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# Applications of agricultural waste in food industry

Saeideh Barati*

*Department of Food Science and Technology, ShahreKord Branch, Islamic Azad University, Shahrekord, Iran*

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**Abstract:** Agricultural wastes are by-product outputs of production and processing of agricultural products that contain bioactive compounds, which have many benefits on human health. Agricultural wastes produced from various sources such as cultivation, livestock, industrial means, and etc are great concern because of the problems of environmental pollution, recycling and utilization. Therefore, application of agricultural wastes in any other environmentally friendly way like compost production by fermenting the agricultural, animal feed production, food production and energy production (bio gas) is suggested. It can be concluded that recycling agricultural wastes is important and necessary for environment and economical saving. This recycling of agriculture wastes enhance agricultural and food production along with improve their quality.

**Keywords:** Agricultural waste, bioactive compounds, food fortification, Fruits pomace

## 1 Introduction

### 1. 1. Agricultural waste

Agricultural wastes (agro-wastes) are defined as the residues from the growing and processing of raw agricultural products like fruits, vegetables, meat, poultry, dairy products, and crops. Agricultural waste is composed of animal waste, food processing waste, crop waste (corn stalks, sugarcane bagasse, residue from fruits and vegetables) and toxic agricultural waste (pesticides, insecticides and herbicides) (Sabiiti, 2011). Application of agricultural wastes have been discussed from different points of view, like production of pharmaceutical ingredients, nanomaterials such as nano-silica and nanocellulose, agro-composites for packaging, nano-

*e-mail: saeideh.barati@yahoo.com

adsorbents, bioenergy production, and bioactive compounds (El-Ramady et al., 2022). These wastes are rich source of nitrogen, potassium, phosphorus that would improve soil fertility and increase nutritional value of food products and enhance food security. Agricultural wastes are widely available, renewable and relatively free, thus they can be an important resource for the production of bioactive compounds (Hansen and Cheong, 2019). Waste can be used as a resource for production of heat, steam, charcoal, methanol, ethanol, bio diesel, animal feed, energy and biogas and etc. Nevertheless, many of the agricultural wastes in developing countries are underutilized, and left to rot or openly burned (Mamo and Zewide, 2022). There are many economic benefits include increasing the resource use efficiency of agricultural production, increasing farm incomes and reducing the costs of production, enhancing the profitability of farming, producing novel products, minimizing the disposal of the by-products into the environment for agricultural waste (Tiwari and Khawas, 2021). The principal challenges have been identified in agro-waste management include poor or unpredictable nutrient bioavailability for cultivated plants, lack of biorefinery technologies for nutrient re-use and biofuel production, hazardous pollutants that could threaten food safety, insufficient information about reducing greenhouse gas emissions, and lack of awareness on how to enhance soil health and functions through the application of organic fertilizers (Chen et al., 2020). Summary of types of agro wastes are presented in Table 1 (Lai et al., 2017).

Table 1. Summary of types of agro wastes (Lai et al., 2017)

| **Types of agro wastes** | **Value added products** |
|---|---|
| **Plant parts, wastes cassava bagasse** | Gluten-free noodle, lactic acid |
| **Sugarcane bagasse** | Lactic acid, ethanol, inulinase, xylitol |
| **Coffee husk, corncobs** | Anthocyanin, vanillin,xylitol, anthocyanin, prebiotic (oligosaccharide) |
| **Palm empty fruit bunch** | Xylose |
| **Rice hull** | Antioxidant and phenolic compounds, rice hull smoke extract |
| **Wheat bran** | Antioxidant and phenolic compounds, flour, arabinoxylooligosaccharides, bread, meat patties, noodle |
| **Pressed cakes, defatted corn germ** | Wheat flour, wheat bread, cookies |
| **Defatted rice bran** | D -lactic acid, bakery products (bread), pan bread, vitamins B, rice bran protein, phenolic acids |
| **Palm mesocarp fiber, palm pericarp fiber, sunflower seed** | Phenolic-saponins rich fraction, Β-carotene, bread, oil, wheat bread, sunflower seed protein |
| **Fruit rinds, skins, wastes, apple pomace** | Cake, pectin, fat replacer, phenolic and antioxidant compounds |
| **Citrus wastes, grape pomace** | Xyloglucan, pectin, polyphenol and antioxidant compounds, xylanase and pectinase, procyanidin |
| **Jackfruit seed** | Fiber source for cookies, anthocyanin, monascus pigments, starch as thickener and stabilizer in chili sauce, starch, floor |
| **Kiwi fruit peel, Pineapple wastes** | Pectin, polyphenol, bromelain, citric acid, vinegar, bioprotein |

