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THERAPEUTIC POTENTIAL OF *BRASSICA OLERACEA* VAR. *BOTRYTIS*: A COMPREHENSIVE REVIEW

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ABSTRACT

Cauliflower (*Brassica oleracea* var. *botrytis*), a cruciferous vegetable, is a rich source of bioactive compounds with significant anti-inflammatory properties. Chronic inflammation, a key factor in the progression of various diseases such as cardiovascular, metabolic, and autoimmune disorders, can be mitigated by natural dietary interventions. The bioactive constituents of cauliflower, including glucosinolates and omega-3 fatty acids, contribute to its anti-inflammatory effects through molecular mechanisms such as the activation of the Nrf2 pathway and the modulation of inflammatory mediators. Glucosinolates, upon hydrolysis, release sulforaphane, which enhances antioxidant defenses and reduces oxidative stress, while alpha-linolenic acid (ALA), an omega-3 fatty acid, promotes the production of anti-inflammatory eicosanoids. These mechanisms underscore cauliflower's potential as a functional food for managing inflammation-related diseases. This review explores the molecular pathways through which cauliflower exerts its anti-inflammatory effects, highlighting its therapeutic relevance in chronic disease prevention and management.

KEYWORDS: Cauliflower, *Brassica oleracea* var. *botrytis*, Anti-inflammatory, Glucosinolates, Sulforaphane.

INTRODUCTION

Cauliflower, scientifically known as *Brassica oleracea* var. *botrytis* belonging to the family Brassicaceae. A versatile and nutritious cruciferous vegetable which has a distinctive appearance and bounty of culinary possibilities. Cauliflower is a cool-season vegetable known for its edible head/curd, which consists of tightly packed, undeveloped flower buds. It is available in several colors (white, purple, green, and orange) each with distinctive flavors and nutritional benefits. Size varies from 6 to 12 inches in diameter. Typically grows to about 18 to 24 inches (45-60 cm). Leaves are large, broad and lobed with wavy margins. Prominently dark green, some varieties exhibit lighter or bluish hues. Alternately arranged, forming a rosette around the base. Stem is generally robust to support the weight of the curd.[1] Roots are of a fibrous root system that aids in nutrient and water uptake. According to the harvesting period, there are different types of cauliflower like Spring cauliflowers (harvested during spring or early summer), summer and autumn cauliflowers (harvested during summer or fall)[2], and winter cauliflowers (harvested during winter). Cauliflower prefers temperate climates, grown in all regions of the world. World's largest producer is China[3], with a production close to India. Cauliflower prefers cooler temperatures (60-70°F or 15-21°C)[4] and requires loamy soil rich in organic matter ranging in pH of 6.0-7.0.[5] Growing conditions require consistent moisture; soil should be kept evenly moist. It is a rich source of vitamins such as C and K, fibers, and antioxidants.[6] Culinary uses such as these can be eaten raw, steamed, roasted, or incorporated into various dishes such as soups, stir-fries, and casseroles.[7] Raw cauliflower consists of water-92%[8], carbohydrates-5%, proteins-2%, fats-0.3%, high content of vitamin C (58%DV)[9], vitamin B and K in moderate levels (13-15%DV), and dietary minerals in less content (7%DV or less).[10]

Table 1: Taxonomical Classification of Brassica Oleracea.

Kingdom	Plantae
Division	Angiosperms
Class	Eudicots
Order	Brassicales
Family	Brasicacceae
Genus	Brassica
Species	Brassica oleracea

Table-1 tabulates the Taxonomical classification of Brassica oleracea - Cauliflower belongs to the kingdom plantae under the category of flowering plants and falls under division Angiosperms and class eudicots with in order Brassicales belonging to the family Brasicacceae. Genus is Brassica and Species Brassica oleracea. It is classified as a variety var. botrytis.

HISTORY

Cauliflower originated in the Mediterranean region, specifically in what is now Cyprus, where it has been cultivated for over 2,000 years.[12] The ancient Greeks and Romans were among the first to grow and eat this vegetable, appreciating its subtle flavor and nutritional benefits.[13] Eventually, cauliflower spread to other parts of Europe, including France and Italy, where it became a popular ingredient in traditional cuisine.[14]

Cauliflower arrived in North America in the 17th century with European immigrants.[15] It didn't gain widespread popularity until the 20th century, when it was embraced by both chefs and home cooks. Today, cauliflower is a staple in North American cuisine, appearing in popular dishes such as cauliflower rice, cauliflower crust pizza, and buffalo cauliflower wings.[16]

Cauliflower is a type of cabbage that is harvested before it flowers, specifically during its bud stage.[17] The flower buds are the most nutritious and commonly eaten parts. It is generally thought that cauliflower originated in the Middle East and Italy during the 15th century, possibly migrating to Europe from Cyprus.[18] By the 16th century, it became popular in Italy and later spread to France.[19] It appeared in North America by the late 1600s.[20]

