**A Comprehensive review on functional benefits and therapeutic uses of fruit peels.**

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**Abstract:**

Oxidative stress is the most common risk factor common for the various metabolic disorders like diabetes and degenerative diseases like cancer. Fruit peels have low glycemic index loaded with polyphenols, minerals and vitamins. Fruit peels possess antioxidant, anti-microbial, anti-inflammatory, anti-cancerous and anti-diabetic effects. Moreover, peels, pods, pomace, seeds, and stems, which are usually discarded, despite being known to contain potentially beneficial compounds, such as carotenoids, dietary fibers, enzymes, and polyphenols. The generation of waste causes serious economic and environmental burden in addition to the micronutrient deficiencies in humans. So supplementing fruit peels for therapeutic benefits is currently required.

However, there is still a lack of knowledge about this aspect in the research field and might rarely reviewed; hence this review focus on the different aspects of fruit peels which includes antioxidant, anti-inflammatory, anti-diabetic, anti-microbial properties.

Key words: fruit peels, therapeutic uses, antioxidants

**Introduction:**

As the population of the country increases rapidly, it the right time to act on the maximum utilization of resources and minimize the wastage for the environment and to improve sustainability. India is the leading producers of fruits and vegetables and also the perishable food waste. It accounts for about 40% of the total production. This review emphasis on the utilization of fruit peels for the effective treatment and management of various infectious, inflammatory and metabolic diseases and disorders.

The major health problems prevalent among the world population includes diabetes mellitus, cardiovascular diseases and cancer. These are responsible for the higher increase in the mortality and morbidity patterns of human population.

Advancements in the recent technologies in food engineering, preservation and storage facilities have led to increase in the possible therapeutic targets though the exploration of novel food preparation.

There is tremendous increase in the number of available reports in recent years on fruits and vegetable peels, and specifically on their biological activity, their content of different bioactive compounds, their chemical characterization, understanding of their structure-activity relationships, isolation and purification of commercially important chemicals and its incorporation into foods. Fruit and vegetable peels should present immense possibilities for drug discovery and development of cost-effective therapies that have fewer or practically no side effects. This virtual explosion of interest in fruit and vegetable peels as a source of medicinal and nutritional value has the major role in preventing and controlling of diseases. (8)

**Anti-obesity and Anti – diabetic effects:**

Quercetin is a flavonol pigment present in various fruits and vegetables. It’s mechanism of action in the context of diabetic skeletal muscle was studied by the inhibition of relevant protein kinases in L6 myotubes, quercetin was proved to stimulate the glucose uptake mainly via the AMPK pathway and its downstream p38 MAPK rather than the insulin signaling pathway. The rise of intracellular calcium after quercetin treatment also indicated the possible calcium-calmodulin mediated protein kinase (CaMKK) may also be involved. (1)

Another study on Japanese individuals who are prone to develop diabetes are selected and given a daily consumption of sudachi peel extract power which contains 4.9 mg sudachitin for 12 weeks significantly reduced the ratio of visceral fat to subcutaneous fat by around 3.6%, compared with the placebo group. Waist circumference was also moderately reduced by around 4%. (2)

The research studies on citrus fruit peels have shown their therapeutic potential toward obesity or associated metabolic syndrome, and the underlying physiological and cellular mechanisms. Many bioactive citrus flavonoids exerted their beneficial effects against obesity, diabetes and other associated disease through multiple targets and diverse intracellular processes. This multiple-layer regulation seems to be a favorable feature for the drug development against obesity and related metabolic diseases. (3)

Moreover, the utilization of peel-enriched probiotic drinks and yogurt is another option where food industries explore the synergism between plants and microbes to improve the human gut health.

**Antioxidant activity:**

The crude extract of peels of M. indica as a potential source of natural antioxidants as it has the strong antioxidant capacity of acetone extract. (4) The pectin obtained from the Burmese grapes has antioxidant and anti-inflammatory properties and from star fruit has anti-microbial, anti-inflammatory and anti-ulcer property. (5) (6)

The normal cellular and metabolic processes, ionizing radiation and xenobiotics produce reactive oxygen species which is responsible for wide range of chronic diseases including cardiovascular diseases and cancer. Superoxide radicals, lipoperoxides, hydrogen. The toxic effects of ROS depend on their capacity to damage relevant and sensitive biological substrates, such as DNA, RNA, proteins and membrane lipids. ROS include superoxide radicals, lipoperoxides, hydrogen peroxide, and hydroxyl free radicals.

Pomegranate peels are characterized by an interior network of membranes comprising almost 26–30% of total fruit weight and are characterized by substantial amounts of phenolic compounds, including flavonoids (anthocyanins, catechins and other complex flavonoids) and hydrolyzable tannins (punicalin, pedunculagin, punicalagin, gallic and ellagic acid). These compounds are concentrated in pomegranate peel (PoP) and juice, which account for 92% of the antioxidant activity associated with the fruit (Afaq et al., 2005, Negi et al., 2003, Zahin et al., 2010).

