Review of Agro-industrial Wastes and Their Utilization using Solid-state Fermentation

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ABSTRACT: Bioactive chemicals abound in agricultural wastes. These leftovers may be utilized as a raw material in many studies and businesses for the manufacture of various goods such as biogas, biofuel, mushroom, and tempeh. The use of agro-industrial wastes as raw materials can help to reduce the production cost and reduce the pollution load from the environment. Agricultural-based companies produce a significant amount of residue each year. If these leftovers are not properly disposed of and released into the environment, they may contaminate the ecosystem and harm human and animal health. Because the bulk of agro-industrial wastes are untreated and underutilized, they are often burned, dumped, or dumped in an unexpected landfill. Solid-state fermentation is used to produce biofuels, enzymes, vitamins, antioxidants, animal feed, antibiotics, and other compounds from agro-industrial waste (SSF). Through SSF procedures, a variety of microbes is utilized to create these important compounds. As a result, the impact of SSF on the development of value-added goods is examined and debated.

KEYWORDS: Agriculture, Biofuel, Fermentation, SSF, Waste.

1. INTRODUCTION

Every year, agricultural-based businesses generate a large quantity of residues. If these leftovers are discharged into the environment without being properly disposed of, they may pollute the ecosystem and damage human and animal health. Because the majority of agro-industrial wastes are untreated and underused, they are often disposed of by burning, dumping, or unplanned landfilling. These untreated wastes contribute to climate change by increasing the amount of greenhouse gases released. Aside from that, the usage of fossil fuels has an impact on greenhouse gas (GHG) emissions. As a result, it is now a global issue to mandate the development of alternative, cleaner, and renewable bioenergy supplies. These wastes are difficult to dispose of. For example, the juice business generated a large quantity of trash in the form of peels, the coffee sector generated waste in the form of coffee pulp, and the cereal industry generated husks. Throughout 147.2 million metric tons of fiber, sources are found around the globe, while wheat straw residues and rice straws were projected to be 709.2 and 673.3 million metric tons in the 1990s, respectively. Because the composition of these agro-industrial residues has a high nutritional potential, they are being given greater attention for quality control and are being classified as agro-industrial by-products [1].

The various wastes, such as pomegranate peels, lemon peels, and green walnut husks, may be utilized as natural antimicrobials. Although organic compound wastes pose a threat to the environment, they may be a source for the production of mushrooms as well as other bio-based goods such as bio-energy and Biofertilizers. Animal feed is made from some of the agricultural leftovers. However, such wastes include a wide range of compositions, including significant levels of proteins, carbohydrates, and minerals. Because of their high nutritional content, these leftovers are not regarded "trash," but rather "raw materials" for the creation and development of new products. The presence of these nutrients in raw materials provides ideal conditions for the development of microbes. With the help of fermentation processes, these bacteria are able to reuse the basic materials. Agro-industrial waste is utilized as a solid foundation in SSF advancements to create a variety of useful goods. It also aids the synthesis of fermentable sugars by lowering the cost of production using food crops. Various research has been conducted to learn how various microorganisms convert agricultural waste into sugars. Finally, the potential applications of agro-industrial wastes via SSF processes were discussed in this study [2].

1.1 Agro-industrial wastes come in a variety of forms:

1.1.1 Agricultural by-products:

Agriculture residues and industrial residues as two distinct kinds of agro-industrial wastes. Field residues and process residues are two types of agriculture residues. Field residues are leftovers from the agricultural harvesting process that remain in the field. Leaves, stalks, seedpods, and stems are among the field residues, while process residues are those that remain after the crop has been processed into a different valued resource[3].

