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Waste valorization of fruits and vegetable peels

Shreya and Dr. Shweta Sharma

Abstract
Wastes from fruits and vegetables can be found all along the supply chain and vary greatly based on how they were processed. Between 10 and 60 percent of waste or byproducts were produced by the preparation of fruits and vegetables in liquid and solid states. Waste material should be used in a way that allows the greatest advantages to be obtained without causing financial loss or environmental problems. Therefore, waste products produced from these by aerobic or anaerobic treatment, biogas production, the creation of animal feed, and the production of value-added goods, industries can be used for landfill and composting. Fruits and vegetables are perishable, so their waste rapidly goes bad. As a result, garbage disposal is a severe issue since it attracts rats and insects. The use of fruit and vegetable waste for the bioconversion of renewable energy is growing in popularity because it has been shown to be an effective way to use the leftover perishable vegetable material. Livestock is currently one of the agricultural subsectors in emerging countries that is expanding at the fastest rate. According to recent research, processing byproducts from fruits and vegetables can be employed as functional feed ingredients in farm animals' diets. The research done on fruits and vegetables for their use in various ways is the topic of the current review.

Keywords: Anaerobic digestion, essential oil, and fruit and vegetable waste

Introduction

Food processing is a significant area of agriculture, one whose potential has grown significantly and which can significantly reduce the wastage of perishable goods. Due to their high biodegradability, fruits and vegetable wastes (FVW) are produced in enormous quantities in markets and are a nuisance in municipal landfills. The Food production, processing, and preparation all result in the creation of enormous amounts of trash that pose health risks because pollution of the environment. India produces 12% of the world's total fruit production, making it the second-largest producer in the world (FAO, 2010). Around 675 million metric tons of fruits and vegetables are produced annually around the world, with 1.3 billion metric tons going to waste. Fruit and vegetable production in India is 86.602 million metric tons. veggies account for over 5.6 million tons of garbage each year. These garbage are currently dumped outside of the city limits of cities. Large-scale food waste is a result of unregulated agri-economy practices and the food processing industry. Table 1 provides production (MT) figures for various significant fruits in India and around the world.

Table 1: Production (MT) statistics for some important fruits in India and the world (P.K. Omre, Shikhangi Singh, Shikha)

Crop	India	World
Bananas	26.2	93.3
Mangoes	13.64	34.89
Citrus fruits	7.16	124.57
Grapes	1.73	66.64
Watermelon	0.25	98.4
Pineapple	1.30	19.26
Total fruits	68.35	587.67

Landfilling and composting

All industrialists now have to deal with the problem of proper garbage disposal, particularly those who live in cities with high land prices. The Times of India reported this on September 6, 2017. "In Gurugram, smoke plumes rising from padded fields have made disposing of waste material difficult for processors, as various organizations are putting pressure on a city's edges and smog covering the skies in winter as awareness of the environment's exposure to hazardous impacts of agricultural and horticultural waste spreads home. The city's horticulture waste, which includes flowers, leaves, fruits, and vegetable peel from residences, would be roughly estimated to be about. Composting is one of the finest methods for disposing of the 400 tons of vegetable mandis waste, or 40% of the daily 1000 tons of solid waste. solutions for addressing the issues with trash disposal. This can be accomplished using a variety of techniques, including natural weathering,

For 12 to 18 months, aerobic and anaerobic processes were conducted in pits. After composting, the manure is ready to be applied to crops cultivation. The used mushroom substrate can be used as organic manure, which involves adding it to soil with inadequate soil nutrition neutralizing acidic soils, and occasionally for cleaning up contaminated areas. Vermicomposting is another excellent option for making use of the trash. Fruit, vegetable, and floricultural plant leaves similar techniques can be used with crops for composting and vermin-composting. Composting is a preventative technique in the disease or insect spread to nearly every crop or processing facility. Consequently, the finished product of composting or vermin-composting in a situation where the soil or land is entirely barren, material can be used for a process, and the finished product can be used for landfilling. Composting trash for 12 to 18 months increases the NPK content, water holding capacity, organic carbon, etc., which can improve soil fertility.