Gallic acid, ellagic acid and punicalagin, in addition to their free radical-scavenging properties, also possess antibacterial activities against intestinal flora, particularly enteric pathogens, i.e., Escherichia coli, Salmonella spp. Shigella spp., as well as Vibrio cholerae (Aviram et al., 2008, Lu et al., 2007, Pai et al., 2011, Taguri et al., 2004). The therapeutic potential of PoP has been widely recognized by different cultures. In Egyptian culture, several common ailments such as inflammation, diarrhea, intestinal worms, cough and infertility have been treated by exploiting pomegranate peel extract (PoPx). The exceptional antioxidant potential and strong medicinal properties of PoP led the international scientific community to initiate intensive research in the last decade to further investigate its role in human health (Lansky and Newman, 2007).

Several studies have demonstrated the antimicrobial, antihelminthic, and antioxidant potential of the active ingredients of pomegranate extracts (PoMx), suggesting their preventive and curative role in gastro-mucosal injuries, cancer chemoprevention, ethanol- and acetone-induced ulceration and diabetic oxidative damage (Al-zoreky and Nakahara, 2003, Arun and Singh, 2012, Negi et al., 2003). The mechanism of antimicrobial activity of pomegranate peel phenolics involves precipitation of membrane proteins resulting in microbial cell lysis. The ethnopharmacological profile of PoPx makes it a valuable traditional asset due to its antimicrobial and anti-mutagenic properties. Moreover, the phytochemical concentration of PoP is high enough to be effective without further enrichment with the extracts of any other fraction of the fruit (Sestili et al., 2007). (10)

**Anti-microbial:**

The research studies carried out to evaluated the effects of using passion fruit peel flour together with diet therapy and counseling in 36 patients with HIV lipodystrophy. It is found that the use of passion fruit peel flour was effective in reducing total cholesterol and triacylglycerides after 30 days. The concentrations of LDL-C and triglycerides decreased, while HDL-C increased in the blood of lipodystrophy patients after 90 days’ passion fruit peel flour treatment. (7)

Pumpkin peel methanolic and ethanolic extracts have [antibacterial activity](https://www.sciencedirect.com/topics/chemistry/antibacterial) with an [inhibition zone of](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/zone-of-inhibition) 6-10 mm in [disc diffusion](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/disk-diffusion) method. The extracted pectic polysaccharides from the pumpkin peel and checked its effect on growth of human [intestinal bacteria](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/intestine-flora) (12). The pectic polysaccharide fractions showed growth promoting activity to good intestinal bacteria such as B. bifidium, B. longum and L. brevis, whereas growth retarding activity was observed towards bad intestinal bacteria such as E. coli and C. perfringins. They concluded that pectic polysaccharides of pumpkin peel have growth promoting effect on helpful intestinal bacteria and also possess glucose and [bile acid](https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/bile-acid) lowering effects due to which pumpkin peel might be used as a good functional ingredient in foods.

**Anti-cancerous:**

unica granatum (P. granatum) fruit peel contains 30–40% of the fruit protein although it is considered a waste material [21]. In terms of cancer treatment, it has been reported that P. granatum has high anticancer activities against human bladder cancer T24 cell [22], cervical cancer HeLa cells [23], prostate cancer cells [24], breast cancer cells [25], colon cancer cells [26] and thyroid cancer cells [27]. Up to date, there is no report on using P. granatum peel extract as a stabilizer to synthesizing IONPs for treatments of colon, breast, cervical and lung cancers.

**Anti-inflammatory: (9)**

Dried citrus peel derived from Citrus reticulata, also called “chenpi”, possesses a complex mixture of flavonoids and has a history of traditional use to treat a variety of digestive disorders. We compared three sources of conventional chenpi from California (USA), Guangxi, Zhejiang, and two sources of “nchenpi”, which contain greater nobiletin content, from Sichuan and Xinhui (China). Xinhui orange peel extract (OPE) had highest content of polymethoxylated flavones, along with greatest capacity to scavenge 2,2-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS), 2,2-diphenyl-1-pcrylhydrazyl (DPPH), and 2,2′-azobis-2-methyl-propanimidamide, dihydrochloride (AAPH) radicals and nitric oxide (NO). OPE also had higher NO, inducible nitric oxide synthase (iNOS) and cyclooxygenase (COX-2) inhibitory activity than an equivalent mixture of flavonoids (P < 0.05). In conclusion, nobiletin is a good chemical marker for assessing the anti-inflammatory potential of OPE from different sources. Obtaining “nchenpi” from either Sichuan or Xinhui provided potentially superior health benefits compared to conventional chenpi sources.

 In Traditional Persian Medicine (TPM) pumpkin peel was used to cure peptic ulcer, hepatic disorders, gastrointestinal bleeding and a variety of wounds including burn wound. Due to cool and wet nature pumpkin fruit peel is useful for hot and dry diseases such as burn wound ( (13)

**Conclusion:**

These are novel, natural and economic sources of antioxidants, which can be used in the prevention of diseases caused by free radicals. The above comprehensive content covers the literature about the potential utilization of fruit and vegetable peels in preventing and reducing the chronic inflammatory diseases. Fruit peel have accorded to contain sustainable bioactive compounds, with a wide range of biological potential and nutritional values that can be used for developing healthy food products. This is a initial and mandatory step toward waste reduction in the food chain and a new way to develop diversified and innovative food products, creating a market for sustainable and functional products. Thus, it has become crucial for sensory scientists, food technologists, and nutritionists to collaborate and face the challenge of formulating more well-accepted and palatable foods. Furthermore, efforts must be made to understand the potential food safety concern, as well as consumers' perceptions of utilizing fruit peels in food production, formulation and its therapeutic role.

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