Advances in comprehensive utilization of fruit peel in China

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ABSTRACT

As a by-product, fruit peel can extract a variety of active ingredients, it has great value, which can turn waste into treasure and improve the utilization rate of raw materials. Orange peel, pomelo peel, banana peel and granatum are the main fruit peel utilize in China. This review focuses on the function, extracting ways and application of some components in this fruit peel. In order to make rational use of resources and protect our environment, the research progress on comprehensive utilization of this by-product.

Key words: Fruit peel, active ingredients, comprehensive utilization, extraction.

INTRODUCTION

China is one of the big fruit producing country of the world. With the promotion of agricultural industrialization, fruit growing areas is on the increase which has led to yearly increase in output as well as relatively fast development speed. In addition to the edible part of the fruit, the fruit peel has high utilization value, therefore there is need to make full use of discarded fruit peel. Furthermore, most fruit peel has a large proportion, which contains rich nutrients and functional components, so it is necessary to make full use of the discarded fruit peel. Comprehensive utilization of fruit peel is of great significance in improving the economic, reduce pollution and protect the environment. In the past, most of the domestic fruit peels were discarded, resulting in a great waste, environment pollution and other problems. In recent years, the study on the processing technology of comprehensive utilization of fruit peel has made great progress and has a good prospect (Li, 2011).

The structure and nutritional value of fruit peel

The peel of fruit, does not only protect the parenchyma of the fruit from pathogenic microorganisms, but also has a high nutritional value. The peel of fruit is composed of the epidermis and the peripheral skin, the epidermis is a primary tissue. The cell wall of the fruit is cellulose, and the outer wall is thicker than the inner wall. The periderm is formed in the epidermis, which is composed of the cork formation layer, cork cambium and phelloderm complex (Liu et al., 1988).

Part of the fruit peel is rich in abundant chemical constituents such as pigments (chlorophyll, carotene, anthocyanin etc.), nutrients (vitamins, minerals, water, sugar, fat, protein, etc.), flavor (acid, tannins, glycosides, etc.), construction material (the glue material, cellulose, etc.), so the fruit peel has rich nutritional and use value.

Utilization of fruit peel in China

In China, most of the fruit are consumed fresh, only a small amount is stored and as a result, only a small amount of fruit peel is used for processing compare to countries like Brazil, the United States etc, which have mature and advanced technology to handle fruit peel. Therefore they can make good use of fruit peel and other by-products, resulting in essentially no waste (Ye et al., 2008). China has a widely planted area of citrus whose production ranks second in the world. However, during citrus processing, 40 ~ 50% of citrus peel failed to get fully utilized and most of them stripped landfill or are processed into animal feed (Single, 2008). The annual output of pomelo is more than 200 million tons in China; these will produce an annual 40 million tons of pomelo peel (Deng et al, 2013). Due to the
porous structure and rich nutrients of the pomelo peel, it is fully utilized as adsorbents, processed into food and extracting active components (Tian, 2015). Banana is one of the world's four largest fruit and the world's largest trade volume of fruit; it has a high edible and medicinal value (Aurore, 2009). In China, the banana is fourth biggest fruit, the annual output is nearly 9 million 500 thousand tons (Ke et al., 2012). Each banana fruit has 35-40% banana peel (Huang et al., 2012) after eating, thus a large number of banana peel is discarded as waste which result to a large extent of pollution to the environment and produce a great negative impact. Banana peel has high use value, in recent years; most valuable substances have been extracted from banana peel such as pectin, dietary fiber, polysaccharide for production of feed additives and for sewage adsorption of heavy metals as well as in the field of health care (Ye et al., 2012). Pomegranate peel has anti-diarrhea, bleeding and deworming effects while its extract has antioxidant, antiviral and antibacterial effect (Li et al., 2004). In recent years, with the development of science and technology, our country has gradually improved utilization level of fruit peel such as orange peel, pomelo peel, banana peel, pomegranate peel and other fruits.

**EXTRACTION AND UTILIZATION OF ACTIVE INGREDIENTS IN FRUIT PEEL**

According to the research and analysis on fruit peel, it contains a large number of beneficial substances to the human body, such as sugar, protein, vitamins, carotenoids and other trace elements. The fruit peel of these fruits (orange peel, pomelo peel, banana peel, pomegranate peel etc) contained very high value of essential oil, pectin, dietary fiber, pigment and biological active components which can be obtained by proper physical and chemical treatment.