Recipe books from the 18th century show that people enjoyed cooking cauliflower in various ways, such as boiling, frying, and stewing.[21] Interestingly, in the 19th century, some cooks even boiled cauliflower in milk to soften its flavour.[22] Historical accounts highlight the

difficulty of growing it successfully in regions with harsh winters and hot summers, yet it remained a viable crop.[23] The French referred to it as "flower-cabbage," and it was often prepared with butter or white sauces as a side dish for meat—a sign of prosperity, with many families aiming to include meat in their meals three times daily.[24]

Early gardening authors pointed out that the only cauliflower varieties were early (spring-sown and fall-harvested) and late types (Cobbett, 2003).[25] Mark Twain humorously noted that "cauliflower is nothing but cabbage with a college education." This vegetable is celebrated for its high vitamin C content and good levels of iron. It thrives in cool, moist conditions, ideally between 50 and 68 degrees Fahrenheit, and can tolerate light frost, making it adaptable to various climates worldwide, which explains its global popularity.

Among the recommended open-pollinated varieties is a self-blanching type that takes about 71 days to harvest and produces 7-inch heads with excellent leaf protection. Additionally, Arapaho and Arctic are also suggested varieties. The Seed Savers Exchange offers two cauliflower varieties. Peter Henderson & Company introduced the Early Snowball variety in 1888, known for its ability to thrive in harsher conditions and for producing solid, crisp, and tender white curds of excellent quality. The other variety available from this company is the 613-Purple Cape, which traces its origins back to South Africa in 1808.

Brassica oleracea var. *Botrytis* herbal extract consists of various chemical constitutents responsible for pharmacological activity is as follows

Table 2: Research existing on the herbal active constituents and pharmacological actions of Brassica oleracea.

SL. NO	CHEMICAL CONSTITUENTS	SOLUBILITY	REPORTED PHARMACOLOGICAL ACTIVITY
1	Quercetin	Soluble in ethanol (2 mg/ml), dimethyl sulfoxide (30 mg/ml), dimethyl formamide (30 mg/ml); limited solubility in water.	Thrombolytic activity[26]
2	Kaempferol	Soluble in ethanol, dimethyl sulfoxide, ethers; slightly soluble in water.	Antioxidant, antimicrobial[27]
3	Indolylsulfide	Soluble in ethanol, methanol, dichloromethane; sparingly soluble in water.	Anticancer, cardiovascular agent[28]
4	N-Hexadecanoic acid	Soluble in chloroform, ether, and ethanol; low solubility in water.	Hypercholesterolemia, antiarrhythmic, anti-inflammatory[29]
5	Tocopherol (Vitamin E)	Soluble in oils, fats, and alcohols; insoluble in water.	Analgesic, anti-aging, anti-inflammatory, anesthetic, antileukemic, antitumor[29]
6	Ascorbic acid (Vitamin C)	Highly soluble in water; soluble in ethanol; low	Anti-proliferative,

		solubility in lipids and non-polar solvents.	chemoprotective[30]
7	Polyphenols	Soluble in ethanol, methanol, acetone.	Metabolic activity (increases ROS in colorectal cancer[31]
8	Folate	Soluble in water, ethanol.	Antifungal[28]
9	Carotenoids (e.g., Beta carotene, lutein, zeaxanthin)	Soluble in hexane, ethanol, acetone; insoluble in water.	Antioxidant[27]
10	Ferulic acid	Soluble in ethanol, methanol, acetone; limited solubility in water.	Anti-thyroid activity[32]

Table-2 tabulates the research existing on herbal active constituents and pharmacological actions of Brassica oleracea. The flower part of Brassica oleracea have different constituents and those constituents are responsible for particular pharmacological activity which are helpful in treating various inflammatory associated diseases. Various constituents like Quercetin, Kaempferol, DPPH, SOD, Indolyl sulfide, Indolyl phytoalexin, N-Hexadecanoic acid, Tocopherol, Ascorbic acid, Polyphenols, Folate, Carotenoids, Ferulic acid are responsible for Thrombolytic activity, Antioxidant, Antimicrobial, Anticancer, Cardiovascular agent, Antiproliferative, Antileukemic, Antiarrhythmic, Antiaging, Anti-inflammatory, Antitumor, Antifungal, and as analgesic, anaesthetic. Most of the constituents discussed in the table were soluble in organic solvents.

Table 3: Research existing on the herbal formulations developed using Brassica oleracea.