**1. 2. Valorisation of agro-industry wastes**

Many studies indicate the effective application of agro-industry waste as a raw material for the production of value- added products. Nowadays, bioethanol and liquid-fuels mainly generate by the utilize agro-industry waste as raw materials, that obtained by hydrolysis of waste followed by fermentation or simultaneous saccharification and fermentation. Currently, the use of agricultural waste for the production of various enzymes has received much attention. These wastes are a rich source of polysaccharides (cellulose, hemicellulose, starch, pectin, and inulin), fiber, protein, and minerals (Table 2) (Ravindran et al., 2018).

Table 2. Chemical composition of agro-industry residues (Ravindran et al., 2018)

| Agro-industry residues | Carbohydrates (%) | Crude fiber (%) | Ash (%) | Pectin (%) | Fat (%) | Protein (%) | Lignin (%) |
|---|---|---|---|---|---|---|---|
| **Sugarcane Bagasse** | 66.48 | - | 8.80 | - | - | 2.3 | 17.79 |
| **Rice Bran** | 14.10 | 26.90 | 3.40 | - | 30.40 | 38.20 | 25.63 |
| **Wheat Bran** | 56.8 | 33.40 | 3.90 | - | 3.50 | 13.20 | 5.60 |
| **Spent Coffee Waste** | 55.53 | 60.46 | 1.30 | - | 2.29 | 17.44 | 23.90 |
| **Brewer’s spent grain** | 79.90 | 3.30 | 7.90 | - | - | 2.40 | 30.48 |
| **Cassava peel** | 75.50 | 11.20 | 2.40 | - | 3.10 | 1.70 | 1.92 |
| **Apple Pomace** | 48.00 | - | 4.70 | - | - | 3.90-5.70 | 23.50 |
| **Crude Olive Pomace** | 34.80 | - | 6.60 | - | 16.65 | 0.4 | 43.20 |
| **Banana peel** | 79.00 | 9.30 | 2.70 | - | 3.00 | 0.6 | 6.40 |
| **Citrus peel** | 30.00 | - | 1.70 | 14.40 | - | 7.90 | 1.00 |

It is well known that agricultural and food wastes are a rich source of recovering highly valuable bioactive compounds, because of these wastes are good sources of carbohydrates, proteins, phenolic compounds, dietary fibers, sugar derivatives, organic acids, vitamins, and minerals (Fig 1) (Ali et al., 2022).

