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Recovery of Organic Acid and Biofuel from Industrial Waste

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Abstract

Waste generation has been a significant cause of concern ever since the beginning. Waste volume has grown in recent years along with waste diversity, in contrast to the ancient times, when wastes were merely a nuisance that had to be eliminated. Massive amounts of waste materials, including peels, seeds, stones, and oilseed meals, are produced during the processing of fruits, vegetables, and oilseeds. Wastes food sector creates an environmental danger and pose a significant operational challenge for the corresponding food businesses. The waste generated from one industry may also be regarded as raw material in other industry like bagasse generated from sugar industry and utilized as raw ingredient in paper industry. The production of a number of useful by-products, including pectin, organic acids, biofuel, etc., required the application of specially devised procedures, such as fermentation, saccharification, thawing, filtration, and evaporation. Diverse strategies have been used to make use of the wastes in order to recover valuable byproducts and/or ingredients while also lowering the pollution level.

Keywords: Waste, processing, fermentation, saccharification, thawing

Introduction

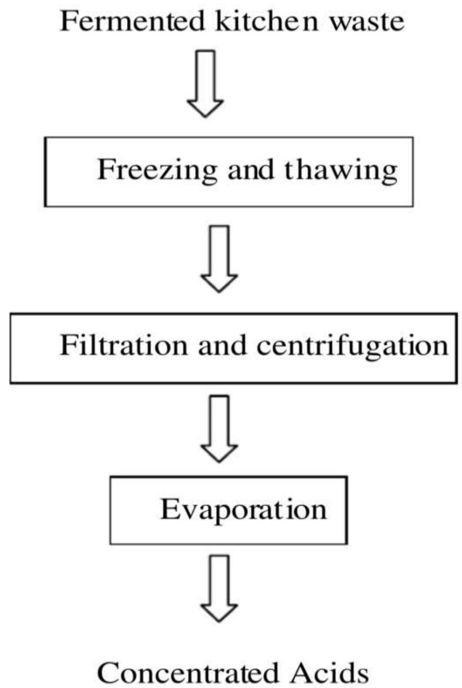
Food waste contains about 80% of moisture which is easily biodegradable and is rich in nutrients and microflora. Due to these characteristics, biological treatments are preferred. One of the most practical biological treatments is anaerobic digestion. It is a great tool to stabilize a large volume of waste materials economically and effectively.

Waste valorization is the process of reusing, recycling or composting waste materials and converting them into more useful products including materials, chemicals, fuels or other sources of energy. “Waste-to-energy” aspects are becoming more prominent due to the rapid depletion of natural resources and increase in waste generation.

Recovery of organic acids

- **Fermented Kitchen Waste**

Organic acids could be produced from anaerobic digestion of kitchen waste and were recovered by using freezing and thawing method in combination with centrifugation, filtration and evaporation. After the fermentation, the organic acids content increased by about 56% (Omar *et* *al*., 2009). By the freezing and thawing process, the organic acids content increased by 16%.



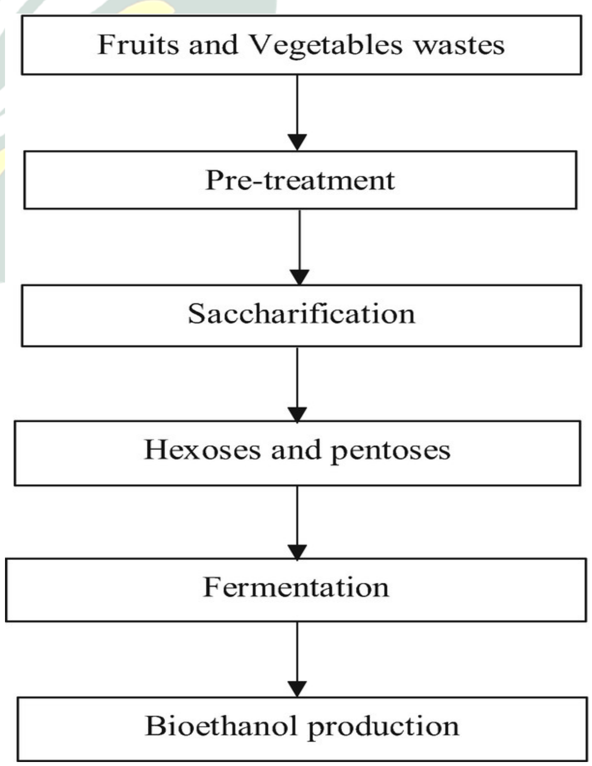
Anaerobic digestion consists of a few stages including hydrolysis, acidogenesis, acetogenesis and methagonesis. The filtrate was centrifuged and filtered (0.8 µm, cellulose acetate filter paper) by using a vacuum pump filter. The centrifugation and filtration process do not affect the concentration of the organic acids. Water evaporates at 50°C in vacuum and the remaining organic acids were concentrated. Evaporation was carried out by using a rotary evaporator. After the evaporation step, the organic acids content is increased.