SL. N0	NAME OF THE PLANT	PLANT PART USED	EXTRACTION METHOD	FORMULATION PREPARED
1.	Brassica oleracea var. botrytis	Flower	Soxhlation Maceration	Anti-acne cream

Table-3 tabulates the research existing on the herbal formulations developed using flower part of the plant Brassica oleracea var. botrytis. The formulation prepared using flower part of Brassica oleracea is Anti-acne cream by using the extraction methods like Soxhlation and Maceration for the treatment of acne-vulgaris.

Soxhlation is the process of continuous extraction in which the same solvent can be circulated through the extractor several times. The process involves the extraction followed by evaporation of the solvent. The vapours of the solvent are taken to a condenser and the condensed liquid is returned to the drug for continuous extraction.

Maceration involves the separation of medicinally active portions of the crude drugs. The process is based on the immersion of the crude drugs in a bulk of solvent or menstruum.

NECESSITY OF ANTI-INFLAMMATORY ACTIVITY

Inflammation is the body's inherent defense mechanism against injury and infection. Chronic inflammation arises when this response triggers sometimes without any actual injury or illness and lingers for months or years. This persistent inflammation can lead to substantial damage, resulting in serious long-term health issues such as heart disease, cancer, autoimmune disorders, and diabetes.[33]

Inflammation plays a crucial role in the pathogenesis and progression of various diseases. Its effects can vary widely depending on the disease, the type of inflammation (acute vs. chronic), and the tissues involved.[34] Here's a look at how inflammation affects some key diseases:

Diseases Associated with Inflammation

1. **Autoimmune Diseases**
   - **Rheumatoid Arthritis:** Inflammation leads to joint swelling, pain, and damage to cartilage and bone. Chronic inflammation can result in deformities and reduced mobility.[35]
   - **Lupus:** Inflammation can affect multiple organs (skin, kidneys, heart), leading to symptoms like fatigue, joint pain, and organ dysfunction.[36]
2. **Chronic Inflammatory Diseases**
   - **Inflammatory Bowel Disease (IBD):** Chronic inflammation in the gastrointestinal tract causes abdominal pain, diarrhea, and malnutrition. It can also lead to complications like fistulas or colon cancer.[37]
   - **Chronic Obstructive Pulmonary Disease (COPD):** Inflammation in the lungs causes narrowing of the airways, leading to difficulty breathing, chronic cough, and increased mucus production.[38]
3. **Metabolic Disorders**
   - **Type 2 Diabetes:** Chronic inflammation contributes to insulin resistance, making it harder for cells to use glucose. This can lead to elevated blood sugar levels and associated complications (e.g., neuropathy, kidney damage).[39]
   - **Obesity:** Inflammatory markers are often elevated in obese individuals, contributing to metabolic syndrome and increasing the risk for heart disease and diabetes.[40]

4. **Cardiovascular Diseases**
   - **Atherosclerosis:** Inflammation contributes to the formation and instability of plaques in blood vessels, increasing the risk of heart attack and stroke.[41]
   - **Heart Failure:** Chronic inflammation can lead to changes in heart structure and function, exacerbating heart failure symptoms and progression.[42]
5. **Neurological Disorders**
   - **Alzheimer's Disease:** Inflammation in the brain is associated with the accumulation of amyloid plaques and tau tangles, which are hallmarks of the disease. Chronic neuroinflammation can contribute to cognitive decline.[43]
   - **Multiple Sclerosis:** Inflammation damages the protective myelin sheath of nerves, leading to neurological symptoms like weakness, coordination problems, and sensory disturbances.[44]
6. **Skin Disorders**
   - **Psoriasis:** Inflammation leads to rapid skin cell turnover, resulting in thick, scaly patches. Chronic inflammation can also affect joints (psoriatic arthritis).[45]
   - **Atopic Dermatitis (Eczema):** Inflammation causes itchy, red, and inflamed skin, which can lead to secondary infections.[46]
7. **Respiratory Diseases**
   - **Asthma:** Inflammation of the airways leads to bronchoconstriction, mucus overproduction, and airway hyperresponsiveness, causing wheezing and difficulty breathing.[47]
   - **Interstitial Lung Disease:** Inflammation causes lung tissue scarring, leading to progressive difficulty in breathing and reduced oxygen exchange.[48]
8. **Infectious Diseases**
   - **HIV/AIDS:** Chronic inflammation can occur due to ongoing viral replication and the body's immune response, leading to immune system exhaustion and increased susceptibility to other infections.[49]
   - **Tuberculosis:** The immune response to the TB bacteria leads to granuloma formation, which can cause lung damage if inflammation persists.[50]

Molecular Mechanisms of Anti-Inflammatory Activity of Cauliflower

Cauliflower (*Brassica oleracea* var. *botrytis*), a versatile and nutritious cruciferous vegetable, exhibits anti-inflammatory activity through various molecular mechanisms. The involved mechanisms include glucosinolates, omega-3 fatty acids, fibers, and other compounds.[51]

