# Possibility for Preparation of Nutraceutical food using fruits peel of Banana, Apple, Manilkara Zapota as adjunct raw materials: A review

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## Abstract

Fruit peels, often discarded as waste, are rich sources of bioactive compounds with potential health benefits. This review explores the possibility of utilizing fruit peels from banana, apple, and Manilkara zapota (sapodilla) as adjunct raw materials in the preparation of nutraceutical foods. These peels are abundant sources of dietary fiber, antioxidants, vitamins, and minerals, which can confer various health-promoting properties. The review examines the bioactive compounds present in each peel and their physiological effects, including anti-inflammatory, antioxidant, antimicrobial, and anticancer activities. Furthermore, it discusses various methods for extracting and incorporating these compounds into food matrices to enhance their nutritional profile and functional properties. Additionally, the culinary applications of fruit peels in the development of functional foods, such as snacks, beverages, bakery products, and condiments, are explored. The review also addresses challenges and opportunities associated with the utilization of fruit peels in food production, including issues related to extraction techniques, flavor profiles, and consumer acceptance. Overall, this review highlights the potential of banana, apple, and Manilkara zapota peels as valuable adjunct raw materials for the development of nutraceutical foods that offer both health benefits and sensory appeal.

**Keywords:** ***Nutraceuticals, Fruit Peels, Banana, Apple, Manilkara Zapota, Bioactive Compounds, Functional Foods, Health Benefits, Culinary Applications.***

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## Introduction

Foods having elements that can provide medical and health benefits are considered as nutraceutical food and the food prepared from plant or animal origin having nutraceutical component is known as functional food. Thus, functional food provides the body with the required amount of vitamins, fats, proteins, carbohydrates, etc, needed for its healthy survival. When functional food aids in the prevention and/or treatment of disease(s) and/or disorder(s) other than anemia, it is called a nutraceutical. (Since most of the functional foods act in same way or the other as antianemic, the exception to anemia is considered so as to have a clear distinction between the two terms, functional food and nutraceutical (Kalra 2003). Thus, a functional food for one consumer can act as a nutraceuticals for another consumer. Of late, the craze for nutraceutical food is growing day by day and demanding relatively new section of the food industry. This growth has been due to several, possible primary reason may be consumers are increasingly concerned about their health and how it is achieved through food. Secondly there are more and more evidences coming up that relates to diet and health.

Scientific investigation revealed that phytochemicals and essential nutrients are largely present in the peels, seeds, fruits and vegetables (Kumar 2020). For example, the skin of grapes, avocados, lemons along with seeds of mangoes and jackfruits comprise up to a 15% larger phenolic content than fruit pulp (Gorinstein 2001, Soong 2004). Fruit waste also 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 contain 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 wellbeing by producing valuable products for human being which help to prevent diabetes mellitus, cardiovascular disease and cancer.

In this review, the focus has been made on use of fruit peels of Banana, Apple and Manilkara Zapota as a source of bioactive compounds and its implication in food products.

## Banana peel

Banana is a widely cultivated and consumed fruit crop in the tropical and subtropical region. Banana plants belongs to the Musaceae family. Banana plants are derived from three genera (Musa, Ensette and Musella) under the same family, but they universally comprise several species in Musa (Mathew & Negi, 2017). Bananas are an important source of vitamin B6, vitamin C, and potassium. Banana peel, is the outer covering of the banana fruit peels are used as food for animals, an ingredient in cooking, in water purification, for manufacturing of several biochemical products as well as for jokes and comical situations. Banana peel is the major byproduct of banana processing which account for 30% of the banana fruit and also constitute to environmental hazard. Banana peels are promising byproduct for different applications in nutraceuticals and medicinal usage duo to the high dietary fibre and phenolic content present in them. Numerous studies have identified banana peels as a rich source of phytochemical compounds, mainly antioxidants such as phenolics, flavonoids, gallocatechin,

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anthocyanins, delphinidin, and cyaniding, and catecholamines, carotenoids, vitamins and minerals (Egbuna 2022). In Ayurveda it has been used to treat the constipation problems since time immemorial. Banana peel carries anti-inflammatory properties which can be used in daily life as a first -aid at home to control, reduce, cure the inflammations and infections.

