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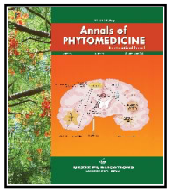

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Fruits that heal: A natural boon to cure colon diseases

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Abstract

Colorectal diseases are the most common problems in developed as well developing countries due to changes in feeding habits and daily lifestyles. The number of new cases related to different colon diseases are annually increasing. Various allopathic treatments are available at the initial level of disease, but it has many unknown side effects. Fruits are wonderful gifts to mankind. They are rich in various bioactive and medicinal compounds and are gaining great attention to treat many diseases which also include colon related problems. They are great source of vitamins, minerals, simple sugars, soluble dietary fiber, many phytonutrients, phytoestrogens, anti-inflammatory agents and antioxidants. Daily intake of fruits provides several advantages to the body such as fibre intake is linked to smooth bowel movements as well as offer relief from constipation ailments, antioxidants (polyphenolic flavonoids, vitamin C and anthocyanins) reduce against oxidative stress, scavenge free radicals and protect the body from cancers and infection, *etc*. Fruits also help in detoxification of the body through various metabolic activities which reduces the various colon diseases such as annal fissure, colon cancer, inflammatory bowel syndrome, *etc*. This article summarizes the recent pharmacological research on colon diseases using various bioactive compounds extracted from fruits.

1. Introduction

Botanically fruits are ripened ovaries. They are the part of plant that may or may not be purely derived from ovary of the flowers. Dictionary definition of fruits include 'the edible part of a plant or tree, consisting of seed. They may be fleshy or pulpy in character, often juicy and predominantly sweet with somewhat acidic taste, fragrant aromatic flavor and often consumed without cooking. However, consumer defines fruit as 'plant produce with aromatic flavor, which is naturally sweet or normally sweetened before eating'. Fruits are generally acidic with high moisture content, hence being highly perishable in nature. They are excellent source of dietary fibre, vitamins, and various phytochemicals. Owing to the presence of cellulose, pectin, and various organic acids, fruits act as natural laxatives. Due to all these nutritive components, fruits become a valuable part of the diet. They play a key role in the defense system of the human body and increases the responses of immune system to fight against various diseases. In addition, fruits are being used from ancient times to treat various diseases and are part of traditional medicine in different ancient civilizations. Fresh fruits are valuable source of numerous vitamins like vitamin C, vitamin A, vitamin B 6, vitamin E, *etc*., whereas, dry fruits and nuts are considered as a good source of important fiber, calories, amino acids, high in good fats and other bioactive components (Samtiya *et al.,* 2021). Fruits contain different antioxidants that play an important role in altering the metabolic processing and detoxification of different diseases, particularly degenerative. It is well documented that, regular consumption of fruits, nuts, and vegetables reduces the risk of cardiovascular diseases (CVD), chronic diseases, and different types of colon diseases (Abobatta, 2021).

Colon is a part of our digestive system (also called the digestive tract) and performs various functions in the human body. It absorbs water, nutrients and electrolytes from partially digested food. Many digestion-related problems are increasing currently due to changed eating habits and daily lifestyles. Some functional and structural disorders, infections, and irritations such as diverticulitis, ulcerative colitis, microscopic colitis, proctitis, appendicitis, necrotizing enterocolitis, rectal ulcer, hemorrhoids, colorectal cancer, constipation, irritable bowel syndrome, *etc.,* affect the regular functioning of colon. Therefore, promoting a healthy lifestyle with nutritious diets comprising at least 400 g of fruits and vegetables improves health and rejuvenates the human system (Amine *et al.*, 2003). It is predicted that overall, 2.7 million lives may be protected by fruit and vegetable consumption (Chellammal, 2022).

2. Colon diseases and medicinal role of fruits

Colon disease, also known as colorectal diseases, refers to a range of conditions affecting the large intestine or colon. While medication and surgery are commonly used to treat these conditions, diet and lifestyle changes can also play a significant role in managing symptoms and promoting overall colon health. In particular, certain fruits have been found to have potential healing properties for those suffering from colon disease. Given below is a brief description of some colon related diseases and fruits associated with their prevention.

