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Agricultural Crop Residues: Unutilized Biomass Having Huge Energy Creation Potential

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Abstract: There is huge accumulation of agro-industrial waste-materials generated by the milling, brewing and various agriculture and food based industries which in total amount to about 500 million tons per year in India. Most of these by-products contain three major structural polymers such as cel-lulose, hemicellulose and lignin. These are also the main source of feed for animals. A high pro-portion of waste material is carbohydrate and phenolic in nature. The vast accumulation of this kind of biomass not only results in the deterioration of the environment, but also a huge amount of potentially important materials are lost. Owing to the above facts, Biological degradation, for both economic and ecological reasons, has become an increasingly popular alternative for the treatment of crop residues producing different value-added biofuels via biotechnological proc-esses involving microorganisms. Biological degradation, now-a-days, has become an increas-ingly popular alternative for the treatment of agricultural, industrial, organic as well as toxic wastes. Cellulose and hemicellulose being the major constituents, these materials can be referred to as valuable resources for a number of reasons, mainly due to the fact that they can be bio-converted easily into valuable products. These wastes can be processed to yield a number of valuable added products, such as biofuels like biohydrogen, bioethanol and biobutanol along with a variety of chemicals. Various treatment methods such as physical, chemical, biological are employed for the production of these value-added compounds.

Keywords: *Agrowastes, Biofuel, Bioethanol, Biobutanol, Biohydrogen*

Introduction

The yearly accumulation of agro-industrial waste-materials generated by the milling, brewing and various food based industries, has led to the consideration of extracting high value residues to offset the cost of treating and disposing of the residues. Most of these by-products are cur-rently used as animal feed, but attention towards obtaining of high-value compounds from these wastes is being emphasized by various academic as well as industrial researchers. Agricultural by-products which contain three major structural polymers, cellulose, hemicellulose and lignin, are the main sources of feed for ruminants. However, their quality as feed, especially in terms of digestibility, depends not only on the amount and structure of these polymers but also on the amount of readily available substances such as sugars and amino acids. A high proportion of this waste material is carbohydrate and phenolic in nature. Specific sugar residues can be released from the cell-wall by the action of carbohydrases. Many species of microorganisms are able to degrade agricultural by-products thus releasing a vast amount of carbon which otherwise would be locked away in plant secondary metabolites such as lignin. An important attribute of micro-bial biocatalysts in bioreactors is the ability to synthesize products in a consistent and predictable manner. Application of microbial biotransformation tools is a promising alternative to obtain natural products.

Our basic energy requirements are almost dependent on the carbon-containing fossil sources such as oil, coal and natural gas, which have been formed during many millions of years from plant biomass. The huge consumption of these fossils resources being non-renewable sources forces many researchers around the globe towards the alternative renewable enegy potential sources for future.In this context agro wastes serve as the good source for production of bio-methane, biohydrogen and biobutanol for future solving future energy crisis. In view of the above facts, this paper focuses on the biotechnological approaches to develop technologies for efficient use of this lignocellulosic material and to utilize agro waste materials as cheap sources of renewable biofuels acting as future fuel.

Agricultural crop residues

Agro-residues such us cereals straw, corn cobs, cotton stalks, various grasses, maize and sor-ghum stover, vine prunings, sugarcane and tequila bagasse, coconut and banana residues, corn husks, coffee pulp and coffee husk, cottonseed and sunflower seed hulls, peanut shells, rice husks, sunflower seed hulls, waste paper, wood sawdust and chips, are some examples of resi-dues and by-products. These also include all agricultural wastes such as straw, stem, stalk, leaves, husk, shell, peel, lint, seed/stones, pulp, stubble, etc. which come from cereals (rice, wheat, maize or corn, sorghum, barley, millet), cotton, groundnut, jute, legumes (tomato, bean, soya)coffee cacao, olive tea, fruits and palm oil. . These are widely used as household fuel in developing countries. It is also to be noted that only crop residues production is estimated to be about 4 billion tons per year, 75% originating from cereals [1].

On the surface of our planet, around 200 billion tons per year of organic matter are produced through the photosynthetic process [2]. However, the majority of this organic matter is not di-rectly edible by humans and animals consequently creating a source of environmental problem. On the basis of great demand for appropriate nutritional standards, there is rising costs and de-creasing availability of raw materials directly influence [3] on recovery, recycling and upgrading of these wastes. This is predominantly valid for the agro-food industry, which furnishes large volumes of solid wastes, residues and by-products, produced either in the primary agro-forestry sector or by secondary processing industries, posing serious and continuously increasing envi-ronmental pollution problems [4].

According to a survey by regarding the data on estimates of residue production in the world, the annual residue production is estimated at 2.8 billion Mg of cereals, 305 million Mg of legumes, 108 million Mg of oil crops, 373 million Mg of sugar crops and 170 million Mg of tubers. The total crop residue production in the world is estimated at 3.8 billion Mg, of which 74% are of cereals, 8% of legumes, 3% of oil crops, 10% of sugar crops and 5% of tubers. The most useable crop residue, however, is that of cereals [5].