Glucosinolates

Glucosinolates are sulfur-containing plant metabolites common in the Brassicales order. Upon tissue damage, they release isothiocyanates and other hydrolysis products that exhibit protective activities against inflammation and inflammatory diseases like cancer.[52]

- **Nrf2 Pathway Activation**

Sulforaphane, a hydrolysis product of glucosinolates, activates the Nrf2 (nuclear factor erythroid-2-related factor 2) pathway. Nrf2 regulates gene expression in response to cellular stress.[53]

- This activation enhances the expression of antioxidant enzymes, such as glutathione S-transferase, increasing antioxidant defense and reducing oxidative stress and inflammation.[54]

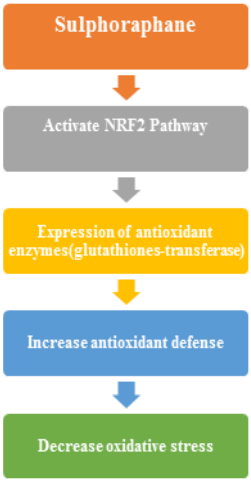

Figure 2: Nrf2 Pathway Activation 1.

Other by inhibiting NF – $_K$B pathway – Nuclear factor kappa-light chain enhancer of activated B cells (NF – $_K$B) is transcription factor protein complex that controls transcription of DNA, cytokine production and survival of cell found in the cytoplasm and nucleus of almost all animal cell types. In the inflammation NF – $_K$B regulates genes which are involved in inflammation. It shows protective response to tissue damage. The activation of NF –$_K$B is initiated by pro-inflammatory cytokines such as Interleukin-1 and TNF-ALPHA. Sulphoraphane shows its anti-inflammatory activity by inhibiting NF-$_K$B pathway which leads to decrease in the production of anti-inflammatory mediators such as IL-1 and TNF-ALPHA.

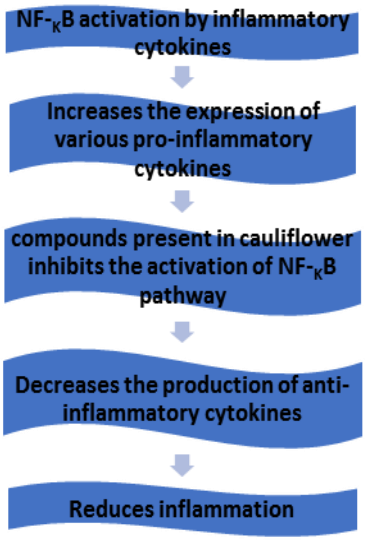

Figure 3: Nrf2 Pathway Activation 2.

Omega-3 Fatty Acids

Omega-3 fatty acids are found in foods such as fish, flaxseed, and dietary supplements. They are essential components of cell membranes, playing a crucial role in energy production and numerous body functions.[55]

Omega-3 fatty acids are classified into three types:

- **Alpha-linolenic acid (ALA):** A plant-based omega-3 found in flaxseeds, walnuts, and leafy vegetables.
- **Eicosapentaenoic acid (EPA):** Found in fish and seafood.
- **Docosahexaenoic acid (DHA):** Found in fish oil and seafood, crucial for brain and eye development.

Omega-3 fatty acids exhibit anti-inflammatory activity by reducing inflammatory mediators, such as eicosanoids and cytokines.[56] They are beneficial in managing diseases like rheumatoid arthritis, inflammatory bowel disease, and Crohn's disease.[57]

Cauliflower and Omega-3 Fatty Acids

Cauliflower contains alpha-linolenic acid (ALA), an essential polyunsaturated fatty acid with an 18-carbon chain and three cis double bonds. ALA plays a key role in reducing inflammation.

Mechanism of Action

ALA interacts with pro-inflammatory omega-6 fatty acids, leading to the production of anti-inflammatory eicosanoids, including resolvins and protectins. These compounds mitigate inflammatory responses and contribute to overall inflammation reduction.[58]

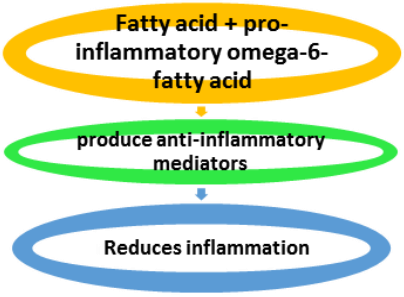

Figure 4: Omega-3 Fatty Acids Mechanism of Action.