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2.1 Inflammatory bowel diseases (IBD)

The prevalence of inflammatory bowel disease (IBD) is increasing worldwide, with substantial variations in levels and trends of disease in different countries and regions. There were 6.8 million cases of IBD globally recorded in the year 2017 (Alatab *et al*., 2020). It is characterized by non-infectious chronic inflammation of the gastrointestinal tract and primarily includes Crohn's disease (which can affect any segment of the gastrointestinal tract from the mouth to the anus), ulcerative colitis (which is limited to the colonic mucosa), and indeterminate colitis (Sairenji *et al*., 2017). The inflammation can lead to symptoms such as abdominal pain, diarrhea, and rectal bleeding. Inflammation is a complex immune response characterized by the sequential release of pro-inflammatory cytokines. Inhibiting the overproduction of inflammatory mediators, particularly pro-inflammatory cytokines like interleukin (IL)-1b, IL-6, nitric oxide (NO) and tumor necrosis factor alpha (TNF-α), may thus prevent or suppress a variety of inflammatory diseases (Kim *et al*., 2003).

Since ancient times, inflammatory conditions and their related disorders have been treated with plants or plant-derived formulations. Talcott and Talcott, conducted a study to assess the effects of mango consumption as an adjuvant treatment to conventional therapy in IBD and found beneficial effects of mango intake in the progression and severity of the IBD, which might be due to a reduction in the levels of IBD-relevant molecules in plasma, improved composition of the intestinal microbiota and decreased serum endotoxin level. Punicalagin, punicalin, strictinin A, and granatin B, the anti-inflammatory components of pomegranate peel, significantly decreased the production of NO and PGE2 (prominent contributors to chronic inflammatory diseases) by inhibiting the expression of pro-inflammatory cytokines (Lee *et al*., 2008; Romier *et al*., 2008). Similar anti-infflammatory effects of phytochemicals from different fruits are discussed in Table 1.

Table 1: Anti- infflammatory properties of some fruits

Classes of phytochemicals	Source	Components	Mechanism of actions	References
Crude extracts	Grape (*Vitis* sp.) seeds	Procyanindin extract	Inhibit the overproduction of NO and PGE2	Terra *et al*., 2007
	Strawberry (*Fragaria ananassa*) and mulberry (*Morus alba*)	Fruit juice ethanol extracts	Decrease splenocytes' (IFN-g C IL-2 C IL-12)/IL-10 (Th1/Th2) cytokine secretion ratio	Liu and Lin, 2013
	Citrus (*Citrus sinensis*)	Citrus peel extract	Decrease the release of TNF-α and NO	Etoh *et al*., 2013
	Chinese pear (P*yrus pyrifolia*)	Ethyl acetate extract	Inhibition of edema formation 0.5–5 h after edema induction	Li *et al*., 2012
Phenolics	Blueberry (*Vaccinium sect. cyanococcus*)	Polyphenols	Inhibit the production of NO, IL-1b and TNF-α	Lau *et al*., 2007
	Pomegranate (*Punica granatum*)	Punicalagin, punicalin, strictinin A and granatin B	Reduce production of NO and PGE2	Lee *et al*., 2008; Romier *et al*., 2008
	Citrus (*Citrus sinensis*)	Narirutin	Inhibit the release of NO, PGE2, IL-1b and TNF-α	Ha *et al*., 2012
	Acai fruit (*Euterpe oleracea*)	Flavone velutin	Show excellent anti-infflam-matory capacity	Kang *et al*., 2011
	Kaffir lime (*Citrus hystrix*)	Monogalactosyldia-cylglycerol	Exhibit higher anti-inflammatory activity	Murakami *et al*., 1995

