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REVIEW RRJoFST

Application of Fruit and Vegetables Peels as Functional Ingredients in Baked Cookies: A Review

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Abstract

About half of the waste produced by industrial fruit and vegetable manufacture is in the form of peels, cores, pomace, and unripe or damaged fruits and vegetables. Many fruits and vegetables, including citrus, apples, peaches, pears, bananas, pomegranates, berries, mangoes, and sugar beet, have peels, pulp/pomace, and seeds that contain concentrations of phenolics and other phytochemicals that are typically much higher than in the edible tissues of those fruits and vegetables. This suggests that these waste materials and residues could be sources for isolating bio-active compounds. A significant volume of pomace from the wine and juice industries is an inexpensive source of dietary fibre. Because of its improved functionality resulting from a balanced ratio of soluble/insoluble fibre, superior hydration qualities, greater fermentability, and the inclusion of phytochemicals, fruit and vegetable pomace represents a novel ingredient for fibre enrichment in bakery goods. Its functionality is affected by the pomace source and the way it is processed into a powder using different drying methods, size reduction procedures, and pre-treatments. Because of its functional qualities, fruit and vegetable pomace can be employed to increase the functioning of meals. Fruit and vegetable pomace can therefore be utilised as a useful functional component in the creation of baked goods that are high in fibre.

Keywords: Dietary fibre, fruit and vegetable pomace, cookies, value added products, antioxidants, sensory assessment

INTRODUCTION

Due to a decline in resources and an increase in demand, food insecurity results from an expanding global population and a corresponding need for food. Since it is well recognised that not all fruits and vegetables can be consumed by consumers, the agriculture industry contributes significantly to waste creation. Furthermore, these leftover components—seeds, seed coat, husk, peels, hull, pomace, etc.—cause problems for the environment [1].

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These days, one of the biggest issues facing the food industry is food waste from industrial fruit processing of various goods, including as candies, ice cream, wines, juices, jams, and others. Therefore, in an effort to reduce the amount of waste produced by the food industry, the majority of fruit and vegetable pomace and peels that are still useful are now mostly used to make baked goods [2].

In addition to being high in dietary fibre, fruit wastes are also commonly enhanced with micronutrients like vitamins, minerals, and other bioactive substances. The utilisation of fruit peels and pomace in functional foods, nutraceuticals, and food items will be a very warranted move. As things

are right now, malnutrition linked to food instability and the spread of infectious diseases are highly prevalent [3].

The very perishable and seasonal character of fruit and vegetable processing waste presents issues for both the processing industry and pollution monitoring authorities. This problem can be resolved by utilising its high-value components, including the dietary fibre fraction, which has huge potential in the production of functional foods. It's becoming increasingly common to find alternate sources of dietary fibre that contain particular bioactive components; this could provide conventionally touted items new and advantageous properties [4].

By-product waste is responsible for almost half of the garbage generated during the industrial production of fruits and vegetables. This waste is costly and has a negative impact on the environment.

However, fruit and vegetable by-products (FVB) are thought to be exceptionally nutrient-dense and contain additional nutritional compounds that offer a number of health advantages, including better bowel health, weight management, lowered blood cholesterol, and enhanced insulin and glycemic responses. Since most baked goods have a high glycemic index, their favourable effects on glycemic carbohydrates (such starch) and their bioactive components make them great food systems for absorbing FVB [5].

It was crucial to figure out how to include peels and pomaces, by-products of fruits and vegetables that are a great source of dietary fibre and antioxidants, as a healthy food ingredient in human diets that offers numerous health benefits, since interest in foods high in these nutrients has grown in recent years [6]. The waste produced by the fruit processing industry is highly diverse due to the wide variety of fruits and vegetables used, the various techniques used, and the multitude of product kinds produced.

The by-product seeds are a vital source of carbohydrates, minerals, organic acid, dietary fibre, and phenolics with a range of activities, such as antiviral, antibacterial, cardio-protective, and antimutagenic qualities. Fruit and vegetable seeds, among other agricultural wastes, are released into the environment and can serve as a source of antibacterial microorganisms. Antioxidant capacity is high in seeds [7].

