



Food Wastes as Biodegradable Plastic Mulches

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In general, food waste generated during preparation, production, and consumption creates not only pollution problems but also valuable biomass and nutrients get lost. The Food and Agriculture Organization (FAO) reported that globally around 1.3 billion tonnes of food is wasted or lost which accounts to about one third of food produced for human intake/ consumption. Mulching of agricultural crop fields or the soil has the major advantage of decreasing input cost of fertilizers, reducing the irrigation water demand as well helps in improving yield of crops. But, utilization of plastic mulches in agricultural soil may leads to generation of plastic pollution. Hence, biodegradable plastic mulches (BDM) which are easily degradable through *in-situ* decomposition in the soil itself will be a best alternative for plastic mulches. Bioconversion, recovery, and utilization of important constituents from food waste is gaining momentum nowadays. The major composition of fruits and vegetables dry matter includes hemicelluloses and sugars (75%), cellulose (9%) and lignin (5%). These constituents can be very well utilized for bioplastic mulch production.

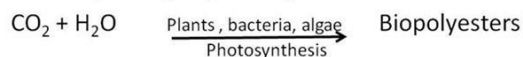
Biodegradable plastics

Bioplastics, being developed in the early 1980s, are the polymers or the materials produced from biologically degradable materials like straw, corn starch, vegetable oils, fats, saw dust, food wastes, woodchips etc., Sugar derivatives *viz.*, cellulose, starch, lactic acid in these degradable materials are used for bio-plastics production. These bio-plastics can be decomposed easily through microbial actions into carbon-dioxide, water and biomass. Polyesters with their hydrolysable ester bonds play a significant role as biodegradable plastics. Globally, corporate and governmental sectors, encourages the production of bioplastics, since they reduce the utilization of LDPE (Low density polyethylene), which is considered as an environmental pollution problem (Hadaly Serrano-Ruiz *et al.*, 2021). Some of the commercially developed biodegradable polyesters includes Polyhydroxyhexanoate (PHH), Polyhydroxyvalerate (PHV), Polylactic acid (PLA), Polybutylene succinate (PBS), Polyhydroxybutyrate (PHB), Polyhydroxyalkanoates (PHA), Polycaprolactone (PCL) and Polyethylene terephthalate (PET). As the oil prices continues to swift, bioplastics will prove to be economically feasible compared to petroleum based plastics. One of the bioplastics being sold in market and commercially available is Polybutylene succinate (PBS). Due to its excellent mechanical properties, it is proved to biodegrade in liquid, soil as well in compost medium.

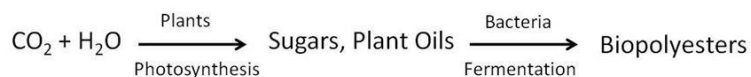
Bioplastics can be produced in three ways, i) One stage ii) Two stage iii) Three stage production process (Fig.1). In one stage process, substrates are directly converted to bioplastics. In two stage process, substrates are converted to sugars and then to bioplastics through fermentation of bacteria. In three stage process, substrate is converted to sugars and then to lactic acid (monomers) through fermentation and then to bioplastics by chemosynthesis and catalytic reactions as well.



1 – Stage Biopolyester production



2 – Stage Biopolyester production



3 - Stage polylactides production

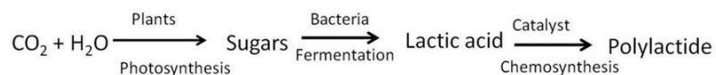


Fig 1. Production process of biodegradable plastics

Biodegradable plastic mulches

“Plastic” is the word derived from Greek language “plastikos” which represents “ability to mold into different shapes”. These are the human made long-chain polymers. Commonly used materials for making plastics includes extractants from coal, oil and natural gas. Plasticulture is the defined as the technology wherein plastics are used in the agricultural sector. Biodegradable plastics mulches are prepared from plant based starch materials using conventional plastics processing technology. Usually, starch will be blended with polymer materials to avoid the brittleness properties of starch. Polyhydroxyalkanoate (PHA) and Polylactic acid (PLA) are the two commonly used polymers for bioplastic mulch production. PLA is more flexible and can be made from plant based starch, which will be converted into lactic acid by fermentation process. Because of its nature of turning easily out into filaments, it can be used for various medical and biological applications. PHAs are considered to be as “green polymers” since, their primary source is microorganisms and plants, and also they are produced in one-stage process during bacterial fermentation of sugars. These PHAs serve as source of both carbon and energy, when they are obtained from microorganisms. The fact about PHAs is that the products made out of it will be more brittle, since they are made from microbial process, and needs blending with PLA. These BDM does not require any disposal mechanisms because, as their life time completes, they will be incorporated into the soil and the soil microbes will convert them into CO₂, H₂O and biomass.

Some of the commercially available bio-mulch film includes 50-µm-thick film *Mater-bi* made of PCL with starch blend supplied by Deltalene, Novara, Italy; 60-µm-thick film *Ecoflex* made using aromatic and aliphatic polyesters marketed by BASF, MI, USA; and 36-µm-thick film *Actimais* made using PE with oxiant additives supplied by SMS Trioplast, Poulange, France.

