

Antioxidant activities and biochemical analysis of *Capsicum annuum* L. varieties at different ripening stages

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Capsicum (*Capsicum annuum* L.) is a high-demand crop due to its versatility, which adds flavour, colour and nutritional value to various culinary products. Besides this, capsicum contains a significant number of biochemicals, including carotenoids, phenols, ascorbic acid, capsaicinoids and anthocyanins that impart various medicinal properties like antimicrobial, anti-cancer, pain reliever, and also help in the prevention of obesity, hypertension, dyslipidemia, diabetes and atherosclerosis. This crop demonstrates an array of vibrant colours reflecting different ripening stages that correspond to various biochemicals and nutritional activity. Hence, the objective of the present study was to examine the effect of ripening stages, i.e., green and red (mature stage), on the secondary metabolites and protein content of ten different varieties of *Capsicum annuum*. Across the study, all green and red capsicum varieties were studied and the highest total phenol content (TPC) (97.23 ± 0.14 mg GAE/g fw) was observed in Sita variety at red mature stage, total flavonoid content (TFC) from JF-3 variety at red stage (47.47 ± 0.24 mg QE/g fw), tannin content in NS-82 at red stage (34.32 ± 0.18 mg TAE/g fw). Similarly, the highest DPPH activity was observed in the Queen variety at green (132.42 ± 0.35 mg AAE/g fw) and red stage (158.30 ± 0.30 mg AAE/g fw). The maximum protein content was recorded in the Dolly variety at the green stage ($20.5 \pm 0.34\%$). The TPC, TFC, tannin, and protein contents of the Queen, Dolly, Rosy-400, and Durga varieties at red stages and Durga, KSP-1070, JF-3, and KSP-160 varieties at green stages are at par, which makes them ideal as alternatives for each other. Therefore, the findings of the study offer a basis for encouraging the utilisation of capsicum at both stages, as they contribute to a well-rounded nutritional profile and play a significant role in disease prevention.

Keywords: Antioxidant, bell pepper, nutritional, phenol, protein, sweet pepper, tannin.

HORTICULTURAL crops are a crucial component in

shaping and expanding the landscape of the continuously evolving food market. Various horticultural crops, including *Capsicum annuum* L., are recognised as functional foods and are an important ingredient in global cuisines, contributing to the production of diverse, flavourful, and colourful dishes¹. *C. annuum*, also known as bell pepper and sweet pepper, belonging to the Solanaceae family, is a spice crop that holds significant agricultural importance in the mid-hills of Uttarakhand, contributing to the rural economy of the state². The visually appealing, vibrant colours of sweet pepper are rich in antioxidants, beta-carotene, phenols, flavonoids and vitamin C that help in reducing harmful oxidation reactions that can lead to a variety of ailments, including neurological disorders, cardiovascular diseases, cancer, etc.³. Moreover, sweet pepper contains 0.99 g protein, 0.33 g total fat, 10.6 g carbohydrate, 2.73 g dietary fibre, 133 mg vitamin C, 46.79 calories (cal) and 195.58 kJ energy^{4,5}. Paprika powder made from these peppers is a versatile spice widely used in the food industry for its flavour and colour-enhancing properties, particularly in soup, sauces, snacks and meat products. However, its potential biological properties, which include antimicrobial, anti-inflammatory, anticancer, anti-allergenic and antioxidant activities, further expand its application in food processing⁶.

Bell pepper contains a colourless, crystalline, and aromatic compound known as capsaicin, which improves cholesterol and is currently being used in the pharmacy industry for a variety of therapeutic applications such as anti-microbial, anti-cancer, pain reliever, and also in the prevention of obesity, hypertension, dyslipidemia, diabetes and atherosclerosis⁷⁻⁹. Capsicums (sweet, spicy, green and red peppers) are becoming an important food crop due to their widespread use in the food industry. Dried capsicum powder is used as a colouring agent and adds an extra layer of flavour to sauces, candies, processed meats, and alcoholic drinks¹⁰. The crop consists of various colours, such as green, red, yellow, and orange, that indicate the different stages of ripeness and signify variations in nutritional and polyphenol content¹¹. For instance, the phenols observed in green capsicum include protocatechuic acid (116 µg/g), myricetin (658 µg/g), gallic acid (89 µg/g), py-

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