Fruit tissue contains high concentrations of phytochemicals called carotenoids. Carotenoids have the potential to be extremely important for human health since they act as biological antioxidants and protect cells and tissues from the damaging effects of singlet oxygen and free radicals. They are used as natural food colouring as well.

Despite the great concentration of beneficial compounds found in the skins and seeds of exotic fruits, care must be given to their antinutritional and toxic consequences, such as the high tannin content in these tissues.

Such by-products appear like a valuable supply of natural food additives, and employing them to further exploit food additives or supplements with high nutritional value and economic appeal seems like a sensible strategy to alleviate environmental difficulties [8].

Now let’s see what effects these said characteristics of fruits and vegetables peels and pomace actually have when added in food products.

HEALTH BENEFITS OF DIETARY FIBRE

Dietary fibre is beneficial to human health because it ferments either fully or partially in the large intestine, is resistant to being broken down by the digestive enzymes produced by humans, and often consists of cellulose, hemicellulose, lignin, oligosaccharides, pectin, gums, and waxes.

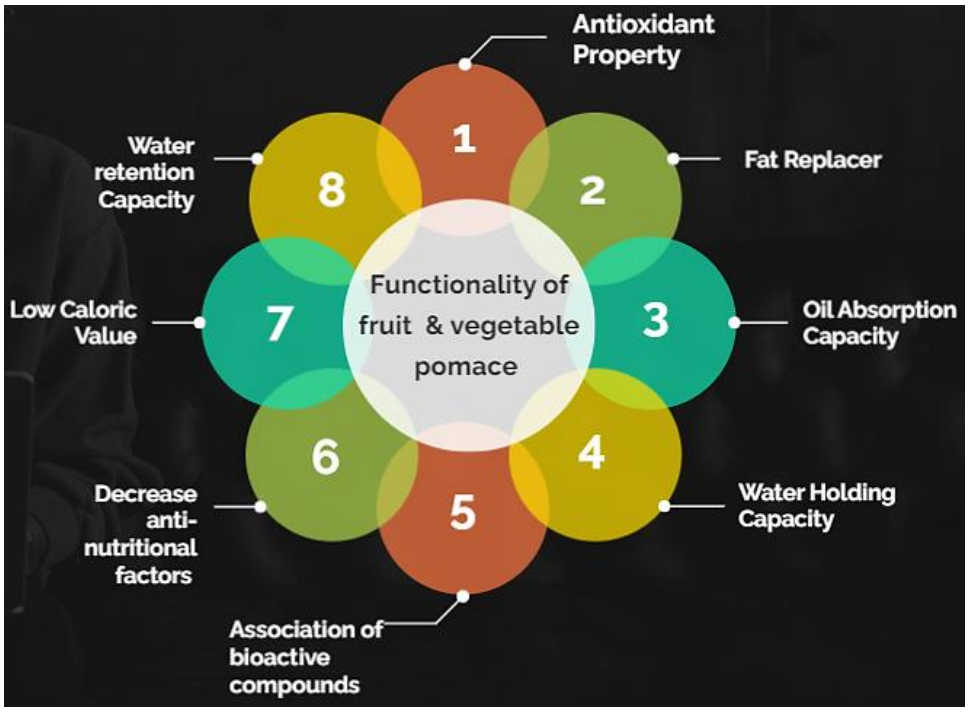

Figure 1. Functionality of fruit and vegetable pomace.

Constipation, cancer, heart disease, and diverticulosis have all been related to inadequate dietary fibre consumption. Diets high in dietary fibre have the potential to prevent, mitigate, or treat illnesses such as diabetes, heart disease, and colon cancer.

Low consumption of simple carbohydrates indicates a high intake of dietary fibre. Although food fibre adds calories to a meal, it is much harder for the small intestine to digest and even somewhat resistive in the large intestine. It also appears that dietary fibre slows down the breakdown of fat. They might be connected to less energy that can be metabolised from a diet high in fibre [9].

Eating DF has been associated with better colon health and is recognised to protect the colon from several illnesses. DF usage induces regularity and lessens constipation by increasing the volume of stool and speeding food through the digestive system. Soluble fibre makes stool softer and larger and makes passage simpler; insoluble fibre makes the colon take longer to transit.