Fig 1: Smoke rising in gurugram.

Table 2: Percentage of food waste and by products in fruits and vegetables production

Production process	Waste and by-product (%)
White wine production	20-30
Red wine production	20-30
Fruit and vegetable juice production	30-50
Fruit and vegetable processing and preservation	5-30
Vegetable oil production	40-70
Sugar production from sugar beets	85

(Source: De Las Fuentes, *et al*., 2004)

Biogas

Australian canneries and juice processors create about 750000 tons of fruit and vegetable waste annually. According to Dr. Alan Lane of the CSIRO Division of Food Research, the processing plant has an annual.

A waste output of 30,000 tons with a 90% moisture content might result in 1.5 million cubic meters of gas being produced annually. At a test facility the digester, which was built at the Lerona Cooperative Cannery, produces 30 to 40 cubic metres of gas daily. These materials come in a variety of shapes and sizes and typically contain a lot of fibre. Volatile solids make up 34 of all the current solids. They are not all biodegradable. according to the type of waste material and hardening state. Each vegetable has a different carbon to nitrogen ratio, although mixed it can be between 1:20 and 1:30. The Persians are thought to have invented biogas. They learned that decaying organic material Vegetables produced a combustible gas that was useful for other things. An economical technology is anaerobic digestion of sorted organic wastes from municipal solid waste (MSW), particularly food waste (Baere, 2000) [42]. Fermentation of methane is a difficult process. Anaerobic digestion is a broad term for a number of processes, including enzymatic hydrolysis.

Each metabolic stage, including acidogenesis, acetogenesis, and methanogenesis (Veeken *et al*., 2000) [40], is aided by a variety of microorganisms. The rate-limiting stage for fruit vegetables waste among the four stages is hydrolysis (Vavilin *et al*., 1996; Christ *et al*., 2000) [39, 7]. The microorganisms that produce acid break down macromolecules like cellulose, proteins, starches, and carbs into organic acids (steps 1 and 2). The third phase is where organic acids are subsequently converted to acetate, and in the final step, the methanogens convert the acetate to CH_4 and CO_2. The duration of steps 1 and 2 is greater, which takes up the majority of the time. Volatile fatty acids are produced more quickly in substrates like fruit and vegetables waste that are high in carbohydrates (Mata *et al*., 2000) [25] and causes an excess acid buildup that results in acidity, a low pH, and the blockage of the process. Increasing the concentration of fruit and vegetables waste substrates cause the pH to be lowered, which results in less biogas being produced. Biogas typically contains 45–70% methane, 30–45% carbon dioxide, 0.5–1.0% hydrogen sulphide, 1–5% water vapour, and a small amount of other gases. other gases (hydrogen, ammonia, nitrogen, etc.) in minute quantities (Uzodinma *et al*., 2011) [38]. A specific biofuel's composition varies. Biodegradable biomass is used as a feedstock and a mixture (Wantanee and Sureelak, 2004). Gas production from biogenic waste production is significantly influenced by the nature and metabolic makeup of the substance (Sagagi *et al*., 2009) [32].

Fig 3: Cows feeding on fruit and vegetables wastes

Table 3: Characterization of waste samples

Parameters	Results
Moisture Content (%)	8.51
Volatile Matter (%)	77.16
Ash (%)	7.07
Fixed Carbon (%)	7.25
Calorific Value (Cals/Gm)	1913.4
C:H:N	83:12:5

(**Source:** Das and Mondal, 2013).

Despite the fact that waste samples have been characterised, temperature has a significant impact on the AD process (Ahring, 1994; Cheunbarn and Pagilla, 2000) [1, 6]. The AD process typically operates in either a mesophilic or thermophilic environment, with thermophilic digestion being cited as the more effective approach.

Gryphon and associates, 1998 [15]; Ahring and associates, 2001. Dry AD method is significantly more advantageous to compact digesters with high

Organic loading rate and performance in terms of energy efficiency (Pawan *et al*., 2000; Kuroshima *et al*., 2001) [29, 20]. According to an assessment of the literature, India is the second-largest producer of fruits and vegetables worldwide. It produces between 10% and 14% of the world's production of fruit and vegetables. Vegetable marketing, processing, and other activities result in transportation, harvesting, and other activities that quickly go bad and smell bad. Numerous researchers used laboratory-scale reactors to study the anaerobic digestion of vegetable wastes in single-stage systems.

