, smooth surface, light red, characteristic aroma
	Maam Jolokia	Elongated, 1.5–1.75 cm long, width 0.5–0.75 cm, smooth surface, light red, characteristic aroma
	Totta Bias	Elongated, 4.0–5.0 cm long, 1.0 cm wide, smooth surface, orange to light red in color
<i>Capsicum baccatum</i>	Ohm Jolokia	Rough shape with a flat base, 2.0–3.0 cm diameter, 2.0–2.5 height, and base divided into three lobes, each having 3–4 grooves, dark red
<i>Capsicum pubescens</i>	Bhikue Jolokia	Bell shaped like a tomato with a flat base, 2.0–2.2 cm diameter, 1.5 cm height, smooth surface, dark red, characteristic aroma

Table 1.
Indigenous *Capsicum* varieties of India [10, 11].

3. Chemistry and pungency

The pungency of *Capsicum* pods is mainly attributed to the presence of a group of closely related compounds called capsaicinoids. Capsaicinoids refer to a group of pungent alkaloids that accumulate in the placenta of matured *Capsicum* pods [12]. Chemically, these are acid amides of vanillylamine with C9–C12 branched-chain fatty acid. All capsaicinoids possess a common 3-hydroxy-4-methoxybenzylamide (vanilloid) skeleton, but differ in their hydrophobic alkyl side chain. Differences in the side chain include saturation of the carbon carbon double bond, absence of a methyl group and also changes in the length of hydrocarbon chain [13]. Some important capsaicinoids are capsaicin, followed by dihydrocapsaicin, nordihydrocapsaicin, homodihydrocapsaicin, and homocapsaicin. Capsaicin and dihydrocapsaicin together account for approximately 80% of total capsaicinoids content of *Capsicum* pods. These two compounds are the most important and potent members of capsaicinoids family [14]. The chemical structures of capsaicinoids are displayed in **Figure 2**.

Most of the *Capsicum* species cultivated in India contain around 1% of capsaicinoids, but *Capsicum chinense* L. (*Bhut Jolokia*) and *Capsicum frutescens* (*Dhan Jolokia*) possess around 2–4% of capsaicinoids [15]. However, though seven different indigenous varieties of *Capsicum* are found to be cultivated in the Assam state of India, the *Bhut Jolokia* and *Dhan Jolokia* have been documented to be the most potential *Capsicum* varieties in terms of their capsaicinoids content and level of pungency [16]. The capsaicinoids content (%) of indigenous *Capsicum* varieties of India is depicted in **Table 2**.

It is noteworthy that the capsaicinoids content is a measure of the degree of hotness or the level of pungency of *Capsicum* pods. However, it is also responsible for medicinal properties as well as for the nutritional value of *Capsicum* spice. The Defense Research Laboratory, Tezpur, India reported that the potential of the *Bhut*

