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REVIEW ARTICLE

Agricultural waste management generated by agro-based industries using biotechnology tools

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ABSTRACT

The amount of agricultural waste generated by agro-based industries such as palm oil, rubber, and wood processing plants have more than tripled. Selangor, Perak, and Johor account for 65.7 percent of the total number of recognised pollution sources in the manufacturing and agro-based sectors. Livestock dung is another major cause of pollution, contributing significantly to increase pollution levels in the environment. Large portion of agro-industrial waste is untreated and unused, it is frequently disposed of by replicating or dumping then again off the cuff landfilling. These untreated wastes wreak havoc on natural change by releasing ozone-depleting chemicals. Aside from that, the usage of fossil fuels is also leading to an increase in ozone-depleting compounds. Agro-waste is a huge environmental hazard in the current epidemic situation. The management of agro-waste and the conversion of agro-waste into a usable product through the application of biotechnological technologies in agriculture are receiving a lot of attention in today's world. Solid state fermentation is the finest approach for converting agro-waste into valuable bio products among biotechnological instruments. Various agro-wastes such as wheat straw, barley straw, cotton stalks, sunflower stacks, and oil cakes from various agriculture goods, as well as major horticulture wastes such as apple, mango, orange peels, and potato peels, were used to create beneficial products in this review. All aspects of the production of industrial products from various agro-waste by using microorganisms such as Amycolatopsis Mediterranean, Xanthomonas campestries, and Aspergillus niger producing biopolymers such as polysaccharides, similar to starch, cellulose, agar, hemi-celluloses, gelatin, alginate, and carrageenan are covered in the current revels. Yeasts and cyanobacteria are commonly employed to make bio-lipids, whereas Bacillus species are utilised to make proteins and bio-enzymes. Cucumber and orange strips, on the other hand, have recently been employed to create proteins and bio-enzymes. As a result, this review covers the many forms of agro-wastes and their by-products as well as biotechnological technologies used to treat them.

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INTRODUCTION

According to Duque-Acevedo *et al.,* 2020, horticulture production has significantly increased to 23.7 million tonnes of food per day during the last 50 years. This current increase has put a lot of pressure on typical assets, which has led to some questions about rural manageability. Some portion of biomass from agriculture products, generate waste, which may not be used as food (Duque-Acevedo *et al.,* 2020). Other major concerns about the manageability of agro-biological systems should be mentioned in this unique situation. Agribusiness consumes a significant amount of soil and water (Aguilera *et al.,* 2020) and it should be recognised that in the next years, there will be an increasing need to improve rural efficiency to care for the growing total population (Sarkar *et al.,* 2020), which has expanded substantially since 1960 and is expected to fill faster in the following many years (Blattner *et al.,* 2020). According to one study, the global population will reach 9.1 billion people by 2050 (Leisner *et al.,* 2020). Natural change is causing a slew of problems. Natural change and subsequent temperature rise documented from 1951 to 2010 are largely due to anthropogenic activities (Dobrynin *et al.,* 2015). On a global basis, temperatures have shown an unmistakable upward trend since 1980. There have been a few gaps, but astonishingly strange warming zeniths have been observed to some extent recently (Hegerl *et al.,* 2019). Transmissions of ozone-depleting substances (methane, nitrous oxide, and carbon dioxide) are thought to be at danger for rising temperatures at globally. The Corban dioxide is released to the atmosphere primarily as a result of the consumption of fuel subordinates (Poore *et al.,* 2018). An increase in global temperature will have a direct impact on the water cycle, fundamentally altering organic structures, with moist areas drying out and dry areas becoming wet (Polson *et al.,* 2013). Among the food domains, it is estimated that soil products account for a significant portion of waste generation about 45 percent of the total production and utilisation chains, resulting in an enormous amount of waste material (Fidelis *et al.,* 2019). According to the advancement of the agro-evolved of life in which they are formed, squanders and side-effects can be divided into four source groups: i) in the fields prior to harvesting, due to irritant invasion and yields impaired by inclement weather; ii) in post-harvest and transportation, when wrecked and injured soil goods are disposed of; iii) in the many assembly phases cycle, like stripping, washing, and cutting; iv) in the retail business sectors, due to waste generation at the end of the time span of usability; (Ravindran and Jaiswal 2016). The cost of recovery and board for these squanders is not insignificant. Irregularity, cross-domain appropriation, and perishability due water and supplements, aswell as the variability of the goods, may address potential problems and challenges for agri-food waste executives (Girotto *et al.,* 2015). Polyphenols found in skins, crush, seeds, or pomace are the most commonly recognised target blends from normal item by item (Kelly *et al.,* 2019), since, at high temperatures, the extraction levels and targeted blends are getting reduced. As a result, top-tier systems should replace old-style strong fluid extraction tactics. In any event, the equipment required and the smoothing out of limits are major challenges for obtaining dynamic combinations from incidental effects in the current situation. Extraction procedures such as squeezing, microwave, and ultrasounds are the most appropriate and frequently utilised for removing polyphenolic components from normal goods outcomes. Extraction procedures usually include certain pre-treatment and post-treatment measures to maximise the yield of bioactive combinations while reducing the proportion of solvents required and energy consumption. Traditionally, pre-treatment techniques are utilized for reducing the cellulose crystallinity, removing lignin and increasing the cell porosity (Kumar *et al.,* 2009). Polyphenols developed non-covalent interactions with polysaccharides, making them polar solvent insoluble. Pre-treatment removes the cross linking of polyphenols and allows for the selection of more important returns (Pérez-Jiménez *et al.,* 2013). As previously stated, the use of modern extraction procedures results in increased yields of various unique mixes (Pereira *et al.,* 2019).