**Extraction of essential oils**

The main component of citrus flavor is terpenes, half terpene and higher alcohols, aldehydes, ketones, esters and other oxygen containing compounds, of which 95% is terpenes and half terpene, although the oxygen containing compounds accounts for less than 5% proportion, which is the main source of essential oils of rosemary aroma and is a high-quality raw materials of food fragrance, cosmetics, fragrance and perfume ingredients (Liu, 2007). The essential oil from citrus peel has strong antibacterial activity against *Escherichia coli*, *Staphylococcus aureus* and green enzyme. Citrus peel essential oil is the main component of lemon essential oil, which can be distilled out at atmospheric pressure and will not be broken down (Gao and Fang, 2005). Citrus peel essential oil extraction methods are commonly used in the press for example, solvent extraction and steam distillation and supercritical carbon dioxide extraction technology (Cheng and Zhang, 2007). Chen et al. (2010) use steam distillation in the extraction of essential oil from orange peel, they also use meteorological chromatography - mass spectrometry (GC-MS) method analysis in the determination of its chemical composition. Through the filter paper method, the orange peel essential oil of *Escherichia coli*, *Staphylococcus aureus* and *Penicillium maximum* was measured. Inhibition zone analysis of antimicrobial activity of essential oils, resulted in the minimal inhibitory concentration (MIC). It provides a good reference for the comprehensive utilization of citrus peel processing production.

**Extraction of pectin**

Natural products of pectin have a good gelation and emulsification property which is widely used in the world. Part of any fruit peel contains pectin components. Pectin is a white or pale yellow colloid, in acidic or alkaline conditions it can undergo hydrolysis, and it does not dissolve in alcohol and glycerin and has the physiological activity of polysaccharide derivatives. It has been widely used in the food, medical and pharmaceutical industry. Pectin is widely found in fruits, roots, stems and leaves of plants, and exists in the presence of cellulose. At present, most pectin is extracted from the peel of citrus, pomelo, banana, etc. the main methods of extraction are acid hydrolysis, ion exchange, enzymatic hydrolysis, etc (Yu et al., 2013). In the industrial extraction of pectin, the most valuable raw material is the fruit peel of citrus. Dai and Shi (2011) use cellulase liquid in the extraction of pectin, which is cell wall cellulose. Through the process of c333cellulose enzymolysis, pectin is free from the peel, to maximize the extraction of citrus peel pectin, pectin extraction rate is increased, and this could serve as a new pectin source for the food industry.

Banana peel contains a good quality of pectin. They can be used as raw material for industrial production of pectin. The research of extracting pectin from banana peel was earlier, acid alcohol precipitation method was mainly used but this method has produced a lot of waste residue in the production process, which has a great impact on the environment and restricts the development of the technology.

**Extraction of dietary fiber**

Dietary fiber is known to have seven nutrients, which is one of the essential nutrients in a balanced diet. The main function of the dietary fiber is to prevent constipation, colitis, arteriosclerosis, hyperlipemia, obesity. Dietary fiber prevents harmful metal adsorption, cleaning intestinal endotoxin to prevent colorectal cancer, colorectal cancer and other diseases. As a functional food raw material,
people pay more and more attention to it. At present, the extraction of cellulose from the peel has not formed a large-scale production. Dietary fiber is divided into soluble dietary fiber and insoluble dietary fiber. The content of soluble dietary fiber in citrus peel was up to 15%, which was a good source of dietary fiber (Zhu et al., 2003). There are many methods for extracting dietary fiber from citrus peel, such as chemical method, enzymatic method, membrane separation method, extrusion method etc. In citrus peel, the dietary fiber has antioxidant function and can be used as a high quality food additive. Citrus fiber also contains vitamin C, CA, K and other mineral elements, such as a higher concentration of brass (Zheng 2001), which is an added advantage over other products, so it has a broad market prospect. In addition to dietary fiber, the citrus peel contains crude protein, fat and sugar.

In banana peel, most of the insoluble dietary fiber has become waste, and has not been fully utilized. At present, the methods of extraction of dietary fiber from banana peel are alkali and enzyme methods (Jia et al., 2014). Wei and Wei (2016) used the response surface method to optimize the extraction process of insoluble dietary fiber from banana peel. The banana peel insoluble dietary fiber industrialization production provide theoretical basis, which is conducive to the comprehensive utilization of resources in the banana peel.