2.2 Ulcerative colitis

Ulcerative colitis is a chronic inflammatory disease with unclear etiology and pathogenesis which belongs to inflammatory bowel disease (Sandborn, 2008). It is characterized by relapsing and diffuse mucosal inflammation, starting from the rectum and extending continuously to proximal segments of the colon. This kind of disease usually recurs and accompanies by some clinical symptoms such as persistent abdominal pain, bloody diarrhea, hematochezia, as well as severe weight loss, so it seriously affects patients' daily life. In addition to these symptoms, ulcerative colitis also causes infiltration of inflammatory cells, upregulation of proinflammatory factors, ulcerative damage of the intestinal wall and even abnormal proliferation, which increases the risk of intestinal tumors (Feagins *et al*., 2009; Kulaylat and Dayton, 2010). Some clinical drugs and immunosuppressive agents are commonly used in the treatment of this disease but these drugs alone are not efficiently effective to cure the disease and even sometimes it causes serious side effects to other parts of the body (Filimon *et al*., 2015). Therefore, some researchers studied diet therapy and include various natural fruits in the diet of the patients to heal the disease.

According to the medical history increased intake of dietary fiber, particularly from fruits, for long-term is associated with lower risk of inflammatory bowel disease and ulcerative colitis (Ananthakrishnan *et al*., 2013). The valorization of fruit waste as a dietary fiber source in ameliorating ulcerative colitis offers several

advantages: nontoxic, therapeutic effectiveness, safe, costeffective, biocompatible, and ease of drug administration through the oral route. They regulate the immune responses by impeding various signal transduction pathways, regulating the secretion of multiple cytokines, maintaining epithelial barrier function, and aiding in the proliferation of beneficial microbes producing favorable metabolites. Additionally, polysaccharides from these sources can be used as an additive with marketed drugs for mucosal healing, maintaining gut tone and microbiome milieu for intestinal disorders, including ulcerative colitis (Bhatt and Gupta, 2023). Recent work has been done by Lin *et al*. (2020) in mice to treat ulcerative colitis using aqueous extract of *Bruguiera gymnorrhiza* fruit, a medicinal mangrove for a week and found that *Bruguiera gymnorrhiza* fruit is rich in pinitol and showed strong antioxidative activity *in vitro* which effectively reduced the body weight loss and disease activity index (DAI), restored the colon length, repaired colonic pathological variations. Some other research work regarding treatments of ulcerative colitis by including different fruits in the diet is presented in Table 2.

Table 2: Fruits used for treatment of ulcerative colitis

Fruit	Sample/ extract	Animal model/ participants	Treatments	Results	References
Nitraria tangutorum Bobr.	Chloroform extract	DSS-induced ulcerative colitis in 50 male C57BL/6 mice	High-dose (150 mg/kg) and low-dose (75 mg/kg)	Chloroform extract treatment remarkably elevated the superoxide dismutase, catalase, and glutathione levels and significantly reduced myeloperoxidase levels in a dose-dependent manner (p<0.05).Chloroform extract from *N. tangutorum* fruit inhibited the increase in the levels of these inflammatory cytokines and promoted the increase in IL-10 levels (p<0.05) which confirmed that fruits could effectively prevent colitis progression.	Zou *et al*., 2022
Ziziphus spinachristi	Aqueous extract	Acetic acid (AcOH)-induced colitis in 49, adults, amle wistar rats	Aqueous extract of fruit with varying doses 100, 200, and 400 mg/kg/day for 7 days	*Ziziphus spinachristi* fruit at different doses suppressed the spread of inflammation, inhibited mucosal damage and also reduced ulcer size and mitigated colitis markers. In addition to this, it not only histopathologically ameliorated AcOH-induced colitis but also restored the balance between the oxidants and antioxidants.	Almeer *et al*., 2018
Heritier alittoralis fruit	Aqueous extract	DSS-induced ulcerative colitis (UC) in (male balb/c mice	200, 400, and 800 mg/kg for 10 days *via* daily gavage	*Heritiera littoralis* fruit significantly improved the disease activity index (DAI) score, relieved colon shortening, and repaired pathological colonic variations in colitis. In addition, proteins in the NF-κB pathway were significantly inhibited using this fruit. Furthermore, *Heritiera littoralis* fruit recovered the diversity and balance of the gut microbiota.	Lin *et al*., 2020
Actinidia arguta (hardy kiwi)	Liquid suspension of freeze-dried powder of hardy kiwi	DSS-induced ulcerative colitis in balb/c 50 mice	Oral administration of *Actinidia arguta* fruit @ (300mg/kg and 600mg/kg for 10 days	Reduce disease activity index (DAI), reduce the incidence of colon and spleen edema which caused by inflammation, and alleviate the pathological changes of ulcerative colitis. Decrease the expression of inflammatory markers myeloperoxidase (MPO) and attenuate oxidative stress levels.Overall, *Actinidia arguta* might have potential to treat ulcerative colitis as a dietary supplement.	Lian *et al*, 2019
Indian gooseberry (*Emblica officinalis*)	Methanolic fruit extract	Acetic acid (AcOH)-induced ulcerative colitis in 30 male wister rats	Oral administration of fruit extract @ 100 and 200 mg/kg for 7 days	Prevent tissue damage and significant decrease in lactate dehydrogenase (LHD) were recorded which indicate that Indian gooseberry can protect to colon against ulcerative colitis.	Deshmukh *et al*., 2010
Moringa oleifera root and *Citrus sinensis* rind	Ethanol and aqueous extract of *M. oleifera* alone and mixed with equal combination with ethanol extract of *C. sinensis*	Acetic acid (AcOH) -induced ulcerative colitis in mice	Treatment of *M. oleifera* alone @ 100 and 200 mg/kg body weight while 50 mg/kg each of *C. sinensis* and *M. oleifera*	The combined effect of extract significantly decreased myeloperoxidase and malondialdehyde level in blood and tissues which indicate that combination of *M. oleifera* root extracts with *C. sinensis* fruit rind extract is effective in the with the standard drug prednisolone.	Gholap *et al*., 2012

