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Medicinal Properties of Cruciferous Vegetables: A Review

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ABSTRACT

Cruciferous vegetables, members of the Brassicaceae family which includes cabbage, cauliflower, broccoli, mustard greens, and radish, are widely cultivated and consumed in India. These vegetables offer a potent blend of culinary value and medicinal benefits. They are rich in bioactive compounds such as glucosinolates, isothiocyanates (e.g., sulforaphane), indoles, vitamins, minerals, fibre, and antioxidants. This phytochemical composition in the crucifers helps to contributes to a range of medicinal properties which includes properties like antioxidant, anti-inflammatory, anti-cancer, cardiovascular, and immune-supporting properties. But despite India's position as a leading producer of cruciferous vegetables, the domestic consumption of crucifers remains below recommended levels. These vegetables play a vital role in "silent nourishment," as they are used in daily Indian diets and quietly supports physiological well-being. Different modern researches suggest their potential in enhancing resilience against heat stress which is a growing public health challenge in India due to recent climate change. Their water and potassium content provides hydration and electrolyte balance, and antioxidant and anti-inflammatory properties helps in cellular protection against heat-induced damage. But as per the demand, India is lagging behind in higher research on both bio efficacy and bioavailability of these bioactive compounds as well as cruciferous vegetables. Promoting Cruciferous vegetables as a dietary staple will help to develop more prevention against different cancer diseases as well as heat stress like conditions.

Keywords: *Cruciferous vegetables, silent nourishment, heat stress resilience, anti-cancer, public health management*

Introduction

Cruciferous vegetables belong to Brassicaceae family which includes a wide range of commonly consumed plants such as cabbage, cauliflower, broccoli, mustard and radish (Bhandari, 2020). These vegetables are very much integral to the common man diet worldwide and holds a significant agricultural and culinary importance in India. One of their main characteristics of a Pungent flavour in them actually results from sulphur containing compounds which are responsible for a wide range of health benefits (Yahia *et al.*2019). The general consensus in nutrition science is that the regular consumption of cruciferous vegetables helps to maintain good health and well-being (Pajor, 2019).In India, according to Indian Council of Agricultural Research (ICAR) there are total 127 agroclimatic zones, which shows the diversity of weather and also a significant contributor for growth and development and cultivation of different cruciferous vegetables in different regions in India. Cruciferous vegetables hold a significant share in the Indian Markets and also it is

one of the major exported vegetables across the globe according to APEDA (Agriculture and Processes Food Export Development Authority). Now a days due to climate change, the average temperature of the earth is rising and due to this, we face extreme weather events in summer and winter. In summers the temperature goes up to 45°C in some places of India making it more responsible for disrupting our physiological processes and causing heat stress, sunstroke like emergency medical conditions. In this scenario, daily intake of cruciferous vegetables can help in resistance of such conditions and deliver a good amount of nutrients to the body for developing immunity for different diseases in summer times. This paper aims to provide a comprehensive review on the medicinal properties of cruciferous vegetables and a detailed account on their bioactive compounds and their mechanism of actions. It also addresses about the production and consumption patterns of cruciferous vegetables in India and also put a significant focus on "silent nourishment" by these vegetables which helps to build our immunity.

Cruciferous Vegetables: An Overview

The Brassicaceae family is characterized by the flowers, which have four petals and they are arranged in cross shaped. Due to this the name 'cruciferous' name is derived. This family includes some of the most economically important vegetable crops of the world and staple crops in India like cauliflower, cabbage, radish and mustard (Bhandari, 2020). The health benefits of cruciferous vegetables are due to their richness in different bioactive compounds.

1. Sulphur Containing Compounds: These are the most distinctive and major focus of research as they contain major health benefits. These compounds are responsible for pungent aroma and spicy taste of cruciferous vegetables.

- **Glucosinolates and their derivatives:** These are the primary sulphur containing compounds in crucifers. When any part of any cruciferous bplant material is chopped, chewed, cooked or damaged in any means, it releases an enzyme called Myrosinase. This enzyme hydrolyses the Glucosinolates into their active forms (Yahia *et al.*2019). The glucosinolates can be classified into 3 major categories. These are –

a) **Aliphatic Glucosinolates:** These are derived from aliphatic ammino acids which includes glucoraphanin (which is a precursor to Sulforaphane, found in broccoli) and sinigrin (which is precursor to allyl isothiocyanate, found majorly in horseradish and mustard).
b) **Indole Glucosinolates:** These are derived from Indole Ammino Acids. A key example is glucobrassicin which is a precursor to indole-3-carbinol.
c) **Aromatic Glucosinolates:** These are derived from Aromatic amino acids. A key example of this is gluconasturtin which is precursor of phenethyl isothiocyanate.