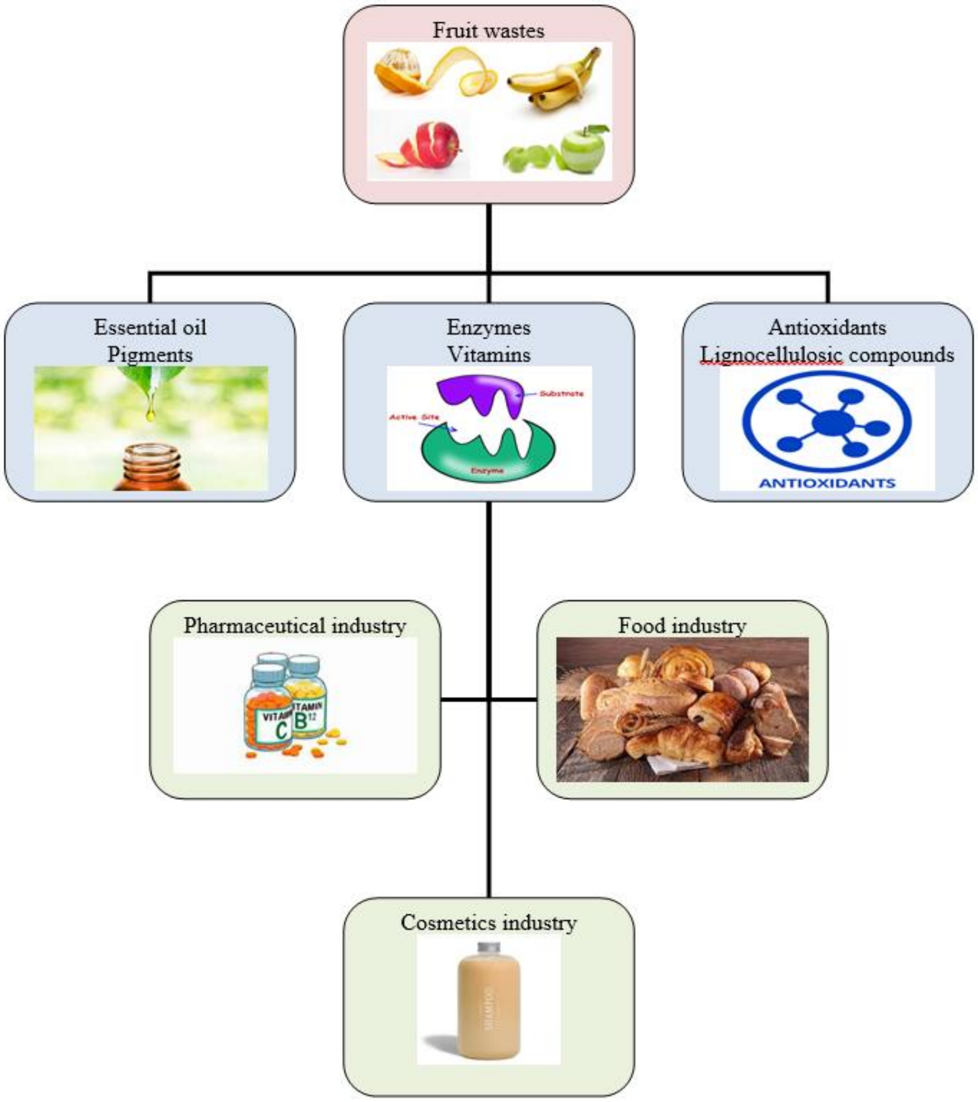


Figure 1. Schematic of fruit and vegetables wastes and its usage in different industrial sectors (Ali et al., 2022)

### 1. 3. Agricultural waste in the food industry

Agro-industrial wastes, include the wastes generated during the industrial processing of agricultural or animal products in the form of corn steep liquor, wheat bran, soybean meal, sugarcane bagasse, bagasse from legumes or cereals milling, spent coffee grounds, whey, and etc (Fig 2). Agro-industrial wastes are composed of cellulose, hemicelluloses and lignin, sugars, fibers, proteins, and minerals. Food processing waste treatments may consist of physical, chemical, and enzymatic that can be given to these by-products in order to make them easily consumed by microbes. The wastes generated from the different food industries have been discussed in the following sections (Panesar et al., 2016).

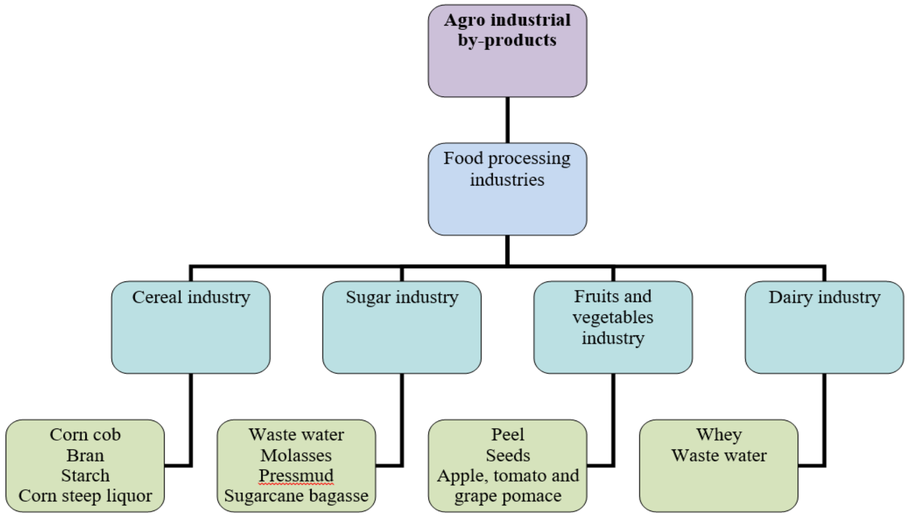


Figure 2. Schematic generation of agro-industrial by-products from different food processing industries (Panesar et al., 2016)

### 1. 3. 1. Dairy industry

Dairy wastes are mainly dilutions of whole milk, separated milk, butter milk, and whey. They are high in dissolved organic matter in the form of the proteins and lactose but low in suspended solids, except for the fine curd found in cheese processing wastes. The most visible source of waste in the dairy processing plant is in the whey resulting from the various cheese processing operations. Dissolved air flotation (DAF) is one of the most useful waste treatment for different types of food processing wastes, including dairy processing waste, especially in cheese production process. Schematic of whey processing into various products is shown in Fig 3 (Panesar et al., 2016).

