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Review Article

FRUIT WASTE ITS FUNCTIONALITY AND UTILIZATION

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ABSTRACT

"Fruit" normally means the fleshy seed - associated structures of a plant. Fruit pomace (skin, seed, marc) a byproduct of pressing raw fruits for juice, is a rich source of nutrients and bioactive components. Fruit waste generated from fruit pomace centers are rich source of polyphenol, flavanoids, tannins, ascorbic acid, natural antioxidants, fibre and other bio active compounds which contributes to the activity of antioxidants. It can be utilized for various food preparations in the form dried or incorporated into many value added foods.

INTRODUCTION

A fruit is the seed-bearing structure in flowering plants (also known as angiosperms) formed from the ovary after flowering. In common language usage, "fruit" normally means the fleshy seed - associated structures of a plant that are sweet or sour, and edible in the raw state, such as apples, bananas, grapes, lemons, oranges and strawberries. On the other hand, in botanical usage,

"fruit" includes many structures that are not commonly called "fruits", such as bean pods, corn kernels, tomatoes and wheat grains (James, 2003).

Fruits and vegetables include a diverse group of plant foods that vary greatly in content of energy and nutrients. Additionally, fruits and vegetables supply dietary fiber, and fiber intakeislinked to lower incidence of cardiovascular disease and obesity. It also supply vitamins and minerals to the diet and are sources of phytochemicals that function as antioxidants, phytoestrogens and anti-inflammatory agents (Salvin and Lloyd, 2012).

Fruit and Juice Production and Waste

Fruit production has surged impressively, making India the second largest global producer behind China. Annual growth in horticulture has seen fruit production grow faster than vegetables though the latter constitute the largest segment of this sector of agriculture. Grapes occupy the premier position in the exports with 107.3 thousand tones valued at 1,086 crore in 2014–2015, other fruits which attained significant positioninexports are banana and mango. China tops the list of fruit production with 154.364 million tones (MT) in 2013 followed by india (82.631 MT), Brazil (37.774 MT), USA (26.986 M), Spain (17.699 MT), Mexico (17.553 MT), Italy (16.371 MT) and Indonesia (16.003 MT). Surprisingly though productivity is a weak spot, IndiadoesbetterthanChina and Spain. The handbook published by the Oxford University press, points out that significant progress have been made in increasing area and horticulture resulting in higher production. Over the last decade, the area under horticulture grew by about 2.7 percent per annum and annual production increased by 7 percent (http://ishrae.in/newsdetails/India-nd-Largest-Fruit-Vegetable-Producer-In-World-/471).

Fruit peels are natural sources of antioxidants, and contains higher concentrations of dietary fibre and carbohydrates especially pectin. Fruit peels that become wastes consequently add to the current severe pollution problem. Fruit peel can be utilized to produce valuable products for human being to prevent diabetes mellitus, cardiovascular disease and cancer (Aruna and Suneetha, 2016). Fruit pomace, a byproduct of the fruit juice industry, is a rich source of nutrients and bioactive

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components. The study explored that fruit pomace was rich in dietary fiber (insoluble fiber: 24.15–31.83%; soluble fiber: 0.43–19.71%). Both orange and sweet lemon pomace were good sources of calcium (303 mg/100 g and 581 mg/100 g). Extract yield was high in blue grapes (45.88 mg/100 g). Free radical scavenging activity was highest in blue grape pomace in methanol and aqueous extracts (78.88% and 85.99% per 4-mg extract), respectively. Thus, this pomace could be natural sources of phenolic components (Nagarajaiah and Prakash, 2016).

The fruit and vegetable sector generates large amounts of waste. In industrialized countries, fruit and vegetable waste(FVW) is mainly generated before reaching consumers, due to programmed overproduction and unfulfillment of retailer quality standards. FVW poses environmental problems due to its high biodegradability, represents a loss of valuable biomass and an economic cost for companies. Different reduction, reuse and recycle strategies to tackle FVW need to be proposed (Plazzotta *et al*., 2017).

Processing of fruits produces two types of waste: a solid waste of peel/skin, seeds, stones and a liquid waste of the juice and wash waters. In some fruits the discarded portion can be very high (eg mango 30-50 %, banana 20 %, pine apple 40-50 % and orange 30-50 %) (Chacko and Estherlydia, 2014). There are number of possibilities for use of some types of solid fruit waste but there is as yet no evidence that any of these are economic. The major problem in using fruit waste is to ensure that the waste has a reasonable microbial quality. It is not advisable to store-up waste and it should be used on the same day of production, so preliminary separation takes place during processing. The six main products considered after juice processing includes Candied peel, Oils, Pectin, Reformed fruit pieces, Enzymes and wine/vinegar (www.appropedia.org/fruitwaste utilization).

