FRUIT WASTE'S POTENTIAL FOR PRODUCING BIOPOLYMERS

Abstract

Fruit waste includes the unused part of fruit e.g. peel, pomace, and seed. Fruit waste composed of bioactive compounds, lipids and biopolymers. According to the FAO, harvesting, transportation, and processing account for 30% of total food loss. Mango produces the most waste followed by citrus fruits, passion fruit, and peas. The fruit peel and seed include biopolymers such as cellulose, hemicelluloses, starch, pectin, and lignin. Biopolymers are entirely derived from organic sources and are used in the development of bio based films. Traditional plastic can be replaced with bio based film. Synthetic plastic has useful features, but because it is not biodegradable, it harms the entire environment. Researchers produced a bio based packaging film out of biopolymers derived from fruit waste and utilized it for food packing. This chapter discusses the fruit waste obtained from orange, apple, banana, watermelon, and mango, as well as the biopolymers obtained from it.

Keywords: Biopolymer, byproducts, food packaging, waste utilization

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I. INTRODUCTION

Food losses and agricultural byproducts generated from food processing industries create an environmental pollution. Agricultural wastes and industrial byproducts are appealing sources of new valuable materials from zero-value wastes[1]. Food loss is the reduction in mass or quality of food initially produced for consumption. These losses occur across different stages of the food supply chain[2]. Fruits are the good source of vitamins, minerals and fibers. Fruit peel, pomace, seed are the byproducts of the beverage and pulp industry. These byproducts contain industrial importance components like polyphenols, vitamins and minerals [3]. Some of the most important material that can be extracted from agro-industrial leftovers are dietary fibre, proteins, lipids, phenolic compounds, carotenoids, sterols, tocopherols, and terpenes [4]. In numerous models, these compounds have demonstrated important bioactivities as antioxidants. Food additives can be extracted from industrial byproducts and it is use as a coloring, flavoring, and texturizing agent [5]. Fruit leftovers can be composted, transformed into liquid plant fertilizers, or used as animal feed. Fruit waste can also be used to produce biogas, feed worms and insects. According to the FAO 30% of total food lost. Food waste and loss is a worldwide problem. It is a threat to the food business, food security, the economy, and society. No accurate estimates of the extent of food loss and waste (FLW) are available, but studies indicate that FLW is roughly 30 percent of all food globally (FAO 2015*)*. Utilization of these wastes is challenge. By valuing these waste and byproducts, environmental pollution will be decreased, and value-added goods will be produced, potentially opening up new markets and revenue streams[4].

Fruit processing industry concerned about the waste generation and pollution due to improper handling of waste. There are many ways to utilize the fruit byproducts to extract the needful products from them. The byproducts and waste from fruit processing industries generally use as animal feed, composting, adsorbent and extraction of biopolymers. Development of biopolymers from fruit waste is one of the emerging ways to use waste effectively. Biopolymers are the polymers extracted from biomass, biopolymers like cellulose, hemicelluloses, starch, pectin, lignin [6]. Mango produces the most waste (60%), followed by citrus fruits (50%), passion fruit (45%), peas (40%), pineapple (33%), and pomegranate (40%) [7].The biomass produced from the fruit processing industry is a rich source of polysaccharides such as cellulose, pectin, starch, dietary fibers, and bioactive compounds [8]. Dry citrus peels are rich in pectin, cellulose, and hemicelluloses whereas apple pomace are the main product of apple cider and juice processing industries and which contains 7.2- 43.6% cellulose, 4.26- 24.40% hemicelluloses, 15.2-23.5% lignin, 3.5-14.32% pectin, 4.7- 51.10% fiber [9]. Biopolymers along with plasticizers form a biobased film with good properties. This biobased film can be use as alternative to traditional plastic. The entire world is dealing with issues caused by traditional plastics and their waste disposal. In such cases, using bioplastics for food packaging can be a viable alternative to reducing the use of synthetic plastics. This chapter deals with the use of fruit waste for the biopolymer preparation. There are following some of the fruit whose byproducts are generally used in the bioplastic production. Bioplastics are completely made from biopolymers.

1. **Orange:** Citrus waste is a globally abundant, environmentally challenging, and underutilized waste. Sweet oranges are the most commonly grown tropical fruits worldwide among citrus fruits. According to third advance estimates for 2019-20, total orange production in India was 63.97 lakh tonnes. Orange processing generates approximately 50–60% residue of the original orange mass. This massive amount of waste is high in organic matter and water, with a pH of 3-4, and improper handling could cause severe environmental damage. Orange waste also contains pectin, soluble sugars, hemicelluloses, cellulose, starch, protein, lignin, ash, fat, and flavonoids, which have been shown to be beneficial. Pectin is the main component of orange peel. Applications for disposal and recovery that are not up to standard. These compounds, on the other hand, have the potential to be useful in bioplastics applications. Already, orange waste has been used as reinforcement in petrochemical or biobased matrices [10]. Terzioglu et al., 2021[11]developed the orange peel biobased film by adding orange peel to chitosan/polyvinyl alcohol solution. Hosseini et al., 2015 [12] extract the pectin from the orange peel. Pectin is a biopolymer as well as binding agent.