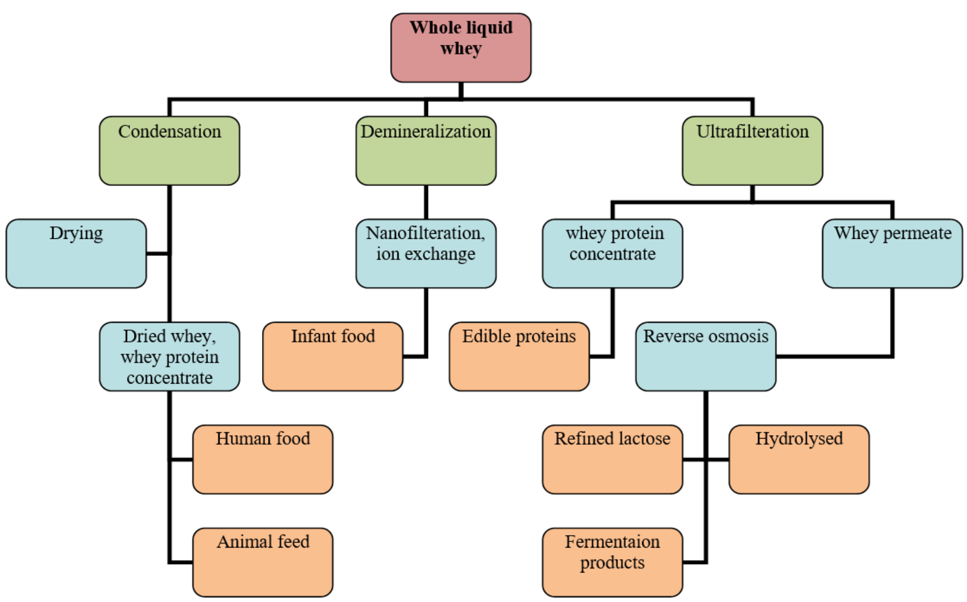


Figure 3. Schematic presentation of whey processing into various products (Hansen and Cheong, 2019).

The type of waste treatment for these wastes includes screens and fat traps to remove particles contained in the wastewater, flotation with some chemical addition to remove suspended solids and emulsified fats, aeration of the waste to minimize organic and nitrogen load, anaerobic lagoons to destroy organic solids, biofilters, carbon filters, and scrubbers to control odors and air emissions, disinfection of the final effluent, and anaerobic digestion (Panesar et al., 2016).

**1. 3. 2. Fruit and vegetable industries**

The increasing processing of fruits and vegetables has led to the production of large volume of wastes in the form of leaves or straw during the processing, or seeds after processing or pulp and pomace (Panesar et al., 2016). Waste from fruit and vegetable originates from trimming, culling, juicing, and blanching of fruit and vegetables. They are high in suspended solids, colloidal and dissolved organic matter, the main components being starch and fruit sugars. For example, major part of the organic wastes from a cannery is sugar. Sugar beet waste is also comprised of sugars, which more than 90% of total sugar is sucrose with raffinose making up most of the remainder, although the waste is low in nitrogen and phosphorous. Nowadays, in all over the worldfood fortification with bioactive compounds deriving from agricultural waste is of great interest. The citrus peel waste is generated from the citrus fruit, which plays as a potential substrate for fermentative process. Moreover, fruits pomace is the potential substrates for microbial cultivation as these are rich source of antioxidants, antimicrobial compounds, phytochemicals and vitamins to help these operations (Schieber et al., 2001). For example, the one extracted component obtained from grape and wine pomace is anthocyanins. Grape seed oil is another extracted product obtained from grape seeds. Tartaric acid and different phenolic compounds is another interesting product recovered from wine pomace. Tartaric acid is widely used in various food industry including dairy products, edible oils, fish and meat products, fruit and vegetable products, and alcoholic drinks (García-Lomillo and González-SanJosé, 2017). Citrus by-products are a cheap and abundant source of flavonoids and phenolic compounds. Important glycosylated flavanones and aglycones like hesperidin, narirutinare, hesperetin and naringenin exist in this type of pomace (Pratik and Surekha, 2016). Younis and Ahmad (2015) reported that buffalo meat sausages incorporated with apple pomace powder showed high cooking yield and emulsion stability. Moreover, the dietary fiber content of buffalo meat sausages increased with the incorporation of apple pomace powder (Younis and Ahmad, 2015). In another study, results showed that the replacement of a percentage of meat with apple pomace in salami production improved fibre and phenol content, together with the lower fat and calories of product (Grispoldi et al., 2022). Common fruit and vegetable waste treatment processes are includes screening, trickling filters, sedimentation, activated sludge process, aerated lagoons and stabilization basins, anaerobic lagoons, anaerobic digestion, fungal treatment, and tertiary (chemical, chlorine, ultraviolet light) (Hansen and Cheong, 2019).

