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Review Article

FRUIT PEELS HEALTH BENEFITS AND POTENTIAL USES: A REVIEW

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A R T I C L E I N F O

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A B S T R A C T

The horticulture crops fruits have been in demand remarkably for its tremendous health benefits in the present scenario of increasing population and changing lifestyles. The fruit processing produces significant wastes or residues, which constitute about 20% to 30% of a whole commodity group. Fruit waste peels are enriched with various naturally valuable bioactive compounds, such as dietary fibres, polyphenolic compounds, carotenoids, vitamins, and enzymes etc. It can be utilized in food products in the dried form or incorporated into many value added food products.

INTRODUCTION

A fruit is the part of seed-bearing structure in flowering plants and generally consisted of fleshy seed linked structures of a plant that are mostly sweet or sour, and are edible in the raw state. Along with vegetables, fruits are the most usable piece of merchandise among all horticultural crops. These crops have a vital role in our daily diet. Due to increase in growing population and dietary lifestyles, the demand for fruits have increased tremendously (Schieber *et al.,* 2001; Vilari˜no *et al;* 2017). Fruits had a huge loss due to scarcity of appropriate handling techniques and infrastructure. The increase in production and growth is also one of the reasons for this loss. In developing countries these losses are higher due to be short of proper management techniques. These losses are seen throughout the supply chain of processing. They are the results which are unintended in the way food production and processing systems function in their institutional and legal framework (Parfitt *et al;* 2010).

Fruit waste includes skin, seeds, pomace, and rind, which are the sources of valuable bioactive compounds, such as dietary fibres, polyphenols, carotenoids, vitamins, enzymes, etc. Fruit peel, is the skin or the outer protective covering in fruits which are natural sources of antioxidants, and contains higher concentrations of dietary fibre and carbohydrates especially pectin. In most of the cases, peels are discarded even when it is found safe for human consumption. It holds many vital nutrients that play an important role in human health well being by producing valuable products for human being which help to prevent diabetes mellitus, cardiovascular disease and cancer.

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These valuable phytochemicals can be used in various industries most importantly the food industry, for the enlargement of value added food products, the production of medicines in pharmaceutical industry and use in the textile industry. The concept of application of fruit peels have gaining popularity because researchers have found that peels possessed better biological activities in comparison to other parts of the fruit (Moon and Shibamoto., 2009). With the growing demand of natural sources of bioactive compounds and the burgeoning trend of functional foods, food products supplemented with fruit peels are been enlarged (Babiker *et al.,* 2013 ; Altunkaya *et al.,* 2013).

The purpose of this review is to summarize the research findings on the application of fruit peels used as a source of intended compounds or as whole ingredients in the food industry. In this review, the focus is on fruit peels and attributed health benefits, sources of bioactive components and its implication in food products have been covered.

Bioactive Compounds present in the Fruit Peels

Fruits peel wastes are rich sources of phytochemicals, phenolic compounds, dietary fibers, and many other biologically active compounds (Galanakis *et al;* 2012).

Phenolic compounds and attributed health benefits

The waste of fruits peels possesses significant amounts of phenolic compounds. The citrus industry creates major amounts of seeds and peel residues, which comprise about 50% of the total fruit (Ignat *et al.,* 2011). Citrus waste is a rich in phenolic compounds (Balasundram *et al.,* 2006). Banana peel have considerable amount of polyphenolic compounds and exhibited higher radical scavenging activity in comparison to other fruit peels (Morais *et al.,* 2015). The Pomegranate

peels have been identified with 48 polyphenolic compounds. Pomegranate peel is investigated for antioxidant, antiviral, anticancer activity and antitumor action and consequently the antioxidants activity protects our body from Low Density Lipoprotein LDL cholesterol as well as reduces cancer risks and heart disease (Jung, K.H *et al;* 2006). Likewise pomegranate peel citrus peel is also source of enormous phenolic compounds that has health benefits of antimicrobial, antioxidant, anticancer, anti-inflammatory, antimutagenic and antiallergic (Ferreira *et al.,* 2018; Kurup, *et al.,* 2018; Singh *et al.,* 2016; Sridharan, *et al.,* 2016; Shetty *et al*., 2016). Srividhya *et al.,* (2013) proved that antioxidant and antimicrobial activities present in citrus fruit peel extract from Citrus. Banana peels contain Norepinephrine, dopamine present that boosts blood pressure and increase the smoothening of intestine muscle. Banana skin reported efficiently to diminish the swelling and pain produced due to mosquito bites (Ehiowemwenguan *et al;* 2014).

Table 1 Phenolic compound in fruit waste

Fruit peel	Polyphenolic compound	references
Banana peel	Rutin, ferulic acid, proanthocyanidins, dopamine	Vu *et al.,* (2018)
Pomegranate peel	anthocyanins, gallotannins, hydroxycinnamic acids, hydroxybenzoic acids and hydrolysable tannins i.e. ellagitannins, and gallagyl esters	Akhtar *et al.,* (2015)
Citrus peel	Ferulic acid (major) caffeic acid(minor)	Gorinstein *et al.,* 2001
Kiwifruit peel	Caffeic acid, p-coumaric acid, protocatechuic acid,	Mattila *et al.,* (2006), Wijngaard *et al.,* (2009)
Mango Peel	Flavonol glycosides	Schieber *et al.,* (2000)

Dietary fibres

The major compositions of fruit peels are non-starch polysaccharide and lignin. Dietary fiber components are divided into two major classes: water soluble dietary fiber and water insoluble dietary fiber. The water soluble dietary fibers include pectic polysaccharides, gums, etc. whereas water insoluble includes cellulose, lignin, some hemicellulose, etc. With the enduring demand of consumers for exceptional dietary fiber ingredient, by-products such as peel from fruit processing have attracted extreme notice as a basis of dietary fiber during the past decade (Grigelmo-Miguel *et al.,* 1999). In apple peel the dietary fiber is higher than the pulp. Similarly, grapes peel also consists of good amount of dietary fibers, namely, cellulose, small proportion of pectin, hemicelluloses, (Kammerer *et al.,* 2005). Mango peel contains around 51.3% DM of total dietary fibers (33% DM insoluble fibers and 20% DM soluble fibers) (Ajila *et al.*, 2008).

