Local Fruit Wastes as a Potential Source of Natural Antioxidant: An Overview

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Local Fruit Wastes as a Potential Source of Natural Antioxidant: An Overview

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Abstract. Food industry in Malaysia which used fruits as one of the raw material such as the production of fruit juices, concentrates, jams and dried fruits, the main wastes of the production are the peel and the seed of the fruit. Nowadays, people have shown the interests to study the antioxidant content in the fruit wastes. All kind of fruits are believed to contain high amount of natural antioxidant properties such as vitamins, phenol, flavonoid and carotenoid. Thus, this paper presented the work done by researcher on antioxidant activity in the peel especially on local fruit such as mango peel, watermelon rind, banana peel and mangosteen pericarp. The review shows that the peel of the fruit is a good source of antioxidant and other bioactive compounds which have many benefits especially towards human health.

1. Introduction

The use of fruit and vegetable waste recently has becoming more popular to be studied by taking into account that these residues are one of the important sources of polyphenols. Researchers become interested to study about the residue because agricultural and industrial residues are attractive source of antioxidants and dietary fiber besides reducing environmental pollution [1,2]. For example, fruit wastes are so many in Egypt but the constraint is lacking information regarding their activity and content of antioxidant compounds [3].

Research has been done in some vegetable and fruit wastes to investigate the extraction and identification of antioxidant compounds existence [4]. Researchers are now inventing new by-products applications and interested to turn them into useful products and to have a positive environmental impact. The functional properties of some peel components such as pectin, flavonoids, carotenoids, limonene and polymethoxy flavones should be considered accordingly [5].

Based on the epidemiological studies, it has been shown that consumption of fruits frequently is related with a lower risk of chronic diseases [6]. Vitamins and polyphenols contained in fruits and vegetables are natural source of antioxidants and considered to be responsible for human health benefits [7,8]. One of the most important categories of natural antioxidants of interest is phenolic compounds [9]. There is much evidence is derived on the antioxidant potency together with their prevention of diseases capability [10]. Based on the recent studies that have been done, the peel and

seed of some fruits contain high amount of phenolic compounds and antioxidant potency [11]. This studies indicate that fruit residue has the potential to be utilized as one of the source of bioactive compounds such as natural antioxidants.

Malaysia is one of the countries that having a fast-economic growth and high population of people. Along with the rise of the economy, Malaysia produced different varieties of vegetables and fruit. This locally grown agriculture is not only consumed by Malaysian but also being export to other countries. The vegetables and fruits that are being grown in Malaysia also undergo some industrial processing for example the production of canned fruit, fruit juice and also as the flavoring. Due to the high consumption and industrial processing of the edible parts of the fruits, fruits wastes such as watermelon rind, mango peel, rambutan skin and other fruit residues principally the peels and the seeds are generated in large quantities especially at the food industrial area and in big cities for example Kuala Lumpur. In fact, one of the main sources of municipal solid waste (MSW) is fruit waste which has been an increasingly tough environmental issue.

Furthermore, some synthetic antioxidants have the potential risks towards human health and due to that the attention to identify natural source of antioxidants that is possibly more economical and effective is increasing. Synthetic antioxidants that are commonly used are butylatedhydroxytoluene (BHT) and butylatedhydroxyanisole (BHA). These synthetic antioxidants are used in order to reduce free radical damage to the human body. Their usage as a food preservatives are significant and thus consumed in appreciable quantities by humans. The problem with the usage of synthetic antioxidants is that, such compound has been related to health risks. Besides that, synthetic antioxidants have been suspected as one of the cause of liver damage and carcinogenesis. That is why strict regulations over their use are applied especially in foods.

For all the stated reason, the municipal solid waste need to be reduced and one of the way is reduce the fruit waste especially the peel. Besides that, the use of synthetic antioxidant should also be replaced with natural antioxidants to lower the risk towards human health. One of the beneficial approaches is to recover the bioactive constituents in the fruit waste especially the phenolic compounds and antioxidant properties, making full use of them in some sectors and industry such as food, pharmaceutical as well as cosmetics industry. Thus, sources of bioactive from fruit wastes utilization might be considerable in terms of human health, environment and also economics.

2. Antioxidant in Fruit Wastes

In food industry that used fruits as one of the raw material such as the production of fruit juices, concentrates, jams and dried fruits, the main wastes of the production are the peel of the fruit. For examples, in the production of mango juice or mango concentrate, the used part of the fruit is only the flesh of the mango whereas the peel will become the waste. Researchers have becoming more interested to study the antioxidant content in the fruit waste such as the peel. This is because, as people knows, any kinds of fruits contained high amount of natural antioxidant such as vitamins, phenol, and carotenoid, thus, researchers believed that, the peel of the fruits also have the antioxidant activity. Researchers have done some study on the peel of various fruit to prove that antioxidant activity exist in the peel of the fruit. As a result, it shows that the peel of the fruit is a good source of polyphenols, carotenoids and other bioactive compounds which have many benefits especially towards human health [12].