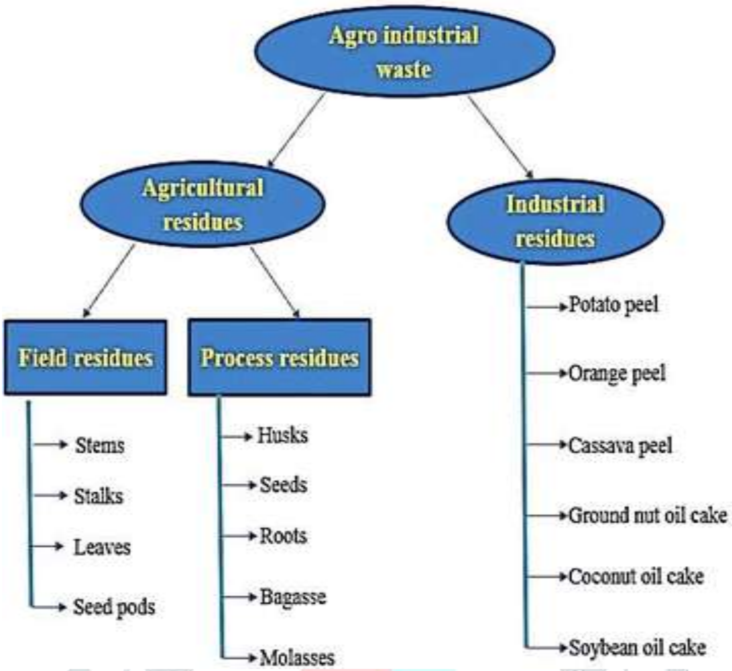

Figure 1: The above figure shows the Agro-industrial wastes and their types [bioresourcesbioprocessing].

Molasses, husks, bagasse, seeds, leaves, stems, straws, stalks, shells, pulp, stubble, peel, roots, and other leftovers are utilized for animal feed, soil development, fertilizers, manufacturing, and other activities. Field wastes are produced in large quantities, with the majority of them going unused. Irrigation efficiency and erosion control may both benefit from the controlled utilization of field leftovers. Wheat and barley are the most important crops in the Middle East. Aside from rice, lentils, maize, chickpeas, fruits, and vegetables, a variety of other crops are grown all over the globe. Agricultural leftovers are classified according to their availability and features that distinguish them from other solid fuels such as charcoal, wood, and char briquettes [4].

1.1.2 Waste from the manufacturing industry:

Food processing businesses such as juice, chips, meat, confectionery, and fruit generate a large quantity of organic wastes and associated effluents every year. These organic wastes may be used to generate a variety of energy sources. As the world's population continues to grow, so does the need for food and its uses. As a result, many food and beverage businesses have grown dramatically in that area to meet the growing need for food.. Because India produces a significant quantity of apple, cotton, soybean, and wheat, about 20% of the output of fruits and vegetables in India goes to waste each year. As a result, as the country's output grew, so did the proportion of trash generated. Similarly, waste from the food industry has a high concentration of BOD, COD, and other suspended particles. The majority of these wastes are left unutilized or untreated, causing harm to the environment as well as human and animal health. However, the composition of these wastes contains a large number of organic compounds, which can be used to create a variety of value-added products while lowering production costs. Huge amounts of processed leftovers are generated following oil extraction from seeds, particularly in the oil industry; these residues are known as oil cakes. Because these wastes include significant concentrations of fat, oil, grease, suspended particles, and dissolved solids, these industries pollute the air, water, and solid waste [5]–[11]. Oil cakes come in a variety of shapes and sizes depending on the substrate (Table 3). Canola oil cake (CaOC), sunflower oil cake (SuOC), coconut oil cake

(COC), sesame oil cake (SOC), mustard oil cake (MOC), palm kernel cake (PKC), soy bean cake (SBC), groundnut oil cake (GOC), cotton seed cake (CSC), olive oil cake (OOC), rapeseed cake (RSC) are some of the different types of oil cake (Ramachandran et al. 2007). These agro-industrial wastes are very inexpensive, include a large number of components, and have virtually infinite potential for use as alternative fermentation substrates.