- **Waste Salt Solution**

The organic acid recovered from waste salt solution, is cyclohexanone that to by means of single anion-exchange membrane electrodialysis. The present treatments of the waste salt solution (Wang *et al*., 2006) for the production of cyclohexanone are characterized by the following sequence of steps: acidification, esterification and distillation. Electrodialysis in many cases represents a powerful technology, where charged compounds are separated from the solution. It is an environmental friendly alternative to the technology, which is currently in use. In recent years, electrodialysis has been widely used for the purification and recovery of organic acid solutions. Unfortunately, such processes are usually frustrated by the considerable costs and enormous energy consumption for the separation of these saleable organic acids. Short chain aliphatic carboxylic acids, such as butyric and adipic acids in waste salt solution, are important reagents for the chemical and food industries.

Recovery of bioethanol

- **Vegetable**



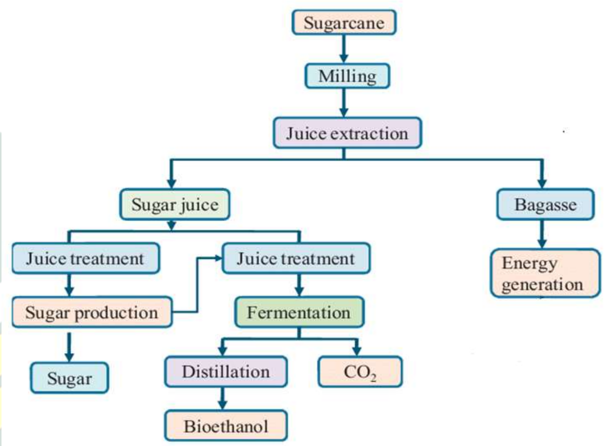
Vegetable waste is a renowned nonedible source of lipids, amino acids, carbohydrates, and phosphates. All of these nonedible lignocellulose biomasses can also use for the production of bioethanol. Lignocellulose contains of 20-40% of hemicelluloses, 30-50% of cellulose and lignin around 10-15% (Khandaker *et al*., 2020). Vegetable waste is widely used raw material for the production of bioethanol because it contains hemicellulose and cellulose, which can be changed into sugar by the hydrolysis method in presence of microorganisms. After, production of glucose and other simple sugar from all the sugar sources, the bioconversion endures till bioethanol is produced. The sugar content in vegetable waste extracts is around 5%. Yeast, fungi and bacteria can be used for the fermentation process.

- **Fruits**

Fresh citrus fruits are consumed or the citrus juice is mostly preserved in ready-to-eat or concentrated form. After the extraction of citrus fruit juice, the remaining parts of the fruits serve as a rich source of lignocellulosic material and also utilized as a raw material for the fermentation of bioethanol (Khandaker *et al*., 2020). Simillarly saccharification and fermentation of banana, pineapple etc peel, through culture of S. cerevisiae and A. niger is performed to obtain bioethanol. Different temperature (20-50°C) was used to examine the saccharification and fermentation of the peels at different pH of 4-7.

- **Sugarcane**

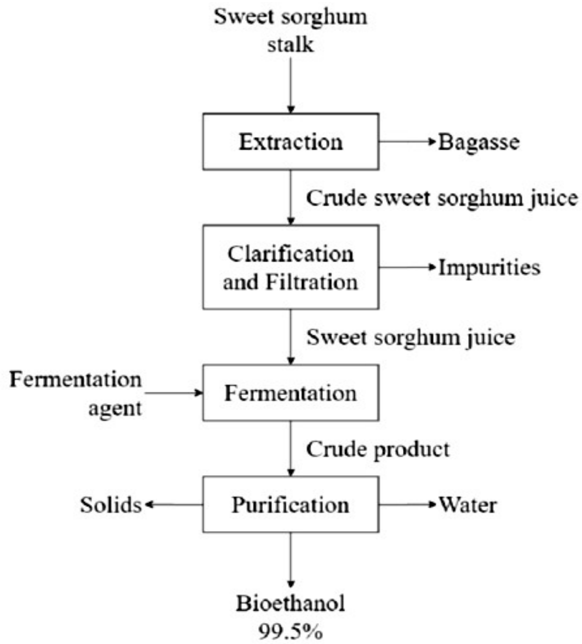
Sugarcane (*Saccharum spp*.) is an important crop worldwide not only for sugar production, but also increasingly as a bioenergy crop due to its phenomenal dry matter production capacity (Vohra *et al*., 2014). Brazil is the largest producer of sugarcane which is the main source of bioethanol production in the country. Most of worldwide bioethanol is produced from sugarcane and remaining bioethanol produced from other crops such as sugarbeet, sorghum, wheat, rice etc. The other countries like US and Europe mainly uses starch from corn, wheat and barley, respectively.



