# Utilization of Agro-Industrial Waste by Using Solid State Fermentation: A Review

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***ABSTRACT***

*A staggering amount of residues are generated annually by industries centred on agriculture. These leftovers might harm people's and animals' health as well as contaminate the environment if they are not disposed appropriately. Due of their insufficient use and without treatment, the bulk of agro-industrial wastes are said to be burned, dumped into an landfill. These untreated wastes lead to greenhouse gas emissions, which contribute to a number of climate change-related problems. As a consequence, improving alternative, cleaner, and renewable bioenergy sources is currently a global concern. These residues have great nutritional potential based on their composition, these agro-industrial residues are receiving increased attention for quality management and are also classified as agro-industrial by-products. These leftovers are very nutritive and are not regarded as "wastes," but rather as raw ingredients for the production of novel goods. The presence of these nutrients in raw materials provide optimal environment for microbial development. Through the use of fermentation processes, various microorganisms are able to reuse the raw material. The substantial support of the Solid State Fermentation (SSF) advancements in the production of various useful goods comes from the agro-industrial residuals. To find out the way by which microorganisms transform agricultural waste into sugars, several methods have been mentioned in this article. Lastly, this review discussed the potential applications of SSF procedures for agro-industrial wastes.*

***KEYWORDS***

*Agro - Industrial waste, Solid State Fermentation, waste, residues, microorganism*

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**Introduction:**

Agriculture sector is very important sector in Indian economy. It provide various benefits to people. Globalisation and increased industrialization, together with population expansion, have greatly fuelled the rise in industrial and agricultural activity worldwide. Large volumes of agro-industrial wastes are produced yearly by household and commercial farms, processing industries. An important concern for the agro-based sector is waste management. Because of their disposal methods, they are responsible for seriously harming human health in addition to damaging the air and water supplies. According to the United Nations Environment Programme, agro-industrial wastes account for one-third of global agricultural production, or 1.3 billion tonnes of food produced for human consumption, and cause an estimated 800 billion euros in economic losses (Yafetto et al. 2023). Solid waste has historically been handled using a variety of chemical treatments. But chemical treatment has various disadvantages. So, more attention has recently been focused on biological conversion of these agricultural wastes into valuable goods.

Solid-State Fermentation is the microbial fermentation that occurs in the absence or near absence of free-flowing water and involves the cultivation of microbes on wet, solid, non-soluble organic materials that supply food sources for growth of bacteria. Microorganisms get carbon and energy sources from solid organic substrates in SSF conditions, which are similar to those seen in nature. Agro-industrial wastes are eventually transformed by SSF into valuable products with added value, including enzymes, food and feed additives, biofuels, biosurfactants, bio-pigment, singe-cell proteins, and animal feed. The microbes utilised in SSF are classified as "generally regarded as safe" (GRAS). Agro-industrial wastes must meet certain requirements in order to be chosen for biotransformation and value-adding under SSF. They consist of (i) solid and organic materials; (ii) conveniently accessible; (iii) good sources of fermentable carbohydrates; and (iv) highly cellulosic and lignified yet poor in nutrients. (Mattedi and others, 2023)

**BY PRODUCTS FROM AGRICULTURAL RESIDUES**

As mentioned in figure 1 the agricultural residues and industrial residues are two distinct categories of agro-industrial waste. There are two other kinds of agricultural residues: process residues and field residues. Field residues are the remnants that are left in the field after harvesting crops. Leaves, stalks, seedpods, and stems make up field residues. Process residues, on the other hand, are byproducts remaining after the crop is transformed into another beneficial resource. These wastes, which include pulp, stubble, peels, roots, molasses, husks, bagasse, seeds, leaves, stems, straw, stalks, shells, pulp, stubble, peels, and so on, are used to make a range of goods, including antibiotics and biofuel. Some of the valuable products are described in fig 2.