Cupressus arizonica Greene	Fruit extract and fruit essential oil	Acetic acid (AcOH)-induced ulcerative colitis in 35 wister male mice	Use fruit extract at different level, *i.e*., 100, 250 and 500 mg/kg administered orally and use fruit essential oil administrated intra-rectally at the level of 0.5 and 1 mg/kg	The extract at doses of 100 mg/kg and 250 mg/kg and essential oil at doses of 0.5 mg/kg showed significant effects on *Ulcerative colitis* (p<0.05). Essential of fruit is rich in α-pinene which helps in reducing the ulcer in colon Results also revealed that extract and essential oil of *C. arizonica* fruits had therapeutic on *Ulcerative colitis*, and this effect may be related to the presence of polyphenolic and terpene compounds.	Majnooni *et al*., 2022
Aegle marmelos (Bael)	Aqueous extract	Acetic acid (AcOH)-induced ulcerative colitis in wister albino rats	The extract was administered orally at different doses of 150, 200 and 250 mg/kg body weight for 14 days	A dose-dependent decrease in intestinal inflammation and significant protection in mast cell degranulation was observed.	Behera *et al.,* 2012
Aegle marmelos (Bael)	Ethanolic extract	Acetic acid (AcOH)-induced colitis in rats	Treatment with different doses (100, 200 and 400 mg/kg) daily for 14 days	The extract was possess antibacterial activity and enhanced antioxidants, decreased free radicals and myeloperoxidase activities. It also reduced colonic mucosal damage and inflammation and afforded ulcer healing.	Gautam *et al.,* 2012

2.3 Irritable bowel syndrome (IBS)

Irritable bowel syndrome (IBS) is a gastrointestinal (GI) disorder characterized by altered bowel habits in association with abdominal discomfort or pain in the absence of detectable structural and biochemical abnormalities. It affects 9-23% of the population across the world (Saha, 2014). The exact cause of IBS is not known, but it is thought to be related to a combination of factors, including abnormal muscle contractions in the intestine, sensitivity to certain foods, and changes in gut microbiota.