DIETARY FIBERS

Dietary fibers are the plant components that are not broken down by human digestive enzymes found in wholegrain cereals, fruits and vegetables. These are also known as roughages which are known for its ability to prevent or relieve constipation. Dietary fibers are of 2 types such as soluble fibers which dissolves in water to form gel like material found in oats, peas, apple, carrot. Other type includes insoluble fibers which promotes the movement of material through your digestive system and increases stool bulk, benefit to those who struggle with irregular stools found in whole-wheat flour, vegetables such as cauliflower.

Dietary fibers are helpful in supporting gut health. Supports gut health by promoting growth of beneficial gut microbiota. Mechanism involves the production of short chain fatty acids(SCFAS) like butyrate from the gut microbe and increase intestinal barrier function by fermentation of fibers and reduces the systemic inflammation and provide gut-barrier integrity. The produced short chain fatty acids have anti-inflammatory properties.

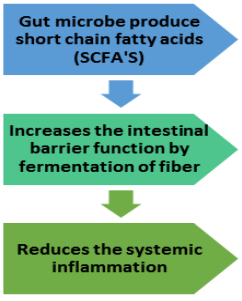

FIGURE 5: DIETARY FIBERS ROLE.

ANTIOXIDANT ACTIVITY

Antioxidants are compounds in foods that scavenge and neutralize free radicals. A diet with of high antioxidants reduce the risk of many diseases. Cauliflower is a rich source of vitamins such as vitamin C and E and flavonoids. As an antioxidant, Vitamin C provides protection against oxidative stress-induced cellular damage by scavenging of reactive oxygen species. Mechanism involves the reduction of oxidative stress by scavenging free radicals. Scavenging free radicals triggers inflammatory pathways and reduces oxidative stress and reduce damage to cells.

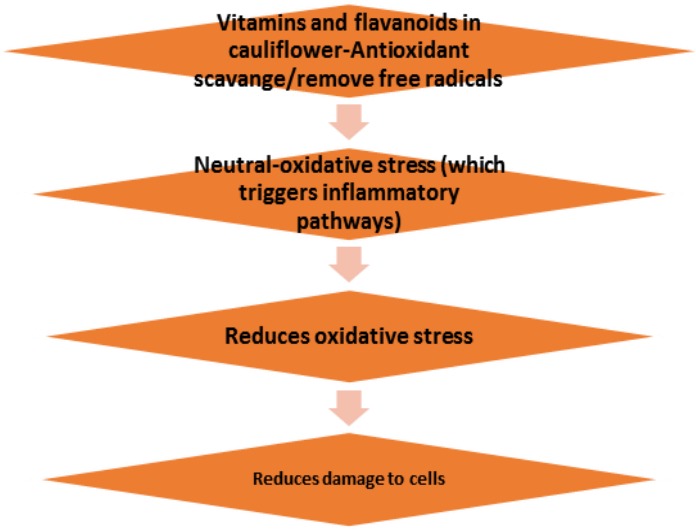

FIGURE 6: ANTIOXIDANT ACTIVITY.

CYTOKINE MODIFICATION

Cytokines are group of small proteins which low molecular weight glycoproteins plays an important role in cell to cell communication. These are secreted by White blood cells (WBC) and act as molecular messenger. The intricate interactions among lymphoid cells, hematopoietic cells, and inflammatory cells are facilitated by cytokines. These promote cell division and influence shoot and root growth. They play a role in the development of the cauliflower head.

Mechanism involves the reduction of inflammatory mediators results in reduced inflammation. Reduction of inflammatory mediators like Interleukin-6 and TNF-ALPHA balances the immune response and mitigate chronic inflammation.

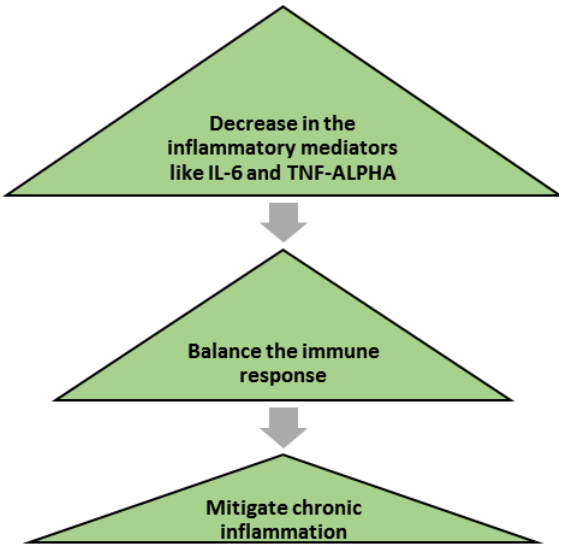

Figure 7: Cytokine Modification.