As early in the year of 1994, researches have started the study of antioxidant activity in the peel of plant. Potato peel has been studied on the antioxidant activity in 1994 by Rodriguez de Sotillo et al. [13]. The result is positive as the aqueous extract of potato peel is a good source of phenolic acid and exhibit a good antioxidant activity. This study has set a benchmark in later studies to see whether other fruit peel also contained a good antioxidant activity. Not long after that, mango peel has become the subject for antioxidant activity study. As the result, it was found that mango peel also contains

polyphenols which is a type of antioxidant and a good source of dietary fiber [14]. Banana and tomato peels also reported to be a good source of antioxidant that is carotenoids [15].

Based on all the research that has been done, it proves that the peel of the fruit contained antioxidant activity in a significant amount. More research should be done to investigate any other peel that might also contain antioxidant activity and also maybe can be utilize the antioxidant contained in the peel of the fruit.

3. Local Malaysian Fruit Wastes

3.1. Water Melon Rind

Watermelon (*Citrulluslanatus Thunb*.) is from the family of cucumber (*Cucurbitacea*). Watermelon is a large fruit having a shape of oval, round or oblong and a type of tropical fruit [16]. Watermelon can be found in many tropical countries. The skin of the watermelon is smooth having dark green rind or sometimes pale green stripes and when the fruit is fully ripe, the green stripes turn into yellowish green. Commonly found watermelon has either red or yellow flesh. Watermelon fruit is a very refreshing fruit to be eaten in hot weather because it contained vast amount of water and the sweet taste is irresistible.

In food industry, such as the production of watermelon juice, the rind (Figure 1) is usually discarded as wastes. The application of watermelon rind is up to fertilizer application or applied to animal feeds only. Less people know that watermelon rind is also edible and can be used as a vegetable. In China for instant, the watermelon rind is de-skinned and de-fruited before it is stir-fried together with olive oil, garlic, chili peppers, scallions, sugar and rum. In China, the watermelon rind is also available in powdered forms and Chinese used the watermelon rind as a traditional medicine extensively to clear away heat in the body and eliminate toxic substances. Watermelon rind is also can be found in pickled form and is commonly consumed in the Southern US, Russia, Ukraine, Romania and Bulgaria. Watermelon rinds are also fermented, blended and consumed as juice in Nigeria. Based on what other countries applied watermelon rind, it shows that watermelon rind also has its own value and not just a waste like people always did.

Figure 1. Watermelon rind

Watermelon has been reported to have therapeutic effect which has been ascribed to antioxidant compounds [17]. The major antioxidant activity in watermelon rinds is citrulline. Because of the antioxidant activity of citrulline in watermelon rind, it has the ability to protect human from free-radical damage besides an efficient hydroxyl radical scavenger. Moreover, citrulline can be converted to arginine which is a type of amino acid that is vital to human heart, circulatory system as well as immune system [12]. Researches also believed that watermelon rind has the potential in relaxing blood vessels as well as cancer and cardiovascular diseases besides improving sexual stamina and erectile function.

Researchers are becoming more interested to study the watermelon rinds properties and moving towards utilizing it in food products. Recently, watermelon rinds had been utilized by using it in the making of bakery products by turning the watermelon rinds in the form of powder and mixed with the flour to make a cake batter [3]. The result was very promising as the cake that forms from the mixture of watermelon rinds powder and flour had a longer shelf-life. This shows that the antioxidant activity in watermelon rinds can slow down the oxidizing process in the cake and as a result prolonged the shelf-life of the cake.

Citrulline is a non-essential amino and was first identified from the juice of the watermelon (*Citrullus vulgaris*) [18]. The richest known source of citrulline is watermelon [19]. Watermelon as reported has the therapeutic effect and this effect has been ascribed to antioxidant compounds [20]. The antioxidant property that comes from the citrulline in the watermelon rinds helps to protect human being from free-radical damage. Besides that, an amino acid that is being produced form the conversion of citrulline to arginine plays an important role to the heart as well as circulatory system and immune system. Furthermore, some researchers also speculate that watermelon rind has the potential in relaxing blood vessels including cancer and cardiovascular diseases.

3.2. Mango Peel

Besides watermelon, *Mangiferaindica* L. or commonly known as mango is also one of the most important tropical fruits consumed in fresh or processed form globally. Typically, mango has a bright yellow-flesh with either green or yellow skin, together with having a sweet-sour taste. Mango can be consumed freshly even though it is not fully ripe.