Dietary fiber plays an important role in the management of IBS symptoms. Soluble fiber dissolves in water and forms a gel-like substance, which can help to slow down the movement of food through the digestive system, allowing for better absorption of nutrients and reducing the likelihood of diarrhea. Insoluble fiber, on the other hand, adds bulk to the stool, which can help to prevent constipation and promote regular bowel movements. Insoluble fiber can also help to reduce the risk of colon cancer by speeding up the movement of food through the digestive system. Whole fruits are known to be a suitable source of fibers, with low-moderate energy density levels. The fiber content in kiwi (*Actinidia deliciosa*) helps to protect the colon mucous membrane by decreasing exposure time to toxins as well as binding to cancer-causing chemicals in the colon (Kandasamy and Shanmugapriya, 2016). A summary of the studies concerning the potential beneficial effects of fruit supplementation on gut microbiota is provided in Table 3.

Table 3: Fruit species investigated for their potential beneficial role on gut microbiota

Fruit	Sample/ extract	Animal model/ participants	Treatments	Results	References
Orange (*Citrus sinensis*)	Juice	10 women	Consumption of 300 ml/d for 60 days	Increased levels of *Lactobacillus*, *Akkermasia*, and *Ruminococcus* spp.	Fidélix *et al*., 2020
Tart cherry (*Prunus cerasus*)	Juice	10 young, healthy participants (5males, 5 females)	8 oz. of juicedaily for 5 days	Increase in *Ruminococcus*, *Lachnospiraceae*, and *Collinsella* in high-*Bacteroides* individuals. Increase in *Bacteroides* inlow-*Bacteroides*	Alba *et al*., 2018
Sweet cherry (*Prunus avium*)	Juice	45 mice	Increased concentration of juice added to drinking water for 23 days	Increase in *Barnesiella* and *Akkermansia*	Al *et al*., 2020
Banana (*Musa* sp.)	Cooked green banana mixed with rice flour	62 children	250 g/l ofcooked greenbanana for 7 days	Reduced vomiting, stool, and diarrheal duration and reduced need for oralrehydration solution	Rabbani *et al*., 2010
Raspberry (*Rubus idaeus*)	Freeze-driedblack raspberry powder	Dextran sulphate sodium (DSS)-inducedulcerative colitis in C57BL/ 6J mice	5% or 10% raspberry sample for 7-14 days	Anti-inflammatory activity, with reduction in colonic shortening and ulceration and suppression of different proinflammatory cytokines	Montrose *et al*., 2011

2.4 Colorectal cancer

Cancers of colon and rectum are a major public health concern with over 1.93 million cases and approximately 916000 deaths globally in 2020 (WHS, 2022). It is the third most common cancer worldwide, and the second most common cause of death (Ferlay *et al*., 2020). Colorectal cancer (CRC) is a complex and multifactorial disease that is thought to arise from a combination of genetic, environmental, and lifestyle factors (Markowitz *et al*., 2002). A key mechanism of CRC development is the accumulation of mutations in key oncogenes and tumor suppressor genes, such as *adenomatous polyposis coli* (APC), K-Ras, TP53, and SMAD4 (Chung, 2000). These mutations can disrupt critical signalling pathways, and promote uncontrolled cell proliferation, survival, and invasion, which can initiate the formation of preneoplastic lesions such as *aberrant crypt foci* (ACF) in the colon. Over time, these preneoplastic lesions can progress to adenomas and eventually to colorectal carcinoma (Terziæ *et al*., 2010). In addition to genetic alterations, environmental and lifestyle factors are also thought to play a role in the development of CRC. These include a high-fat, low-fiber diet, smoking, and physical inactivity.