It has been noted that pectin stimulated the in vitro growth of particular *Bifidobacterium* and *Lactobacillus* strains. The quantities of these bacteria suggest a population of healthy microflora, and it is believed that these bacteria directly affect the health of the large intestine.

Diets high in fibre encourage satiety, which is why they help people lose weight. Fibre-rich diets are associated with a lower risk of cardiovascular disease, particularly in relation to increased excretion of cholesterol in faeces. Bile acid binding in vitro is linked to elevated cholesterol excretion. It has been demonstrated that raising the amounts of oat bran, total and insoluble dietary fibre, and beta-glucan in pre-digested oat-based extrudates increases the binding of bile acids in vitro [10].

It has been found that certain minerals are less absorbed and retained when they are in fibres with phytic acid and cation exchange capacity, such wheat fibres. Certain highly fermentable fibres, like pectin, gums, resistant starches, cellulose, fructo-oligosaccharides, and inulin, even at lower phytic acid concentrations, improve the metabolic absorption of certain minerals, like calcium, magnesium, and iron [11].

BENEFITS OF FIBRE FROM FRUIT AND VEGETABLE PEEL

Fruits like grapes, apples, oranges, pineapples, guavas, etc. that are mostly utilised to make juice produce a lot of peel and pomace. This waste signals significant losses and could lead to high prices for the processed final goods if the right procedures are not followed to recover it.

Various fruits and vegetables have varying nutritional contents, including:

The fruit skin of a plantain, which resembles an unripe banana, has the following nutritional values per 100g: 5.84g of moisture, 5.89g of protein, 5.12g of fat, 7.83g of ash, and 11.03g of carbohydrates. The Indian version is called "Nendran," and it is essentially utilised as flour. It is one of the major agricultural crops grown in the southern parts of India and is highly popular there [4].

Food products have also included mango peel powder (MPP) and mango kernel powder (MKP). When pure, mango kernel fat has a nutty flavour and pleasant aroma, making it a viable option to replace cocoa butter in chocolate recipes. Since both MKP and MPP are high in dietary fibre, antioxidants, polyphenols, sesquiterpenoids, and tocopherols, they are both very advantageous to humans when added to food products. Phytosterols and microelements including zinc, copper, and selenium are also abundant in these [12].

Beta-carotene, a precursor of vitamin A and other vitamins, is abundant in carrots. Carrot pomace is used to add value to baked goods because carrots have been shown to be high in antioxidants as well [6]. Root vegetables like carrots are a great source of calcium pectate, a type of pectin fibre with cholesterol-lowering qualities. In addition to being high in the B complex vitamin and a number of minerals like calcium, potassium, phosphorus, iron, folic acid, copper, etc., carrot juice is also high in pro-vitamin A [9].

Producers of plant materials have recently become interested in the fruits of uncommon horticulture species, like elderberry, rowan, and rosehip, which were traditionally largely used in traditional folk medicine. The high anthocyanin level and overall polyphenol content of elderberry fruit set it apart from other berries and added to its powerful antioxidant qualities. Rosehip fruit has the potential to be transformed into functional foods because to its high content of polyphenols, essential fatty acids, vitamins A and C, and minerals (Ca and Fe).

Even after juice extraction, the remaining pomace is a valuable source of bioactive materials such as essential unsaturated fatty acids, vitamins, provitamins, dietary fibre, and polyphenols, which include anthocyanins. Pomace addition to bakery and confectionery goods appears to be an easy and quick method of managing it, as it produces some clear advantages, such as enhancing the nutritional value of white wheat bread, cakes, and cookies with dietary fibre, vitamins, minerals, and antioxidants [10].

Consumers today look for goods that help them preserve both their emotional and physical well-being. Additionally, their diet should contain bioactive substances including vitamins, pro- and prebiotics, antioxidants, and plant sterols to meet their needs. These can be obtained as food additives to improve the nutritional value and extend the shelf life of food products, using by-products of raw materials like blackcurrant and raspberry seeds. Additionally, studies indicate that utilising a specific quantity of rapeseed oil may offer a suitable supply of antioxidants for the stabilisation of dietary lipid [13].