Feed for animals

There needs to be a decrease in the volume of economically produced food waste on both a large and local scale. Almost half of this waste was made up of fruits and vegetables. By-/coproducts from the processing of fruits and vegetables are a possible source of worthwhile outcomes, as shown in Table 3. compounds from plants, such as carotenoids, antioxidants, antimicrobials, vitamins, or dietary lipids with beneficial technological properties, like as polyphenols and flavonoids, nutritious qualities (Fernández-López *et al*., 2008; Schieber *et al*., 2001) [34]. There is already a substantial lack of feed available in majority of underdeveloped nations. Using Bangladesh and Pakistan as examples from Asia, respectively, roughages and concentrates are in low supply in those nations by 43.9, 49.7, and 81.9 percent (Uddin, 2013) [37]. According to Habib (2008) [16], there has been a documented 44.2 percent of dry matter (DM), crude protein (CP), and total digestible nutrients (TDN). In According to Jie (2012) [43], China had a protein feed, energy feed, and aquatic feed deficiency of 10, 30, and 20 million tonnes, respectively.

There are accordingly shortages of 25, 159, and 117 million tonnes of concentrates, green forages, and crop wastes in India. According to Ravi Kiran *et al*. (2012), 32, 20 and 25% of the necessary amount have been estimated. Due to urbanisation and rising human population, it is impossible to expand the area used for the production of fodder, and the industrial intensive model of livestock production is severely constrained by rising fossil fuel prices, competition for food, feed, and fuel, and other biophysical limitations. Feed materials like maize, wheat, fish meal, and soybean meal are now more expensive globally (up 160, 118, 186 and 108 percent over the past ten years, respectively, whereas the price increase for livestock goods including chicken, hog, and lamb was only around 59, 32, and -37 percent, compared to 142 percent for beef (Index Mundi, 2013). In these circumstances, to fulfil the livestock's nutrient needs and to maintain their productivity and profitability appear to be only attainable if alternative, non-conventional feed is used.

Resources are looked into. Plant materials subjected to a variety of physical and chemical processes in order to extract economically significant Co-products can be used to describe components (Serena and Knudsen, 2007) [36]. In this regard, grapefruit pulp—the solid byproduct after Juice obtained by pressing the fruit is a by-product, while citrus molasses, a syrup made from the concentrated juice released from the It is a co-product—citrus peel. However, some products—like fermented grape pulp—cannot be categorised as co- or by-products. The distinction between co- and by-products in terms of animal feeding is insignificant and unrelated to the nutritional content of these products. Co-/by-products will henceforth be referred to as co-products going forward for convenience's sake. The European Food Safety Authority states that feed additives for better

Animal product quality can "favourably affect": (a) the products' sensory qualities and acceptance, such as their antioxidants and colourants; (b) their nutritional worth, such as their long-chain triglycerides;

conjugated linoleic acid (CLA), chain polyunsaturated fatty acids, and (c) the items' microbiological quality.

Table 4: Functional ingredients from fruit and vegetable processing co-products

Fruits And Vegetables	Fractional Ingredient
Apple Skin/Pomace	Polyphenols
Orange Peel	Hesperidin
Orange Pulp	Carotenoids
Grape Pomace/ Skin/ Seeds	Polyphenols
Carrot Peel	Polyphenols Carotenoids
Tomato Seeds	Unsaturated Fatty Acids
Tomato Skin	Carotenoids (Lycopene)
Potato Peel	Polyphenols
Red Beet	Polyphenols
Sunflower Seed	Phytosterols
Soybean Seed	Phytosterols
Olive Pomace	Polyphenols

