

SCIENTIFIC APPROACHES ON RED CABBAGE: A REVIEW

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ABSTRACT

Red cabbage is a vegetable known for its enriched bioactive constituents. Generally among the population it is used as an ingredient in raw salads or coleslaws, pickle, boiled and steamed dishes for its impact on human health and low calorie, high fiber composition. It is extensively used in food processing to enhance the aesthetic value of food as natural colorant in beverages, candies, gums and to provide health benefits. It has several health benefits over cancer, diabetes, boosts immune system, helps in detoxification of body, promotes weight loss, improves skin, inflammation, has gut healing power, relieves constipation. The antioxidant capacity of red cabbage helps to prevent chronic ailments and management of condition like Alzheimer's, depression etc. This paper reviews on the scientific approach and pharmacological activity of red cabbage.

Keywords: Red cabbage, *Brassica oleracea* var. *capitata* f. *rubra*, pharmacological uses, antioxidant.

INTRODUCTION

Brassicaceae vegetables represent an important part of the human diet worldwide, are consumed by people all over the world and are considered important food crops in China, Japan, India, and European countries¹. Due to its bioactive constituents it not only acts as antioxidant but also has several health promoting benefits.²

Red cabbage is the member of *Brassicaceae* family. It is a cool season cruciferous vegetable. Red cabbage (*Brassica oleracea* var. *capitata* f. *rubra*) is type of cabbage, widespread in the Mediterranean region³ although its grown in various parts of the world⁴. Red Cabbage is a herbaceous, biennial, dicotyledonous flowering plant. It has short stem above which is a crown with a head of red coloured leaves⁵. It is called purple cabbage since its leaves are purple or red in colour due to the pigment called anthocyanin. According to the PH of soil the colour varies. The reddish leaves are from acidic soil, leaves grow purple in neutral soil and alkaline soil will produce greenish yellow coloured cabbage⁶. The optimum temperature for growth is 15-18 degree celcius. It is less tolerant to high temperature but can withstand freezing temperature⁷.

SYNONYMS

English : red cabbage, purple cabbage, red kraut or blue kraut after preparation

Hindi : laal pattha gobi; **kannada** : kempu elekosu; **Malayalam** : cuvanna kabej; **Tamil** : civappu muttaikkos; **Telugu** : Erra kyabeji; **Marathi and gujrathi** : lal kobi. **Bangla** : lal bamdhakapi



The genus *Brassica* is classified as:⁸

Kingdom	Plantae
Subdivision	Spermatophyta
Class	Angiospermae
Subclass	Dicotyledonae
Order	Papaverales
Family	Cruciferae or Brassicaceae
Genus	<i>Brassica</i>
Species	<i>Brassica oleracea</i>
Subspecies/var.	<i>Capitata F. Rubra</i>

Macroscopy⁹

Color : purple
Taste : bitter
Odour : characteristic

Chemical constituents

Red cabbage is enriched with phenolic compound anthocyanins which is predominant over other flavanoids¹⁰.

The strongest antioxidant capacity of red cabbage is attributed to anthocyanins which has a power of 150 flavanoids¹¹.

Among the substances present in the red cabbage responsible for these properties are the isothiocyanates (glucosinolates), polyphenols, The anthocyanins pigments of the red cabbage comprise mainly of cyanidin 3-sophoroside-5-glucoside and cyanidin 3-sophoroside-5-glucoside acylated with sinapic acid, ferulic acid, p-coumaric acid and malonic acid¹².

It contains glucoraphanin, sinigrin, and glucoiberin as major GLSs. Among them, glucoraphanin is transformed into sulforaphane, which is a very well known cancer chemopreventive ITC.¹³

Red cabbage is a source of vitamin A, C, K and B, thiamin, riboflavin, folate. Calcium, magnesium, manganese, iron, nickel, zinc and dietary fiber¹⁴. Vit E carotene and tocopherol¹⁵

Phytochemical constituents

Alkaloids, glycosides, steroids, flavonoids, saponnin, tannin, terpenoids and phytosterols¹⁶