- **Sweet Sorghum**

Sweet sorghum is a perennial plant belongs to Poaceae family. Sweet sorghum reduces carbon emissions. All components of this plant have economic value, the grain from sweet sorghum can be used as food, the leaves for forage, and the stalk for fuel, the fiber either as mulch or animal feed.

The juice obtained from sorghum stalks may result high ethanol productivity. The stalk of sweet sorghum cultivars contains the high levels of carbohydrates (15-23%) (Muhammad *et al*., 2021). Total fermentable carbohydrates are characterized into three main sugars: sucrose (70%), glucose (20%) and fructose (10%).



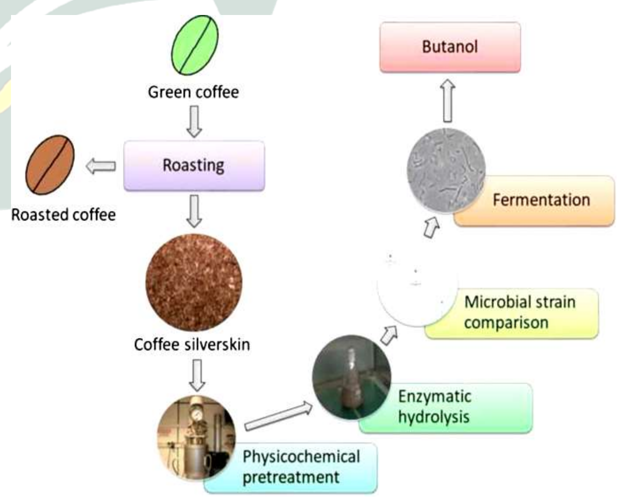
Recovery of biobutanol

- **Cassava**

Tapioca starch factories generate a large amount of wastewater and solid waste, which take several steps of waste treatment to manage. The solid waste contains high level of starchy lignocellulosic materials, especially cassava pulp. The cassava waste residue is a potentially promising substrate for the production of biobutanol (Johnravindar *et al*., 2021). *Clostridium* sp. strain AS3 isolated from a cassava waste processing industrial site utilized as a wide range of carbohydrate substrates in a pre-optimized CWR medium. Overall, the batch study showed promising results that the CWR was potentially valorized by solventogenic *Clostridium* sp. AS3, and this strain has the potential for continuous biobutanol production. Due to the low cost and availability, utilization of cassava waste residue (CWR) as a feedstock is one of the most promising and most economically feasible choices for biobutanol production.

- **Coffee**

During the processing of coffee fruits either by wet or dry methods the outer skin, pulp, pectic adhesive layer and parchment are removed, whereas the green coffee beans surrounded by an attached silver-skin are preserved and sent to roasting industries in consuming countries (Hijosa-Valsero *et al*., 2018). Coffee silver-skin is a thin tegument obtained as a by-product after the roasting process and it constitutes about 4.2% (w/w) of coffee beans. Coffee silver-skin contains important amounts of cellulosic and hemicellulosic fibres, as well as interesting molecules such as caffeine and polyphenolic compounds, which makes this by-product an interesting source of cellulose, dietary fibres and antioxidants, and its use has also been proposed as fuel, compost, fertilizer and feedstock for amylase or ethanol production by fermentation.



- **Potato peel**

Potato peel waste (PPW) is a carbohydrate rich waste from potato industries, which is an environmental threat worldwide (Abedini *et al*., 2020). The biobutanol is produced via acetone-butanol-ethanol (ABE) fermentation by *Clostridium acetobutylicum*. The PPW contain considerable amount of glycoalkaloids, which severe as inhibitor for the bacterium. Thus, three processes, i.e., dilute acid pretreatment (Process I), the inhibitors extraction followed by dilute acid hydrolysis (Process II) and ethanol organosoly pretreatment (Process III), were employed before hydrolysis and fermentation to produce ABE. The fermentation of overall hydrolysate resulted in a high ABE concentration, indicating that PPW is an appropriate substrate for butanol production after the removal of its bacterial inhibitors.

Conclusion

Food waste has a significant impact on food safety, quality, natural resources and environmental protection. Results in reducing the waste production, valorizing the by-products and improving the waste management.

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