1.1.3 Fermentation in a solid state (SSF):

Solid-state fermentation (SSF) refers to any biotechnological method in which organisms grow on non-soluble materials or solid substrates in the absence or near absence of free water. Cereal grains (rice, wheat, barley, and maize), legume seeds, wheat bran, lignocellulose materials such as straws, sawdust, or wood shavings, and a broad variety of plant and animal materials are often used substrates in SSF. These substrates' components are polymeric and insoluble or sparingly soluble in water, yet they are often inexpensive and readily available, and they provide a rich supply of nutrients for microbial growth. Fermentation is one of the earliest techniques of food preparation. According to a review of the literature, using a small amount of water or not using any water in SSF has several advantages, including easy product recovery, lower overall production costs, smaller fermenter sizes, less downstream processing, and lower energy requirements for stirring and sterilization. Before beginning any fermentation process, many variables such as microorganisms, solid support utilized, water activity, temperature, aeration, and the kind of fermenter used should be examined. Single pure cultures, mixed identifiable cultures, or a consortium of mixed indigenous microorganisms may all be utilized in SSF. Some SSF processes, such as tempeh and oncome manufacturing, need the development of moulds that require low moisture levels in order to carry out fermentation using extracellular enzymes produced by fermenting microorganisms. Table 4 lists the many microorganisms utilized in SSF processes, including fungi, yeasts, and bacteria. Moulds are often employed in SSF to increase the production of value-added goods since they naturally grow on solid substrates including wood, seeds, stems, and roots. Bacteria and yeasts, which need a greater moisture level for effective fermentation, may be utilized for SSF as well, although the output will be reduced. SSF is a multi-step procedure that includes the stages below:

- Substrate selection.
- Pre-treatment of substrates, such as crushing straw and shredding vegetable materials, to increase the availability of bound nutrients while simultaneously reducing the size of the components, e.g., to optimize the physical features of the process. However, the expense of pre-treatment should be weighed against the value of the final product.
- Polymeric substrates, such as polysaccharides and proteins, are hydrolyzed.
- Hydrolysis products are used in a fermentation process.
- Purification and measurement of products in the downstream processes.

Different fermented foods were a frequent component of the diet in most Asian and African nations. Different types of activated oxygen, such as free and non-free radicals such superoxide anion radicals (O2), hydroxyl radicals (OH) and H2O2 and solitary oxygen (O2), have been shown to cause oxidative damage in living organisms. As a result, these species played a role in a variety of illnesses, including cancer, emphysema, atherosclerosis, and arthritis. SSF has mostly been used for food processing since ancient times, but it is currently receiving a lot of attention owing to the increased usage of various kinds of organic wastes and the increased manufacture of value-added goods (Pandey et al. 2000; Wang and Yang 2007). In the industrial sector, the quest for sustainable and green methods for bioconversion of organic wastes into useful products may replace non-renewable resources and convert chemical operations into cleaner practices, highlighting the potential of SSF. SSF is of special interest because of its relatively simple method, which utilizes plentiful low-cost biomaterials with little or no pre-treatment for bioconversion, produces less wastewater, and may simulate comparable microenvironments that are conducive to microbe growth. SSF has also ushered in a new era of bioconversion of organic solid wastes by producing physiologically active metabolites on a lab and industrial scale. Enzymes, organic acids, biofertilizers, bio pesticides, bio surfactants, bioethanol, fragrance compounds, animal feed, pigments, vitamins, and antibiotics have all been documented to use SSF in the manufacture of various bio-products. SSF, on the other hand, mimics natural microbial processes like composting and ensiling (Thomas et al. 2013). As a result, the effects of solid-state fermentation on the creation of value-added products by this method are examined and addressed.

1.1.4 *Solid-state fermentation, a substrate is utilized:*

SSF uses solid waste from a variety of sectors, including food, beer, and wine, agriculture, paper, textiles, detergents, and animal feed. Solid-state substrates have low moisture content, which is desirable for SSF. Figure 2 depicts part of the SSF substrate. Several researchers utilized rice, seim, black-eyed pea, and peanut press cake (Arachis hypogea) as substrate. The suitability of 10 agro-industrial wastes as fungal immobilization carriers for SSF. They discovered that certain waste materials have a higher potential for use as an immobilization carrier in SSF because they have a high water absorption capacity and a good microorganism growth rate.