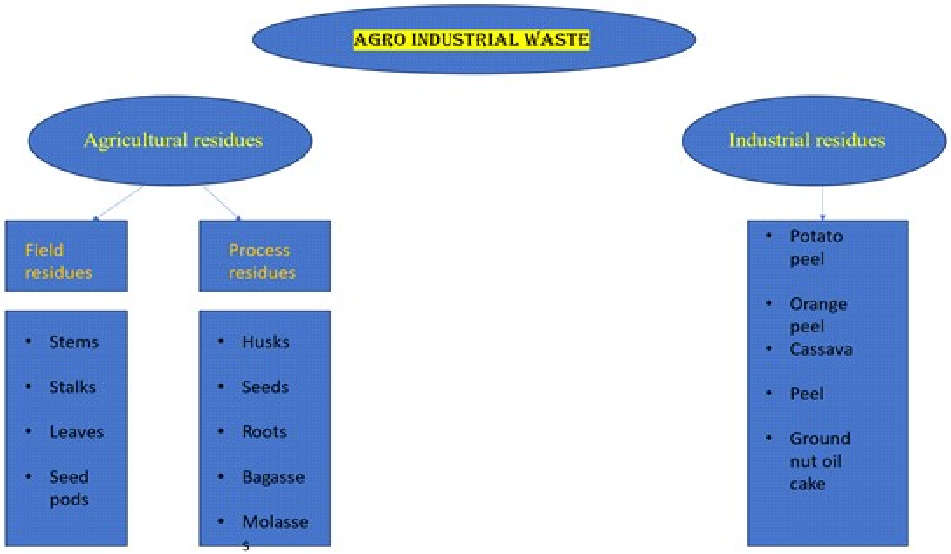


**Figure 1:** Different type of agro- industrial waste


**Figure 2 :** By products of agriculture residue

**(i) BIOFUEL**

Due to rapid industrialization and population increase, the majority of emerging nations have a significant demand for inexpensive energy sources made from affordable agricultural leftovers. These nations have an abundance of garbage that is needed for the manufacturing of biofuels. Since biofuels are crucial and can replace fossil fuels. Prior research (Duhan et al. 2013; Kumar et al. 2014, 2016) has demonstrated the synthesis of biofuels from favourable agro-industrial wastes such as rice straw, sweet potato waste, sawdust, potato waste, maize stalks, sugarcane bagasse, and sugar beetroot waste.

Maiti et al. (2016) produced butanol from agro-industrial waste by using Clostridium beijerinckii. The starch industry effluent from agro-industrial waste generated the most butanol—11.04 g/l (SIW)—after 96 hours of fermentation. Therefore, a better option to meet energy needs while using limited resources is to produce useful biofuels from cheap and environmentally friendly agricultural waste.

**(ii) ANTIBIOTICS**

Antibiotics are compounds that, at extremely low concentrations, selectively limit the development of other bacteria or kill them (Tripathi 2008). These molecules are generated by many microbes. Different antibiotics are produced from a variety of agricultural wastes. When low-cost carbon sources from different agricultural leftovers were used, the cost of producing antibiotics was dramatically reduced. These leftovers can serve as an excellent stand-in for neomycin and other antibiotic synthesis (Vastrad and Neelagund 2011). Utilising oil-pressed cake, which is also considered an agro-industrial waste, as a raw material and Amycolatopsis mediterranean MTCC 14 for solid state fermentation, Vastrad and Neelagund (2011) investigated the synthesis of extra cellular rifamycin B. Two of the several agro-industrial wastes- coconut oil cake and crushed nut shell—exhibited the highest levels of antibiotic production. The utilisation of outside energy sources was employed to boost antibiotic manufacturing.

**(iii) ANIMAL FEED**

Animals get the nourishment and energy they need from animal feed. However, the availability and digestion of nutrients in meals, feeds, and agro-industrial wastes are hampered due to the presence of anti-nutritional factors (ANFs), which include hydrogen cyanide, caffeine, oxalates, phytates, tannins, polyphenols, and saponins. Thus, agro-industrial wastes can undergo mechanical, chemical, or biological (microbial) procedures to improve nutritional quality and decrease ANFs. Compared with labour- and capital-intensive chemical and mechanical approaches, increasing the nutritional composition of agro-industrial wastes is safer and less expensive when done through the biological fermentation process. Furthermore, it is necessary to develop strategies that enable the efficient utilisation of agro-industrial wastes into single-cell proteins, especially for animals, due to the high demand for protein-rich foods and feeds for both humans and animals, as well as the low nutritional contents of most agro-industrial wastes and the high cost of formulated feeds (Parmar et al. 2019).The safety and acceptability of animal feed for animal consumption are enhanced by the fermentation process that uses GRAS bacteria. SSF technology is a cutting-edge method used in animal husbandry to transform agro-industrial wastes into high-value, protein-rich animal feed that may be able to address issues with insufficient protein intake in animal diets (Aruna et al. 2017)

The careful selection of appropriate agro-industrial substrates and microorganisms for use in the fermentation process is the first crucial stage in the SSF process. Owing to their large size and lignocellulosic composition, the substrates typically undergo a step of chopping, grinding, or cracking to reduce their particle size. This increases their surface area and facilitates microbial colonisation, nutrient utilisation, and fermentation (Mitchell et al. 2000). Notwithstanding this, not all of the vital elements required for microorganisms to flourish are present in agro-industrial wastes (Zepf and Jin 2013). Some agro-industrial wastes, including peels from cassava, yam, and plantains, may have little to no nutrients at all, while other wastes may include some nutrients at all. It is not possible to regard such nutritionally inadequate substrates as optimal for microbial development, and hence, for the effective colonisation and fermentation of the substrates. Because of this, external nutrition sources are typically added to solid substrates (Mitchell et al. 2000). Therefore, improving the nutritional needs for microbial growth and product creation during fermentation is the goal of adding nutrient supplements to agro-industrial residues.