Advantages of BDM

- BDMs should have similar properties of LDPE.
- Avoiding plastics waste generation
- Save time and cost in plastic fragments (waste) collection in crop field
- Reduce the usage of agrochemicals in farming

Bioconversion of food waste into bioplastics

Major constituents from various food wastes generated during preparation, production and consumption may be utilized for bioplastics production (Table 1).PHA one of the best performing bio-plastics can be produced by using food waste as a substrate (Cecilia Cecchini, 2017). Saccharides (arabinose, xylose lactose, maltose, and glucose, fructose), together with n-alcohols (ethanol, methanol, glycerol and octanol), n-alkanes (octane and hexane), n-alkanoic acids (oleic acid, propionic acid, acetic acid, lauric acid, valeric acid and butyric acids), gases (methane and carbon



dioxide), and acids (succinic acid and fatty acid) are considered as key carbon sources for PHA biosynthesis. Some of the bacterial strains used for commercial production of PHA includes *Pseudomonas oleovorans*, *Cupriavidus necator*, *Bacillus megaterium*, and *Alcaligenes latus*.

Table 1. Production of bio-plastics from food waste

| S.No | Food Waste | Bioplastics production |
|------|---------------------------|---|
| 1 | Pineapple peel | Main constituent in pineapple peel is cellulose which undergoes etherification process for bioplastics production |
| 2 | Banana peel | Banana peel contains cellulose, starch, pectin, and other polymers. Bioplastics are obtained from the peel through the acetylation process. |
| 3 | Jackfruit seed | Seeds contain more amount of starch. The bioplastic making was a combination of starch, chitosan, and sorbitol as a plasticizer. |
| 4 | Cassava peel | Cassava peel is rich in starch and mixed with chitosan to produce bioplastic with good tensile strength |
| 5 | Sludge from food industry | Polyhydroxy butyrate (PHB) is produced from sludge with the help of microorganisms viz., <i>Pseudomonas</i> , <i>Alcaligenes</i> , <i>Staphylococcus</i> , <i>Rhodococcus</i> , <i>Bacillus</i> |
| 6 | Chicken feather | Keratin content is rich in feathers. Bioplastics with good mechanical properties is produced by mixing extracted keratin solution with glycerol |
| 7 | Avacado seed | Seeds of avocado are rich in starch. Bioplastics is produced by mixing the seed starch with glycerol and chitosan |

(Ramadhan and Handayani, 2020)

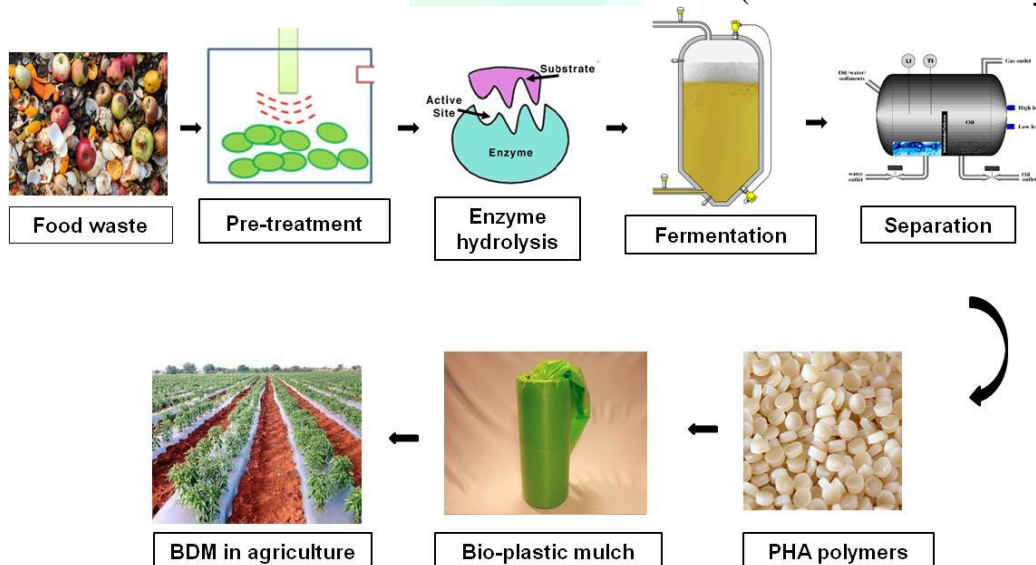


Fig 2. Schematic sketch of biodegradable plastics mulch production

Conclusion

Farming community (large scale, medium and marginal farmers) are practiced to use plastic mulch for controlling weeds and thereby increasing the crop yield also these mulches are economic viable too. To cope up with the increase of plastic pollution, biodegradable plastics become the promising options to reduce the pollution load as well increasing the crop yield. Disposal of mulch film produced with biodegradable materials viz., PLA, PHA, PHB and other starch based films is highly feasible. Hence, production of biodegradable mulchs with food waste will be promising option for reducing the plastic waste generation and pollution, managing food waste, and increasing crop yield through BDMs.



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