1.1.1 *Production of biofuels:*

Biofuels are important because they can be used to replace fossil fuels. Biofuels may be made from favourable agro-industrial wastes such as rice straw, sweet potato waste, sawdust, potato waste, maize stalks, sugarcane bagasse, and sugar beet waste, according to previous research. Bioethanol production rose globally in 2011, as shown by the production of 85 billion litres of bioethanol. It helps to reduce deforestation by decreasing our reliance on forest woody biomass with the assistance of agricultural leftovers. Furthermore, since agricultural leftovers have a short harvest period, they are more often supplied for bioethanol production. Many studies have concluded that ethanol can be produced from lignocellulose materials. The synthesis of bioethanol from a variety of agricultural wastes derived from diverse crops. Explored the use of different agricultural wastes in the manufacture of second-generation bioethanol. They concentrated on the utilization of various agro-industrial wastes' lignocellulose compositions. They concluded that biofuels are viable alternatives to different fossil fuels such as gasoline and diesel. Based on their discussion and analysis of different biofuel production methods, it is apparent that lignocellulose-derived biofuels are a cost-effective, environmentally friendly, and alternative source of energy for the future. Biogas utilizing various agricultural wastes from various sources as well as two weeds.

Figure 2: The above figure shows the Substrates used for solid-state fermentation [bioresourcesbioprocessing].

Most developing nations' rapid population expansion, as well as their rapid industrialisation, results in a strong need for low-cost energy sources derived from agricultural leftovers. These nations have a significant quantity of trash that may be used to produce biofuels. Potato peels, carrot peels, and onion peels were among the typical vegetable wastes utilized. Bioethanol production may be the greatest alternative for agricultural residue use. Because of the abundance of banana pseudo stem as a waste in India, using banana stem as a substrate for bioethanol production is a viable alternative. Banana pseudo stem as a substrate and pre-treated it with Aspergillus ellipticus and Aspergillus fumigatus to generate bioethanol. Clostridium beijerinckii to produce butanol from agro-industrial waste. After 96 hours of fermentation, the highest amount of butanol, 11.04 g/l, was obtained from agro-industrial waste starch industry effluent (SIW). As a result, using low-cost and environmentally friendly agricultural waste to produce valuable biofuels is a superior approach to meet energy demands with limited resources.

2. DISCUSSION

Nutrient composition and bioactive substances are abundant in agro-industrial wastes or leftovers. Sugars, minerals, and proteins are all present in such wastes, thus they should be treated as "raw material" rather than "trash" in other industrial operations. The presence of these nutrients in these leftovers provides ideal circumstances for microbes to thrive. Through fermentation processes, bacteria may be able to utilize waste as source materials for their development. Agro-industrial wastes may be utilized as a solid support in SSF processes to produce a variety of valuable chemicals. Aside from that, fossil fuel consumption has an effect on greenhouse gas (GHG) emissions. Therefore, mandating the development of alternative, cleaner, and renewable bioenergy sources has become a worldwide problem. It is tough to get rid of these wastes. The juice industry, for example, produced a lot of garbage in the form of peels, the coffee industry produced waste in the form of coffee pulp, and the cereal industry produced husks. Sources for 147.2 million metric tons of fiber may be found all over the world, whereas wheat straw residues and rice straws were estimated to be 709.2 million metric tons and 673.3 million metric tons, respectively, in the 1990s. The utilization of agricultural and agro-based-industry wastes as raw materials may assist decrease-manufacturing costs while also contributing to trash recycling and environmental protection.

3. CONCLUSION

Bioactive chemicals and nutritional composition are abundant in agro-industrial wastes or leftovers. Because such wastes include a variety of components such as carbohydrates, minerals, and proteins, they should be treated as "raw material" rather than "trash" in other industrial operations. The presence of such nutrients in these leftovers provides ideal circumstances for microbial proliferation. Through fermentation processes, bacteria have the ability to utilize waste as source materials for their development. Agro-industrial wastes may be utilized as a solid foundation in SSF processes to create a variety of important useful chemicals. Using agricultural and agro-based-industry wastes as raw materials may assist decrease-manufacturing costs while also contributing to trash recycling and making the environment more environmentally friendly.

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