It should be mentioned that the Commission established the European Union Register of Feed Additives in accordance with Article 17 of Regulation (EC) No 1831/2003 on additives for use in animal nutrition. Fruit and vegetable co-products are heterogeneous products because their physical characteristics (peels, seeds, stems, stones, pulp, etc.), how they are processed to make the food product, how they are stored, and how they are handled affect the composition and concentration of the target ingredients. For instance, lycopene levels in tomato skins are higher than in tomato seeds (Knoblich *et al*., 2005) [19]. Additionally, sodium hydroxide is used to mechanically peel tomatoes, which raises the sodium content of the tomato skins. The terms for the co-products (pomace, (Pulp, cake, garbage, etc.) may not accurately describe the product's components and contents. Consequently, determining the Before being used in livestock feeds, the co-product's chemical makeup is indicated. Several common fruit and vegetable functional ingredients

Table 4 lists vegetable co-products acceptable for use in farm animal nutrition (Galanakis, 2002; Oreopoulou and Tzia, 2003, 2007) [13, 28].

Making items with value added:

The massive output of fruit and vegetable wastes and byproducts worldwide, both in the organized and unorganized food industries Sectors can be used productively. These resources, such as peels, pomace, seeds, and others, are abundant in bioactive compounds.

be removed and used in the biofuel, medical, cosmetic, and food industries. Several of these innovative value-added products and

Below is a discussion of utilities.

- **Essential oils:** Citrus peels can be used to produce essential oils, which can range from 0.5 to 3.0 kg per tons of fruit. Due to its aromatic flavor, citrus essential oil is frequently used in alcoholic beverages, confections, soft drinks, perfumes, soaps, cosmetics, and home items. In pharmaceutical preparations, it also functions as a masking agent (Njoroge *et al*., 2005) [26]. It increases the fresh fruit's safety and shelf life (Javed *et al*., 2011) [17], skim milk, and low fat milk (Dabbah *et al*., 1970) [8], as well as having broad range antimicrobial action. Tea recipes use oils from both sweet and bitter oranges and as a component in formulations that are laxative, carminative, and stomachic. D-limonene, an ingredient in lemon essential oil that boosts immunity and fights reduces mood swings, encourages purpose and thinking clarity, energizes and stimulates the body and mind, opens and unblocks emotional blocks, promotes the health of the skin, and minimizes wrinkles (Falsetto, 2008) [11]. Prolapse of the uterine and rectum, diarrhoea, and piles are all conditions that are treated with dried bitter orange oil. Polyphenolic chemicals are concentrated in the peels, pulp/pomace, seeds, and flesh of citrus fruits, apples, peaches, pears, yellow and white flesh nectarines, bananas, and other fruits. more than twice as much of pomegranate, mulberry, blackberry, tomato, sugar beetroot, and other foods are found in non-edible tissue. Proanthocyanidins and flavonoids are abundant in apple and grape pomace, banana In catechin and gallocatechin, mango seed kernels (Puravankara *et al*., 2000) [30], carrot pomace (Zhang and Hamauzu, 2004) [41], and carrot pomace in hydroxycinnamic derivatives like chlorogenic acid and dicaffeoylquinic acids Mango peels in gallic and ellagic acids (Larrauri *et al*., 1996) [22]. For application in the food and pharmaceutical industries, kinnow peel, litchi pericarp, litchi seeds, and grape seeds can all be potential sources of antioxidants. Flavonoids are abundant in the pomace of beetroot roots (Anadanovi *et al*., 2011). L-tryptophane, p-coumaric, ferulic, and derivatives of cyclodopa glucoside are all visible in the phenolic layer of the beetroot root peel. In vertebrates, the polyphenolic chemicals have actions that are anti-cancer, anti-microbial (pathogens), anti-oxidative, and immune-modulating. According to Jimenez-Escrig *et al*. (2001) [45], the peel and pulp of guava fruits could be used as a source of dietary fibre with antioxidant properties. Polyphenols are believed to decrease LDL oxidation and lower the prevalence of cardiovascular illnesses (Rice-Evans, 2001) [31]. Both in people and in animals, polyphenols can lower systolic blood pressure, lower plasma cholesterol levels, inhibit platelet aggregation, and prevent thrombosis. Banana leaves contains terpenoids and flavonoids that have anthelmintic effects (Marie-Magdeleine *et al*., 2010b) [24].
- **Edible oils:** The fatty acid and triglyceride profiles of the fat found in mango seed kernels are similar to those of cocoa butter, making it a prospective source of edible oil. Usually abandoned during the production of juice and pulp, guava (Psidium guajava L., Myrtaceae) seeds contain 5-13 percent oil rich in
- Fatty acids that are important (Adsule and Kadam, 1995). The oil from the seeds of the passion fruit has a high percentage of unsaturated fatty acids (87.6%), primarily linoleic (73.1%) and oleic (13.8%) acids (Malacrida and Jorge, 2012) [23]. The oil has the ability to scavenge free radicals.
- **Colourants:** Tomato peel is a great source of lycopene and other carotenoids. It might be helpful in treating chronic illnesses like cancer, coronary heart disease, and others (Knoblich *et al*., 2005) [19]. The inclusion of tomato due to the lycopene and fibre inherent in this tomato processing byproduct, adding peel to meat products can result in a healthier product. Carotenoids are also abundant in carrot pomace (Zhang and 2004) [41]. Hamauzu. The potential of anthocyanin pigments in beetroot root pulp and banana bracts (under-calyx leaves) was assessed. Application as organic food dyes. Beetroot peel is a possible source of rich water-soluble nitrogenous pigments, called betalains, which are divided into two main categories, the red and yellow betalains. The beetroot pomace contains 11–23 mg xanthins/g of dry extract. Betaxanthins, which are yellow, and betacyanins. They are free radical scavengers and stop biological molecules from oxidising as a result of active oxygen and free radicals. Betalains have been studied in depth in the modern food sector as natural colourants (Azeredo, 2009) [3].
- **Food additives:** Onion pomace can be utilized in snacks, whereas carrot pomace can be used in bread, cake, dressing, and pickles (Osawa *et al*., 1995) [46]. Synthetic ingredients used in the food antioxidants like butylated hydroxyanizole (BHA) and butylated hydroxytoluene (BHT) have been used for a very long time as antioxidant additives to protect and stabilize the flavor, freshness, and nutritional content of food. BHT could be hazardous, especially at large doses (Schilderman *et al*., 1995) [35]. Consequently, interest over the past few years, there has been an increase in the use of natural food antioxidants in place of synthetic ones. The anti-oxidant components from food industry waste could be utilized to protect the