Most people consumed the mango flesh only but other parts of mango such as peel and kernel are being thrown as waste. Apparently, mango waste contains a very significant number of phytochemicals, which can be utilized for value-added applications in functional foods and nutraceuticals. Mango peel is a rich source of pectin, lipids, proteins, carotenoids, cellulose, hemicellulose, vitamins, and polyphenols with excellent health-promoting properties, mainly antioxidant activity [21].

In the manufacturing of processed mango such as mango juice, concentrate or puree, massive amount of peel is being generated and become the major waste in industry. Although the peel waste is biodegradable, huge amount of it takes time to be decomposed and can also cause environmental pollution. Studies have shown that mango peel contains various numbers of valuable compounds such as polyphenols, carotenoids, enzymes and dietary fibres together with excellent antioxidant activity and functional properties [22].

Based on the antioxidant activity contained in mango peel (Figure 2), it has been utilized and produced in a powdered form that is mango peel flour. However, the use of the mango peel flour has not yet been widely applied. Mango peel flour has many potential as it can be used as a functional ingredient especially in developing healthy food products for examples bread, biscuits, cakes, and as well as noodles or other bakery products. Mango peel flour can also be the essential ingredients in making baby foods [23].

Figure 2. Mango peel

3.3. Banana Peel

Banana is an edible fruit that has grown worldwide nowadays. Banana plants are the largest herbaceous plant in the world which has grown in large quantities in many developed countries [24]. Banana also is the one of the most inspired fruits in tropical and subtropical regions [25]. Banana is obtainable in many types according to their size, colour and inflexibility. In 1753, Linnaeus who has published his book which is Species Plantarum, the origin of botanical nomenclature has given the first scientific name for banana which is *Musa Paradisiaca Linn*. The straightforward explanation has made based on plantain cultivar manners and lean fruits that maintain its own starchy even when fully ripe. The dried relics on the male bud rachides are firm and remain as their male flowers and bracts of plantains.

Fruits from banana plant are the main purposed in the banana cultivation. The flesh of banana fruits has variety of taste from starchy to sweet depending to their own cultivar and ripeness. Many people have used banana as a food as banana is easy to obtain and banana also is free from toxics affect. A few countries have labelled the banana fruit as the golden fruit of the nature. It is contributing to their behaviour that can promote the natural beauty by providing the body with essential nutrients. In fact, banana fruit also prevent constipation, diarrhoea and other digestive problems because a nutrient in banana improves digestive system. Banana also has been reported that its fruit can prevent many diseases. Banana should be well thought-out to be a good basis of natural antioxidant for foods and functional food source in opposition to cancer and heart disease [26].

The fruit is protected by its peels (Figure 3) which are leftover as a waste after the inner flesh has been eaten [27]. Peels are often being a waste of all fruits. Instead of recycled, usually all fruit waste especially peels always been discharged. This is because that many people do not know that there are many benefits of commercial use can be extracted for those peels. 30% from banana fruit is peels which act as main by-product. Environmental problems can be in serious condition from peels because it contains large quantities of nitrogen and phosphorus and its high-water content makes it vulnerable to adaptation by microorganisms [28].

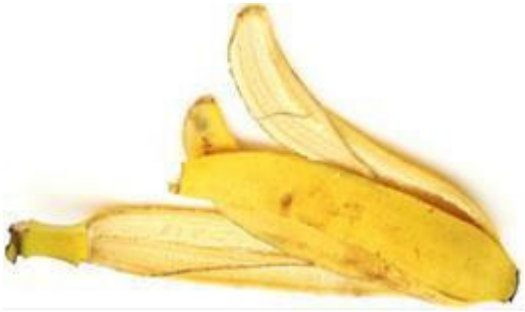

Figure 3. Banana peel

Surprisingly, many researchers have found that there are higher antioxidants activities and total phenolic contents from some of various fruits such as banana are from their peel and seed fractions, not in their pulp. The banana peels chemical composition influence the potential application of the banana peel. It has been found that total phytochemical compounds especially antioxidants are wealthy in banana peel [28]. The banana peel can be the major source of obtaining natural antioxidant. Nowadays, banana peel also is often use as a home therapy for quite a few skin problems such as allergies, bruises and skin irritation. Acne, poison ivy rashes irritation from mosquito bites, wrinkles and many more can be treated and managed by banana peels. Furthermore, banana peel helps skin to look much healthier, fresh and radiant as it can manage wrinkles although it will not have instantly effect.

Kanazawa and Sakakibara [29] have classified banana as one of the antioxidative foods. Banana fruits also can protect themselves from the oxidative stress that caused by intense sunshine and high

temperature because they have strong ability to increase their own antioxidant levels. Banana is acknowledged by people as weak primary antioxidant source but in terms of secondary antioxidant they are powerful [30, 31, 32]. Ascorbic acid, tocopherol, beta carotene, phenolic groups, dopamine and gallocathechin are antioxidant compounds identified in banana peel [33].