**(iv) Enzymes:**

**a. Pullunase:**

An enzyme engaged in the substrate-producing process of maltose enzyme that contributes to the cyclodextrins synthesis. Important pharmaceuticals are housed in cyclodextrins. It is employed in industries based on starch, particularly those that produce glucose. It help in b reak of own the 1-6 glycosidic linkages in the oligosaccharide linked to starch and amylopectin.

In order to produce pullulanase as efficiently as possible during solid state fermentation, Kumar et al. 2022 investigated screened agricultural waste substrates. The medium based on 5 g of green gram husk and incubation done for 3 days at 30 °C showed the greatest enzymic activity (9.74 U/gds) among the several agricultural wastes utilised as a substrate. Using the Plackett–Burman experimental design, the effects of sixteen different nutrients on the yield of pullulanase production were investigated. In contrast to the unoptimized media, the pullulanase production medium exhibited a 5.7 times increase (56.25 U/gds) in yield upon the addition of $FeSO_4$, $MnSO_4$, and $MgSO_4$. Upon completion of complete optimisation, the yield increased 6.37 times overall.

**b. Amylase:**

á-amylases are widely utilised enzymes among the many vital enzymes for industry; they are necessary for the fermentation of various foods. In addition to the food and starch sectors, á-amylases find extensive use in paper pulp, textile, and other related industries (Gupta et al. 2003). Almanaa et al. 2020 studied the amylase production using *Bacillus subtilis* as a bacterial strain using solid residue such as wheat bran, banana peel and rice bran.

**c. Cellulase:**

A polymer of glucose units joined by â-1,4 links is called cellulose (Alvira et al. 2013, Bayer et al. 1998). It is the most prevalent organic substance on Earth, serving both a significant mechanical support for vegetation and a replenishable source of energy. Combining agro wastes with cellulose yields additional bioactive chemicals and a low-cost carbon source. Thus, agricultural waste may be efficiently utilised as a substitute energy source to create various goods (Bhargav et al. 2008, Bhatt 2000). Cellulase is primarily responsible for reducing cellulose and is often generated by bacteria. Through the combined activities of endo-â-1,4 glucanase, cellobiohydrolase, and â-d-glucosidase, cellulases may effectively break down cellulose into glucose units (Caramihai and Jecu, 1997).

Navaneethapandian et al. 2020 analysed *Aspergillus flavus* SB04's 28-day biological transformation of rice bran's cellulose in SSF was the goal of the study. The pH, temperature, and moisture content of the culture were all adjusted to maximise the enzyme's ability to be produced in SSF. The impact of carbon and nitrogen sources on the synthesis of cellulase in SMF was further evaluated and measured every 24 hours for a period of seven days. The highest amount of cellulase production for rice bran was found to be produced at starting moisture levels of 75 millilitres, pH levels of 6, temperature levels of 33°C, and fermentation length of 14 days, which was optimised using response surface approach. The Lowry protein method, filter paper assay, and dinitrosalicylic acid (DNS) technique were used to analyse each enzyme's synthesis separately. By using FTIR and SEM, the lignocellulosic degradation was seen and verified. After seven days, there is a periodic rise in cellulose breakdown, which affects the amount of cellulase enzyme produced.

## CONCLUSION AND FUTURE PROSPECTUS:

Wastes and leftovers from the agro-industrial sector are abundant in bioactive chemicals and nutrients. These wastes include a variety of constituents, including minerals, proteins, and carbohydrates; as a result, they need to be regarded as "raw materials" rather than "wastes" for use in subsequent industrial operations. These wastes include nutrients that provide an ideal environment for the rapid development of microorganisms. Through fermentation processes, the microorganisms possess the capability to utilise the waste as starting ingredients for their growth. A variety of important useful chemicals may be produced using SSF methods with the solid support provided by the agro-industrial wastes. Utilising the wastes from the agricultural and agro-based industries as raw materials may lower production costs and aid in trash recycling, which protects the environment.

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