Scientific studies

Anticancer

The anticancer activity of red cabbage was conducted in human hepatocarcinoma cell (HepG2) and human cervical cancer cells (HeLa). The findings of the study revealed a selective anticancer action on HeLa cells when compared to HepG2. It was found that red cabbage (RC) extract is a potent inducer for apoptosis via caspase dependant both intrinsic and extrinsic pathway and caspase independent pathway in treated human cancer cells. RC extract had a potential to induce apoptosis and cell cycle arrest. The main mechanism pursued by RC extract to exert G1 cycle arrest was by cdk inhibitor proteins (p21, p27, p53). In addition the study also revealed the increased level of TNF α and suggests that the growth inhibition in (HepG2) and (HeLa) may be partly due to antitumor effect of TNF α . Hence it was concluded in the study that red cabbage extract could be a promising anticancer agent due to its multimechanism and synergistic anticancer effect¹⁷. A study on rodent model of hepatocellular carcinoma recommends that increased dietary intake of red cabbage may be advantageous to patients with liver cancer since the findings from the study disclosed the protective action of red cabbage against hepatocellular carcinoma in rats.¹⁸

Red cabbage color extract was shown to inhibit adenoma and carcinoma formation in rats initially treated with 1,2-dimethylhydrazine (DMH) followed by fed diet containing 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine (PhIP). It also showed protective action against formation of aberrant crypt foci by PhIP in non DMH treated rats.¹⁹ However in contrast another subsequent study showed less effective action of red cabbage towards 2-amino-3-methylimidazo[4,5-f] quinoline (IQ)-induced preneoplastic lesions²⁰. Further studies conducted on anticancer activity of red cabbage on human colon cancer cells, human Caucasian breast adenocarcinoma and human hepatocellular carcinoma cell line also drew light on its anticancer activity²¹.

Hypnotic

According to a book of traditional medicine, red cabbage has anticonvulsive, sedative, and hypnotic effects; also, it is used in aromatherapy for relieving stress and insomnia²². In a study the effect of hypnotic effect of hydro alcoholic extract (HAE) of red cabbage and its fractions were conducted based on potentiating of sleep

induced by pentobarbital method. It was found that the hypnotic effect of HAE of red cabbage was comparable to that of diazepam but did not decrease the motor movement and did not have muscle relaxation effect when evaluated by rotarod test as in the case of diazepam. The study has also postulated the sleep prolonging action of HAE of red cabbage is mediated by potentiating GABAergic system by flavanoids. The results of this study suggested that red cabbage potentiates pentobarbital hypnosis without any toxic effect²³.

Antiplatelet And Antioxidative Activity On Platelet

One of the invitro study was designed to focus on the ability of anthocyanins extracted from red cabbage to diminish platelet activation by antioxidative activity. The study revealed the antiaggregatory property of anthocyanins in the presence of thrombin by inhibiting the arachidonic acid metabolism which leads to malondialdehyde and also by distinctly decreasing O₂ generation. In the same study when the human blood platelets were treated with powerful oxidizing agents peroxynitrite and hydrogen peroxide (ONOO⁻ or H₂O₂) the results demonstrated that ATH extract of red cabbage diminished protein oxidation and nitration and had preventive effect on lipid peroxidation in blood platelet. This result with some other works reveal the antiradical activity by prevention of lipid peroxidation is one of the route by which anthocyanins resist cells from oxidative damage and maintain membrane integrity. From this study it can be concluded that anthocyanins from red cabbage have antiplatelet and antioxidative activity and could be beneficial in prevention of cardiovascular problems.²⁴

Hypolipidemic and dyslipidemic

Red cabbage exhibited a promising effect against hypercholesterolemia and hypertriglyceridemia in a study conducted to determine the hypolipidemic effect of red cabbage showing an involvement on amelioration of lipid profile of Triton WR 1339 induced in hyperlipidemic rats. It was shown that levels of total cholesterol, triglycerides, serum VLDL -c content was decreased and it did not augment HDL -c levels as compared to control group in the hyperlipidemic rats. This study suggested that red cabbage could be involved in the role of PPAR α and can provide lipid lowering compounds.²⁵ In addition to this an

invitro study conducted on erythrocyte membrane with normal and high concentration of cholesterol also evidenced the direct influence of red cabbage polyphenols on hypercholesterolemic erythrocyte.²⁶ Red cabbage has also revealed its therapeutic effects in dyslipidemia.²⁷