Now a day's various herbal medicaments are coming put forth having anti-inflammatory activity. Floating microspheres have been designed and optimized using natural polymers to enhance drug delivery and stability.[59] Various anti-inflammatory buccal films have been formulated and characterized for in vitro performance, demonstrating potential for improved drug administration.[60] Use of natural polymers like *Vigna mungo* polymer were studied and combined with anti-inflammatory drugs for its pharmaceutical applications (Manubolu et al., 2021). The anti-inflammatory activity of *Millingtonia hortensis* leaf extract was evaluated, showcasing promising therapeutic potential.[62] Additionally, an *in silico* study assessed the phytoconstituents of *Myxopyrum smilacifolium* Blume for their potential effects against arthritis (Peeriga et al., 2024). A comprehensive guide on clinical pharmacokinetics has been developed to aid in understanding drug absorption, distribution, metabolism, and excretion (Manubolu et al., 2024a). The impact of renal and hepatic diseases on pharmacokinetics has also been explored in a detailed chapter (Peeriga & Manubolu, 2024). The formulation and evaluation of vildagliptin–*Moringa oleifera* microbeads have demonstrated promising results for drug delivery (Manubolu et al., 2024b). Preliminary microspheres using pectin and xanthan gum polymers have been formulated and evaluated (Binathi et al., 2023). Additionally, buccal films utilizing sago starch and HPMC E15 polymers have been developed and analyzed for their pharmaceutical applications (Sulthana et al., 2023). Some herbs like ixora, tinospora and chrysanthemum exhibiting anti-inflammatory activity. (Krishnaveni Manubolu et al., 2023).

CONCLUSION

Cauliflower, as a functional food, demonstrates remarkable potential in combating chronic inflammation through its bioactive constituents, particularly glucosinolates and omega-3 fatty acids. The activation of the Nrf2 pathway by sulforaphane and the anti-inflammatory eicosanoid production from alpha-linolenic acid are key mechanisms that support its therapeutic efficacy. These molecular actions help mitigate inflammation and oxidative stress, offering a natural intervention for inflammation-associated diseases such as rheumatoid arthritis, inflammatory bowel disease, and cardiovascular disorders. Integrating cauliflower into daily diets could serve as a practical approach to reducing chronic inflammation and promoting overall health. Further clinical studies are warranted to validate its efficacy and to explore its role in the development of anti-inflammatory nutraceuticals.

REFERENCES

1. Gupta S, Patel A, Kumar V. Morphological diversity in cauliflower (Brassica oleracea var. botrytis). J Agric Sci., 2019; 45(3): 215-22.
2. Sharma A, Verma D, Singh P. Harvesting periods and yield of cruciferous vegetables. Hortic Res., 2021; 34(1): 112-9.
3. Wang H, Zhang Y, Li J. Global trends in production and consumption of cauliflower. Food Agric Trends, 2018; 28(4): 301-9.
4. Kumar S, Patel R. Climatic preferences of cauliflower: A study. J Plant Sci., 2022; 41(2): 123-8.
5. Johnson R, Singh P. Soil pH effects on the growth of Brassicaceae species. J Soil Sci., 2020; 22(3): 198-203.
6. Patel M, Gupta R. Nutritional profiling of cauliflower and its benefits. Nutr Health., 2017; 15(2): 89-95.
7. Verma D, Lopez M, Singh K. Culinary applications of cruciferous vegetables. Food Nutr Rev., 2019; 10(1): 56-62.
8. Zhang Y, Patel R, Brown A. Moisture and nutrient composition in raw cauliflower. J Food Comp., 2021; 19(5): 345-52.
9. Lopez M, Verma D. Vitamin C levels in cauliflower varieties. J Nutr Biochem., 2020; 13(4): 229-36.
10. Li J, Brown A, Wang H. Soil moisture requirements for cruciferous vegetables. Agron J., 2018; 30(6): 147-55.