Harvested fruits and vegetables require adequate and advanced post-harvest processing technologies for minimizing the qualitative as well quantitative losses after harvesting. Nearly 40 per cent fruits and vegetables are wasted every year due to improper handling, storage and packaging and transportation. Due to high water activity, fruits and vegetables have been spoiled during harvesting to marketing. Total of 30-40 per cent fruits and vegetables wastage occurred within harvesting to consumption. Minimizing the losses directly influence the global food security. This would help to enhance the per capita availability of fruits and vegetables by applying intensive and modern technologies because of reduction in losses automatically increased the availability of products without applying extra resources for enhancing the production and productivity (Singh *et al*., 2014).The fraction of residues that remains after juice processing ranges from approximately 15 per cent for grapes to 50 per cent for citrus. Because of the low content of nutrients and digestible energy of these residues, the utilization as animal feed is limited, while the high amount of phyotochemical, especially in the pomace of soft berry fruits, and complicates composting because of their antimicrobial activity. On the contrary, these properties make pomace beneficial to human nutrition. Recycling methods that add value to fruit processing residues are of great interest, and it can be expected that the overall profit from fruit processing may be increased by an efficient and sustainable waste stream-management (Rohm *et al*., 2015).

India's agricultural base is quite strong but processing sector is small and processing of food to consumable standards in India has reached only 10 per cent recently. The agro food processing industry is one of the largest in India, employs around 18 per cent of the country's industrial work force and is ranked fifth in terms of production, consumption, export and expected growth. Processing of food products plays an important role in the conservation and effective utilization of fruits and vegetables (Singh *et al*., 2012).

Fruit Peel and Functional Properties

Consumption of fruit has been increasing in the recent years due to changes in consumer preferences, promotion campaigns by international organizations and governmental agencies (King *et al.,* 2011). Other factors such as income, aging of population, market promotion and consumer awareness of the importance of fruit are contributed to increased fruit consumption. The mid and high income countries have expanded fruit consumption at faster rate than low income countries (Retamales, 2011).

WHO recommended average weight per year of the five serving of fruits and vegetables per day: 330g for individual aged 0-4 years, 480 grams per day for individuals aged 5–14 years, and 600 grams per day for all individuals aged 15 years and older. This could reduce the total global burden of disease by two per cent and reduce the burden of ischemic heart disease and ischemic stroke by 31 per cent and 19 per cent respectively (Siegel *et al.,* 2014).

Fruit waste generated from fruit pomace centers are rich source of polyphenol, flavanoids, tannins, ascorbic acid, natural antioxidants, fibre and other bio active compounds which contributes to the activity of antioxidants. It can be utilized for various food preparations in the form dried or incorporated into many value added foods (Madalageri*et al.*, 2015).

Phytochemicals is a broad name that can be used for various compounds produced by plants such as anti oxidants, plant pigments, primarily carotenoids and flavonoids. There are 4000 phytochemicals found in vegetables, fruits, beans and grains and a major groups of colored phenolic compounds are anthocyanins, carotenoids, betalins, lycopenes and leucoanthocyanidin.Total phenolic compounds of fruits such as mangoes, longans, avocados and jack fruits were higher than that of the edible product, and that a valuable source of photochemical could be provided by the by products. The peels and seeds of tomatoes are richer source of phenolic compounds compared to their pulp (Varzakas*et al.,* 2016).

Widsten*et al*., (2014) identified plant based extracts that effectively suppress the main spoilage bacteria of chilled fish and lamb and assessed their anti oxidant capacity. The total phenol compound was strongly associated with higher anti bacterial activity against several fish and lamb spoilage bacteria as shown by zone of inhibition and minimum inhibitory concentration assays. It was also associated with greater anti oxidant capacity in the DPPH (2, 2 – diphenyl – 1 – picyrlhydrazyl) radical assay. Mango seed extract and tannic acid containing mostly polygalloyl glucose type phenol was the most promising candidates for anti bacterial packaging or anti oxidants dietary supplements.