2. **Apple:** The Foreign Agriculture Service (FAS) New Delhi (Post) forecasts the Indian market year 2021-2022. Apple's output stands at 2.3MMT. Apple pomace accounts for 25–30% of the original apple weight. The Food and Agricultural Organization (FAO) reports that 86.14 million tonnes of apples were produced worldwide in 2018. 20% of the apple pomace produced is used as animal feed, while the remaining 80% is transferred to locations for compost [13]. Apple pomace has a 50% carbon content hence it can be used as a microbial feed for the biopolymer synthesis [13]. As a result, million tonnes of apple pomace are produced worldwide each year as a byproduct of juice, cider, or wine production. Because of the acidic nature of apples, as well as their high sugar and low protein content, pomace is unsuitable for land filling and animal feedstock [14]**.** This residue has high moisture content and a biodegradable organic content, making it suitable for the production of bioplastics. Apple pomace's dry mass comprises 7–44% cellulose, 14–17% starch, 15-20% lignin, and 4–14% pectin, all of which can be utilized to make biopolymers [15]. Apple pomace is mostly made up of polysaccharides, which can be used to make films. Wang and Zhao 2021 [16] used the different bleaching procedures to remove the celluloses from apple and kale pomace, and the resulting apple pomace celluloses were then turned into films by adding a plasticizer.

3. **Banana:** Banana cultivated in tropical and subtropical areas. It is one of the large selling fruits among the world. Processed products from banana are chips, jam, and powder. Banana peel is rich in fibers. Banana peel is composed of biopolymers such as lignin, pectin, cellulose, hemicelluloses, fiber, proteins, and some low-molecular-weight compounds[17]. Wasted banana peels are utilized for a variety of purposes, including water filtration, fertilizer, and the manufacturing of ethanol, and cellulose[18].

Table 1: Banana Peel Composition

Sl. No	Parameter	Peel composition (%)
1	Cellulose	12.17
2	Hemi cellulose	10.19
3	Lignin	2.88
4	Sucrose	15.58
5	Glucose	7.45
6	Fructose	6.2
7	Pectin	15.9
8	Protein	5.13

(Source: [17]**)**

Harini et al., 2018[19] developed the method for the extraction of cellulose nanofiber from banana peel. Banana peel extract were used by Bankar et al., 2010[20] to develop a silver nanoparticles. Banana fiber has a superior physical and mechanical property and is important in textile industry. Cellulose and banana peel powder bio composite films were developed by Kumar et al., (2019) [21] using banana peel powder in concentrations ranging from 5% to 25% in a cellulose matrix. The tensile and thermal properties of the produced film were determined, and it is suitable for food packaging and wrapping applications.

4. **Watermelon:** Watermelon is a fleshy, lycopene and water rich fruit. The term "watermelon processing waste" refers to the byproducts and remains produced during the processing of watermelons into various products. China is the largest watermelon producer in the world. To access the edible flesh, watermelons are normally processed by removing the peel, seeds, and other unwanted components of the fruit. Green colored rind is the main byproduct of the watermelon processing industry and it accounts for 30%[22]. Watermelon rind waste utilization is very low. Watermelon rind contains 92-94% moisture, 7-18% protein, crude fiber 3-39%, 9-26% pectin, 26% cellulose, and 0.10% hemicelluloses [23].Watermelon peel contains large amounts of pectin, suggesting that it may serve as a potential source of pectin [24].Watermelon with multiple green hues peels provided the cutin isolate, which produced 6.77 U/ml [25]. Guo et al., 2021[24] prepared the biofilm from watermelon peel pectin and improved the commercial value and performance of the pectin film using ultrasound treatment.

5. **Mango:** Mango is a popular tropical fruit. India, Indonesia, China, Pakistan, Brazil, and Mexico are the top mango producing countries. India accounts for 55% of global mango production. Processing of mango leads to the production of significant amounts of by-products mostly peel and kernels (seed) representing around 24% and 40% of fresh weight, respectively. Peel and seed are key byproducts of mango processing. Mango peel accounts for roughly 15-20% of the fruit. While the seed accounts for 20% to 60% of the total fruit weight, depending on the mango variety, and the kernel within the seed accounts for 45% to 75% of the total seed weight[26].Mango peel is rich in pectin, cellulose, hemicelluloses, lipids, proteins, polyphenols and carotenoids [27]. Currently mango peel is not used for the extraction of valuable compounds but it is a rich source of pectin and dietary fiber [28]. Mango kernels are characterized by a high carbohydrate and protein content and good profile of essential amino acids and lipids [29]. The total

phenolic content of mango peel was found to be higher (92.6 mg gallic acid equivalents (GAE)/g) than that of mango flesh (27.8 mg GAE/g) [7]. Mango peel constitutes 7-24% of total fruit; composition of mango peel is given in the table 2.

Table 2: Mango Peel Constituents

Sl. No	Constituents	Value
1	Crude fat	42.24%
2	Protein	11.67%
3	Carbohydrate	32.31%
4	Crude fiber	6.32%
5	Moisture	7.51%

(Source: [30])

Cheng et al (2021)[31] synthesized the AgNPs nano particles by reducing silver nitrate with mango peel extract and combining it with the biodegradable polymer PLA. Adilah et al. (2018)[32]made a film out of fish gelatin and mango peel extract. Mango peel extract can be used to make active packaging film.

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