The two fruits that are processed the most worldwide, especially for the manufacture of juice and beverages, are apples and grapes. The seeds are often removed in both cases to avoid contamination with hazardous materials, the so-called caking effect (produced by the oil part), and the production of fine flours based on fructo-oligosaccharides. Apple peels and pomace are excellent sources of flavonoids, including phenolic acids, procyanidin, quercetin, and magnesium. However, a notable source of anthocyanins, flavanols, and gallic acid is grape pomace [5].

Due to their higher quantities of phenolic compounds, beta carotene, lycopene, and other colours, as well as their high vitamin C content and antioxidant potential, guava peels have also been employed in place of wheat flour [14].

Bakery goods also contain watermelon rind. The white flesh that lies between the outer skin and the coloured meat, which is typically red or yellow, is called the watermelon rind. A good source of amino acids, citrulline, beta-carotene, vitamin C, potassium, and antioxidants like lycopene is this fruit. Cucurbituril, which is found in watermelon seeds, lowers blood pressure and enhances kidney function. In addition, the seeds can be used to treat diabetes, hypertension, kidney stones, diarrhoea, gonorrhoea, and urinary tract infections (UTIs) (17).

Tomatoes have gained popularity among vegetable by-products due to their high lycopene content. This substance is well renowned for its anti-carcinogenic and anti-oxidant qualities. Tomato pomace also has a high content of insoluble fibre, proteins, and a sizable amount of glucose and fructose. Since potato peels are strong in phenolic compounds, which have potent antioxidant and antidiabetic properties, and because they are high in fibre, they can also be considered useful in this situation [5].

Produce by-products such as onion and carrot pomace, apple, pear, orange, peach, blackcurrant, cherry, artichoke, asparagus, mango peels, and cauliflower trimmings are used as dietary fibre supplements in processed foods (gelling and thickening agents). Furthermore, they attach to toxins in food, shielding the gut mucosa and reducing the risk of colon cancer. Furthermore, dietary fibres bind to bile salts and stop them from being reabsorbed, lowering cholesterol and low-density lipoprotein (LDL) levels in the blood. Broad bean pods have a fibre content of over 40%, whereas pea pods and okra have a content of over 50%. You may think of these pods as sources of dietary fibre. The impact of adding dietary fibre from fruit by-products (peels, pulps, and seeds) of processing (apple, banana, or passion fruit) on the total treatable acidity after acidification has been assessed [7].

PHYSIOCHEMICAL AND FUNCTIONAL PROPERTIES OF POMACE

"Optimal dietary fibre" should be completely flavourless, colourless, and odourless; it should also be highly concentrated and free of any ingredients that are nutritionally undesirable; it should also have appropriate and balanced bioactive chemicals, a long shelf life, compatibility with food processing machinery, and physiological effects. Compared to dietary fibre contained in grains, the fibre in fruits and vegetables is of a better calibre. Fruits and vegetables have a well-balanced soluble and insoluble fibre content, and they have better functional qualities (such being hydrated).

The fibre’s particle size has a major impact on its functional properties as well as important digestion processes as transit duration, fermentation, and faecal expulsion. The capacity of fibre to hold onto moisture is essential for both its physiological role and its capacity to modify the techno-functional properties of food. Fruit and vegetable pomace powders can enhance food functioning by enhancing emulsion stability and water and oil retention, which is determined by the hydration quality of the fibre. Because of this, they can be used as inexpensive, non-caloric bulking agents in food, partly substituting for ingredients like wheat, fat, or Sugartown's potent stool-bulking properties. Its abilities to hold water and to swell can provide information about how well-hydrated fibre is as well as how it behaves during intestinal transit and food processing [11].

Researchers have shown that certain fruits and vegetables, such as apples, carrots, and beets, have significant levels of crude fibre (21.51 percent, 17.94 percent, and 11.12 percent, respectively). Additionally, fruit and vegetable pomace has been observed to have a high ash content and fair levels of lipids, indicating that their supplementation in meals will boost mineral content in addition to fibre enrichment [7].

A study also reports that the pulp waste from beetroot and carrots had a moisture percentage of 79–84 percent and a protein content of 6.21 and 13.23 mg/100 g, respectively [6].

