

## Valorization of food by product from selected tropical fruits pomace

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**Abstract.** In several countries, majority of food by product or food waste is produced by households, while approximately 39% losses occur in the food manufacturing industry where approximately 14% in food service sector and the other remaining 5% in retail and distribution. A large number of food by-products or food waste are increasing recently due to several reasons. This situation will cause serious environmental problems and will cause economic losses if the food by-product is not utilized. The way to solve this problem is to improve the economic value by valorization of food by-products. Unfortunately, after the juice production, the pomace as a by-product is not utilized completely. Tropical fruit production, trade, and consumption will increase since the domestic and also the international market will increase in the future. Several tropical fruits that have been widely used for juice making are passion fruit, citrus, orange, star fruit, etc. During the juice making, the by-product is commonly discarded and not fully utilized, especially in developing countries like in Indonesia. Several by-products of tropical fruits still contain high levels of various health enhancing substances that can be extracted from the by-products, and can be used as a raw material for nutraceutical, nutritional and also for further purposes. The purpose of the research was to study the application of valorization of tropical fruits pomace as a source of bioactive compounds, enzyme recovery and also for functional product development.

**Keywords:** valorization, tropical fruits, bioactive compounds, enzyme, functional food

### 1. Introduction

In several countries, the majority of food waste is produced by households, while 39% losses occur in the food manufacturing industry where 14% in food service sector and the other remaining 5% in retail and distribution. A large number of food by-products or food waste are increasing recently. This situation will cause serious environmental problems and will cause economic losses if not utilized [1]. The way to solve this problem is to improve the economic value by the valorization of food by-products. In the fruit and vegetable juices making industries, the edible portions of those sources are commonly used, whereas all the peel and seeds are discarded as the industrial waste [2]. This will be considered to valorize the food by-product as a source of valuable ingredients to be used in several industries e.g. food, nutraceuticals, pharmaceutical, etc. Nowadays, in several countries, there is more concern to the industrial ecology concepts such as cradle-to-cradle and a circular economy that will be



considered as leading principle for eco-innovation aiming at zero waste economy that means waste is used as raw material for new products and be applied afterward.

Several tropical fruits are commonly used for juice making in several countries. Unfortunately after the juice production, the pomace as a by-product is not utilized completely. Tropical fruit production, trade, and consumption will increase since the domestic and international market will increase in the future. Several tropical fruits that have been widely used for juice making are papaya, mango, jack fruit, pineapple etc. During the juice making, the by-product is commonly discarded and not fully utilized, especially in developing countries like Indonesia. In several developing countries, these by-products potentially can be used further by the concept of valorization of by-products. Several by-products of tropical fruits still contain high levels of various health enhancing substances that can be extracted from the byproducts, and later be used as a raw material for nutraceutical, nutritional and further purposes [3]. The aim of our research was focusing on the use of food waste coming from tropical fruits by-products, screening for different bioactive compounds in food waste, and also isolating crude enzymes from selected pomace with carotenoid-cleavage activities that can be applied for natural flavor production.

Fruit processing industries contribute more than 0.5 billion tons of waste worldwide. The global benefit of this feedstock and its untapped potential has encouraged researchers to perform detailed studies on value-addition potential of fruit processing waste (FPW). Compared to general food or other biomass-derived waste, FPW are found to be selective and concentrated in nature. The peels, pomace and seed fractions of FPW could potentially be a good feedstock for recovery of bioactive compounds such as pectin, lipids, flavonoids, dietary fibers etc. A novel bio-refinery approach would aim to produce a wider range of valuable chemicals from FPW. The wastes from the majority of the extraction processes may further be used as renewable sources for the production of biofuels. The literature on value addition to fruit derived waste is diverse [4]

This fruit waste (FPW), being rich in moisture and microbial loads, lead directly to environmental pollution. Processing industries, especially in several developing countries, face the constraints of finance, space and in some cases stringent government regulations with respect to waste disposal. The majority of these industries are micro and small-scale (Small Medium Enterprise) which mainly fall under informal sector and, thus, processing waste is considered to be of negligible value compared to the processed fruit [4]. The current classification of FPW (fruit processing waste) as “general waste” makes it an ignored feedstock. Compared to developed countries such as Europe, where the fruit processing waste was found to be a fifth highest contributor (8% of total food waste) to overall food waste, the majority of the fruit and vegetable processing sector data for developing countries was found to be fragmented and insufficient [4].