### Extraction of pigment

Most of the fruit peel contains pigment; the pigment in the fruit peel is natural plant pigment (Bao et al., 2005). Edible plant pigment composition is mainly of two parts, chlorophyll and multi terpene pigments. Natural pigment can be divided into water soluble pigment and fat soluble pigment; water soluble pigment can be extracted with water, ethanol, glycerol and other polar solvents, while the fat soluble pigment can be extracted with ethanol or other organic solvents. In the extraction of pigment from the peel, such as from citrus peel pigment extraction, Li and Xie (2002) studied the influence of microwave extraction of pigment from citrus peel, the various factors affecting the quality of orange pigment extraction. For stable performance, 40 times the orange peel plus ethanol solvent, under 35% moisture content and 10 min of microwave extraction conditions yielded the highest pigment (Li and Xie, 2002). Zhu (2010) used anhydrous ethanol and petroleum ether as extraction agent, the orange peel water soluble and oil soluble pigment dissolved on extraction, hence the stability of pigment was studied. The extracted pigment can be used as food additive, for thermal stability, and as reference for wide pH range s(Zhu, 2010). The melanin in banana peel can not only be used as a natural food pigment, but also has the function of protecting liver, promoting immunity etc. At present, the development of melanin in banana peel has become a hot research topic at home and abroad.

### Extraction of bioactive components

Polyphenols have antioxidant capacity; pomegranate peel contains a variety of polyphenols. Polyphenols has antioxidant, antibacterial, anti - aging, of lowering blood pressure and preventing cardiovascular disease such as multiple physiological and pharmacological activities (Li et al., 2004). Pomegranate Peel Polyphenols in food, medicine and other fields has a high value of application. However, presently, at home and abroad, pomegranate polyphenols extraction method is not deep; mostly, the decocting method was used for extraction. Therefore, further research is needed to find new methods of extracting pomegranate polyphenols.

Flavonoids have a strong ability scavenging free radical, thus its antioxidant effect. The general method of extraction is the heat extraction and soaking extraction method. With the development of science and technology, the microwave extraction and ultrasonic extraction is being used (Li, 2016). At the moment, the new method is to use ultrasonic to extract flavonoids; the microwave method is still in the experimental stage. Ma et al. (2010) used the ultrasonic and microwave assisted extraction extract flavonoids from the peel of the fruit, to explore the effect on the extraction rate about related factors and open up a new way on the development of orange peel, thus improving the utilization rate of citrus products as well as promoting the development of comprehensive utilization of citrus peel. Liu et al. (2014) used the reflux extraction method to study the antioxidant activity of the extract of total flavonoids. Extraction of total flavonoids from banana peel not only provide a theoretical basis for preparing flavonoids but also in the comprehensive development of the banana peel flavonoids by providing technical support.

### THE PROCESSING OF FRUIT PEEL

Most fruit peel is made into feed, for animal consumption, this has led to an increased in the supply of animal nutrition. Banana peel can be use to produce feed additive - microbial biomass protein (Song and Xu, 2005). Orange peel can be fermented to produce single cell protein feed (Xiao et al., 2013), which can be fermented to produce enzyme preparation and ethanol (Fu et al., 2009). The conventional practice is to make food from fruit peel; most of the fruit peel pickling, fruit puree products can be done with fruit peel for example pomelo peel jam is a class with nutrition and health function, as a low sugar food, it has certain market development potential. Fruit peel can be dried to serve as tea for example the orange peel and grapefruit skin can be dried and placed in tea.

In developed countries, using new technology to achieve
the cleaning of the peels has resulted in the complete utilization of fruit peels. Srialatha et al. (1995) used orange peel as the raw material for production of methane, more so the used of Aspergillus and Penicillium strains for selective pretreatment of biogas and methane has improved the yield. According to Ajmal et al. (2000), grinded orange peel because of its adsorption capacity was used as an adsorbent in the preparation of water processor. In fermentation production of enzyme preparation, Mrudula (2011) used orange peel as fermentation substrate thus under solid state fermentation using Aspergillus niger resulted in a high activity of the enzyme protein.

With the development of biotechnology, more and more attention will be given to the comprehensive utilization of fruit peel.

In summary, fruit peel has great potential for development, it has profound significance. Further study is required in the extraction of its functional and medicinal components, in order to increase its added value. Research and development of fruit peel is still in the initial stage, many machining process are yet to be solved, such as fruit peel component extraction, processing technology processes etc need to be improved. Industrial research need to be studied deeply, chemical fertilizer and pesticide residues in fruit peel need to be tackled, however the fruit peel is a rich resource, if people pay attention to, it has very high value in use and can bring higher economic efficiency, and reduce pollution to the environment.

Reference