There has been a surge in interest in biotechnological methods for using cutting-edge wastes as components of microorganism growth medium. Such a method enables the complete biodegradation of normal blends as well as the production of something else with added consideration. By using side-effects as medium portions lowers the hard and fast generation costs. The list of by-products extracted from different fruits are presented in Table 1 and various biotechnological products from fruit wastes are shown in Fig. 1. The main contaminants present in the potato wastewater are COD and BOD with the value of 30000 and 22000 mg/L. Its liquid structure and massive totals conveyed pose additional challenges to its use. Potato wastewater was used under regular conditions before the implementation of harsh restrictions for normal protection, by soaking and arable meadows (Muniraj *et al.,* 2015), as a result, the soil nitrogen levels improved and that could be absorbed easily by plants (Singh *et al.,* 2012). Despite the fact that the process allows for total natural disinfection of waste water, it also comes with a slew of major drawbacks. Soil becomes deterred and water vulnerable on a postponed water framework with potato wastewater.

The approach triggers the unfavourable consequence of water eutrophication. Methods involving thermophilic bacteria can be used to lower the quantity of unknown chemicals in potato wastewater. the molasses wrote was prepared from the potato wastewater. The medium with the segment of 77 percent potato wastewater yielded the best return of dry cell material of Saccharomyces cerevisiae (50.1 g/L) after 12 h of retention period. *S. cerevisiae* yeast biomass refinement in the medium was more successful than normal cook's

Table 1: List of by-products extracted from different fruits

Name of the fruit	Fruit by product	Principle	Method of extraction	Reference
Apple	Pomace	Phenolic compounds	Supercritical fluid extraction	Ferrentino *et al.*, 2018
Mango	Peels	Carotenoids, phenolics and flavonoids	Supercritical CO_2 extraction followed by pressurized ethanol from the residue of the stage	Garcia-Mendoza *et al.*, 2015
Orange	Peels	Essential oil, polyphenols and pectin	Ultrasound and microwave extraction	Boukroufa *et al.,* 2015
Orange	Peels	Ferulic acid	Solid liquid extraction by deep eutectic solvents	Ozturk *et al.,* 2018
Grape	Grape marc, skin, pomace, seeds	Polyphenols	Supercritical fluid extraction; ultrasound-assisted extraction; microwave extraction; pulsed electric fields processing; enzyme-aided extraction; high voltage electrical discharges	Kelly *et al.,* 2019