The chemical composition of six varieties of fruit peels of the banana was studied by Emaga *et al*. (2007). Their results reveal that the varieties did not consistently affect chemical constituents. However, the maturation of fruits involved an increase in soluble sugar content and, at the same time, a decrease in starch. The degradation of starch under endogenous enzymes may explain the increase in the soluble sugar content. They attributed the degradation of starch to the action of endogenous enzymes, which may explain the increase in the soluble content. They pointed out significant quantities of amino acids such as leucine, valine, phenylalanine, and threonine. Potassium was the most important mineral element. (Hikal 2022)It has been shown that banana peel (Musa sapientum) contains many nutrients and minerals. They found crude proteins in the amount of 19±0.14%, crude fat 5.93±0.13%, and 11.82±2.17% carbohydrate in the banana peel. The mineral composition of banana peel was phosphorus, iron, calcium, magnesium, and sodium. Zinc, copper, potassium, and manganese were found in very low concentration as mg/100g.

The utilization of fruit peels in nutrient supplementation primarily relies on their chemical composition. Similar to its pulp counterpart, banana peel contains rich organic content (lipids, fibre, carbohydrate, and protein) as a key source of many bioactive compounds with various functionalities. Nutritional compositions, which are found in banana peel, are summarised in Table 1. The nutritional value of banana peels varies based on the cultivar and maturity stage, as the plantain peel contains less fibre than dessert banana peels, and lignin content increases with ripening (from 7 to 15% dry matter). Dried banana peels contain 6-9% protein and 20-30 % fibre.

Table. 1: Nutritional component of Banana peel (Essien *et al.* 2005; Lee, Yeom, Ha, & Bae, 2010; Emaga *et al*. 2007).

| Nutritional component | Average content, %DM |
|---|---|
| Starch | 3.5 – 6.3 |
| Resistant starch | 2.3 – 2.5 |
| Dietary fibre | 47 – 53 |
| Crude fat | 2.24 – 11.6 |
| Crude protein | 5.5 – 7.87 |
| Ash | 9 – 11 |
| Carbohydrate | 59.51 – 76.58 |

Studies have shown that the total and LDL cholesterol levels are decreased by dietary fibre intake (Reynolds *et al.*, 2020). In addition, the same study results have shown that in the tested doses (50-250 mg of dietary fibre), the soluble dietary fibre from Musa paradisiaca displays better cholesterol absorption capacity than the insoluble dietary fibre (Arun et al., 2017). Oxidised low- density lipoprotein (LDL) increases the expression of pre-inflammatory

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genes that proceed to monocyte recruitment into the vascular endothelial cells of a dysfunctional blood vessel wall, and oxidised LDL is destroyed through the generation of free radicals. Thus, inhibition of LDL oxidation is essential in the management of CVDs and atherosclerosis. The findings of a study by Arun et al. (2017) showed that the extracts of methonal and ethyl acetate from Musa paradisiaca effectively prevented LDL oxidation dose-dependently with $IC_{50}$ values of 169.52 and 217.45 µg/mL, respectively. The enzymes that transforms angiotensin I (ACE) to angiotensin II is a potent vasoconstrictor, which plays a critical role in blood pressure control. Angiotensin II has been implicated in the progression of vascular complication of diabetes as a crucial promoter of insulin resistence. Therefore, another clinical approach in the treatment of diabetes tends to be ACE inhibition. According to Arun *et al.* (2017), Musa paradisiaca extracts have an inhibitory effect against ACE within the tested concentrations comparable to the positive control, captopril (100-200µg/mL.)

**Banana peels' effective usage**

Banana peel is an effective whitening agent and an excellent source of nutrients for the teeth. Brushing with banana peel nourishes the teeth with potassium, remineralizing them. Bioactive compounds present in banana peel are used for prevention of cancer. Cell viability of MCF-7 reduced from 91.14% to 24.7% when Nendran variety of banana peel extract concentration increased from 20 to 200 g/ml. Banana peel was used for treatment of heel fissures or heel crack caused especially in female because of lack of moisture and thickening of the skin. It leads to increase in the crack level because cracks create space for microbial attack and cause infection of the foot which may increase swell. So, a gel is prepared by fusion of banana peel extract with carboxyl methyl cellulose. This gel is very effective than other chemical ointments, and is eco-friendly. Wound on skin is prevented with banana peel, which helps to recover soon and is eco-friendly in nature. Mosquito and insect bites lead to scratch, so endocarp of banana peel should be applied immediately before ointment use; it will be quite effective and simultaneously relieves inflammation and itching.

