

Bioconversion of agricultural and industrialised waste to generate valuable products

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Abstract. Agro and industrial wastes are rich in bioactive compounds. These wastes can be used as an alternate source for the production of different valuable products as the raw material in various industries. The use of agro-industrial wastes as raw materials can help to reduce the production cost and also reduce the pollution load from the environment. Agro-industrial wastes are used for manufacturing of enzymes, biofertilizer, biofuel, antibiotics, and other chemicals through solid state fermentation (SSF). A variety of microorganisms are used for the production of these valuable products through SSF processes. This reviewed work was aimed at bioconversion of agricultural and industrial wastes to generate valuable products.

Keywords: Agrowastes; Enzyme; Biofertilizer; Biofuel; Antibiotics.

Received
August 16, 2019

Accepted
December 27, 2019

Released
December 31, 2019



Full Text Article



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Introduction

Agricultural waste represents one of the most important crops of the humid tropics, with a global annual production of more than 250 million tons (Akaranta, 2006). Africa produces more

than half of this global supply with the annual production from Nigeria alone (about 45 metric tons) representing more than a third of the total African output. Nigeria has consistently also been ranked as the world's largest producer of agricultural product since

2005 (Gillian, 2001). Agricultural crop has many important industrial uses including serving as raw materials for the food, chemical, and pharmaceutical industries. According to Safeguard International Training Institute (SITI, 2001), cassava starch has equally been found to be a very promising raw material for the production of bio-ethanol and in the production of high quality biodegradable plastics. These wastes generated during processing of agricultural product constitutes about 20%-35% by weight of the original products.

Despite the large amounts of wastes generated, this rich organic material has received very little attention as a low-cost by-product and is usually discarded and allowed to be decomposed by microorganisms such as bacteria and fungi, without any value added products. Agricultural wastes could serve as a potential valuable resource for industrial exploitation in the production of several value-added products such as organic acids, flavour and aroma compounds, microbial enzymes, biofertilizers, biofuel and many others industrial product that can enhance the socio-economic development of any nation (Salihu et al., 2011).

Microbes can be more easily subjected to genetic manipulation such as mutation and recombinant DNA technology in order to improve the productivity of industrial products. Different microbial sources such as bacteria, yeasts and fungi have been utilized for the production of industrial products by utilizing different substrates like starch, glycerol, glucose and other inorganic salts (Salihu et al., 2011). A major part of the production cost of most industrial products are mainly due to the cost of the fermentation media and processes. Therefore, to minimize the cost of production and to fulfil the needs and challenges of industries, a variety of microorganisms and cheap agro-industrial substrates have been tested to facilitate the economic production of

Most industrial products. The food and agricultural industries generate excessive volumes of agro-industrial wastes worldwide. These wastes pose a serious threat to the environment through environmental pollution (Saline et al., 2011). Being rich in nutrients, the agro-industrial residues should not be considered as wastes, and rather can be used as a substrate for microbial cultivations in order to enhance industrial production of value-added products such as enzymes, biofuel, biofertilizer and many other industrial products. The aim of these technologies is to convert waste using appropriate microorganisms for the production of value-added products; thereby reducing the environmental pollution and solving the issues associated with their disposal (Ezejiofor et al., 2017).

Agricultural waste

In Nigeria, large amount of waste and crops residues can be found every where. Which leads to different problems associated with the environment. Agricultural waste such as cassava peels, Rice husks, Yam peels, sweet potatoes peel, remains the major environmental concern in Nigeria which are disposed off indiscriminately during their processing in industries that can be harmful to our health (Oyeleke et al., 2012). According to Akaranta (2006), some of these waste material from agriculture are fibrous material which contains about 30%-50% starch on dry weight basis due to their rich organic nature and low ash content, they can serve as an ideal substrate for microbial processes for the production of value added products. Attempts have been made to produce several products such as organic acids, flavour and aroma compounds, mushrooms, biofuels, biofertilizer, enzymes and many more industrial products from agricultural wastes. Solid-state fermentation has been mostly utilizing for biotransformation, agricultural waste generated as a by-product from farm,

home and food industries, would be processed into useful products which are useful in chemical, food and others industrial setting.

According to Gillian (2001), there are six benefits of waste transformation:

- ✓ It minimizes the amount of waste requiring disposal.
- ✓ It saves natural resources including non-renewable resources such as petroleum.
- ✓ It reduces the amount of energy needed to manufacture new products.
- ✓ It reduces pollution and destruction caused while obtaining new raw materials.
- ✓ It provides employment opportunities.
- ✓ It helps the national economy because fewer raw materials have to be imported.

Technique used for cultivating the soil, harvesting crops, reared livestock have changed with time. Today's agriculture relies on a wide range of fertilizers, fungicides, herbicides, other pesticides and hormones. The benefits of using these chemicals in modern agriculture include increase in agricultural produce and reduction in crop losses. Increase in agricultural produce leads to a corresponding increase in agricultural wastes, which have the abilities of causing environmental pollutions (Salihu et al., 2011).

Agricultural wastes are all forms of plant-derived or animal-derived materials that are considered useless either because they have no known positive economic importance or because they are not grown or raised for any specific purpose (Akaranta, 2006). Wastes produced due to agricultural activities are classified as: Crop residues, Pruning residues from trees and dead palms, Weeds and water weeds harvested from rivers, canals, and drains,

Animal droppings, Food processing wastes.

All these categories of wastes mentation above are raw materials for the production of most industrial products using appropriate microorganisms, and it differ from one another with respect to factors such as structure, chemical composition, moisture content, etc. While the majority of the composition is dominated by non-starch carbohydrates and lignin, grain waste varieties also contain high amounts of proteins, lipids, starch and glucans (Sun et al., 2008).