**1. 3. 3. Sugar industry**

Milling of the cane stalks for sugar production results in the generation of several by-products such as waste-water, and molasses, sugarcane bagasse (Harish et al., 2020).

### 1. 3. 4. Cereal industry

The major by-products of cereal processing are the bran and the germ obtained during milling processes. Another by-product obtained during the wet milling of corn is corn steep liquor, which is used as a nutrient source in feed and fermentation processes. During the processing of rice, rice hulls and rice bran are obtained that is a good source of thiamin, amino acids, proteins and crude fat, and a poor source of crude fiber (Tufail et al., 2022). Herrmann and Souza (2021) showed that the sausage formulation with addition of 3% of barley malt pomace had high protein and fiber content, thus indicating an increase in product nutritional value (Herrmann and Souza, 2021).

### 1. 3. 5. Oil industry

Argan press-cake is a low-cost agricultural waste generated from the oil production of argan nuts. Argan press-cake is a good source of cellulose and other components, such as hemicelluloses, proteins, and lipids. Hu et al. (2017) by using an alkaline processing approach consisting of applying a mild heating at 80 °C in a solution containing sodium hydroxide (12%) and sodium sulfate (8%) could extracted cellulose from argan press-cake (Ancuta and Sonia, 2020).

## 1. 4. Modification (by-products to food product)

Agro-industrial wastes are often under-utilized and create a main disposal problem. Food processing wastes are promising sources of compounds like dietary fiber, antioxidants, essential fatty acids, antimicrobials, minerals due to their nutritional and functional properties. The higher-value products may be developed by several modification methods (Lai et al., 2017).

### 1. 4. 1. Extraction

Different compounds such as tocopherols, flavonoids, coumarins, cinnamic acid derivatives, and chalcones; phenolic diterpenes; and phenolic acids can be isolated using solvent extraction. Non-polar solvents can be used for the extract of tocopherols and certain phenolic terpenes. Solvents of higher polarity can extract flavonoid glycosides and higher molecular weight phenolics (Lai et al., 2017).

### 1. 4. 2. Thermal processing

Thermal processing (steaming, microwave, sterilization) has also been found to enhance the extract of phenolic compounds. Researchers revealed that the total phenolic content of citrus peel increased after heating at 150 for 40 min (Jeong et al., 2004). Benítez et al. (2011) reported that the sterilizing onion by-products improved the soluble: insoluble fiber ratio along with less oil holding capacity, cation exchange capacity and swelling capacity (Benítez et al., 2011). Microwave heating increased recovery of total phenols from berries pomace compared to the conventional solid-liquid extraction (Galanakis et al., 2013).

### 1. 4. 3. Supercritical fluid extraction

Supercritical fluid extraction has advantages over the conventional methods, including shorter operation times, high selectivities and high extraction yields. Many applications have been Known using supercritical fluid extraction in the extract of components from grape residues, including oil from seeds, tannins from seeds and polyphenols from both skins and seeds (Fierascu et al., 2019).

**1. 4. 4. Solid-state fermentation**

Agro-industrial wastes are introduced as the best substrates for solid-state fermentation, especially for enzyme production. Various studies have shown that apple pomace undergone solid-state fermentation causes production of organic acids, heteropolysaccharide (xanthan, chitosan), volatile aromatic compounds, bioethanol, enzymes, edible mushroom, and antioxidants, because of the presence of lignin, cellulose and hemicellulose in apple pomace acts as natural inducers, ehancing fungal growth and thus making the process more economical for enzymes production (Fierascu et al., 2019).

**1. 4. 5. Extrusion**

Extrusion process at high temperature bring gelatinization of starch, denaturation of protein, modification of lipid and inactivation of enzymes, microbes and antinutritional agents. Nowadays, the fruit wastes such as defatted hazelnut flour and durum flour can be used in combination with cereal flours for production of extruded snack foods (Lai et al., 2017).