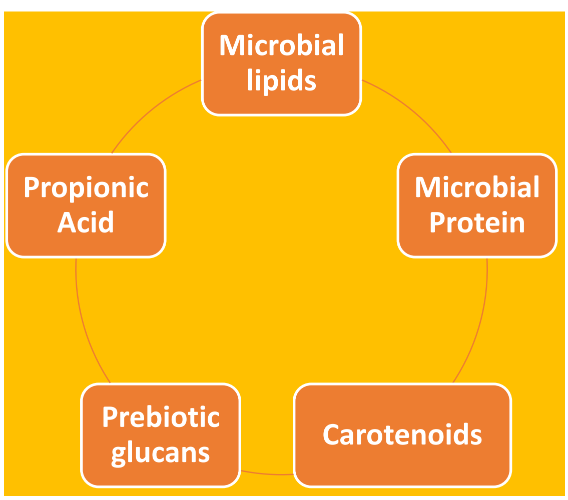

Fig 1: Biotechnological products from fruit wastes

yeast in treating potato effluent; also, it had quality comparable to normal cook's yeast, with better maltose and sucrose maturation activity. Discarded potatoes are among the most abundant starch-rich wastes. In 2019, the whole potato production is expected to exceed 370 million tonnes. Around 30% of the total potato production is thrown and not used for human consumption (Torres *et al.,* 2020), containing a wellspring of frequent tainting since moist potato trash is prone to rapid microbial decay. Potato waste is predicted to be avoided or limited through green for the biodegradable abuse of biomass waste to obtain high-value added items (Jagtap *et al.,* 2019), just as green methods for the environmentally friendly abuse of waste biomass to obtain high-value added items are expected to avoid or limit potato waste creation (Torres *et al.,* 2020). With minor differences in shape, size, and strip damage, discarded potatoes take identical dietary proportions for human consumption. The majority of potato waste is used to generate manure or biogas, resulting in the squandering of nutritious nutrients (Javed *et al.,* 2019). Regardless, the enhancement of abandoned potato that generates various high value products using various biotechnological applications (Ubando *et al.,* 2020). Damaged food supplies, crops left in the field, soil squander products, households, and eateries, and other lost food at any phase in stockpile chains are all examples of food squander. Food waste may not be avoided, but it can be reduced to a possible extent. In recent year, the cost-effective procedure for valorising food waste was established (Ong *et al.,* 2018). Because of its homogeneity, food waste has a lot of promise for making biofuels (Pourkarimi *et al.,* 2021), stage synthetics, and bio-based products using the bio-refinery concept (Matharu *et al.,* 2016). The bioeconomy system of European Unions devised the method for valorisation of food waste (Cristóbal *et al.,* 2018). The bioeconomy is the knowledge-based creation and usage of natural assets to provide things, measures, and benefits in all monetary domains inside the boundary of a reasonable financial framework, according to the bio-economy group. The current review focused on identify the different agro-waste, management of agro-waste by using biotechnological tools and the production of different agro-products from different agro-waste. Previous researchers detailed a few agro-waste management practises, which leads to the conclusion that more research is needed to cover all agro-waste management solutions. By addressing diverse types of agro-waste and transforming them into marketable bioproducts utilising biotechnological approaches, this review paper fills a research vacuum. The main goals of the review are to identify different types of agro-waste and convert them into valuable biotechnological instruments. The review's work is intriguing, and it focuses on detecting different types of agro-waste, managing agro-waste utilising biotechnological tools, and producing various agro-products from various agro-waste. This study has been carried out in Kalasalingam School of Agriculture and Horticulture, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, India in 2021.

Different types of agro waste

Agricultural residues

Horticulture deposits and contemporary build-ups are two different types of agro-mechanical squanders. Horticulture build-ups can also be divided into two types: field deposits and cycle build-ups. Field build-ups are deposits that form in the field after the yield collection cycle has completed. Leaves, stalks, seed units, and stems make up these field build-ups, while interaction deposits are deposits present even when the crop is prepared as a replacement major asset (Table 2). Bagasse, Molasses, husks, seeds, stems, leaves, straw, tails, shells, mash, stubble, strip, roots, and other materials are found in these deposits and are used for animal feed, soil improvement, manures, and other purposes. A large number of field deposits are produced, the most majority of which are underused. Controlled use of field leftovers can improve the water system's capability and reduce disintegration. Wheat and grain are the most important crops in the Middle East. Other crops such as rice, lentils, maize, chickpeas, natural products, and vegetables are distributed to all locations. Farming deposits are classified based on their accessibility as well as characteristics that distinguish them from other powerful forces such as charcoal, wood, and roast briquettes (Sadh *et al.,* 2018).

Industrial wastes

Every year, food handling activities such as

Table 2: Agriculture industrial waste chemical composition

Industrial waste	Chemical composition % (w/w)					References
	Cellulose	Hemicellulose	Lignin	Ash (%)	Total solids (%)	
Rice straw	39.2	23.5	36.1	12.4	98.62	El-Tayeb *et al.*, 2012
Wheat straw	32.9	24.0	8.9	6.7	95.6	Nigam *et al.*, 2009 and Martin *et al.*, 2012
Barley straw	33.8	21.9	13.8	11	-	Nigam *et al.*, 2009
Corn stalks	61.2	19.3	6.9	10.8	97.78	El-Tayeb *et al.*, 2012
Cotton stalks	58.5	14.4	21.5	9.98	-	Nigam *et al.*, 2009
Sunflower stalks	42.1	29.7	13.4	11.17	-	Motte *et al.*, 2013

Table 3: Fruit industrial waste chemical composition

Fruit Industrial waste	Chemical composition % (w/w)					References
	Cellulose	Hemicellulose	Lignin	Ash (%)	Total solids (%)	
Potato peel waste	2.2%	-	-	7.7%	-	Weshahy and Rao, 2012
Orange peel	9.21%	10.5%	0.84%	3.5%	-	Rivas *et al.*, 2008
Pineapple peel	18.11	-	1.37	-	93.6	Paepatung *et al.*, 2009

Table 4: Oil cake properties

Name of the oil cake	Dry matter	Crude protein	Crude fibre	Ash	Calcium	Phosphorus	References
MOC	89.8	38.5	3.5	9.9	0.05	1.11	Kuo *et al.*, 1967
PKC	90.8	18.6	37	4.5	0.31	0.85	Owusu *et al.*, 1970
GOC	92.6	49.5	5.3	4.5	0.11	0.74	Kuo *et al.*, 1967
OOC	85.2	6.3	40.0	4.2	–	-	Maymone *et al.*, 1961

juice, chips, meat, confectionery, and normal item organisations transport a significant amount of regular stores and related effluents. These standard form-ups can be used with a variety of fuel sources. As the world's population grows, the importance of food and its uses grows as well. As a result, in the vast majority of countries, numerous food and reward firms have expanded spectacularly around them to meet the need for food. Table 3 depicts various mixtures of natural item modern wastes that make up various bits of cellulose, hemicellulose, lignin, clamminess, trash, carbon, nitrogen, and so on. These constituents can interact biochemically to convey important things like biogas, bio-ethanol, and other economically significant models. In view of the fact that India produces a lot of apples, cotton, soy bean, and wheat, about 20% of the development of food types generated from the beginning in India goes to waste every year. As the country's population grew, so did the amount of rubbish that needed to be transported. The waste from food businesses has significant levels of chemical oxygen demand, biochemical oxygen demand and suspended particles. The waste having those parameters may create a negative impact on the environment, human beings and animal prosperity. The waste also contains high value-added natural compounds (Rudra *et al.*, 2015). Particularly in oil explorations, oil cakes are produced from the extraction of seeds. Oil cakes come in a variety of shapes, sizes and properties depending on the substrate (Table 4). The different