While medical treatments for colon cancer are certainly important, there is a growing recognition for the importance of dietary factors, together with a healthy lifestyle in the prevention and treatment of this disease. Particularly, several studies have shown that a diet high in fruits is associated with a lower risk of colon cancer (Gossé *et al*., 2005). The presence of polyphenolic compounds in fruits has been shown to exhibit antiproliferative, proapoptotic, and antioxidant properties (Ramos, 2007). When human colon cancer cell lines were treated with punicalagin, ellagic acid, total pomegranate (*Punica granatum*) extract, and pomegranate juice for 48 h at concentrations of 12.5-100 µg/ml, significant inhibition of proliferation was observed, ranging from 30% to 100% (Seeram *et al*., 2005). In the same way, different edible berry juices (50 µg/ml for 48 h) demonstrated antiproliferative activities in intestinal cancer cell line Caco-2 (Boivin *et al*., 2007). Bermúdez-Soto *et al*. (2007), reported an inhibition of Caco-2 cell proliferation of 40% and 70% when treated in repetitive exposure (2 h daily for four days) with digested chokeberry (*Aronia melanocarpa*) juice at 2% (85 µM total phenolics) and 5% (220 µM total phenolics). Similar studies to assess the effects of the fruits against colon cancer are discussed in Table 4.

Table 4: Effects of the different fruits against colon cancer

Fruit	Sample/extract	Cell line tested	Results	References
Pomegranate (*Punica granatum*)	Juice	HT-29 human colon cancer cells	Inhibition of NFκB activation, AKT activity and COX-2 expression, leading to the prevention of initiation and progression of colon cancer	Paik *et al*., 2002
Date palm (*Phoenix dactylifera*)	Digested date extract, date polyphenol extract	Caco-2 cell	Inducing about 90 % of inhibition at 48 h of exposure	Eid *et al*., 2014
Olive fruit (*Olea europaea*)	Extract	HT-29 human colon cancer cells	The olive extract containing 73.25% maslinic and 25.75% oleanolic acids appears to have cancer chemopreventive activity	Juan *et al*., 2006
Orange (*Citrus sinensis*)	Peel extract	Human colorectal carcinoma-COLO 205 cells	Inhibited the activities of cyclin-dependent kinases 2 (Cdk2) and 4 (Cdk4)	Pan *et al*., 2002

Table 5: Current classification of diverticular disease of the colon

Classification description	Classification description
Asymptomatic diverticulosis	Patients with diverticula and the absence of any sign or symptom of diverticular inflammation
Symptomatic uncomplicateddiverticular disease	Patients with diverticula who experience symptoms, but without signs of diverticular inflammation
Symptomatic recurrentdiverticular disease	Patients with diverticula who experience recurrent symptoms (more than 1 attack per year) but without signs of diverticular inflammation
Complicateddiverticular disease	Patients with diverticula who experience symptoms and demonstrate signs of diverticular inflammation with further complications (hemorrhage, abscess, phlegmon, perforation, purulent and fecal peritonitis, strictures, fistulas)

2.5 Colonic Diverticulosis (CD)

Formation of colonic diverticula, *via* herniation or outpouching of the colonic wall, is responsible for the development of diverticulosis and consequently diverticular disease. Diverticular disease can be associated with numerous debilitating abdominal and gastrointestinal symptoms (including pain, bloating, nausea, constipation and diarrhea). It is characterized by sac-like protrusions of the colonic wall (Maxner *et al.,* 2020). This disease is progressively more prevalent with ageing, occurring in about 30% of people at the age of 60 years and 70% of people 80 years (Spiller, 2015). However, only 10-25% of individuals with diverticulosis develop symptoms such as abdominal pain and changes in bowel habits and 4% have a lifetime risk of developing serious life-threatening complications with high medical and hospitalization costs. Clinical classification of diverticular

disease of the colon is provided in Table 5. Several risk factors associated with diverticular disease include obesity, and diets low in fiber and high in red meat (Carabotti and Annibale, 2018). Diverticular disease of the colon is among the most prevalent conditions in western society and is among the leading cause of hospital visits and admissions (Dreher, 2018). Contrary to this, there is scarce data on colonoscopic prevalence of diverticular disease in India (Shiekh *et al*., 2021). Less than 10% of most Western populations consume adequate levels of whole fruits and dietary fiber with typical intake being about half of the recommended levels. Evidence of the beneficial health effects of consuming adequate levels of whole fruits has been steadily growing, especially regarding their bioactive fiber prebiotic effects and role in improved weight control, wellness and healthy ageing (Maxner *et al.,* 2020).