Myocardial infarction

The effect of Anthocyanin rich red cabbage extract (ARCE) when assessed for its cardioprotective potential in H₂O₂ treated rat neonatal cardiomyoblasts and isoproterenol induced rodent model of myocardial infarction, the H₂O₂ induced oxidatively stressed cells depicted dose dependant reduction in cytotoxicity and apoptosis. Rats pretreated with ARCE followed by ISO were found to have favorable heart : body weight ratio, reduced circulating levels of CK-MB, ameliorated levels of enzymatic antioxidants and favourable modulation of apoptotic markers (*bax* and *bcl-2*). Less pronounced infarcted areas or derangement of myocardium compared to ISO treated group. Upregulation of *caveolin -3* and *SERCA2a* were witnessed which evidenced for its cardioprotective potential. This study also interpreted the mechanism of action by molecular docking scores of cyanidine -3-glucoside and delphinidin -3-glucoside which provide discernment on the stable interaction with β_1 adrenergic receptor and ARCE mediated myocardial damage prevention. The authors of the study conclude that ARCE demonstrates therapeutic effects by improving the status of intracellular oxidants, preventing membrane damage and apoptosis.²⁸ Another subsequent study conducted in rats fed an atherogenic diet also showed cardioprotective property by attenuating oxidative stress²⁹

Antidiabetic

Red cabbage showed potential antidiabetic effects on diabetes induced rats. The weeks of treatment of diabetic rats with red cabbage extract showed antihyperglycemic effect, improved glucose tolerance^{30,31,32}, increased the values for insulin and its precursors proinsulin and c-peptide suggesting activation of insulin synthesis. It had protective effect on destruction of pancreatic β cells and inhibited the formation of glycated hemoglobin, which was responsible for normalization of erythrocyte structure and functions which ameliorates blood rheology and reduces the risk of vascular complications. In the same study an invitro study conducted on

erythrocyte membrane of diabetic rats also evidenced the direct influence of red cabbage polyphenols on erythrocyte membrane properties³².

Diabetic Nephropathy

Earlier findings suggests that major cause for the development and progression of diabetic microvascular complication such as nephropathy is due to oxidative stress induced by hyperglycemia³³. The therapeutic effect of red cabbage extract against diabetic nephropathy exhibited antihyperglycemic activity, prevented and suppressed symptoms of nephropathy, restored renal function, and body weight loss. Enzymatic antioxidants like Superoxide dismutase enzyme and Catalase and non enzymatic antioxidants like glutathione were ameliorated and increase in malondialdehyde was abolished. In accordance to this study, antihyperglycemic effect depicted by the red cabbage polar extract may modulate oxidative stress induced by hyperglycemia generation of free radicals and ameliorate diabetic nephropathy³⁴.

Antiulcer

Effect of red cabbage methanolic extract studied in ulcerogenic rats produced significant antiulcer activity. The results obtained showed reduced values of lesion index. Significant reduction in gastric volume, total acidity, ulcer index and increase in pH of gastric juice was observed in pylorus ligation model 99.44% curation was observed in acetyl salicylic acid induced ulcer which evidenced for its gastroprotective activities.³⁵

Antimicrobial (Antibacterial And Antifungal)

Effect of red cabbage acid methanolic extract was investigated against 22 strains of pathogenic bacteria and fungi. The extract exhibited a potent antimicrobial activity against the tested strains of gram positive, gram negative and fungi. The study witnessed a remarkable antibacterial for the first time against Methicillin resistant staphylococcus aureus (MRSA), S.aureus, E.coli O157:H7, S.enterica serovar Typhimurima and K.pneumoniae and remarkable antifungal effect against T.rubrum and A.terreus. The findings from the current study revealed red cabbage leaves extract has novel, powerful and broad spectrum antimicrobial activity against large number of human and animal pathogenic microbes including multiple drug resistant (MDR) bacteria out of which three