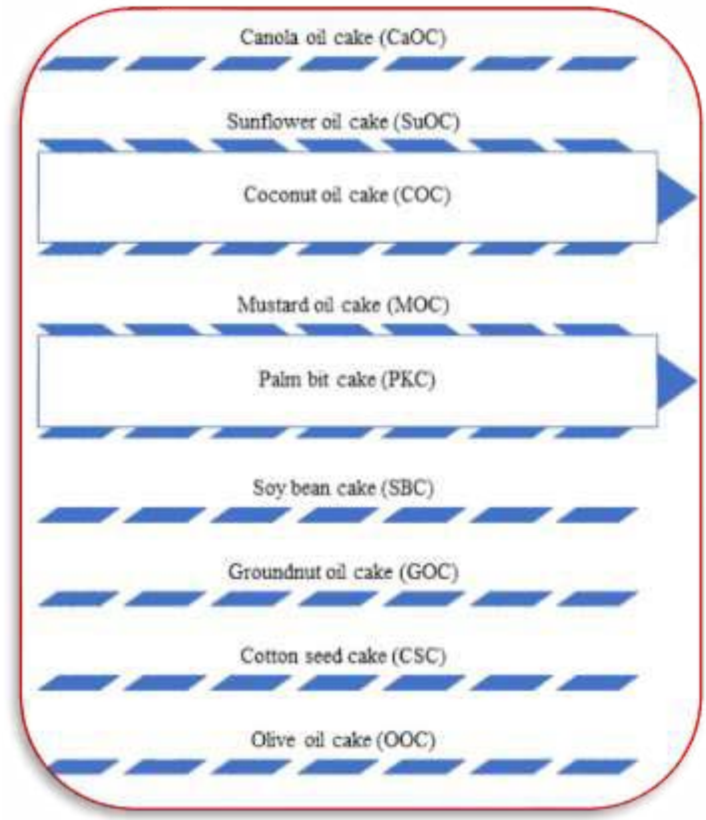

Fig. 2: Different types of oil cakes from the agriculture sectors

types of oil cakes from the agriculture sectors are presented in Fig. 2 (Sadh *et al.,* 2018). The palm oil industry is a major source of pollution and varying degrees of environmental degradation. As a result, environmental problems have multiplied by a factor of ten. Over the previous three decades, immoral behaviours have been substantially to blame for large-scale degradation of the aquatic ecosystem. As a result of environmental degradation, waterborne diseases are on the rise. Palm oil mill effluent (POME) pollutes the environment during palm oil processing, which takes place in mills where oil is recovered from palm tree fruits (Bala *et al.,* 2014).

Biotechnological process of waste

Solid state fermentation (SSF)

In the absence or nearly absence of water, the animal produces the solid substances through solid state fermentation process (Bhargav *et al.,* 2008). All food grains, vegetable seeds, and lignocellulose materials are commonly used substrates in SSF. The polymeric nature of these materials has insoluble, inexpensive and easily accessible for the microbial improvement. Perhaps the most prepared system is food status based on age. A basic examination of the writing reveals that a low proportion of water or a lack of water in SSF has a number of advantages, including easy item recovery, low production measures, less preparation and low energy requirements for mixing and sterilisation (Pandey *et al.,* 2003). Before beginning any development communication, numerous variables such as water, air, temperature, microorganisms, and fermenter should be studied. Single pure social orders, mixed recognised social orders, or a consortium of mixed local microorganisms can all be found in SSF. Some SSF measures, such as tempeh and oncome production, necessitate specified microorganism improvement, such as forms that demand low suddenness levels to conclude development using extracellular impetuses released by developing microorganisms. Table 5 depicts the many microorganisms employed in SSF measurements, such as animals, yeasts, and organisms. Moulds are sometimes utilised in SSF to enlarge the production of large-value-added items since they thrive on fragments of seeds, leaves, stems, woods and roots. The maturation of tiny microorganisms, a higher moisture content is necessary, resulting in a lower yield. SSF involves the following steps: (i) Substrate assurance, (ii) Substrate pre-treatment, which involves improving the binding of polymeric substrates, such as polysaccharides and proteins, either mechanically or biologically to reduce the size of the components, (iii) Hydrolysis of polymeric substrates, such as polysaccharides and proteins, at a very basic level, (iv) The maturation cycle for using hydrolysis products, and (v) Cleaning and measurement of completed results in the downstream process (Sadh *et al.,* 2018).