**1. 4. 6. Enzymatic hydrolysis**

Enzymatic hydrolysis has been used for converting animal by-products, especially fish proteins to hydrolysates with a high degree of hydrolysis and yield. Today, large level of proteinaceous wastes in form of heads, scales, bones and viscera from fish processing are used for the production of protein concentrate and hydrolysate. In addition, chicken wastes such as viscera, head, skin, and feet can also as a source of hydrolysates source of peptone in microbiological media (Yusree et al., 2021).

**1. 5. Using waste to fortification of food products**

Protein-calorie malnutrition is one of the nutritional problems in developing countries. Food fortification introduces as a strategy to eliminate malnutrition. Nowadays, foods including milk, wheat and maize flour, sugar, vegetable oil and etc are being fortified with various vitamins and minerals, especially iron and zinc. Food and agricultural waste are rich in protein, dietary fiber and beneficial bioactive compounds. Therefore, their use in food fortification is recommended. Application of agro-wastes as functional food ingredients in food fortification is summarized in Table 3. For example, defatted seed meal from oil has been widely used in fortification of cereal based products. Researches on high fiber bread and cookies supplemented with palm pressed fiber, defatted palm kernel cake or oil palm trunks have been reported. Cookies were produced using defatted wheat germ, defatted maize germ four, and king palm flour. Apple pomace incorporated with wheat flour to improve the rheological properties of flour in cake making. Apple skin powder was applied to substitute wheat flour in muffin. In another study, noodles, pancakes and cereals bars were produced with grape seed flour extracted from pomace. Mango peel with the aim of improved antioxidant properties was used in the production of macaroni. Apart from bakery products, fruit fibers have been used in the fortification of dairy products. Yogurt with high nutritional value used with fruit fiber, fruit peel powder and white grape pomace (Torres-Leon et al., 2018).

Table 3. Agricultural wastes as fortificants in food products (Lai et al., 2017)

| Agricultural wastes | Food products fortified | Nutrients being fortified |
|---|---|---|
| **Defatted soybean meal** | Tortilla | Increased protein content |
| **Defatted soy flour** | Pretzel products | Protein enrichment, increased calcium, potassium, magnesium, phosphorus and sulphur content |
| **Toasted or partially defatted soy flour** | Pasta | Increased protein content |
| **Defatted soy flour** | Spaghetti | Increased protein content, increased lysine, threonine and amino acids content |
| **Defatted soy flour** | Biscuits | Increased mineral, oil, crude fiber, protein and lysine content |
| **Defatted soy flour** | Wheat bread | Increased protein content |
| **Brown rice flour** | Wheat-based dough, wheat-based flat bread | Increase ash content, decreased gluten content |
| **Defatted wheat germ** | cookies | Increased protein, fiber, calcium, potassium, iron and casein content |
| **King palm flour** | Gluten-free cookies | Increased dietary fiber, calcium, magnesium, potassium, iron, zinc and manganese content |
| **King palm flour, sieved king palm flour** | Cookies | Increased total dietary fiber content |
| **Defatted maize germ flour** | Cookies | Increased protein and fiber content |
| **Defatted rice bran** | Chapatti | Increased total dietary fiber content |
| **Defatted wheat germ flour** | Noodle | Increased mineral, fiber and protein content |
| **Extruded flaxseed meal, partially defatted soy meal, wheat bran, heat germ** | Cereal bars | Enhanced quality and quantity of proteins, dietary fiber and u6:u3 ratio. |
| **Defatted soybean anddefatted melon flour** | Fried cassava balls | Increased protein, ash and energy content |