- **Isothiocyanates (ITCs):** These are formed when Glucosinolates broke down through Myrosinase hydrolysis. In other words, they are so called active forms of Glucosinolates (Raheel *et al.*2023).

a) **Sulforaphane (SFN):** This one is derived from Glucoraphanin. This is predominantly found in Broccoli and Broccoli sprouts. This compound holds a good potential in cancer resistance (Vanduchova *et al.*2022).
b) **Indole-3-carbinol (I3C):** This one is derived from Glucobrassicin. It further converts into different other compounds like **3,3-di-indomethane (DIM)** in the acidic environment of the stomach. I3C and DIM both are well known for their influence in Oestrogen metabolism and potential in anti-cancer activity.
c) **Allyl Isothiocyanate (AITC):** These are derived from Sinigrin, which are majorly found in Mustard Greens and Horseradish.
d) **Phenethyl Isothiocyanate (PIECE):** This derived from Gluconasturtin, which re found in watercress.
e) **Benzyl Isothiocyanate (BITC):** This compound derived from Glucotropaeolin, found in garden cress.

- **Thiocyanates:** These compounds derived from Glucosinolates but less studied in cruciferous vegetables.

2. Phenolic Compounds: These are a broad class of plant chemicals which contains at least one aromatic

ring with one or hydroxyl groups. They are well-known for their anti-oxidant properties. They also possess anti-cancer properties too.

- **Flavonoids:** These are the major group of phenolic compounds.

a) **Flavonols:** These found in various cruciferous vegetables in variable amount depending on the vegetable. These include Quercetin, Kaempferol and Isorhamnetin. These possess both anti-cancer and anti-oxidant property.
b) **Anthocyanins:** These pigments are responsible for red, purple and blue colour in some cruciferous vegetables. These pigments have anti-oxidant properties.

- **Phenolic Acids:** These includes hydrocinnamic acids like Caffeic acids, Ferulic acid, sinapic acid and p-coumaric acid. These possess anti-oxidant properties.

3. Carotenoids: These are fat soluble pigments which are responsible for yellow, orange and red colours in cruciferous vegetables. β-carotene is a well-known as an anti-oxidant is a precursor of Vitamin A which is a very important for eye health. Lutein and Zeaxanthin are also responsible for good eye health.

Cruciferous vegetables also called different Vitamins like Vitamin A, Vitamin C, Vitamin K, Vitamin B9 (Folic Acid) etc. and Minerals like Potassium and Selenium (Singh *et al.*2018). The Cruciferous vegetables also contain Fibres which is essential for better gut health too (Raheel *et al.*2023).

Medicinal Properties of Cruciferous Vegetables

As discussed in the previous section, the cruciferous vegetables contain a variety of different bioactive compounds which responsible for different medicinal properties of these vegetables.

- **Anti-Oxidant Properties:** Bioactive compounds like Vitamin C, Vitamin E, β-carotin and ither compounds directly scavenge free radicals in the cell matrix which helps in reducing oxidative damage directly. On the other hand, the Sulforaphane (SFN) activated the nuclear factor erythroid 2 (Nrf-2) pathway which is a master regulator of cellular defence mechanisms (Baldelli *et al.*2025). Nrf-2 translocated to cell nucleus and binds to anti-oxidant response elements (AREs) in the promoter region of the genes. These genes encode a wide range of cytoprotective and anti-oxidant enzymes like Glutathione S- Transferase (GST) and NADP(H) quinone dehydrogenase (NQO1). This helps in regulation of oxidative stress indirectly (Andres *et al.*2025).
- **Anti-inflammatory Properties**: Chronic inflammation is one of the causes of many diseases. Bioactive compounds from Cruciferous vegetables can suppress different inflammatory pathways like NF-kB pathways which is also have a potential to have conditions like Inflammatory Bowel Disease (IBD) (Mahato *et al.*, 2023). For Poly Cystic Overy Syndrome (PCOS) like conditions also, cruciferous vegetables potentially recognised as an anti-inflammatory diet (Andres *et al.*2025).
- **Anti-Cancer Properties:** Cruciferous vegetables also recognised for its anti-cancer properties majorly. Research suggests Cruciferous vegetables can potentially lower the risk of different types of major and minor cancers like Brearst Cancer, Lung Cancer and many more (Pajor, 2019; Yahia *et al.*, 2019). The bioactive compounds enhance the detoxification mechanisms of carcinogens in our body which help in inducing cancer cell death (apoptosis) and promotes hormone metabolism. Cauliflower also has been popularised as a "Superfood" for cancer prevention.
- **Anti-angiogenesis and Anti-metastasis properties:** Compounds like SFN, I3C and DIM helps in promoting anti-angiogenesis (preventing from formation of new blood vessels) and anti-metastasis (preventing from tumour growth and spread) (Baldelli *et al.*2025). These helps in mitigating and put a check on cancer form the very beginning.
- **Cardiovascular and Other Health Benefits:** Cruciferous vegetables contain a lot of Fibre, anti-oxidant and anti-inflammatory substances which supports our Cadiovascular health (Raheel *et al.*, 2023). Glucosinolates and their derivatives like isocyanates like SFN and improve Lipid profile of patients by reducing blood serum triglycerides like