Bioprocesses with waste for biopolymers synthesis

It is vital to highlight that the synthesis of biopolymers produced from plant waste is dependent on the availability of basic materials. According to the FAO, the crop reserve for 2019 is expected to be 250 million tonnes, resulting in a large amount of waste generation. These wastes contain intriguing molecules (lipids, sugars, and sweet-smelling iotas), which can all be utilised to make polymeric materials. In any case, agro-waste necessitates substance preparation to eradicate and safeguard specific macromolecules. Cellulose, lignin, tannins, and terpenes are particularly appealing because they can be employed to transport bio-plastics. Belgacem and Gandini, 2008 compiled a comprehensive list of the polymers that can be obtained from these sources. This section focused on plant/green development sources (polysaccharides, similar to starch, cellulose, agar, hemi-celluloses, gelatin, alginate, and carrageenan), as well as lignin, lipids, and proteins. The polysaccharides cellulose and starch are important in farming applications. In any case, simple polymers that are comparable to proteins can be used to recognize biodegradable compounds. In a recent movement of works, the value of these various fragments has been adequately appraised, a wonderful framework of the work that standard biopolymers have in the horticulture sector is portrayed. More biodegradable things were produced as a result of this waste, particularly in the farming industry. Mulches, biodegradable seeds, and biopolymer-based dynamic section capsulations are examples of how the speculative round strategy is put to use in the field. In any event, the composition of agricultural waste biopolymers are very limited. The job of traditional biopolymers extracted from growing waste as bio-stimulants and biofertilizers will be examined in the next segment (Chimphango *et al.,* 2020). Using agricultural and industrial wastes as raw materials can reduce manufacturing costs while also reducing pollution levels in the environment. SSF is a result of its relatively simple approach, which uses abundant low-cost biomaterials with little or no pre-treatment for bioconversion, produces less waste water, and can mimic similar micro-environments that are conducive to microbial growth.

Bio-lipids synthesis

The bioprocessing of waste yields both biopolymers and bio-lipids. Since, bio-lipids represent a possible feedstock for biofuels, the commercial and research sectors have been paying increased attention to the manufacture of bio-lipids from waste. The yeasts, cyanobacteria, green development, a few microorganisms, and creatures can accumulate a large proportion of their body weight in lipids (20–80 percent) (Yong *et al.,* 2021). The *Yarrowia lipolytica* MUCL 28849 (oleaginous yeast) used to extract glycerol and microbial lipids as carbon sources from trash. The carbon sources for bio-lipids from waste are low-cost byproducts obtained from *Cryptococcus curvatus* ATCC 20509 yeast cultivation (Gong *et al.,* 2015). *Rhodosporidium toruloides* AS 2.1389 culture was used to produce the bio-lipids of 38.6–48.2 percent through valorised acidic destructive method (Huang *et al.,* 2016) and *Lipomyces starkeyi* DSM 70296 culture was used to produce the bio-lipids of 26.1–26.9 % from sugarcane bagasse hydrolysis method (Xavier *et al.,* 2017). Through the advancement of *Yarrowia lipolytica* W29 (ATCC 20460) with pork fat was used to produce lipase from citrus destructive (Lopes *et al.,* 2018). Pork fat is an animal fat that is only occasionally employed in food preparation due to the risk of vascular and cardiac pollution. As a result,

Table 5: List of microorganisms used in solid fermentation process

Microorganisms	Solid supports	References
	Bacteria	
Pseudomonas spp. BUP6	GOC, COC, SOC, and CSC	Faisal *et al.*, 2014
Amycolatopsis mediterranean MTCC 14	GOC and COC	Vastrad and Neelagund 2011
Xanthomonas campestries MTCC 2286	Potato peel	Vidhyalakshmi *et al.*, 2012
	Fungi	
Aspergillus niger	Wheat bran, rice bran, black gram bran, GOC, and COC	Suganthi *et al.*, 2011
Streptomyces spp	Streptomyces spp	Ezejiofor *et al.*, 2012
Rhizopus arrhizus and *Mucor subtillissimus*	Soybeans, caorncob cassava peel, wheat bran, and citrus pulp	Nascimento *et al.*, 2015
Aspergillus terreus	Palm oil cake	Rahman *et al.*, 2016

it is often regarded as waste. The possibility of using waste from meat handling experiences for microbial oils association was discovered in this study.

Low-value hydrophobic substrates can be converted into microbial oils and other important metabolites by the microbial platform *Yarrowia lipolytica*. This yeast strain was used to manufacture ex novo lipids from animal fat while also synthesizing citric acid and lipase, increasing the utility of the low-cost fatty substrate. The influence of pH, lard content, arabic gum concentration, and oxygen mass transfer rate (OTR) on lipid accumulation in *Y. lipolytica* batch cultures was investigated using a Taguchi experimental design. OTR was by far the most influential parameter in the range from 96 mg/L to 480 mg/L.