Enzymes Production from Agricultural and Industrial wastes

Enzymes are proteins molecules found in the cells of living organisms which have the ability of speeding up chemical reactions but do not get used up in the process. Enzymes are the most essential products in industries obtained for human needs by microbial sources; Infact, many industries such as environmental, food biotechnology and chemical industries make judicious used of enzymes at one stage or the other for the production of valuable products for the socio-economic development of any country (Oyeleke et al., 2010).

According to Burhan et al. (2003) there are three major sources of enzymes:

- Those that are obtained from a variety of plant (pappain),
- those that are obtained from animal's gland (Trypsin and pepsin), and
- those that are obtained from microorganisms (fungi and bacterial).

The potential used of microorganisms for the production of enzymes are far better to those derived from both plant and animal's sources, because they are cheaper and easy to produce, also their enzyme content is

more predictable, controllable and reliable (Burhan et al., 2003).

Production of biofertilizers from agricultural and industrial wastes

After utilization of food wastes mainly by aerobic microorganism, not only is the stench of the waste eliminated, but also the hazardous substances are degraded, the secondary pollution pose by these agricultural wastes is avoided, and has good social and environmental benefits. The degradation products can be divided into organic fertilizer, bio-organic fertilizer and soil conditioner, which contain a variety of plant growth accelerating agent, and as application fertilizer can be used for flowers, trees, vegetables and others. It is a high quality organic mixed fertilizer which when applied to the cultivation of plants can improve soil structure, increase soil fertility and promote crop growth. The use of such fertilizers will not only minimized burden of environmental waste, but also promote the mass production of bio-fertilizer and reduce the use of chemical fertilizers, thereby reducing the pollution of soil and water by chemical fertilizer (Wang et al., 2004).

Bio-fuels and biogas production from agricultural and industrial wastes

Energy is one of the most important factors to global prosperity, in view of continuously rising petroleum costs and dependence upon fossil fuel resources, considerable attention has been focused on alternative energy resources, hence the production of liquid biofuels which has been advocated as a sustainable option to tackle the problems associated with rising crude oil prices, global warming and diminishing petroleum reserves. Biofuel can be produced from local resources such as agricultural wastes, municipal solid waste, market wastes and animal waste, energy (biogas), and manure are derived

by anaerobic digestion (Parawira, 2012). These wastes are rich in lignocellulolytic materials, one of the largest and renewable sources of energy on earth. Significant improvement in biogas production occurs after pre-treatments of these compounds with the help of enzymes such as cellulases and Cellulase-producing microorganisms. Microbial enzymatic hydrolysis of different complex organic matter converts them into fermentable structures, leading to production of biogas. Significant improvement in biogas production occurs when crude and commercial enzymes are used in the pre-treatment of complex organic matter. Bio-fuels can be broadly classified into two major types, gaseous and liquid biofuels. Purification of the conventional biogas into methane-enriched biofuel led to the development of biomethane. Biohydrogen is a relatively new type of gaseous biofuel, which is produced by anaerobic fermentation of agricultural wastes by the synergistic action of a consortium of methanogenic, acidogenic and hydrogenic bacteria (Amigun et al., 2008). On the other hand, liquid biofuels have recently been classified into bioethanol and biodiesel. While bioethanol has recently gained rejuvenated importance in the wake of present energy crisis worldwide, biodiesel occupied the centre stage as a potential substitute for petroleum diesel in the last two decades.

Production of secondary metabolites: Antibiotics, steroids, alkaloids from agricultural and industrial wastes

Despite the obvious problems that agricultural waste can create, the vast quantities of wastes that are generated as a result of diverse agricultural and industrial practices represent one of the most energy-rich resources on the planet. Accumulation of this biomass in large quantities every year results not only in the deterioration of the environment, but also in the loss of

potentially valuable material which can be processed to yield a number of value added products, such as food, fuel, feed and a variety of chemicals. The residues are generated globally, with a major portion left unutilized, and as wastes in the surrounding environment. Such wastes produced annually can be used as a natural bio resource for the production of bioactive compounds such as secondary metabolites from various selected microorganisms. Secondary metabolites are excreted by microbial cultures at the end of primary growth and during the stationary phase of growth. Secondary metabolites represent some of the most economically important industrial products and are of huge interest. The best known and most extensively studied secondary metabolites are the antibiotics, steroids and alkaloids (Azbar, 2004). Bioactive compounds are mostly secondary metabolites produced by microorganisms in an active culture cultivation process. Secondary metabolites usually accumulate during the later stage of microbial growth, in process of fermentation known as the "Idiophase". This later stage of microbial growth follows the active growth phase called "Trophophase". Compounds produced in the idiophase have no direct relationship to the synthesis of cell material and normal growth of the microorganisms. Secondary metabolites are formed in a fermentation medium after the microbial growth is completed. Filamentous fungi synthesize many secondary metabolites and are rich in genes encoding proteins involved in their biosynthesis. Genes from the same pathway are often clustered and co-expressed in particular conditions (Khaldi et al., 2008).

Conclusions

Agro and industrial wastes is the cheapest and most easily available form of carbohydrates for valorisation and subsequent value addition. Both bacterial

and fungal species can be deployed for production of various products using agro wastes. However, inexperienced personnel and facilities have limit the bio-transformation of agro and industrial wastes to generate valuable products. Being rich in nutrients, the agro-industrial residues should not be considered as wastes, and rather can be used as a substrate for microbial cultivations in order to enhance industrial production of value-added products. An extensive analysis of several studies on the use of inexpensive media components for enzyme and other valuable production of various products reveals that agro and industrial waste shows much promise and can be utilized as a carbon source in mainstream upscale fermentation processes.

Conflict of interest

Authors declare that there are no conflicts of interest.

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