- LDL and LDL-cholesterol ratios while increasing HDL-C ratios. They also reduce oxidative stress as earlier discussed which also helps in maintaining a good heart health (Kattel *et al.*2025).
- **Digestive Health benefits and Anti-microbial properties:** As earlier said cruciferous vegetables are high in dietary fibre content which promotes in regular bowel movements which helps in good and healthy digestive system. It also helps in microbiota balance in gut. Broccoli contains some anti-microbial peptides which have a larger potential in food preservation as well as natural alternative to synthetic anti-biotics in daily life (Amare DE *et al.*2020). In human trails, SFN has shown a high potential against *Helicobacter pylori* (a type of bacterium which is responsible for stomach ulcers and gastritis). I3C has also been tested in different trails which shows that it has a quality to prevent colitis (it is inflammation of the large intestine) (Baldelli *et al.*2025).

Role of cruciferous vegetables in prevention of heat stress

During heat stress, there are certain conditions like dehydration, electrolyte imbalance, oxidative stress and inflammations occurs. Cruciferous vegetables during summer days helps in prevention of heat stress conditions and also post heat stress conditions too.

- It's high water and potassium content helps in maintaining body fluids and electrolyte balance which prevents us from dehydration conditions.
- Cruciferous vegetables contain different anti-oxidant systems which helps in counteract with different free radicals caused by heat stress helps in minimizing cell damage (Saha *et al.*, 2023; Vanduchova *et al.*, 2022).
- It also contains a high amount of anti-inflammatory bioactive compounds which helps in combating inflammation in both heat stress and post heat stress conditions (Mahato *et al.*, 2023).

Cruciferous Vegetables in Daily Life Nourishment

Cruciferous vegetables are deeply integrated with our daily diet. From Aloo Gobu to Sarson ka Saag to Mooli ka Paratha, these vegetables are like staple foods. Each region of the country has their own taste and unique preparation styles (Khan et al., 2014; Anjusha et al., 2017). According to Traditional Knowledge, it is suggested that cooking the vegetables with spices help to balance quality and taste. Otherwise, it can create issues name 'vata' dosha (it means irregular breathing and circulation of blood) (Connolly, 2022). In modern research it is found that household cooking processes including frying or boiling, lower down the levels of health promoting compounds which also responsible for ill health in fast day modern life (Bala et al., 2019; Mir et al., 2018). But in daily life, cruciferous vegetables help us in promoting good health in long term which is why we can say that cruciferous vegetables do play an important role in our 'silent nourishment'.

Production and Consumption in India

India is a world's largest producer of Cabbage and cauliflower (National Horticulture Borad Report). The production of cruciferous vegetables is widespread across the country which significantly contribute to the national production. Indian Agricultural research is continuously working on genetic improvement of these crops (majorly broccoli and mustard) so that it can be grown in diverse climatic conditions like in Ladakh areas (Ganesh et al., 2019; Gupta et al., 2017; Pal et al., 2018; Rai et al., 2017; Kumar et al., 2019). Sometimes even if the production is good the farmers often cannot market their goods at a higher price which leads to their losses in production leads to discouragement for cultivation of cruciferous crops (Soni, 2018; Kumar & Singh, 2019).

In India, the consumption of cruciferous crops is lesser even in Urban areas. This also points out to an affordability and accessibility factor of cruciferous vegetables to the average people of India (Sivaramakrishnan et al., 2019). The gap between high production and low consumption levels can be solved out through public health initiates and public awareness which now a days need a critical attention.

Conclusion

As we have seen, cruciferous vegetables are one of the powerhouses among the vegetables which also contains a significant amount of different biologically active compounds or phytochemicals, which helps in providing 'silent nourishment' on daily diet (Ashok *et al.*, 2020). However, the production and consumption that there is a still gap which is not good as per the modern-day lifestyle. In the fast pace lifestyle people tends to eat less healthy foods like fast foods as they are tastier and less time to cook but this is slowly degrading health of many people. Nowadays, due to change in climate high temperature and heat waves are a very normal conditions in India. So, there is a urgent need to fill this gap. Promotion of cruciferous vegetables and intake can build a better future and with good health and a good smile.

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