Bio proteins and bio enzymes

Microorganisms can grow on a range of substrates and are a typical source of low-cost alternative media for enhancing microorganisms to offer quality results in world. The metabolic products and the actual microbe are the source of countless proteins and impetuses. Single cell proteins can be obtained by holding a social event and drying the microbial biomass (Zepka *et al.,* 2008). It's also known as microbial protein, and it's usually transmitted through slowed development and solid state maturation (Kadim *et al.,* 2015). Yunus *et al.,* 2015 developed *Candida utilis* and *Rhizopus oligosporus* on wheat grain to deliver a single cell protein. At ideal maturing circumstances of 30°C and 48 hours, a protein yield of 41.02 percent was obtained. The metabolic analysis of the microalgae *Aphanothece microscopca nageli* improvement on paddy profluent reveals an abundant level of polyunsaturated unsaturated fat (overwhelmingly gamma linolenic destructive) and an outstanding yield of single cell protein (Zepka *et al.,* 2008). After 96 hours of solid state growth of yam strip by *Saccharomyces cerevisiae* BY4743, protein containing main amino destructive material comparable to threonine, lysine, valine, and leucine was obtained. Single cell protein generates the essential amino acids and has the ability to mass-produce in a short amount of time, allowing it to replace expensive protein sources (Aruna *et al.,* 2017). Fish waste-derived protease and esterase molecules have potential applications in current and clinical research. From the sugar beet incidental impact, an isoelectric-ammonium sulphate precipitation technique yielded 55.15 percent protein yield (Akyüz *et al.,* 2021). *Haloferax lucentensis* GUBF-2 MG076078 was used to produce protease compounds from valorization of shrimp waste at pH 6, 30 % NaCl and 42°C temperature (Mg *et al.,* 2021). The yield of pectinase compound was improved by reducing unsaturated fat biosynthesis and further increased by limiting pyruvate dehydrogenase and unsaturated fat biosynthesis with furfural, to triclosan (Guan *et al.,* 2021). *Bacillus* sp. was used to represent high amylase compound formation (29.23 mg/mL) on mango waste. Microorganisms F-11 (Saleh *et al.,* 2020). Food waste biomass is used to isolate a

Table 6: Bio enzymes from different fruit wastes

S.No.	Substrate	Enzymes	Microorganisms	Reference
1	Groundnut oil cake (GOC)	Lipase	*C. rugosa*	Rekha *et al.,* 2012
2	Coconut oil cake	α-Amylase	*A. oryzae*	Ramachandran *et al.,* 2004
3	Fruits peel waste	Invertase	*A. niger*	Mehta and Duhan 2014
4	Orange peel	α-Amylase	*A. niger*	Sindiri *et al.,* 2013

variety of proteins and combinations. These findings demonstrate the common practise of extracting and removing core mixes and proteins from food waste. For solid state fermentation, this is the substrate. The SSF uses solid waste from a variety of industries, including food, ale and wine, agriculture, paper, materials, cleaning agents, and animal feed. Staying-solid substrates have low clamminess levels, which is ideal for SSF. A previous study used a variety of substrates to study rice (Sadh *et al.,* 2018). Microorganisms thrive in agro-industrial waste because of its diversified composition. Fermentation generates a wide range of enzymes. These wastes are used as a raw material. The use of these substrates accelerated fungus growth, resulting in the conversion of lignocellulosic substrate into less problematic substrates via the activity of many enzymes. Amylase, one of the most important enzymes, was used to break down polysaccharides into sugar components in the starch processing industry (Table 6).

Bio fuel production

Bio-empowers are still important because they are utilised as an alternative to oil subsidiary. Biofuels have been made from favourable agro-modern day agricultural stocks (Duhan *et al.,* 2013; Kumar *et al.,* 2014, 2016). The bioethanol production expanded from one side of the globe to the other, as evidenced by the production of 85 billion litres of bioethanol in 2011 (Avci *et al.,* 2013). It keeps deforestation in check by reducing our reliance on forest area woody biomass with the help of cultivating assemble ups. The field stores have a short harvest season, they are more consistently available for bioethanol production (Limayema and Ricke 2012). Several studies have concluded that ethanol can be produced from lignocellulosic materials (Cadoche and Lopez 1989; Bjerre *et al.,* 1996). Najaf *et al.,* 2009 synthesised the bioethanol from diverse agricultural stores of various agriculture waste. The bioethanol was produced from the lignocellulosic agricultural wastes. The bioethanol is used a biofuel as an alternative substitute to various oil products such as oil and diesel. Because of their discussion and examination of numerous processes for biofuel synthesis, it is obvious that biofuels are not fixed in stone as an environmentally friendly and choice source of energy for the foreseeable future. Crop waste and sugar cane bagasse are used as feedstock in the production of bioethanol. There are 17.86 million tonnes of lost crops with the potential to produce 4.91 million gallons of bioethanol per year. Wheat, rice, barely, and corn are the most suitable bioethanol production sources. Agricultural waste materials can be used to make bioethanol fuel. Bioethanol has the potential to be the most effective gasoline replacement. Paepatung *et al.,* 2009 generated the biogas from several cultivation stocks of two weeds namely *Eichornia crassipes solms* and *Typha angustifolia* L.