### 1. 6. Plant food wastes as a source of antioxidant phenolic

Phenolic compounds are known to be the largest groups of secondary metabolites produced by the plants, which play a key role in plant resistance to response from the environment surroundings. Phenolic compounds have bioactivities potentially beneficial for human health, such as antioxidant and antimicrobial properties, antitumor, antiproliferative, anti-inflammatory, anti-obesity, and even ultraviolet radiation protective activity. Phenolic compounds can be used as preservatives, considering their antioxidant and antimicrobial activities; and or to improve the organoleptic properties of products as flavourings and colorants, considering that they are volatile substances and have aroma. Agro-food industry produces a large amount of organic agricultural waste such as plant tissues (seeds or peels) that are a good source of water and organic matter. As well as, they are rich in organic materials turn them into an source for bioactive compounds for the production of high value-added products. In recent years, researchers have focused on the use of agro-food industry wastes to produce bioactive compounds such as phenolic compounds. For example, Kereem and Rahman (2013) studied the extracted citric acid from banana peel (Kereem and Rahman, 2013). Dorta et al. (2014) selected mango peels and seeds for extraction phenolic compounds (Dorta et al., 2014). Table 4 shows a variety of studies dealing with the extraction of phenolic compounds from different organic agricultural waste. Fruit seeds like berry seeds are by-products derived from the manipulation of the fruits, which could become a raw material as a source of ingredients with bioactive capabilities. Tomato leaves waste is a rich source of phenolic compounds, which can be used in a wide range of applications. Coffee by-products such as coffee pulp and husk have a large amounts of polyphenols, chlorogenic acid, gallic acid, rutin and protocatechuic acid, that can also be used in food fortification. Grape waste such as pomace, grape seeds, and grape skin that contain several bioactive compounds like quercetin, catechin, epicatechin, rutin, myricetin, kaempferol, ellagic acid, gallic acid, syringic acid, caffeic acid, and trans-resveratrol, which have health benefits. Soybean by-products are rich in genistein, glycitein, genistin, malonylgenistin or apigenin can be used as a raw material available all year round (Table 4) (Jimenez-Lopez et al., 2020). Citrus peels, seeds and pulp produce in orange and lemon juice processing are a rich source of hydroxycinnamic acids and flavonoids, mainly flavanone glycosides (hesperidin, naringin, and narirestin), flavanones (hesperetin and naringenin), and flavone aglycons (luteolin). Banana peels have high amounts of phenolic compounds, especially flavonoids and proanthocyanidins, and or pineapple peels are in rich of gallic acid, catechin, epicatechin, and ferulic acid. As well as, nut shells endocarps are a good source of phenolic compounds. Carrot pomace from carrot juice production is a rich source of hydroxycinnamic acid derivatives and chlorogenic acid, which have potential antiviral, antimutagenic, anti-inflammatory, cardioprotective, and antiobesity. Potato peels are rich in phenolic acids and derivatives, especially chlorogenic acids. The main phenolic compounds in skin and fleshy leaves of onions are flavonoids such as quercetin and kaempferol glycosides (Panzella et al., 2020).

Table 4. Agricultural waste sources used to obtain phenolic compounds (Jimenez-Lopez et al., 2020).

| Source | By-product | Target individual compounds |
|---|---|---|
| **Mango** | Peel | Tannins and Total phenolic compounds |
| **Tomato** | Bagasse, Leaf | Flavonoids and Total phenolic compounds, Phylloquinone |
| **Grape** | Pomace | Total phenolic compounds |
| **Giant reed** | Stem | Levulinic acid |
| **Pine** | Bark | Total phenolic compounds |
| **Coffee** | Cherry pulp | Gallic acid // Protocatechuic acid // Chlorogenic acid // Rutin // Catechins |
| **Blueberry** | Seeds | Ascorbic acid |