**Apple Peel**

Apples are important dietary sources of phenolic compounds and have strong antioxidant capacity compared to other fruits (Sun *et al*., 2002). Apple polyphenols have various in vitro bioactives, possibly in combination with dietary fibre (i.e. reduced risk of coronary heart disease) (Boyer and Liu, 2004). Higher amounts of polyphenols, in particular flavonol glycosides, are generally found in the skin of the fruit, compared to the pulp (Khanizadeh *et al*., 2008). Some studies have reported about the recycling of apple peels as a source of phenolic compounds and/or dietary fibre; depending in the compounds, different peel waste-derived material were developed.The apple peels were preferably processed into a dried and pulverised bulk material for fibre formulation or nutraceutical use. Phenolics were extracted with organic solvents (or aqueous mixtures thereof) and then characterised for their potential health benefits. The second recycling option involved the preparation crude or purified mixtures of phenolic antioxidants and/or their formulation in nutraceutical or functional food application. To the best of our knowledge, the preparation and characterisation of apple peel extracts for food stabilisation or preservation has not been studied.

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There is an increasing interest about natural plant extracts (i.e. botanicals) in novel food applications, as nutraceutical ingredients or natural preservatives and antioxidants (Coppens *et al.,* 2006; Decker *et al*., 2010; Medina *et al*., 2003; Naidu *et al*., 2000; Pazos *et al.,* 2005). Various agri-food waste and by-products have been screened for the recovery of natural phenolic antioxidants (Moure *et al*., 2001). The recovery of valuable material is a strategy of waste minimisation (Bates, phillips, 1999). Some nutraceutical products have been developed from grape waste or apple peels, and marketed for the functional markets of Japan and U.S.A. (Shoji *et al*., 2004; Yamakoshi *et al*., 2002). In Europe, the use of botanicals such as vegetables and fruits, herbal teas and infusion, and herbs is allowed in food and beverages for taste or functional purposes (e.g gurana, gentian, etc.) (Coppens *et al*., 2006): however, the functional applications of many botanicals have not yet received the scientific opinions of the European Food Safety Authority (EFSA) (Gilsenan, 2011).

Apple peel a by-products are mainly considered as waste, with processing companies facing problems with discarding them in a sustainable way. Most of the time, apple pomace is used as fertilizer, for animal fodder, or as a substrate for aerobic fermentation. However, the disposal of apple by-products as waste causes huge losses. Several studies have shown that apple by-products possess high biological activities due to the high content of phenolic compounds, vitamins, and carotenoids. Therefore, apples and apple by-products are potential sources from which to extract natural antioxidant to be used in the food, cosmetic, and nutraceutical industries. Apples are a rich source of vitamins, especially vitamin C and E. With regard to vitamin C content, apples are placed as the second highest ranked fruit after cranberries. The concentration of vitamin C ranges from 2 to 35 mg/100 g based on the apple variety, and it is found in two forms in apples namely ascorbic acid and its oxidised form, dehydroascorbic acid (Al Daccache 2020 and Campeanu 2009). On the other hand, vitamin E is mainly present in the apple seeds. As a result, apple pomace is a rich source of vitamin, and it has been found that the concentration of vitamin E in apple pomace is 5.5 mg/100 g with free radical-scavnging activity of EC50= 0.30 (Skinner 2018). Phenolic compounds are one of the largest classes of plant secondary metabolites with biological functions in humans. They contain one or more aromatic rings in their molecular structures with one or more hydroxyl groups, which are responsible for exhibiting biological functions. To date, more than 60 phenolic compounds have been found in apples, which are mainly constituted by pheniloc acids and flavonoids. Phenolic acids are the major components belonging to non-flavonoids group of phenolic compounds. They are aromatic acids with a phenolic ring and an organic carboxylic acid (C6-C1 skeleton). They are also known as phenol carboxylic acids. According to their classification, there are two main types: hydroxybenzoic acids (C6-C1) and hydroxycinnamic acids (C6-C3). Hydroxybenzoic acids are derivaties of benzoic acid, found in fruits mostly in the conjugated from (esters or glycosides) but can also be present in the free form. Generally, they are bound to component of cell walls (such as cellulose or lignin or even forming protein complexes) that can be connected to sugars or organic acids. Examples of hydroxybenzoic acids present in apples include gallic acid, proticatechuic acid, vanillic acid, and syringic acid. The most reported hydroxycinnamic acids found in apples are quinic and caffeic acid, and the estimated range is 4 to 18% of total phenolic compounds based on apple varities. Furthermore, 5’-caffeoylquicin or chlorogenic acid, p-

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coumaroylquicin, and p-coumaric are also present in apple. They are more abundant in apple peel in comparison to apple flesh. Apples are enriched with flavonoids. Among eight subclasses of flavonoid, apples contain mainly four subclasses, namely flavonols (71-90%), flavonols-3-ols (1-11%), anthocyanins (1-3%), and chalcones/dihydrochalcones (2-6%). The subgroup "anthocyanins" includes cyanidin 3-galactoside, which is most abundant in red apple peel as it is responsible for the red color.