MDR bacteria which were resistant to 15 powerful antibiotics belonging to 8 different groups, non MDR bacteria and fungi.³⁶ Other studies conducted by different researchers also prove the antimicrobial activity of red cabbage.^{37,38,39}

Anti Inflammatory, Antipyretic And Analgesic

The methanolic extract of red cabbage exhibited anti inflammatory activity by significantly reducing formaldehyde induced paw oedema in rats. The underlying mechanism of action may be attributed by the inhibition of histamine, serotonin or prostaglandin synthesis. In the same study (MERC) also showed significant antipyretic activity in Brewer's yeast – pyrexia model.⁴⁰

The effect of MERC on abdominal writhing test by intraperitoneal administration of acetic acid in mice was demonstrated by percentage inhibition of abdominal constriction and suggested that MERC can be used for alleviating pain.³¹

Ulcerative Colitis

Effect of Polyphenolic fraction isolated from red cabbage (PBO) studied on lipopolysaccharide on stimulated HT-29 colonocytes and in rodent model of ulcerative colitis exhibited a remarkable anti inflammatory and cytoprotective action which were depicted by significant reduction of inflammatory markers and cytokines. Prevention of oxidative damage lead to the regeneration of mucosa, goblet cells and mucin content in rat colonic mucosa. These results attribute the importance of PBO as an anti inflammatory therapeutic agent for ulcerative colitis.⁴¹

Hyperthyroidism

Effect of red cabbage extract on hyperthyroid rodent model was found have thyroid function suppressing action. The extract reduced the increased level of T₃ and T₄ and increased the level of TSH which was altered following the administration of thyroxin a hyperthyroid inducing agent. The reduced body weight was also increased. Red cabbage extract showed increased activity of HMG-CoA reductase, normalized the levels of total cholesterol and triglycerides which according to the author might be due to the presence of procyanidins. The various biochemical estimations performed during the experiment concluded that the red cabbage extract has protective effect against hepatocellular damage, renal damage which attributes to the presence of anthocyanin

content in the red cabbage . In addition to this, the study also suggests that red cabbage is a goitergen due to which it reduced the level of T3 and T4 and had protective effect on protein excretion⁴².

Erythma

The purple cabbage ethanol extract cream assessed for its protective action on acute UV – B exposure on 30 male rats resulted in reduced erythma scores representing its ability to suppress the effects of UV exposure with equal effectiveness for the tested dose. The erythma scores of the control group and cream base group were significantly different from the tested group. In conclusion this study suggests that studies are needed to determine the mechanism and other aspects . However this study was in agreement with several studies conducted in animals and humans which justify the benefit of antioxidants against UV radiation effect.⁴³

Antioxidant Activity

Among the investigated Brassica vegetables, Brussel sprout, broccoli and red cabbage are known as the vegetables with efficient antioxidant activity. Red cabbage demonstrated strong O₂, DPPH, ABTS radical scavenging activity^{44, 45,21}. Red cabbage is reported to reduce oxidative stress in various experiments and hence several researchers suggests the use of red cabbage in oxidative stress related diseases⁴⁶. Red cabbage not only ameliorates antioxidant defense but also has a promising role in maintaining metabolic and energetic balance to strike down complications.⁴⁷ Supplementation with red cabbage also increased lutein, β carotene level and total antioxidant levels in volunteers supplemented with red and black cabbage in the diet⁴⁸. Red cabbage acts as nephroprotective⁴⁹, cardioprotective⁵⁰, hepatoprotective⁵¹, neuroprotective⁵¹.

Conclusion

The main objective of this review was to unfold the pharmacological activities of red cabbage. It is one of the most beneficial Brassica vegetable. The impact on health by red cabbage can be attributed to its antioxidant activity. Red cabbage is easy available and cheap source of anthocyanins. Although preclinical studies revealed that red cabbage is a promising source for its beneficiary effect on diseases , inspite of this there are certain limitations which exist and

further clinical trials should be conducted for its therapeutic use.

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