Enzymes

Fruit peels behave as a substrate for the production of various enzymes like amylases, invertase, cellulose, pectinase, etc. orange peel and banana peel used was studied for pectinase production (Mrudula and Anitharaj 2011). Fruit peel contain amylases and it can be used for food processing as fruit juices, syrup, cakes, chocolate cakes, brewing and baked products (Laufenberg *et al.,* 2009).

Flavouring agents

The fruit residues provide a good mean to form various flavouring agents and aromas as well. Rhamnose a principal component for producing strawberry flavor is obtained by hydrolysis chemically of rutin from citrus fruits. The pineapple flavor component "ethyl butyrate". Pineapple peel contains ferulic acid, a precursor for the flavouring agent vanilla (Sagar *et al.,* 2018).

Use of fruit peel for Food industries perspective

Utilization of fruit peels is one of the important and challengeable practices around the world. The fruit processing industry generates huge amount of fruit pomace which contains potentially valuable source of phenol compounds that can be used in food industry as antioxidant and antimicrobial agents, pharmaceutical industry can also act as a natural supplement. These wastes are environment friendly and easy to obtain and could be used as an important basis of nutrient and compounds with functional properties and may be a potential food in daily diet as per (Abdrabba and Hussein 2015).

The fruit peels are loaded with nutrients and have so many health benefits. Its exploitation gives source of revenue to industries, and helps to boost economic productivity. The peels are utilized in food industry in following ways.

In apple juice industry near about 25% is the by-product which is pomace which can be converted into edible products. These peels are the rich source of pectin, carbohydrates, fibers, and minerals. Apple peel jam, sauce, papad and other food products can be prepared and also have application in confectionery industries.

Table 2 Applications of fruit peels in food products

Peel of fruits	products	Observations	references
Pineapple	Substrate for ethanol, methanol, hydrogen generation	biofuel production	Choonut, A. *et al.,* (2014).
Apple	Fibre enriched bakery products	Viscosity increase, specific gravity decrease, increase in cake weight	Masoodi, F. A., *et al*., (2002).
Banana	Low calorie biscuits	fibre content increase and Calories decreased	Joshi, R. V. *et al;* (2007)
Orange peel	Utilization in cake	Crude fiber, crude ash and ash contents increased moisture and crude protein content decreased, improved texture quality	Iftikhar, M. *et al;* (2019)
Pomegranate	Cheese, fermented milk, beef sausage, cookies	Increases antioxidant activity, shelf life, total phenolic content, improves cooking quality,	Mahajan, D. *et al*; (2015), Chan, C. L. *et al*; (2018), El-Nashi, H. *et al*; (2015), Kaderides,K.

			et al; (2015)
Grapes	Enriched yoghurt	Increased total phenolic content, antioxidant activity and acidity, lower pH and fat	Marchiani, R. *et al;* (2016).

In wine making process different types of waste like stem, seeds, lees, pomace is generated from grapes. Grape peel is fibrous due to its carbohydrate content, and used in different fermentation processes. Banana peel is most commonly used to feed livestock but the value-added products can be prepared. Peels can be low cost and a good source of starch, pectin, cellulose which can be used as thickening agent, stabilizers etc. Similarly, By-products extracted from orange pulp and peel after juice extraction are cheap and abundant source of dietary fiber and dietary fiber powder can be prepared from these peel.

Food industries utilize citrus peel as a resource of molasses, pectin, oil and limone, and has been considered because it contains numerous bioactive compounds, such as flavanones, polymethoxylated flavones, flavanols and phenolic acids. These compounds have lot of benefits as natural antioxidant for pharmaceutical, biotechnological and food industries (Bocco, A *et al.,* 1998).

The fruit peel is also considered as potential source of ingredient for food packaging and in application of edible coating. Pectin which is present in fruits having backbone of galacturonic acid with its side chains consist of arabinose, galactose, xylose (Kohli *and Gupta,* 2015) and also used as solidifying and emulsifying substance. The chemical modification of pectin enhanced properties, and also used in various products dairy desserts, thickening agents for fruits and vegetable canning and food coating (Lopes da silva *et al.,* 2006).

Using banana peels the development of edible coating with 2% starch concentration under gelatinization mechanism was carried out. Pineapple peel produces a fibre which was incorporated in plastic by replacing synthetic fibre. Ali *et al.,* (2018) incorporated pomegranate peel particles into antimicrobial film which made with starch-based ingredients. These pomegranate peels enhance the antimicrobial activity owing to the phenolic toxicity of peels that might be increasing with the proteins in the microorganism.

Future trends

Exploitation of the fruit peels as sources of functional ingredients and possible applications has become a promising field and global requirement in food industry. Natural functional compounds from fruit peels can replace synthetic additives and potentially be adding multifunctional health benefits. Peels used as sources of bioactive compounds and have shown to be promising effect for a wide range of scientific and nutritional purposes in food industry.

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