The primary data from developing countries indicate that large-scale industries process FPW into biogas or compost it to obtain bio fertilizer. Waste from organized and unorganized processing industries, with the exception of very few major composting and biogas generation facilities, is, for the most part, disposed of through municipal waste disposal systems. Many recent reports have focused on food waste recovery and general approaches to lignocellulosic biomass value addition from this waste [4].

The segregation and study of FPW as a particular type of food waste helps in the development of additional bio refinery processes and ultimately improve the economics of food waste based bio-refinery concept. With respect to waste reduction and recovery, a bio refinery operation would have a substantial incentive to develop products and processes for by-product and waste utilization [4].

## **2. Materials and methods**

Proximate analysis was done using AOAC Methods [5]. The total dietary fiber content (TDF) was evaluated by an enzymatic-gravimetric method [6]. Further analysis of bioactive compounds such as a phenolic compound, total  $\beta$ -carotene, and vitamin C were also performed [7–9]. Isolation and partial purification of the enzyme were performed by adapting method developed by Ningrum *et al.*, (2015).

### 3. Results and Discussion

#### 3.1. Recovery of Bioactive Compounds

Several compositional studies of the FPW suggest the presence of a wide range of bioactive compounds in different residual fractions. These bioactive compounds are essentially primary and secondary metabolites of plants. Phenolic compounds, alkaloids, glycosides (the active metabolite bound to a sugar moiety), volatile oils, mucilage, gums, and oleoresins are some of the examples of secondary metabolites. Bioactive-rich extracts may be used in a diverse range of novel applications due to the proven health effects on long-term consumption. Apart from being a rich source of bioactive carbohydrates such as pectin, FPW may be an important source for recovery of cellulose from peels. Our investigation showed that we have recovered several bioactive compounds from several cultivars of citrus and star fruit. Table 1 shows several bioactive compounds in citrus and starfruit pomace.

**Table 1.** Phenolic compound, beta-carotene and vitamin C in several tropical fruit pomace

	Phenolic Compound	Beta Carotene	Vitamin C
<i>Citrus sinensis</i> (L.) <i>Osbeck</i>	800 mg GAE/g	3 mg/g	60 mg/100 g
<i>Starfruit</i>	41000 mg GAE/g	3.56 mg/g	59.33 mg/100g

We also investigated the proximate composition of various FPW from two different cultivars of passion fruit pomace which are presented in Table 2. The various bioactive fractions that were available in FPW generally include carbohydrates, proteins, lipids and secondary metabolites as summarized in Table 2 and discussed further in detail below.

**Table 2.** Characterization of purple and yellow passion fruit pomace

Characteristic	Purple Passion Fruit Pomace	Yellow Passion Fruit Pomace
Water (% wb)	11,84 ± 0,46	10,79 ± 1,78
Ash (% db)	2,49 ± 0,12	2,78 ± 0,07
Protein (% db)	17,08 ± 0,11	18,37 ± 0,65
Lipid (% db)	16,29 ± 0,03	19,02 ± 0,05
Carbohydrate <i>by difference</i> (% db)	52,08 ± 0,38	48,36 ± 2,01
Total Dietart Fiber	40,07 ± 0,55	34,79 ± 0,38
Soluble	1,85 ± 0,12	1,31 ± 0,19
Insoluble	38,21 ± 0,43	33,07 ± 0,18

#### 3.2. Recovery of Active Enzyme for Food Ingredients

The chemical and material potential of FPW still needs to be explored further to find and convert them into more innovative products. FPW is rich in functionalized molecules such as biopolymers, proteins, and carbohydrates which can be recovered, concentrated and used for transformation into value-added precursors, and subsequently be applied in chemical, cosmetic, pharmaceutical and food industries. Thus, attempts have been made to valorize these FPW into new bio-based products such as oligosaccharides, enzymes, bio surfactants, pectin, and high-value chemical intermediates such as furfural and lactic acid [10].