**Application of apple by-products in food products**

Nowadays, fortification of food products using apples or apple by-products has gained more attention as they are a good source of dietary fibres and bioactive compounds. These products, rich in natural antioxidants, could play an important role in replacing synthetic products. In the following subsections, food products formulated with the incorporation of apples or by-products are described.

The expansion of dried apple powder (5% and 10%) expanded the cell reinforcement limit of wheat bread by up to 38.5% and 61.9% contrasted with control bread. In spite of this expansion in cell reinforcement limit, the tangible properties of the bread stayed OK across all examples, including the control tests (Filipčev *et al*. 2010).

Recent examinations have shown that consolidating defatted 5% and 20% apple seed powder from different assortments (Brilliant Delectable, Idared, and Šumatovka) into wheat bread prompted a critical expansion altogether polyphenol content and cell reinforcement potential. The outcomes demonstrated that the complete polyphenol content was 1.7 to 2.9 times higher, with the antioxidant limit being 1.1 to 2.1 times higher contrasted with control bread (Purić *et al*. 2020).

The antioxidant properties of various bakery products, including cakes, buns, cookies and muffins enriched with apple pomace, have been studied by researchers. For example, researchers observed increased antioxidant properties and improved sensory attributes, such as a fruity flavor, when muffins were prepared with 20% apple pomace (Sudha *et al*. 2016, 2007).

The incorporation of apple peel polyphenols (500 ppm) was effective in retaining the color of stored pork hams but ineffective for beef hams. Additionally, all treated samples did not exhibit lipid oxidation and there were no significant differences observed in terms of protein oxidation (Sun *et al*. 2010).

Two different apple peel extracts to protect fish products from oxidation. The total phenolic content of the second apple peel extract, which was prepared by removing sugars and organic acids from the initial extract, was significantly higher than that of the first extract. The total phenolic content of the second extract was 42,025.5 µg/mL, while the first extract had a total phenolic content of 399.1 µg/ML (Rupasinghe *et al*. 2010 )

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**Manilkara Zapota Peel**

From last few decades more focus was emphasis on the identification of new chemical moieties (NCM's) which is derived from natural orrigin and possess biological activity. Among these NCM's 28% are discovered in between 1981 to 2002 which are derived from natural origin. Manilkara zapota (L.) Royen is a popular fruit crop, species from the sapotaceae family, which is widely cultivated in most tropical reasons across the world. Different plant parts such as latex, fruit and timber are being used for various purposes. The fruit is nearly oval, round, oblate, conical or ellipsoidal; unripe fruit is rigid, gummy and very astringent, smooth-skinned coated with a sandy brown scurf until fully ripen. At present, fruit peels are considered to be new sources of bioactive components, focusing an increased interest in search for beneficial phytochemicals present in fruit peels and utilize them in pharmaceutical, cosmetic industries or as food supplement. Health benefits of Manilkara zapota fruits are not limited towards the edible portion of the fruit but non-edible part of the fruit also contribute for the beneficial effect based on the biological principles involved in it. Although the fruit peels of Manilkara zapota fruits are discarded but it contains a variety of medicinally important phytochemicals. The peel of Manilkara zapota is rich in antioxidant principles, containing many important bioactive phenolic compounds known to provide its health benefits. In particular, a rich variety of phenolic compounds (as sources of natural antioxidants) and flavonoids present in it have attracted the attention of many researchers and practitioners. Among these, flavonoids are capable of effectively scavenging reactiveoxygen species and become a strong antioxidant due to presence of phenolic hydroxyl groups. Most of the flavonoids are already repoted as antidiabetic, anti-inflammatory, anti-allergic and antiplatelet agents. While the phenolic compounds are acknowledged to possess a wide range of health benefits such as antimutagenic, antioxidant, anticarcinogenic and also to reduce cardio-vascular complications. Sapodilla fruit is used as a nutritional food, chicle and also used in many local medicines. A boiled decoction of young fruits is taken to stop diarrhea. Young fruits infusion helps in relieving pulmonary complaints. Melted butter soaked fruit helpful in prevention of biliousness and fevers. The tannin content of the unripe fruits helps in resolving stomach problems. Since ages, medicinal plants are known to have valuable anticancerous agents (Ahmad *et al.* 2017) that have been examined in order to find out the effective anticarcinogenic agent. It has been found out that the presence of antioxidants is related to the anticancer activity (Gupta *et al.* 2016). Likewise, sapota is the fruit crop which is not chiefly grown for its medicinal properties. The plant is known with different names in different areas around the world, e.g., called as "mamay" in native Central America, Mexico, and in many parts of the world, where the plant is primarily grown for its nutrients. Antioxidants comprise of the substance or compounds that contain the production of reactive oxygen species or interject the spreading of the free radical. There are various antioxidants present in the nature. Generally, antioxidants can be divided into two major categories such as synthetic and natural. Ascorbic acid, tocopherol, and other natural antioxidants have already been utilized into various types of products. There are various synthetic antioxidants available such as butylated hydroxyl anisole, butylated hydroxyl toluene, ethoxyquin, and propyl gallate. Plants normally produce phenolic and flavonoid compouns, ehich in turn being powerful antioxidants that protect them from sun (Pinnell 2003). The "phenolic