Single cell protein production

Mondal *et al.,* 2012 investigated how single-cell protein (SCP) is made from natural item wastes. Cucumber and orange strips were employed as the substrate for the synthesis of SCP employing *S. cerevisiae* and brought down development. When the cucumber strips were arranged differently from the orange strips, they found that the cucumber strips carried a higher proportion of protein. Cucumber strips are larger than orange strips and occupy a huge substate where they are arranged differently than orange strips. As a result, it was suggested that these natural item wastes be converted to SCP employing reasonable microbes. The benefits of bioconversion of agro-industry wastes include a sensible and pleasantly high protein content. The highest biomass production output and protein production in all of the fruit waste substrates were significantly higher on the fourth day. The PAM substrate yielded significantly more dry biomass of 0.429 g (48.32 %) and protein of 0.004 g (2.84 %) than the others, whereas the PGM substrate yielded significantly less biomass and protein.

Production of poly (3-hydroxybutyric acid)

The consumption of citrus fruits from one end of the globe to the other for a variety of mechanical uses such as natural item presses and sticks. The waste from citrus fruits are transported for making various by-products. The polyethylene (3HB) was produced from citrus waste by Sukan *et al.,* 2014. Sukan *et al.,* 2014 discovered polyethylene (3HB) with an extraordinarily straightforward pre-treatment technique employing orange strip as a lone carbon source. The process was first tested on a small scale before being put through its paces in a constantly stirred tank reactor. Orange peel was chosen as the best candidate for P(3HB) manufacture from a variety of agro-industrial waste. AP(3HB) concentration of 1.24 g P(3HB)/L culture broth was obtained with a 41 percent P(3HB)/dcw yield using orange peel as the sole carbon source in an optimised medium with a modified strain of *Bacillus subtilis* (*B. subtilis* OK2).

Biosurfactant production

The bacterial microorganisms found in the oil-tainted objects are more beneficial to humans. One of the bacterial microorganisms *Pseudomonas aeruginosa* PB3A was isolated from an oil-polluted environment (Saravanan and Vijayakumar, 2014). They used agro-squander, such as sunflower oil, castor oil, grain wheat, nut cake, and rice grain, to make biosurfactant with the strain. Using an isolated *P. aeruginosa* strain, they utilised these events as a rich elective carbon focal point for the creation of biosurfactant. The *P. aeruginosa* PB3A strain was isolated from oil-polluted soil and determined to be a promising biosurfactant-generating bacterium based on the following screening methods: hemolytic activity, drop collapse test, emulsification activity, and surface tension measurement. Both the used corn oil and cassava waste flour demonstrated maximum productivity of 0.62 mg/mL and 0.60 mg/mL when grown separately in the MSM medium.

Xanthan production

Because the high cost of generating Xanthan gum from common substrates like glucose and sucrose is a production bottleneck, researchers focused on non-traditional substrates like whey and whey permeate. As a result, low-cost substrates such as whey, milk permeate, and food waste were sought. The preculturing with lactose fermenting organisms such lactic acid bacteria or *Kluveromyces lactis* to change the substrate for xanthan synthesis has been developed to use newer, less expensive substrates like milk or whey permeate. As a food additive, xanthan is utilised. Xanthan production from agricultural wastes is a significant system to consider as a practical matter Vidhyalakshmi *et al.,* 2012. *X. citri*, *X. oryzae*, and *X. musacearum* produced the xanthan with the help of SSF. The xanthan of 2.9, 2.87, 1.5 and 0.5 g was produced from *X. citri, X. campestries, X. oryzae*, and *X. musacearum*.

Heterotrophic food waste
Microalgae cultivation

In a blended bioreactor, heterotrophic microalgae can be grown at high biomass centres. Regardless, high-cost culture medium containing carbon, nitrogen, and phosphorus are necessary (Pleissner *et al.,* 2012). When ordinary wastes are employed as development feedstock, the expenses of upgrades can be reduced (Ryu *et al.,* 2013). Despite the fact that more food waste is produced, some studies revealed that food waste was used as a supplement source in microalgae development. A significant biomass yield (6.69 g/dL) was produced using only wasted yeast as the growing substrate and simple stirring as the pre-treatment. The biomass output was improved to 31.8 g/L by using sequential cultivation to maximise nutrient utilisation. When the C/N ratio was 20:1 (w/w), DHA productivity was at its peak. DHA made up 38.2 percent of the total fatty acids (w/w). As a result, wasted yeast proved to be an ideal growing medium for the production of DHA.

Microalgal biomass and food waste as feedstocks

The green algae *Chlorella pyrenoidosa* is used to produce xanthophylls that are used in the food industry. In consistent social ordering of *C. pyrenoidosa*, 302 g/L of biomass and 0.65 g/L of flat out xanthophylls concentration were achieved. In nitrogen-sufficient and limited social groupings, around 50 g/L of biomass and 0.2 g/L of lutein were transferred from *Chlorella prototheorids* (Prasanna *et al.,* 2007). Regardless of how heterotrophic green development opens the to distinct shadings, the previously mentioned cycles required a lot of glucose. *Galdieria sulphuraria* utilised 260 g/L glucose to produce phyocyanin, while *Chlorella pyrenoidosa* used 520 g/L glucose to produce xanthophylls. As on there was no investigation onto the improvement of *G. sulphuraria* on food waste hydrolysate has been conducted. As a result, it remains hypothetical whether this could be a viable substitute to glucose. Notwithstanding, *C. pyrenoidosa* produces xanthophyll from food waste, and the creation of xanthophylls results in the generation of glucose. (Pleissner *et al.,* 2013).