| | | |
|---|---|---|
| **Blackberry** | Seeds | Cyanidin 3-O-glucoside // Ellagic acid // Galloyl-HHDP-glucose // Galloyl-bis-HHDP-glucose |
| **Olive** | Green leaves, Dried leaves, Pitted olive pulp, Mill solid wastes | Hydroxytyrosol // Elenolic acid // Verbascoside // Flavonoids // Lignans, Cinnamic acid // p-Coumaric acid // Caffeic acid // 4-ydroxybenzoic acid // Protocatechuic acid // Gallic acid // phenol // Vanillic acid // Veratric acid // 345-Trimethoxybenzoic acid // Syringic acid |
| **Cranberry** | Seed oil | 4-(2-hydroxyethyl) phenol // p-coumaric acid // homovanillic acid vanillic // acid protocatechuic acid |
| **Avocado** | Seed and Peel | Caffeic acid // (-)-Epicatechin // Vanillin // p-Coumaric acid // Ferulic acid // Sinapic acid // Procyanidin B4 // Quercetin diglucoside // Quercetin-3-O-arabinosyl-glucoside // Quercetin-3-O-glucoside // Quercetin-3-O-rutinoside // Quinic acid // Procyanidin dimer A // Procyanidin trimer B1 // Procyanidin dimer B1 // Procyanidin trimer B2 Syringic acid // Procyanidin dimer B2 // (+)-Catechin // Procyanidin trimer A // Procyanidin dimer B2 // Procyanidin trimer B3 // 5-O-Caffeoyl-quinic acid // Quercetin // Phloridzin // Quercetin 3-O-rhamnoside // Quercetin // Apigenin // Kaempferol |
| **Artichoke** | Bracts and stem's | Total phenolic compounds |
| **Sugar Beet** | Pulp | Total phenolic compounds |
| **Beetroot** | Leaves and stems | dihydroxybenzoic acid // 4-aminobenzoic acid // 4-hydroxymethylbenzoic acid // Caffeic acid // Chlorogenic acid // Ellagic acid // Ferulic acid // Gallic acid // Mandelic acid // Methoxyphenylacetic acid // p-Anisicacid // p-Coumaric acid |
| **Lúcuma** | Seeds | Gallic acid // Pyrogallol // Gallocatechin- // Catechin // Dihydroxyphenyl methyl ketone // Vitexin // Epicatechin // Epigallocatechin-3-O-gallate // Methoxy penthoxy catechol // Hidroxy benzoic acid // Ethyl gallate // Myricitrin // Phloretin hexoside // Taxifolin I e II // Methoxy catechol // Myricetin // Quercetin // Syringin // Eriodictyol chalcone // Eridictyol // Apigenin // Naringenin |
| **Eggplant** | Peel | Total phenolic compounds |
| **Pomegranate** | Peel, mesocarp, aril and seeds | Ellagic acid // Ellagic acid-hexoside // Ellagic aciddeoxyhexoside // Ellagic acid-pentoside // Ellagic acid derivative // Galloyl-hexahydroxydiphenoyl-hexoside // Ellagic acid dihexoside // Valoneic acid bilactone // Lagerstannin B derivative // Galloyl-hexoside // Hexahydroxydiphenoyl-gallagyl hexoside (punicalagin) // Caffeic acid hexoside // Ferulic acid hexoside // 5-O-Caffeoylquinic acid // Caffeic acid derivative // Protocatechuic acid derivative // Vanillic acid hexoside |
| **Papaya** | Seeds | Ferulic acid // Mandelic acid // Vanillic acid |

### 1. 7. Using waste to nutrient recovery

Agricultural wastes are rich in nutrients like nitrogen, phosphorus, and potassium. Table 5 shows the nutrient values of agro wastes. For phosphorus recovery from agro-waste, microbes mainly used as phosphorus recycling. In this regards, phototrophic and heterotrophic organisms have a key play in accumulation of nutrients. Generally, proteobacteria such as cyanobacteria, purple non-sulfur bacteria and polyphosphate accumulating organisms using for recovery of nutrients (Vaish et al., 2020).

Table 5. Ntrient content of various agro wastes (Vaish et al., 2020)

| Agro waste | Nitrogen (%) | Potassium (%) | Phosphorus (%) |
|---|---|---|---|
| **Cereals** | 0.10 | 0.00 | 0.00 |
| **Corn cob** | 1.38 | 0.46 | 0.09 |
| **Corn Grain** | 2.15 | 0.42 | 0.34 |
| **Corn leaves** | 1.30 | 1.48 | 0.21 |
| **Corn silage** | 1.30 | 0.90 | 0.16 |
| **Corn stem** | 0.84 | 1.23 | 0.09 |
| **Pine** | 0.10 | 0.00 | 0.00 |
| **Peach leaves** | 0.00 | 2.45 | 0.14 |
| **Sugarcane bagasse** | 0.73 | 0.00 | 0.00 |
| **Rapeseed crop biomass** | 3.3-5.4 | 0.00 | 0.00 |

Blue green algae (cyanobacteria) are most used for nitrogen recovery. In addition, physico-chemical techniques such as ion exchange, electrodialysis, and liquid gas stripping are used for nitrogen uptake. Plantain waste, cocoa waste, water hyacinth and market waste are a good source of potassium. Potassium recycling can conducted by vermicomposting, membrane-based treatment chain, and membrane filtration (Vaish et al., 2020).

# 2 Conclusion

Agricultural wastes are residues that generate from the growing and first processing of agricultural materials, which can be an importance resource for improving nutritional value and security of food; while if not these wastes treated or disposed, can lead to adverse human health or pollution to the environment. Agro-Wastes are heterogeneous and highly nutritious in nature, hence focusing researchist to different recovery ways to obtain bioactive compounds to assistance to a sustainable bioeconomy; in which bio materials extract from organic agricultural waste, and renewed recovery compounds are reinserted in the production chain. We conclude that fruit and vegetables byproducts are a good source of natural food ingredients. In addition, the phytochemicals in fruit and vegetable wastes can use in the food industry for increasing the nutrition value and stability of food products, which can also contribute to health benefits to consumers.

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## Conflict of interests

The author has no conflict of interests to declare.

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