Carotenoids and carotenoid derived aroma compounds are an attractive resource for the industrial production of bioactive substances, such as aroma, food colorants and vitamins, including e.g.  $\alpha$ - and  $\beta$ -ionone,  $\beta$ -damascenone, safranal, retinal and crocetin. Biotechnological production based on natural carotenoid sources promises significant productivity boosts and improved cost efficiencies compared to the current isolation of natural flavors via extraction and distillation. Moreover, recombinant expression of whole carotenoid synthesis pathways followed by cleavage to a final aroma or fragrance is imaginable. Despite the huge amount of products, flavors and food colors based on carotenoids,

biotechnological production has been described only for few biocatalysts on a laboratory scale. Currently used mechanisms lack regiospecific oxidation of the substrate and produce a wide range of cleavage products. The possible in vitro conversion and the unique properties of CCDs make them attractive for research on the substrate recognition and delivery procedures as well as for industrial applications. The variety of flavors, fragrances, and colors created by CCDs is immense, yet only partially elucidated. Colors and fragrances in roses have been investigated in detail and all of them may be synthesized or affected by CCDs. To current knowledge, the ability to cleave carotenoids regiospecific is only possible by using CCDs. Second, molecular oxygen is used for oxidation – the cheapest available oxidant. Third, no cofactors are needed except for a central iron that catalyzes the cleavage reaction. So far no industrial application of CCDs has been developed, but possible applications are investigated, e.g. bleaching of flour or enzymatic conversion of  $\beta$ -carotene into valuable flavors and fragrances.

As a future outlook for the industrial application of the enzyme, dioxigenases can be recombinantly expressed and tailored towards selected properties, e.g. substrates. Based on current knowledge, an industrial application utilizing either organic solvents or surfactants is anticipated. Application of particular surfactants and a specifically tailored CCD seems promising and feasible, whereas the significant activity of CCDs in organic solvents without surfactants is not expected. To current knowledge, a membrane-mimicking environment is essential and cannot be achieved in pure or aqueous mixtures of organic solvents. Eventually this environment can be feigned by immobilization of the enzyme. In this research CCDs enzyme from several tropical fruits e.g. from two different citrus cultivar and two different passion fruit cultivar had been recovered. Each one had a specific optimum pH and temperature for its carotenoids substrate.

### *3.3. Further Development of Functional Food*

According to recent studies, FPW have high potential for reutilization, since most of them still contain many valuable substances, such as phenolic compounds and dietary fiber. Traditionally, the fiber used as functional ingredient is obtained from cereals. However, other plant materials could also be used as potential sources of dietary fiber, such as fruits and vegetables, which have the advantage of containing considerable amounts of antioxidant compounds. Dietary fiber is known as an important compound in human diet, since it supports gastrointestinal health, with insoluble dietary fiber (IDF) acting as a bulking agent to normalize intestinal motility, while soluble dietary fiber (SDF) has an effect on the metabolism of available carbohydrates and lipids, decreasing their intestinal absorbance. Furthermore, fibers have some properties, such as water and oil holding capacity (WHC and OHC, respectively), which can be useful in products that require hydration, to improve yield, and modify texture and viscosity [11].

Antioxidants are substances capable of preventing oxidative damage caused by free radicals. Produced as secondary metabolites in plants, these compounds are used for pharmaceutical, cosmetic, and nutritional purposes. The global trend toward the use of natural components as a food ingredient and the current concern about the safety and toxicity of synthetic additives have led to an increase in the research about natural antioxidants, such as those found in agroindustrial-products. There are several studies that already developed a product from FPW e.g. biscuit from mango and pineapple pomace, candy from beetroot pomace, pasta from carrot pomace, muffin from strawberry, sour cherry, raspberry or black currant pomace, etc [11–14]. Biscuits from passion fruit pomace and enriched coconut oil of carotenoids from passion fruit pomace had also been developed with specific functional value.