Contributions of Food wastes for bioeconomy

Depending on whether offal is deemed trash, the overall rate of producing polyhydroxyalkanoate from butchering wastes, which ranged between EUR 1.41 and 1.64 per kg. 437.5 mg of lycopene and 36.5 mg of Carotene was yielded from the supercritical CO_2 extraction of tomato waste (Kehili *et al.,* 2016). Cristóbal *et al.,* 2018 studied the cost analysis and informed that the cost of production of lycopene and carotene as EUR 40,000 and 4,000 per kg. Regardless, in this investigation, the compensation length of time should be carefully considered (the reward time period for other biorefineries actually execution ran some place in the scope of 3 and 15 years). Biddy *et al.,* 2017 demonstrated the ability of four-cross-over set apart down the expense to expand succinct destructive creation. Only 5–10 biorefineries could meet the premium for some speciality designed materials, and only a few biorefineries could meet the requirements of the extremely valuable medicine markets. It is critical to expand the market by exploring subordinate engineered materials (Yang *et al.,* 2020).

CONCLUSION

Ago-waste such as bagasse, molasses, husks, seeds, stems, leaves, straw, tails, shells, mash, stubble, strip, roots, and other materials are found in these deposits and are used for animal feed, soil improvement, manures, and other purposes. A large number of field deposits are produced, the most majority of which are underused. As the world's population grows, the importance of food and its uses grows as well. As a result, in the vast majority of countries, numerous food and reward firms have expanded spectacularly around them to meet the need for food. Microorganisms are the important source of biodegradation of agro-waste in the environment. The strains of *Pseudomonas* spp., *Aspergillus niger* and *Streptomyces* spp. strain's are degrading agro-waste effectively. The yeasts, cyanobacteria, green development, a few microorganisms, and creatures can accumulate a large proportion of their body weight in lipids (20–80 percent). The metabolic products and the actual microbe are the source of countless proteins and impetuses. Single cell proteins can be obtained by holding a social event and drying the microbial biomass. Bio-empowers are still important because they are utilised as an alternative to oil subsidiary. Biofuels have been made from favourable agro-modern day agricultural stocks. Supplement association and bioactive blends are abundant in agro-modern wastes or build-ups. As a result, such wastes should be considered "rough material" rather than "wastes" for other current cycles, as they recall variance for association like sugars, minerals, and proteins. The occurrence of such improvements in these stores provides ideal conditions for microbes to thrive. Different types of agro-waste have been converted by using of different micrograms through solid state fermentation have been explained. In the present review the important aspects of agro-waste management and industrial products are concluded from different micrograms have concluded such as among all microbial Bio-lipids synthesis *Rhodosporidium toruloides* AS 2.1389 culture was produced more bio-lipids of 38.6–48.2 percent through valorised acidic destructive method. The *Bacillus* sp. was to produce high amylase compound formation (29.23 mg/mL) on mango waste. Bioethanol has the potential to be the finest gasoline substitute among bio-diesel products. The PAM substrate produced much more dry biomass and protein in all substrates. Maize oil (0.62 mg/mL) produced more biosurfactant than cassava waste flour (0.60 mg/mL). The highest xanthan production 2.9 g was produced from *X. citri*. The *Chlorella pyrenoidosa* produced the highest biomass 520 g/L glucose to produce xanthophylls among all other microalgae species.

AUTHOR CONTRIBUTIONS

P. Srikanth has performed the writing and preparing the manuscript. D. Sivakumar has done some part of writing, editing and supervision of writing review. P.W. Ramteke has done some part of the writing work. J. Nouri is the advisor in writing review article and gave some important intellectual inputs.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. The ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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ABBREVIATIONS

%	Percent
BOD	Biological oxygen demand
CaOC	Canola oil cake
C/N	Carbon to nitrogen ratio
COC	Coconut oil cake
COD	Chemical oxygen demand
CO_2	Cobrand di oxide
CSC	Cotton seed cake
DHA	Docosahexaenoic acid
et al.,	And others
FAO	Food and agriculture organization
Fig	Figure
g	Gram
g/dL	Gram per decilitre
g/L	Gram per litre
GOC	Ground nut oil cake
h	Hour
Kg	Kilogram
mg/mL	Milligram per millilitres
mg/L	Milligram per litre
MSM	Minerals slats medium
MT	Metric ton
MOC	Mustard oil cake
OOC	Olive oil cake
OTR	Oxygen mass transfer rate
PGM	Phosphodiesterase mutase
pH	Potential of hydrogen
PKC	Palm bit cake
SBC	Soy bean cake
SCP	Single cell protein
SSF	Soil state fermentation
SuOC	Sunflower oil cake
w/w	Weight concentration

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