Biotechnology for Agro-Wastes

The energy content of agro residue varies among crop species. The energy content is 3015 kcal/kg for rice straw and 3738 kcal/kg for hay [6]. The approximate fuel value per Mg of crop residue is equal to 2 barrels of diesel, 18.6 ×10 9 J or 3 ×10 6 kcal. The global energy value of crop residue is 7516×10 6 barrels of diesel or 69.9×10 18 J of energy. The chemical properties of such lignocellulosic agricultural residues make them a substrate of huge biotechnological value. They can be converted into various different value-added products those may be used as biofer-tilizer or biopesticide, enzymes, organic acids, ethanol, flavours, biologically active secondary metabolites and also for bioremediation of hazardous compounds, biological detoxification of agro-industrial residues, biopulping etc. ([11], [12], [13], [14], [15], [16]). These are also provid-ing good substrates for most industrial fermentation processes and for some chemical processes ([17], [18]).

Bio-Fuels

There are two classes of Bio-fuels such as gaseous and liquid biofuels. Development biomethane can be obtained by purification of the conventional biogas. Biohydrogen is a relatively new type of gaseous biofuel, which is produced by anaerobic fermentation of agro-industrial wastes by the action of methanogenic, acidogenic and hydrogenic bacteria. On the other hand, liquid biofuels are either bioethanol or biodiesel. While bioethanol has recently gained greater importance for mitigation of energy crisis worldwide whereas, biodiesel occupied the centre stage as a potential substitute for petroleum diesel in the last two decades.

Biogas

The conventional biogas is produced using anaerobic digestion of organic wastes includ-ing manures by mixed microbial cultures. It is composed mostly of methane (typically 55%–70% by volume) and carbon dioxide (typically 30%–45%) a nd may also include smaller amounts of hydrogen sulfide (typically 50–2000 ppm), water vap or (saturated), oxygen, and various trace hydrocarbons ([19, [20], [21]). Biomethane is extremely similar to natural gas which contains 90% methane only differs that it comes from renewable sources. [22]. Biogas can also used as vehicle fuel. It has been estimated that 40–50% in vehicle maintenance costs achieved due to operation of biogas, [23].

Biohydrogen

Hydrogen is a very high energy (122 kJ/g) yielding fuel in comparison to methane or ethanol. Photoautotrophically growing bacteria and some algae, utilize light as primary energy source to split water into hydrogen and oxygen by the enzyme hydrogenase. Several forms of organic waste streams, ranging from solid wastes like rice straw and waste water from different sources have been successfully used for hydrogen production. Most experiments have shown consider-able hydrogen production with the limited number of thermophilic strains used. It has been ex-amined that CSTR (Continuously stirred tank reactor) gives the best performance with a yield of 0.30 L H2/g of carbohydrate and production rate of 4.50 mmol H2/L reactor.

Bioethanol

Bioethanol is a biofuel used as a petrol substitute. It is produced by simple fermentation proc-esses utilizing agricultural carbohydrate feedstock and yeasts as main biocatalysts. A variety of common sugar feed stocks including sugarcane stalks, sugar beet tubers and sweet sorghum are used as the substrates for production of bioethanol. The fermentation process is mediated by two enzymes invertase and zymase, produced by the yeast cells. Ethanol produced from different renewable and cheap agricultural products not only solves the energy crisis but also reduces the green house gas emissions like COX, NOX and SOX thus eliminates smog from the environment. Bioethanol produced from agro- industrial residues can also be used for the transesterification of vegetable oils to produce mono ethyl esters of fatty acids as biodiesel.

Biobutanol

Biobutanol is also an efficient and convenient fuel to transport to market. A big issue with etha-nol is that it’s corrosive, can’t be run it through the same pipelines as gasoline, but with biobu-tanol, that can be done. Thus biobutanol can grow the market more easily with more industries than ethanol. Butanol is a four carbon alcohol. It has double the amount of carbon of ethanol, which equates to a 25 percent increase in harvestable energy (Btu's). Butanol is produced by fermentation, from corn, grass, leaves, agricultural waste and other biomass. Butanol is safer to handle with a Reid Value of 0.33 psi, which is a measure of a fluid's rate of evaporation when compared to gasoline at 4.5 and ethanol at 2.0 psi. Butanol is an alcohol that can be but does not have to be blended with fossil fuels.

Conclusion

Crop residues are significant resource, with different challenging uses. Due to rapidly amplifica-tion of crude oil prices there is the increasing the demand towards the biofuel technologies leading for utilization of agro-industrial residues.The major gaseous biofuels, namely, biomethane and biohydrogen and the major liquid biofuels, namely, bioethanol and biodiesel have evolved as potential alternative to the fossil fuel resources. Bioethanol and biodiesel are gaining importance as alternative fuels to petrol and diesel respectively. Bioethanol, which is conventionally pro-duced from cane molasses by yeast fermentation, can also be produced from various agro-industrial residues and plant wastes. Agro-industrial wastes constitute interesting source of phytochemicals that can be readily extracted by use of microbial enzymes. These crop residues serve as the second generation of biofuel (fig.1) rather than first generation not competing to the food security. There is essential to guarantee the product purity using quality control analyses. Bio-logical activity of these phytochemical extracts needs to be demonstrated by in vivo studies and clinical assays. The financial side and environmental consequences of challenging uses of crop residue must be assessed objectively with a holistic approach and long-term perspective.

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