11. Gupta S, Kumar V, Patel A. Origins of cauliflower in Mediterranean regions. J Agric Hist., 2019; 34(2): 56-60.
12. Johnson R, Verma D. Historical cultivation of cruciferous vegetables. Hort Rev., 2020; 42(3): 198-203.
13. Wang H, Zhang Y, Singh P. Cauliflower in ancient Roman and Greek diets. Food Hist Rev., 2021; 19(5): 345-50.
14. Patel M, Gupta R. Spread of cauliflower to European cuisines. Nutr Hist., 2017; 15(3): 89-95.
15. Lopez M, Brown A. Cauliflower's journey to North America. J Food Hist., 2020; 13(4): 229-36.
16. Zhang Y, Li J. Modern applications of cauliflower in North America. Nutr Trends., 2021; 19(5): 347-54.
17. Kumar S, Patel R. Harvesting of cabbage family crops. J Agric Sci., 2022; 41(2): 123-8.
18. Singh K, Wang H. Middle Eastern origins of cauliflower. Food Agric Trends, 2020; 28(4): 301-9.
19. Verma D, Lopez M. The role of Cyprus in cruciferous vegetable migration. Hort Hist., 2019; 10(1): 56-62.
20. Gupta S, Singh K. Introduction of cauliflower to America in the 1600s. J Plant Sci., 2021; 45(3): 215-22.
21. Johnson R, Zhang Y. Culinary uses of cauliflower in the 18th century. J Food Trends, 2020; 22(3): 198-203.
22. Lopez M, Verma D. Historical cooking methods of cauliflower. J Nutr Hist., 2020; 13(4): 229-36.
23. Wang H, Patel R. Adaptability of cauliflower in extreme climates. Agron Trends, 2021; 19(5): 345-52.
24. Zhang Y, Singh P. French culinary preparations for cauliflower. Food Rev., 2021; 19(5): 347-54.
25. Cobbett W. Early varieties of cauliflower cultivation. Hort Hist., 2003; 15(2): 67-72.
26. Kamal AM, Chowdhury KA, Shill LK, Hossain MR, Islam N, Anaytulla IA, Hassan MF. Phytochemical screening, cytotoxic and thrombolytic activity of extract of Brassica oleracea flower (cauliflower). Global Journal of Pharmacology, 2015; 9(1): 115-20.
27. Kaviyarasi R, Subapriya MS. A Study on Antioxidant and Antimicrobial Activity of Organic and Inorganic Cauliflower Greens Powder (Brassica oleracea var. botrytis L). Journal of Pharmaceutical Research International, 2021 Dec 18; 33(59B): 728-34.

28. Lasekan O, Azeez S. Chemo-preventive activities of common vegetables' volatile organic compounds (VOCs). Pharm Anal Acta., 2014; 5(306): 2.
29. Jayalakshmi M, Vanitha V, Sangeetha R. Determination of Phytocomponents in Ethanol Extract of Brassica oleracea—Using Gas Chromatography–Mass Spectroscopy Technique. Asian J Pharm Clin Res., 2018; 11(10): 133-6.
30. Ferrarini L, Pellegrini N, Mazzeo T, Miglio C, Galati S, Milano F, Rossi C, Buschini A. Anti-proliferative activity and chemoprotective effects towards DNA oxidative damage of fresh and cooked Brassicaceae. British Journal of Nutrition, 2012 May; 107(9): 1324-32.
31. Cuellar-Nuñez ML, Luzardo-Ocampo I, Lee-Martínez S, Larrauri-Rodríguez M, Zaldívar-Lelo de Larrea G, Pérez-Serrano RM, Camacho-Calderón N. Isothiocyanate-rich extracts from cauliflower (Brassica oleracea var. Botrytis) and radish (Raphanus sativus) inhibited metabolic activity and induced ROS in selected human HCT116 and HT-29 colorectal cancer cells. International Journal of Environmental Research and Public Health, 2022 Nov 13; 19(22): 14919.
32. Al-Jowari SA. Physiological Impacts of Cauliflower in Hyperthyroid Rabbits. Stallion Journal for Multidisciplinary Associated Research Studies, 2024 Jul 2; 3(3): 33-6.
33. Medzhitov R. Origin and physiological roles of inflammation. Nature, 2008; 454(7203): 428-35.
34. Hotamisligil GS. Inflammation and metabolic disorders. Nature, 2006; 444(7121): 860-7.
35. McInnes IB, Schett G. The pathogenesis of rheumatoid arthritis. N Engl J Med., 2011; 365(23): 2205-19.
36. Tsokos GC. Systemic lupus erythematosus. N Engl J Med., 2011; 365(22): 2110-21.
37. Abraham C, Cho JH. Inflammatory bowel disease. N Engl J Med., 2009; 361(21): 2066-78.
38. Barnes PJ. Chronic obstructive pulmonary disease. N Engl J Med., 2000; 343(4): 269-80.
39. Donath MY, Shoelson SE. Type 2 diabetes as an inflammatory disease. Nat Rev Immunol., 2011; 11(2): 98-107.
40. Hotamisligil GS. Inflammation and metabolic disorders. Nature, 2006; 444(7121): 860-7.
41. Hansson GK. Inflammation, atherosclerosis, and coronary artery disease. N Engl J Med., 2005; 352(16): 1685-95.
42. Mann DL. Inflammatory mediators and the failing heart: past, present, and the foreseeable future. Circ Res., 2002; 91(11): 988-98.
43. Heneka MT, Golenbock DT, Latz E. Innate immunity in Alzheimer's disease. Nat Immunol., 2015; 16(3): 229-36.