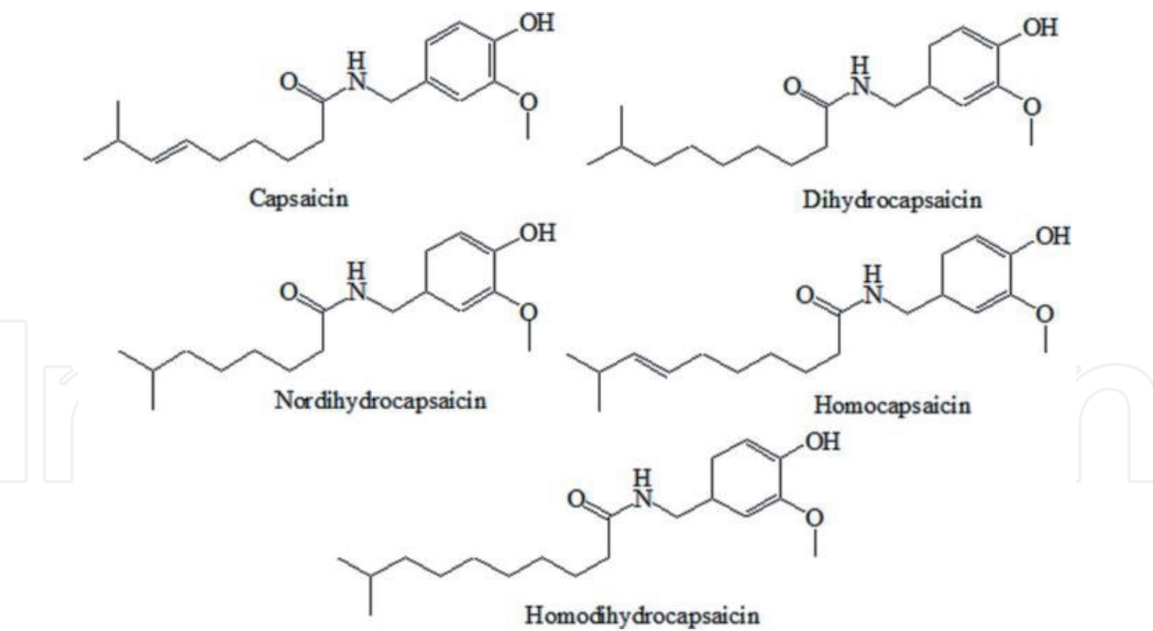


Figure 2.
Chemical structures of capsaicinoids.

Species	<i>Capsicum</i> variety	Capsaicinoids content (%)
<i>Capsicum annum</i>	<i>Jati Jolokia</i>	0.51
<i>Capsicum chinense</i>	<i>Bhut Jolokia</i>	2.45
<i>Capsicum frutescens</i>	<i>Dhan Jolokia</i>	2.14
	<i>Maam Jolokia</i>	1.38
	<i>Totta Bias</i>	0.25
<i>Capsicum baccatum</i>	<i>Ohm Jolokia</i>	0.67
<i>Capsicum pubescens</i>	<i>Bhikue Jolokia</i>	0.92

Table 2.
Capsaicinoids content (%) of indigenous *Capsicum* varieties of India [15, 16].

Jolokia is comparable with that of the Red Savina Habanero of Mexico in terms of Scoville Heat Units (SHUs) [17]. The pungency of *Bhut Jolokia* was recorded 855,000 SHU, while it was 577,000 SHU for Red Savina Habanero. Studies at the New Mexico State University also reported that *Bhut Jolokia* possessed 1,001,304 SHUs, whereas Red Savina had 248,556 SHUs [18]. In September 2006, the *Bhut Jolokia* was officially recognized as the world’s hottest *Capsicum* variety measuring over 1,000,000 SHUs according to the Guinness Book of World Records [19].

4. Medicinal properties

Apart from wide commercial applications of *Capsicum* pods or chili pepper as culinary spice and also their use in various food products such as seasoning blends and in the canning industry, *Capsicum* also possess a diverse range of medicinal and/or pharmacological potential. In medicine, capsaicinoids, the active ingredients of *Capsicum* pods, have been used for the treatment of gastritis, arthritis, toothache, musculoskeletal and neuropathic pain, chronic indigestion, other pharmacological disorders and also microbial infections [20–22]. Capsaicinoids have been reported to exhibit a diverse range of biological effectiveness such as antioxidant, analgesic,

anti-inflammatory, anticarcinogenic, promotion of energy metabolism, and suppression of fat accumulation [23–26].

Traditional practices of *Bhut Jolokia* have been well documented for the management of various human disorders/ailments, particularly in the north-eastern region of India. It has also been found to be effective in tuning up body muscles and in the treatment of wrist pain after a strenuous physical exercise [5]. The treatment of toothache and muscle pain using the hot infusion of *C. chinense* pods has also been reported in other parts of India [27]. Traditional uses of *C. chinense* leaves in several human ailments such as boil, headache, and night blindness have been well documented, for example, the use of leaf paste in the treatment of boils [28]. The use of *Bhut Jolokia* has also been found effective in the symptomatic relief of asthma because of its bronchodilation effect. Regular consumption of small quantities of *Capsicum* pods of *Bhut Jolokia* is highly beneficial in certain gastrointestinal abnormalities [5, 29].