removing oxygen free radicals from living systems, antioxidants can reduce oxidative damage as well as increase food stability by halting the oxidation of lipids.
- **Edible fermented goods:** Fruit wastes can be fermented to produce a variety of alcoholic beverages, including cider, beer, wine, brandy, and vinegar. Cider has been made with apple pomace in the past. The potential use of surplus and culled dried apples for brandy production, Other fruits, such as grapes and oranges, have also been studied. Fruit wastes can also be used to make vinegar. The acetic acid-producing Acetobacter bacteria first ferment the fruit waste into alcohol. Acetic acid is a byproduct of this process. Making vinegar through fermentation. There have been reports of waste from orange peel juice and pineapple juice. Vinegar can also be made by combining apple pomace extract and molasses in a 2:1 ratio (Gautam and Guleria, 2007).

Conclusion

Due to the recent global intensification of food production, which has resulted in the generation of significant amounts of food co-products and wastes, there has been significant societal and environmental pressure for the effective reutilization of agricultural industry residues. The enormous waste due to the absence of regulation over such agri-economy practices. Because they are nutrient-rich byproducts of the food industry, they have numerous health advantages. These byproducts are an excellent source of nutraceuticals, bioactive chemicals, and other functional foods. Utilizing byproducts provides businesses with a new revenue stream, which boosts economic output. Therefore, the methods mentioned above are some of the simple methods that make the best use of the fruits and vegetables that businesses and households waste the least. The following are some benefits of waste valorization that may be inferred from the methods above:

- Reducing pollutants to the environment.
- Beneficial nutritional supplement for the population of people.
- Various forms of value-added goods can be made ready.
- Assist in addressing the issue of food scarcity.
- Excellent dietary supplement that can raise the soil's fertility.
- Find solutions to the salinity dangers issues.
- May boost the economic returns of industry.

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