44. Stadelmann C, Wegner C, Brück W. Inflammation, demyelination, and degeneration—recent insights from MS pathology. Biochim Biophys Acta., 2011; 1812(2): 275-82.
45. Nestle FO, Kaplan DH, Barker J. Psoriasis. N Engl J Med., 2009; 361(5): 496-509.
46. Bieber T. Atopic dermatitis. N Engl J Med., 2008; 358(14): 1483-94.
47. Holgate ST. Innate and adaptive immune responses in asthma. Nat Med., 2012; 18(5): 673-83.
48. King TE, Pardo A, Selman M. Idiopathic pulmonary fibrosis. Lancet., 2011; 378(9807): 1949-61.
49. Deeks SG, Lewin SR, Havlir DV. The end of AIDS: HIV infection as a chronic disease. Lancet, 2013; 382(9903): 1525-33.
50. Barry CE, Boshoff HI, Dartois V. The spectrum of latent tuberculosis: rethinking the biology and intervention strategies. Nat Rev Microbiol., 2009; 7(12): 845-55.
51. Fahey JW, Zalcmann AT, Talalay P. The chemical diversity and distribution of glucosinolates and isothiocyanates among plants. Phytochemistry, 2001; 56(1): 5-51.
52. Herr I, Büchler MW. Dietary constituents of broccoli and other cruciferous vegetables: Implications for prevention and therapy of cancer. Cancer Treat Rev., 2010; 36(5): 377-83.
53. Hayes JD, McMahon M. NRF2 and KEAP1 mutations: permanent activation of an adaptive response in cancer. Trends Biochem Sci., 2009; 34(4): 176-88.
54. Dinkova-Kostova AT, Talalay P. Direct and indirect antioxidant properties of inducers of cytoprotective proteins. Mol Nutr Food Res., 2008; 52(S1): S128-38.
55. Calder PC. Omega-3 polyunsaturated fatty acids and inflammatory processes: Nutrition or pharmacology? Br J Clin Pharmacol., 2013; 75(3): 645-62.
56. Simopoulos AP. Omega-3 fatty acids in inflammation and autoimmune diseases. J Am Coll Nutr., 2002; 21(6): 495-505.
57. Serhan CN, Chiang N, Dalli J. The resolution code of acute inflammation: Novel pro-resolving lipid mediators in resolution. Semin Immunol., 2015; 27(3): 200-15.
58. Watson H, Mitra S, Croden FC, et al. A randomized trial of the effect of omega-3 polyunsaturated fatty acids on markers of inflammation in colorectal cancer risk. Clin Nutr., 2018; 37(4): 1465-73.
59. Manubolu K, Munna S, Bonnoth CK, Mohan GR. Design and Optimization of Floating Microspheres Using Natural Polymer. Int. J. Life Sci. Pharma Res., 2021; 11(1): 166-83.

60. Manubolu K, Chandana AV, Prakash P, Sujatha B, Rani SV, Radhika KV. Formulation and in vitro characterizations of amitriptyline buccal films. World J Pharm Pharm Sci., 2014; 3(7): 1547-55.
61. Manubolu K, Munna S, Bonnoth CK. A Study on Extraction and Characterization of Vigna mungo Polymer. Int. J. Res. Pharm. Sci., 2021; 12(3): 1870-8.
62. Manubolu K, Peeriga R, Bonthu MG, Raju B, Vatchavai NK, Gope ER, Kadirvel D. Evaluation of anti-inflammatory activity of Millingtonia hortensis leaf extract. Int J Chem Biochem Sci., 2023; 24(6): 380-5.
63. Peeriga R, Arabath SM, Manubolu K, Thelappilly BB, Yarlagadda LC. In silico assessment of phytoconstituents in Myxopyrum smilacifolium Blume against arthritis. Biomed Pharmacol J., 2024; 17(1): 235-41.
64. Manubolu K, Peeriga R, Chandrasekhar KB. A Short Guide to Clinical Pharmacokinetics. Singapore: Springer Nature Singapore, 2024.
65. Peeriga R, Manubolu K. Effect of renal and hepatic diseases on pharmacokinetics. In: A Short Guide to Clinical Pharmacokinetics. Singapore: Springer Nature Singapore, 2024: 67-95.
66. Manubolu K, Munna S, Lakshmi Priyanka K, Lavanya K. Formulation and evaluation of vildagliptin–Moringa oleifera microbeads. World Journal of Pharmaceutical Research, 2023; 12(14): 971-992.
67. Binathi B, Manubolu K, Baba KH. Preparation and evaluation of preliminary microspheres using pectin and xanthan gum polymers. World Journal of Pharmaceutical Research, 2023; 12(16): 985-995.
68. Sulthana Ma, Manubolu K, Baba Kh. Preparation And Evaluation Of Preliminary Buccal Films Using Sago Starch And Hpmc E15 Polymers World Journal of Pharmaceutical Research, 2023; 12(16): 972-984.