There is gallocathechin contain at a concentration 160 mg/100g dry weight in the banana peel [26]. Anthocyanins, delphinidin, cyaniding and catecholamines also contain in ripe banana peel. Other than that, carotenoids such as α-carotene, β-carotene and xanthophylls have been discovered in banana peel as well as sterols and triterpenes.

The synthesis of silver nanoparticles also used of the banana efficiently. Currently, silver nanoparticles are utilized in the production of antibacterial and anti-fungal agent's biotechnology and bioengineering, textile engineering, water treatment, and silver based consumed product. There are methods that can be used to synthesize the nanoparticles which are chemical, physical and biological methods. There are facts that mentioned about nanoparticles were one of the useful medium in opposition to the fungal and bacteria.

Currently, the used of banana peel in the silver nanoparticles production is according to their composition as they are naturally rich in polymers such as lignin, hemicelluloses and pectin that contribute to the synthesis of silver nanoparticles as mentioned well by A. Bankar et al. [34]. Banana is the one of the new method in order to obtain silver nanoparticles that produced from its peels for antimicrobials production nowadays.

3.4. Mangosteen Pericarp

Garcinia mangostana or also usually known as mangosteen, is a symbol of "Queen of Fruits" in Asia because of its delicious tasting tropical fruits. The mangosteen is a tropical evergreen tree which usually can be found in tropical countries such as Southeast Asia, Northern Australia, Brazil, Central America, Hawaii, Southern India, Indonesia, Malaysia and Thailand. The tree can grow until 6-25 m and it has leathery, glabrous leaves, and takes a long time to grow. When the mangosteen fruit ripe, it will become deep reddish purple in colour. The fruit diameter is around 5-7 cm. However, the pericarp is around 6-10 mm thickness [35]. At Southeast Asia, they mainly used the fruit hull of mangosteen as a traditional medicine. They treated diarrhea, inflammation, dysentery, skin affection, wounds, and ulcers with the mangosteen's hull [36, 37].

Nowadays, mangosteen become one of the popular ingredient that been used in nutritional supplements. There a lot of mangosteen products available and very famous because of their benefits in enhancing the human health. For example, mangosteen fruit juice was a top-selling "botanicals" product on the market [36]. Mangosteen consists of 17% of outer pericarp, 48% of inner pericarp, 31% of flesh and 4% of cap. Xanthones can be isolate from all parts of mangosteen which are from pericarp, whole fruit, bark, and leaves. Several studies have shown that each part of mangosteen contain xanthones [38].

Figure 4. Mangosteen pericarp

Xanthones are major secondary metabolites that are found in the pericarp of mangosteen (Figure 4). α-mangostin and β-mangostin are compounds of the xanthones. These two compounds that are found

in the pericarp of mangosteen shown cancer chemopreventive agent. α-mangostin was found to have efficacy in inhibiting preneoplastic lesion in rat colon. α-mangostin also reported to have antimicrobacterial properties and act as selective inhibitor against borine brain-derived acidic sphingomyelinase [39]. α-mangostin are believed to decrease human LDL oxidation induced by copper or peroxyl radical which will increase the consumption of α-tocopherol. Extraction of mangosteen also significantly reduces the ROS production of polymorphonuclear leucocytes (PML). Besides that, xanthones from the pericarp significantly have anti-inflammatory properties [40].

4. Conclusion

The growing demand for natural antioxidants observed in food and cosmetic industries forces the search for new sources of these compounds. Numerous scientific investigations point at consecutive rich sources of antioxidants, especially among fruits, but only few of them involve waste parts of plants such as fruit rinds and peels. Plant wastes which are formed in great amounts during industrial processing represent a serious problem, as they exert an influence on environment and need to be managed and/or utilized. Furthermore, they are very rich in bioactive components, which are considered to have a beneficial effect on health.

For the last decade, efforts have been made to improve methods and ways of re-using fruit rinds wastes. The important purpose is the valorisation of the antioxidants and other biocomponents in by-products from the industries. It has been attempted to discuss which plants and their by-products can be considered as a rich source of natural antioxidants and what methods should be used for their efficient extraction. The competition between natural and synthetic antioxidants, in terms of consumer acceptance, legal needs for market access, toxicity and thermal stability, is a big problem.

Therefore, research study must be carried out to identify the potential of bioactive/antioxidant compounds sources in selected local fruit wastes in Malaysia such as watermelon rind, mango peel, banana peel and mangosteen pericarp. Besides the antioxidant activity, other studies such as total phenolic content, total flavonoids content and antimicrobial activities also can be carried out. The data obtain from the study hope will give a beneficial input especially to food, pharmaceutical and nutraceutical industries and generally to public and researchers.

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