## **4. Conclusion**

Food waste from fruits (FPW) generated in the different industrial process is a bio resource for production of high valued products, whilst also address the huge problem of food waste disposal. A new paradigm in the green and sustainable manufacturing of industrially important products is seen in several regions in this world, especially in developing countries, particularly with the persistent efforts

of researchers and increasing government interest of such practices. Innovative valorization products are being explored to recover bioactive compounds and several enzymes and to develop several functional foods.

## Reference

- [1] Mirabella N, Castellani V and Sala S 2014. Current options for the valorization of food manufacturing waste: A review. *J Clean Prod* 2014;65:28–41.
- [2] Jahurul M H, Zaidul I S M, Ghafoor K, Al-Juhaimi F Y, Nyam K-L and Norulaini N 2015. Mango (*Mangifera indica* L.) by-products and their valuable components: A review. *Food Chem* 2015;183:173–80.
- [3] Ayala-Zavala J F, Vega-Vega V, Rosas-Domínguez C, Palafox-Carlos H, Villa-Rodriguez J and Siddiqui M W 2011 Agro-industrial potential of exotic fruit byproducts as a source of food additives. *Food Res Int* 2011;44:1866–74.
- [4] Banerjee J, Singh R, Vijayaraghavan R, Macfarlane D, Patti AF and Arora A 2017 Bioactives from fruit processing wastes: Green approaches to valuable chemicals. *Food Chem* 2017;225:10–22.
- [5] AOAC 1998 *Official methods of analysis of the association of analytical chemists* (16th ed.). Washington: AOAC; 1998.
- [6] Leão D P, Franca A S, Oliveira L S, Bastos R and Coimbra M A 2017 Physicochemical characterization, antioxidant capacity, total phenolic and proanthocyanidin content of flours prepared from pequi ( *Caryocar brasiliense* Camb.) fruit by-products 2017;225:146–53.
- [7] Nagata M and Yamashita I 1992 Simple method for simultaneous determination of chlorophyll and carotenoids in tomato fruit. *Soc Food Sci Technol* (Nippon Shokuhin Kogyo Gakkaishi) 1992;39:925–8.
- [8] Wang L, Jo M J, Katagiri R, Harata K, Ohta M and Ogawa A 2018. Antioxidant effects of citrus pomace extracts processed by super-heated steam. *LWT - Food Sci Technol* 2018;90:331–8.
- [9] Phillips K M, Council-Troche M, McGinty R C, Rasor A S and Tarrago-Trani M T 2016 Stability of vitamin C in fruit and vegetable homogenates stored at different temperatures. *J Food Compos Anal* 2016;45:147–62.
- [10] Ong K L, Kaur G, Pensupa N, Uisan K and Lin C S K 2018 Trends in food waste valorization for the production of chemicals, materials and fuels: Case study South and Southeast Asia. *Bioresour Technol* 2018;248:100–12.
- [11] Selani M M, Bianchini A, Ratnayake W S, Flores R A, Massarioli A P and Alencar S M D 2016 Physicochemical, Functional and Antioxidant Properties of Tropical Fruits Co-products. *Plant Foods Hum Nutr* 2016:137–44.
- [12] Kumar V, Kushwaha R, Goyal A, Tanwar B and Kaur J 2018 Process optimization for the preparation of antioxidant rich ginger candy using beetroot pomace extract. *Food Chem* 2018;245:168–77.
- [13] Juhn K L W T 2016 Food Science and Technology The impact of different baking conditions on the stability of the extractable polyphenols in muffins enriched by strawberry, sour cherry, raspberry or black currant pomace rna 2016;65:946–53.
- [14] Gull A, Prasad K, Kumar P L W T 2015 Food Science and Technology Effect of millet flours and carrot pomace on cooking qualities, color and texture of developed pasta. *LWT - Food Sci Technol* 2015;63:470–4.

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