Quercetin, a plant pigment is a potent antioxidant flavonoid and more specifically a flavonol, found mostly in onions, grapes, berries, cherries, broccoli, and citrus fruits. It is a versatile antioxidant known to possess protective abilities against tissue injury induced by various drug toxicities. It undergoes extensive phase II metabolism in the intestine and liver and presents as different forms of its metabolites (Anand *et al.,* 2016). Moreover, quercetin is claimed to exert many biological functions against allergies, inflammation, microbes, ulcers, hepatotoxin, viruses and tumors (Ju *et al.,* 2018). It is reported that plant extraction may have some nonspecific involvement with proteins in bacteria cell walls, which inactivated enzymes and affect proteins' transport. The feeding of broilers with a mixture of quercetin and other plants herbs extract led to a reduction of microorganisms in the intestine, which showed that the quercetin extraction contributes to the prevention of diverticular disease (Sierzant *et al.,* 2019).

Psyllium is a commonly used soluble dietary fiber from the husks of the psyllium (*Plantago ovata*) seed, associated with a potential role in the treatment and prevention of bowel diseases such as diverticulosis, irritable bowel syndrome and inflammatory bowel disease (Warnberg *et al.,* 2009). Above two studies reported that a high intake of fiber and fruits which are rich in antioxidant flavonoid were associated with a decreased risk of diverticulitis or hospitalization due to diverticular disease (Crowe *et al.,* 2014).

2.6 Other fruits help in curing different colon diseases

Many common Indian fruits such as litchi, bael, plum, karonda, papaya and jamun, *etc.,* contain various medicinal components which help in curing various colon diseases. Many previous studies revealed that these fruits have anticancer, hepato-protective, antioxidant, anti-platelet, antiviral, antimutagenic, antimicrobial, antihyperlipidemic, antipyretic, and anti-inflammatory properties due to the presence of many flavonoids, tannins, anthocyanins, phenolic acids, triterpenes, and sterols, *etc*. (Table 6).

Table 6: Some common fruits with their potential benefits against various colon diseases

Name of fruit	Bioactive compounds	Health benefits	References
Litchi (*Litchi chinensis*)	Epicatechin, catechin, proanthocyanidin, procyanidin, aesculitannin, cinnamtannin, quercetin, luteolin, kaempferol, coumaric acid, protocatechuic acid, ehletianol, sesquimarocanol litchtocotrienol, phlorizin, litchioside, pumilaside, sesquimarocanol, cinnamtannin, procyanidin	Litchi fruits and their seeds impede the growth of colon cancer cells and used in treatment of hyperuricemia. Seeds of litchi fruits traditionally used in the treatments of hernia, ulcers and colon problems. Protect against oxidative stress, reduction of fatigue and visceral fat.	Bhat and Al-daihan, 2014 Ahmad and Sharma, 2001 Sangeeta *et al*., 2023
Papaya (*Carica papaya*)	Papain, chymopapain A and B, endopeptidase papain III and IV glutamine cyclotransferase, peptidase A and B and lysozymesâ carotene, crytoxanthin, violaxanthin, zeaxanthin4-terpineol, linalool, linalool oxide, quercetin, myricetin, kaempferol, thiamine, riboflavin, niacin, ascorbic acid, α-tocopherol	Prevent the risk of colon, prostate, lung and oral cavity cancer, increase prothrombin coagulation, eliminate wounds, burns and colon ulcers.	Nivaasini, 2015 Dotta and Abihudi, 2021
Plum (*Prunus domestica*)	Anthocyanin, l-ascorbic acid, methyl-3-caffeoylquinic, coumaric acid, protocatechuic acid, quercetin-3-o-rutinoside, caffeic acid, cyanidin 3-O-rutinoside, hydroxymethyl-furfural, peonidin 3-o-rutinoside	Treatment of colon cancer by reducing proliferation of cancer. Protect the body from harmful free radicals and reactive oxygen species and also help the body metabolize proteins, carbohydrates and fats. Developed resistance against infectious agents, counter inflammation and free radicals.	Charepalli *et al.,* 2016
Jamun (*Syzygium cumini*)	Gallic acid, ellagic acid, anthocyanin, anthocyanins, glucoside, isoquercetin, kaempferol and myricetin	Control blood sugar level. Effective in the treatment of inflammation, ulcers and diarrhea. Reducing the risk of degenerative diseases by reduction of oxidative stress, and for the prevention of macromolecular oxidation.	Chaudhary and Mukhopadhyay, 2012 Singh *et al.,* 2020