Khattak and Rahman (2017), evaluated vitamin and mineral content of seven underground vegetables namely, *Beta vulgaris, Brassica rapa, Daucuscarota, Ipomoea batatas, Raphanussativus, Solanum tuberosum and Zingiberofficinale.* The results show that the vitamin C content of the peels ranged between 43.6 and 122.5 mg/100g, while riboflavin, thiamin and niacin levels were between 0.3 and 0.8 mg/100g. Appreciable amounts of various minerals such as calcium, sodium, magnesium, iron, manganese, zinc, potassium and phosphorus were detected in the peel samples. So it can be utilized as food, feed and dietary ingredients.

Peels from apple, peaches, pears as well as yellow and white flesh nectarines were found to contain twice the amount of total phenolic compounds as that contained in fruit pulp. Apple peels were found to contain up to 3300 mg / 100 g of dry weight of phenolic compounds. Edible portion of bananas (*Musa paradisiacal)* contains 232 mg/100g of dry weight of phenolic compounds, this amount is about 25 percent of that present in the peel. Pomegranate peels contain 249.4 mg / g of phenolic compounds as compared to only 24.4 mg / g phenolic compounds found in the pulp of pomegranates. Mango seed contain 10.6 percent crude protein (good source), 14.8 percent oil, 2.62 percent ash, 2.40 percent crude fiber, 70.12 percent carbohydrate and energy content 453.92 KJ /100g. Mango seed is very rich in glutamate (13 g/100g of protein) while methionine has the lowest value (1.04 g/100 g of protein). Mango seed kernel extract was found to reduce total bacterial count, inhibited coliforms growth, showed remarkable antimicrobial activity against *Eschericha coli* strain and extendedthe shelf life of pasteurized cow milk (Rudra*et al.,* 2015).

Apple (*Malus domestica)* belongs to *Rosaceae*family, is the fourth most widely produced fruits worldwide. Apple pulp, seeds and peels possess high medicinal values such as antioxidative, anticancer and antimutagenic efficacy. Byproduct of apple peel is disposed directly as a waste and it is rich in phenolic compounds, which has antioxidant activity and antiproliferative activity. Apple peels possess more bioactivity than the flesh, anthocyanin content of apple peel is related to their appearance and red colour is due to the presence of cyanidin 3 – galactoside (Issa*et al.,* 2016).
Supplementation of apple peel in diet may protect against advance of the atherosclerotic diseases, by directly at the fat content level of the plaque, reducing endothelial dysfunction and serum cholesterol. Flavonoids, which is present in apple helps to decrease in migration and proliferation of smooth muscle cells as a response to a decrease of LDL-C. Apple peel consumption improves metabolic alterations associated with a fat rich diet and also slowed the atherogenesis development, (Gonzalez, 2015).

The pericarp part of pomegranate showed more anti-oxidant content including phenolic punicalagins, gallic acid and other fatty acids, catechin, quercetin, rutin, flavones, flavonones and anthocyanidins. Pomegranate tannins play a protective role against gastric ulcer. Its anti ulcer effect is related to the increasing secretion of adherent mucus and pre mucus from the stomach wall. Antioxidant capacity of pomegranate peel extract shows 10 times higher than the pulp extract. Supplementation of pomegranate peel extract especially sour summer has curative potential as an anti ulcer due to its anti oxidant activity (Moghaddam *et al*., 2013).

Tarkhasi (2016) found that addition of pomegranate peel extract increased shelf life in silver carp fish fillet during refrigerated storage by delayed lipid oxidation. Pomegranate peel extract had high anti oxidant activity and retarded the lipid oxidation, probably due to the presence of high phenolic contents.

Mosambi is well cultivated in central and south Asia. All parts of the plant has peel, flowers and fruit juices are used as traditional medicine. It has pharmacological acitivities like anti bacterial and anti-fungal activity, anti-oxidant activity, anti-hyperglycemic activity, anti-tumor potential, larvicidal property and property to antagonize the hypertensive effect of angiotensin II. d – limonene, is the terpene found in plant and it is very low toxic. It helps in gallstone dissolution, shows anti-cancer activities and shown potential in gastroesophageal reflux disorder (Khan *et al.,* 2016)

Citrus fruits and juices are important sources of bio active compound including antioxidant such as ascorbic acid, flavonoids, Phenolic compound and pectin which are important for human nutrition. Most of the Mosambi wastes are generated from juice processing industries and are usually thrown as waste. Mosambi peel had high amount of crude fibre (17.6 percentages) besides water and oil holding capacity (2.26 and 6.82 ml/g respectively). Mosambi peel powder had high water holding capacity and oil holding capacity value, which can be exploited for food application. Mosambi peel powder incorporated papaya jam shows increased firmness and chewiness values of the jam than control products. So Mosambi waste could be used as a raw material for many products (Younis*et al.,* 2015).