Functionality of fruit and vegetable pomace in Bakery products

Powders made from fruit and vegetable pomace have the ability to improve emulsion stability and water and oil retention, which can improve food functioning. They can therefore be used as inexpensive, non-caloric bulking agents in food, taking the place of some of the wheat, fat, or sugar. It has also been investigated how to increase the amount of fibre in drinks, snacks, sauces, frozen foods, canned meats, meat alternatives, spices, and other foods. The focus of supplementation has been on cereal-based products like cookies and crackers [14].

Adding new sources of functional ingredients, such as dietary fibre and bioactive compounds, to baked goods is a frequent technique. To increase the fibre content of various baked items, different plant fibres are incorporated. To boost the fibre content of baked goods, pomace from fruits and vegetables, hulls from legumes, and bran from various cereals are commonly included. Because baked products, particularly cookies and biscuits, are so widely consumed and can be readily absorbed by individuals of all ages, they are a great source of dietary fibre due to their compactness, palatability, ease of preparation, and long shelf life [10].

Utilization of different fruits and vegetable pomaces and peels have been shown in the table 1.

Looks and colour have a major role in influencing customer likeability and contributing to the evaluation of baked goods' quality. Some fruits are more likely to have significant levels of polyphenols, which can result in dark products and act as a substrate for baked foods' enzymatic browning.

Effects of incorporation of different fruit and vegetable waste in bakery products

There have been reports that using a lot of apple pomace powder will darken the cookies' colour and have a detrimental influence on their appearance. Additionally, the specific volume and volume index of cookies with decreased thickness and width were negatively impacted by apple fibre powder. Additionally, the baked goods' redness rose and their lightness reduced.

Beetroot pomace has a high dietary fibre content and can be a great source of phytochemicals. Nonetheless, the inclusion of beetroot pomace powder resulted in cookies with a significantly darker colour, and their enhanced flavour and taste made them more palatable even in modest amounts. Additionally, adding beetroot pomace led to greater spreading, more moisture, crude fibre, protein, and ash; conversely, adding more pomace reduced the amount of carbohydrates [11].

However, research also indicates that, in contrast to apple pomace, the addition of carrot pomace improves the colour of baked goods. The addition of microwave-dried carrot pomace enhanced the baked items' sensory qualities and fibre content. However, it was discovered that cookies made with carrot pomace had a far darker crust and were harder than cookies made with wheat flour. Carrot pomace, however, is what gives buns their higher bulk density and reduced lateral and surface expansion [9].

Mango has a low glycemic index, anti-radical efficacy, and a well-balanced soluble and insoluble dietary fibre when utilised in baked goods. When used in cookie formulation, mango peel and kernel powder increased the nutritional value of the baked goods without changing the texture or sensory aspects of the cookies. It also reduced spreading and softness and soluble dietary fibre in soft dough biscuits [12].

Due to the high dietary fibre content of orange peel, adding it to muffins increases the overall dietary fibre content while increasing the quantity of insoluble fibre, ash, and protein content remain unchanged. The fat and moisture content are also unaffected [8].

A by-product of the juice production industry, pomegranate peel contains a variety of bioactive chemicals, minerals, and fibres to meet a wide range of nutritional needs. Fruit waste has been shown

to have a comparatively greater total phenolic concentration in addition to being a potentially useful source of crude fibre and inorganic residues with health-promoting qualities such as hypoglycaemia, apoptosis, anti-inflammatory, anti-parasitic, and prebiotics [3].

Table 1. Varieties of fruit and vegetable peel and pomace along with their functional properties and nutritional content.