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compounds" comprise of approximately 8000 natural compounds: each one of these has similar structural feature known as phenol. The main group of phenolic known for human-related use is flavonoid, higher molecular weight polyphenol, and phenolic acids (Svobodova *et al*. 2003).

A review by Karle and Dhawale (2019) describes about pharmacological assessment and phytochemical of Manilkara zapota (L.) Royen fruit peel (MZFP) and a juice byproduct which is generally considered as wastage. It turns out the sapota peel comprises of about 20% 3of the fruit. The survey of literature suggested that the peel portion of the fruit is concentrated with the phenolic compounds including tannins, flavonoids, flavonols (catechin and epicatechin), conjugates of 5-caffeoyl quinic acid, phenolic acids, hydroxylbenzoic acids (p-hydroxybenzoic, gallic, and ellagic), hydroxycinnamic acids (ferulic, chlorogenic, and transcinnamic), lycopene, and kaempferol. Generally, it has been recognized that by the optimization of the conditions for extraction, the recovery of the bioactive components from the sapota peel is easy. Primary tyoe of evaluation in this area is mainly undertaken by in vitro methods. So, the clinical trials are required for accurate validation of the health benefits (Karle and Dhawale 2019).

**Application of Manilkara zapota peel in food products**

Manilkara zapota peel, often overlooked, harbors a wealth of untapped potential in culinary realms. Its natural sweetness, coupled with its abundance of fiber and nutrients, makes it an ideal candidate for innovative food applications. With its myriad culinary possibilities, Manilkara zapota peel stands poised to become a cherished ingredient in kitchens worldwide, offering both flavor and nutrition in equal measure.

It offers not only its deliciously sweet fruit but also its peel, which holds significant potential in culinary applications. The peel of Manilkara zapota is rich in dietary fiber, antioxidants, and essential nutrients, making it a valuable ingredient in various food products. From jams and chutneys to teas and infused waters, the peel adds a subtle sweetness and depth of flavor while enhancing the nutritional profile of dishes. Furthermore, its fibrous texture makes it suitable for use in baked goods, providing both flavor and texture. Embracing Manilkara zapota peel utilization in food not only reduces waste but also promotes sustainability and nutrition. The *M. zapota* fruit has various food applications due to its sweet taste. It is commonly consumed fresh as a dessert, used to make sherbets, ice cream, jam, and dehydrated fruit snacks. The pulp of the fruit is utilized to make vinegar and powder for juices. Additionally, the juice can be extracted to produce syrup and vinegar. The milky latex that exudes from the stem and bark of the plant is used as the base for chewing gum (Peiris 2007). *M. zapota* can also be combined with pectin to formulate shelf-stable fruit bars that are a good source of vitamins, carbohydrates and fibers (Salleh et al., 2017).

**Conclusion**

The exploration of fruit peels from banana, apple, and Manilkara zapota (sapodilla) as adjunct raw materials in the preparation of nutraceutical foods unveils a promising avenue for sustainable food innovation. Fruit peels, often overlooked and discarded, present a wealth of bioactive compounds that can contribute to human health and well-being. Through this

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review, it becomes evident that these peels are rich reservoirs of dietary fiber, antioxidants, vitamins, and minerals, offering a spectrum of health-promoting properties including anti-inflammatory, antioxidant, antimicrobial, and anticancer activities. This review underscores the untapped potential of banana, apple, and Manilkara zapota peels as valuable ingredients for the creation of nutraceutical foods that not only nourish the body but also tantalize the taste buds. Embracing these natural resources not only promotes sustainability but also paves the way for healthier food choices in the global landscape.

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**Conflict of Interest**

All the authors of this manuscript do hereby declare that there is no any conflict of Interest amongst the author.

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