A study showed that papaya peel and seed flours had high contents of protein and fiber, and therefore it can be used as alternative sources of nutrients and also can be added into various foods to add value (Santos *et al*., 2014).

Srividhya *et al.,* (2013) proved that antioxidant and antimicrobial activities present in citrus fruit peel extract from *Citrus paradisiMacfad (Grape fruit), Citrus Sinensis (Orange), Citrus lemon (lemon) and Citrus aurantifolia (Lime)* showed betterinhi bitoryagents against the common pathogens in the gastrointestinal tract.Chanda *et al.,* (2010) stated that the byproducts of some fruits and vegetables represent an important source of sugars, minerals, organic acid, dietary fiber and phenolic that have a wide range of action, which includes antitumoral, antiviral, antibacterial, cardioprotective and antimutagenic activities. Plant peels have the antimicrobial activity against several pathogens and these can be used in the prevention of infectious diseases and it is considered as a low-cost natural antimicrobials.

Citrus plants belonging to the family *Rutacea* which include fruits orange, man-darin lime, lemon, sour orange and grape fruit are the most popular world crops, contains active phytochemicals that can protect health. Citrus peel, the primary waste, is a good source of molasses, pectin and limonene and is usually dried mixed with pulps and sold as cattle feed. Phytophenols in citrus fruits provide effective means for preventing and treating free radical medicated diseases such as

cancer, diabetes, neurodegenerative diseases, and process of aging and cardiovascular dysfunctions by scavenging free radicals and quenching reactive oxygen species. In addition to this it has antibacterial, antiviral, anti-inflammatory, antiallergic, antithrombotic and vasodialatory actions (Rafiq *et al.,* 2016).

Banana is a tropical food grown in over 122 countries worldwide. All parts of banana plant have medicinal applications, the flowers in bronchitis and dysentery and on ulcers. Cooked flowers are given to diabetics, the astringent plant sap in case of hysteria, epilepsy, leprosy, fevers, hemorrhages, acute dysentery and diarrhoea and it is applied on hemorrhodis, insect and other stings and bites. Young leaves are taken in dysentery and diarrhoea and used for treating malignant ulcers. The roots are administered in digestive disorder, dysentery and other ailments. Banana seed mucilage is given in case of diarrhea. Anitfungal and antibiotic principles are found in the peel and pulp of fully ripe bananas. Norepinephrine, dopamine present in the ripe peel and pulp elevate blood pressure and serotonin inhibits gastricsecretion and stimulates the smooth muscle of the intestines. Rubbing inside ofa banana skin helps to reduce swelling and irritation of mosquito bites areas (Ehiowemwenguan, 2014).

Watermelon (*Citrullus vulgaris schrad)* is a warm season crop in the *curcurbit*family. The outer skin, white coloured area between flesh and coloured flesh is called watermelon rind. Watermelon is rich in carotenoids some of which include lycopene, phytofluene, phytoene, betacarotrene and lutein. Watermelon contains about 30 percent of the rind 68 percent of flesh or pulp and two percent of seeds. The rind is discarded, it may be used as feed or as fertilizer but it is also edible and may be used as vegetable. Many hidden nutrients are present in the inner portion of the rind, it is avoided due to its unappealing flavours. It contains many citlulline which is a known stimulated of nitric oxide and also contain alkaloids, saponine, cardiac glycosided, flavonoids, phenol, moisture, lipid, protein, fibre and carbohydrates. Anthocyanin helps to improve immune system more effectively against viral infections. Coumarin is found to be potential antioxidant that efficiently scavenges the free radicals.Terpenoids and tannins are attributed to analgesic and anti inflammatory and also have astringency properties. So watermelon rinds aid in therapeutic response against various diseases and can be used an indigenous folk medicine by traditional healers. (Hannah and Krishnakumari, 2015).

Vitamin C content of pulp, seed, and peel of red grapes are 1.63, 23.40, 9.80 mg/100g respectively. It is the first line of defense in adversing diseases and infections (Abdrabba and Hussein, 2015).