Fruit and Vegetable Peel/Pomace	Functional properties	Nutritional content
Apple peel	Rich in dietary fibre. Contains antioxidants. Can be used in production of pectin, animal feed or as a source of bioactive compounds.	Contains pectin and cellulose. Flavonoids such as quercetin and phenolic acids. Provides vitamin C and small amounts of vitamin A.
Banana peel	Contains dietary fibre and resistant starch. Rich in antioxidants (polyphenols). Used in animal feed and as a source of bioactive compounds.	Contains pectin (soluble fibre). Provides vitamin B6, vitamin C, and potassium. Rich in catechin - helps in reducing oxidative stress.
Beetroot pomace	High in dietary fibre. Contains antioxidants with potential anti-inflammatory properties. Used in food processing to extract natural pigments and antioxidants.	Contains pectin and cellulose. Contains betalains which can reduce cancer risk and also supports the body's natural detox process.
Citrus peel (Orange, lemon, lime)	High in dietary fibre, especially pectin. Contains flavonoids and other antioxidants. Used for flavouring and as a source of essential oils.	Rich in vitamin C. Provides flavonoids such as hesperidin and naringin.
Carrot pomace	Good source of dietary fibre and beta-carotene. Can be used in animal feed or processed into dietary supplements.	Contains antioxidants such as polyphenols, flavonoids, and vitamin C.
Guava pomace	Contains dietary fibre, particularly pectin. Rich in antioxidants (vitamin C, polyphenols). Used in extraction of bioactive compounds for functional foods and beverages.	Contains antioxidants such as polyphenols and carotenoids.
Mango peel	Contains dietary fibre and polyphenols. Contains antioxidants. Used in traditional medicine and can be incorporated into food products.	Contains mangiferin and quercetin. Rich in vitamin C, vitamin A (beta-carotene), and small amounts of vitamin E.
Pineapple peel	Contains potential anti-inflammatory properties. Provides dietary fibre and vitamin C. Contains small amounts of vitamin A and manganese.	Contains bromelain.
Pomegranate peel	Contains antioxidants. Rich in dietary fibre and vitamin C. Provides vitamin E and small amounts of other vitamins and minerals.	Rich in tannins and flavonoids.
Raspberry pomace	Contains dietary fibre and pigmented antioxidants. Rich in polyphenols with potential health benefits. Used in production of natural colorants and antioxidants.	Rich in anthocyanins which scavenge free radicals.
Watermelon rind	Rich in dietary fibre and antioxidants. Can be processed into pickles or used in functional food products.	Contains citrulline.

Table 2. Fruit & Vegetable waste as functional ingredient in bakery products.

Source	Bakery products
Apple pomace	Cookies, crackers, cake and baked scones
Apple fibre powder	Cookies
Apple skin	Muffins
Banana peel powder	Cookies
Beetroot pomace	Cookies
Carrot pomace	Cookies and muffins
Guava peel powder	Cookies and cakes
Orange pomace	Muffins, cakes and cookies
Mango kernel powder & mango peel powder	Soft dough biscuits, cookies
Watermelon rind	Cookies

Watermelon rinds are generally thrown away however they can occasionally be eaten as a vegetable. Similar to watermelon, rind flour has a high ash, lipid, protein, crude fibre, and carbohydrate content. However, adding rind to baked goods like cookies extends their shelf life without changing their flavour or other sensory aspects (17).

CONCLUSION

According to the research that has been studied for this paper, it was found that the fruits and vegetables peels and pomace that were very prominently used regarding this matter are apple, beetroot, carrot, guava, mango, orange, plantain, raspberry, watermelon etc. either in combination or as it is.

In conclusion, the substantial increase in dietary fibre content in cookies fortified with fruit and vegetable peels and pomace is one of the study's main findings. Dietary fibre is well-known for helping to maintain digestive health and lowering the chance of developing a number of chronic illnesses. The addition of these by-products to the cookies makes them a viable dietary fibre source, meeting the increasing need for functional meals that improve overall health.

Pomace from fruits and vegetables is rich in bioactive substances, such as antioxidants, which provide additional health benefits. It was discovered that fruit and vegetable pomace powders had a significant impact on the cookies' sensory qualities while they were being stored. The negative impact was primarily seen in the colour of the cookies that included pomace powders; the other cookies retained better sensory qualities when compared to the control group. Compared to control cookies, cookies containing pomace powder showed improved storage stability and required relatively less complicated packaging.

According to the study, the shelf lives of cookies boosted with pomace and vegetable and fruit peels are comparable to those of ordinary cookies. The durability of quality attributes suggests that these by-products do not compromise the bakery items' shelf life. This finding is crucial because it gives manufacturers and customers alike peace of mind that supplementation's nutritional benefits don't come at the expense of a less robust products.

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