Researchers have reported that the capsaicinoids content might be responsible for the pharmacological and/or biological potential of *Capsicum* pods. In modern medicine, the capsaicin has been considered to be an effective yet safe topical analgesic as antiarthritic, antioxidant, and anticancer agent. The antiviral efficacy of capsaicin has been reported in the treatment of herpes zoster infection [30]. The Osteoarthritis Research International (ORI) recommended the topical use of capsaicin as an effective adjunctive or alternative medicament to oral analgesic/anti-inflammatory agent for the treatment of moderate to severe pain and inflammation in case where conventional oral analgesic/anti-inflammatory agents generally do not respond [31].

As mentioned above, capsaicin has, therefore, been included in topical therapy for the relief of different neuropathic pain, although it could produce skin irritation. Capsaicin and its analogues have been used in certain topical dosage forms such as creams and patches in order to treat chronic pain syndromes such as post-herpetic neuralgia, musculoskeletal pain, diabetic neuropathy, osteoarthritis, and rheumatoid arthritis [32, 33]. It has also been found beneficial in relieving pain due to rashes, psoriasis, mastectomy, and bladder disorders. Adverse effects (burning, stinging and erythema) are normally limited to the site of application; however, respiratory irritations and occasional systemic effects arising from the inhalation of cream have been reported [34].

5. Mechanism of action

The mechanism of analgesia that capsaicinoids produce is probably due to their counter-intuitive effect [35]. Capsaicinoids applied directly to the skin or injected by intradermal route induce both hyperalgesia and allodynia. Capsaicin causes excitation of certain subsets of dorsal root ganglia giving rise to the stimulation of thin myelinated A-delta and unmyelinated C fibers. These nerve fibers are specific for the transmission of pain signals and therefore seem to be sensitive to vanilloids such as capsaicin, which blocks particularly the transmission of noxious stimuli [36]. Due to the blockade of terminal peripheral nerves, capsaicin inhibits the release of several pro-inflammatory neuropeptides such as Substance P, calcitonin gene-related peptide, and somatostatin [37]. The prolonged stimulation of neurons by capsaicin may deplete the nerve's ability to release the presynaptic neuropeptides, particularly Substance P. The ability of capsaicin to desensitize nociceptors is the main reason behind its therapeutic efficacy [38]. It has also been attributed that capsaicin could modulate the amount of specific neurotransmitter called Substance P, associated with the feeling of pain and thus helps alleviate pain externally [39]. Research findings claim that pure capsaicin could possess similar efficacy in treating joint and muscle pain induced in rheumatism, arthritis, ankylosing spondylitis, and

fibromyalgia. Further, clinical reports suggest that capsaicin increases not only the secretion of saliva and gastric juice, but also improves the blood flow in the lining of the gastrointestinal tract, which might be beneficial in gastrointestinal abnormalities [40, 41].

6. Conclusion

Based upon ethnomedicinal potential and scientific evidences of possessing extreme pungency, *Capsicum* chili pod of *Bhut Jolokia* (*Capsicum chinense* Jacq.) is an important economically viable crop of north-eastern region of India. Further, it is believed that favorable geographical and agroclimatic factors are primarily responsible for the higher capsaicinoids content of *Capsicum*. The functional quality depends primarily on the capsaicinoids content, which determines the medicinal potential and/or biological efficacy of *Capsicum* pods. However, *Capsicum* chili pods of *Bhut Jolokia* may be studied for further scientific investigation toward their possible development into topically effective analgesic drugs and/or formulations for the treatment of pain-related disorders and inflammatory illness. In addition to *Bhut Jolokia*, another indigenous variety of *Capsicum*, that is, *Dhan Jolokia* (*Capsicum frutescens*) may also be studied for further scientific investigations.

Conflict of interest

Authors declare that there is no conflict of interest.

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