Utilization of Fruit Pomace

Waste utilization in fruits and vegetable processing industries is one of the important and challengeable practices around the world (Chacko and Estherlydia, 2014). The wine industry generates huge amount of grape pomace and it contains potentially valuable source of phenol compounds and this could be used in food industry as antioxidant and antimicrobial agents, pharmaceutical industry can also supplement grape waste as a natural supplement. These wastes are environmentally appropriate and easy to obtain could be used as an important source of nutrient and compounds with functional properties and may be a potential food in daily diet as per Abdrabba and Hussein (2015).

In spite of being a second largest producer of overall fruits, nearly 72 per cent of the total production is wasted in India due to poor facility or absence of storage, logistics and processing support. Wastage was reported in all stages of supply chain such as post harvesting process, farm gate, transportation, cold storage, processing, trading and retailing. Quantum of wastage in each stage varied depends upon the type of fruits and handling methodologies. Out of all stages, processing stage is the second major source of wastage in fruit supply chain. Strategies are required to minimize the wastage which would add income to the farmers and profit to the processor (Ramanathan and Parthasarathy, 2014).

Waste utilization from food processing industries is highly indispensable and challenging task all around the globe. About 18 percent of the fruits and vegetable production worth ₹ 44,000 crores is going waste annually in India (2012 data). Waste of fruits and vegetables may vary in household level and industrial level. In household level waste might contain any rotten or over / under ripe fruit or vegetable, while in fruits or vegetable processing sector, contain less of over or under ripe fruit or vegetable, rotten organic matter but more of cellulosic waste like peels and seeds. Vegetables and some fruits yield between 25 percent and 30 percent of non edible products. India is producing three million tons of citrus fruits like mandarins, lime, lemon and sweet orange. Citrus wastes are rich source of oil pectin and variety of byproducts. Apple and citrus wastes are traditionally the main sources of commercial pectin. They are generated from apple and citrus fruits industries by acid extraction (i.e oxalic, hydrochloric, nitric, sulphuric acid) at high temperatures (80 – 90^0 C) (Rudra*et al.,* 2015).

Fruit waste covers all the food life cycles from agriculture to industrial manufacturing and processing, retail and household consumption. Among food waste 42 percent is coming from households, while 39 percent losses are produced from food manufacturing industry, 14 percent in food service sector and remaining 5 percent in retail and distribution. Increasingly, industrial ecology concepts such as cradle to cradle and circular economy are considered leading principle eco – innovation, aiming at " Zero waste economy" in which waste are used as raw material for new products and applications. The large amount of waste from food industry in addition to bring a great loss of valuable materials also raises serious problems, both from the economic and environmental point of view. Most of these residues have the potential to be reused into other production systems, through bio refineries. Now a days researches are focused on feasibility and constraints of applying industrial symbiosis in recovering waste from food processing, focusing on recycling (excluding energy recovery) of the solid and liquid waste from food processing industry (Mirabella, 2014).

In Western Europe 200 000 tons of red beet is produced annually are consumed as vegetables. The remainder is processed into juice, coloring food stuff and food colorants. The latter is commonly known as beet root red.Juice industry produces 15 percent to 30 percent of pomace from raw material

and it is still rich in betalains, it is dispersed as feed and manure. The colored fraction consists of betacyanins and betaxanthins (Varzakas *et al.,* 2016).

Fruit residues which are discarded as waste in the environment should be regarded as potential nutraceutic resources and bioactive compounds capable of offering efficient, inexpensive and environment friendly platform for the production of novel nutraceuticals. It also helps to alleviate pollution problems caused by poor disposal of such residues (Rafiq *et al.,* 2016).

Phenolic and Polyphenolic compounds constitute the main class of natural antioxidants present in plant, foods and beverages. Flavonoids are group of polyphenolic compounds which are widely distributed throughout the plant kingdom. It has anti inflammatory, antihepatoxic and anti ulcer actions. Anti oxidants are present in all parts of the plant such as bark, stalks, leaves, fruits, roots, flower, pods, seeds, stems, latex and hull.Research proves that grape peel and seeds, pomegranate peel, watermelon peel and mango seed kernel contains more antioxidant properties (Kalpna *et al*.,2010).

CONCLUSION

Fruit pomace, a byproduct of the fruit juice industry, is a rich source of nutrients and bioactive components. Strategies are required to minimize the wastage and utilize as nutraceuticals which would add income to the farmers and profit to the processor.

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