Bael (*Aegle, marmelos*)	Marmelosin, aegeline, xanthotoxol, imperatorin, alloimperatorin, tannin, beta-sitosterol, phenyl proponoids, shahidine	Bael fruit helps in relief from constipation, indigestion, peptic ulcer, piles, scurvy, respiratory problems, haemorrhoids, cholera, diarrhea and dysentery Boosts the immune system, fights off bacterial and viral infections, reduces inflammation and various inflammatory conditions, prevent cancer.	Kandasamy, and Shanmugapriya, 2016 Pathirana *et al.,* 2020
Citrus fruits(*Citrus sinensis*)	Carotenoids, flavones, isoflavones, vitamins (A, C, E), folates, quercetin, kaempferol, flavanones, naringenin, hesperidin, poncirin, apigenin, luteolin, nobiletin, tangerine, polyethoxylated flavones	Potential antitumorogenic apart from its antioxidative properties. Guard against DNA damage that can cause colorectal cancer. Potent inhibitors of reactive oxygen species. Antioxidants that may ameliorate oxidative stress by reducing the toxic effect of reactive oxygen species-ROS in colorectal cancer causation. Reduce colonic mucosal damage and ulcer lesions.	Lima and Gomes-da-Silva, 2005
Kiwi fruit (*Actinidia deliciosa*)	Vitamin C, protocatechuric acid, 4-hydroxybenzoic acid, vanillic acid, caffeic acid, syringic acid, p-coumaric acid, ferulic acid, anisic acid, naringin	The fiber content helps to protect the colon mucous membrane by decreasing exposure time to toxins as well as binding to cancer-causing chemicals in the colon Prevents constipation and other intestinal problems. Helps the body develop resistance against infectious agents and scavenge harmful free radicals.	Satpal *et al.,* 2021 Kandasamy, and Shanmugapriya, 2016
Aritak (*Terminalia chebula* Retz.)	Hydrolyzable tannins (gallic acid, chebulagic acid, punicalagin, chebulanin, corilagin, neochebulinic acid, ellagic acid, chebulinic acid, 1,2,3,4,6-penta-O-galloyl -β-D-glucose, 1,6-di-o-galloyl-D-glucose, casuarinin, 3,4,6-tri-o-glloyl-D-glucose, terchebulin)phenolics compounds (chebulinic acid, ellagic acid and anthraquinones, orilagin, galloyl glucose, punicalagin, terflavin A, maslinic acid)	Dried fruit powder mixed with a pinch of salt and warm water can help against chronic constipation. Help in reducing ulcerative colitis.	Hazarika *et al.,* 2016 Bag *et al.,* 2013
Russian olive (*Elaeagnus angustifolia* L.)	catechin, epicatechin, gallocatechin, epigallocatechin, kaempferol, quercetin, luteolin, isorhamnetin and isorhamnetin -3-0-β-D-galactopyranoside, terpenoids, coumarines, phenol carboxylic acids, amino acids, saponins, carotenoids, vitamins, and tannins.	Methanol extract from fruit helps in reducing ethanol-induced ulcer. A drug (pshatin) is made from *Elaeagnus angustifolia* which has been used for the treatment of colitis from long duration.	Hamidpour *et al.,* 2017

3. Conclusion

Fruits are excellent sources of many phytochemicals. Consumption of fruits as a part of a balanced diet, fruits offer good health and reduces the risk of diseases. It appears that many fruits are most effective against diseases related to digestive system, especially colon problems. The present review suggests that plentiful intake of fruit is helpful for maintaining a healthy life and also to free from various health hazards.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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