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Utilization of Agricultural waste into Useful Materials

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Abstract

Planet globalization, population growth and its consequent need to produce large amounts of food, or individual economic benefits and the prioritization of this over environment health, are factors that that have contributed to the development, in some cases, of a linear-producing modern agricultural system. In contrast to traditional and local agriculture, which was based on circular sustainability models, modern agriculture currently produces tons of waste that is accumulated in landfill, creating controversial consequences, instead of being reintroduced into the production chain with a novel purpose. However, Agricultural residues are rich in bioactive compounds and can be used as an alternate source for the production of different products like biogas, biofuel, mushroom, and tempeh as the raw material in various researches and industries. Usage of agro-industrial waste as raw materials can help to reduce the production cost and pollution load from the environment.

Agro-industrial wastes are used for manufacturing of biofuels, enzymes, vitamins, antioxidants, animal feed, 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. Therefore, SSF and their effect on the formation of value-added products are reviewed and discussed.

Introduction

Waste management is currently a growing concern in many countries around the world. per annum, large amounts of waste are being produced at a world rate. In 2016, solid waste was amassed on a footprint of 0.79 kg per person per day, which amounted to 2.01 billion tons. India alone produces 960 million plenty of solid waste through means of business, mining, municipal and agricultural sectors. Among these, 350 million tons are organic waste from agriculture; 290 million tons are inorganic waste from the industrial and mining sector, and 4.5 million tons are harmful to health and welfare.

The growing population has spiked growth in the economy which came because of growth in industrialization, which is a number of the causes of huge waste generation. As a by-product of a rapidly growing population and urbanization, food demand has multiplied many folds. Therefore, the agricultural sector had to extend its output and a large amount of agro-food waste is being generated annually. Rice husk (RH), Sugarcane leaves (SCL) and Sugarcane bagasse (SCB), Cornhusk (CH), Barley husk (BH), Eggshell, Coconut cell (CC), Peanut cell (PC), and Wheat straw (WS) residue are among commonest agro-waste produce.

Agricultural waste is biodegradable and eco-friendly but, it's a chronic and lengthy process, in some cases. To organize their field for the next crop season, farmers want their fields to be freed from any residue from the previous crops as soon as possible. Because of costly waste management methods, some farmers value more highly to burn crop residue in open fields leading to environmental pollution. It's a quick method and that's why it's urgent to find more viable methods for environmentally-friendly waste management. A more convenient way of utilization is applications like animal feed and dust houses and for energy generation in small-scale industries like sugar and rice mills.

In current times, lots of effort is being given to developing renewable biomass fuels like bioethanol, biogas, and biodiesel, from agriculture waste. It's important to own knowledge of the chemical and physical properties of agro-food waste to seek out their use inappropriate applications. Eggshells and rice husk ash (RHA) have a high level of carbonate and silica, respectively, and hence are utilized in fields that need high calcium and silica content, like calcium silicate glass, $Ca2SiO4$ phase acts as the main ingredient for creating white-light-emitting diodes, and calcium generation sources for animals. And properties like area and little particle size are important in applications like wastewater treatment and also the degradation of organic dyes.

Furthermore, agro-waste may be wont to make bio-composite and biofertilizers to extend soil fertility. It's been found that composted RH, and dry SCL helps in plant growth and enhancement of soil fertility by improving organic content. Biofertilizers provide organic substances to plants. This eco-friendly approach also provides a solution to harmful chemical fertilizers.

Various studies reported that different sorts of waste like pomegranate peels, lemon peels, and green walnut husks are often used as natural antimicrobials (Adámez et al. 2012; Katalinic et al. 2010). Wastes from the organic compounds although at risk to the atmosphere, represent a possible source for creating mushrooms as foodstuffs and other bio-based products like bio-energy. A number of the agricultural residues are used for animal food. However, such wastes contain variability in composition like high proteins, sugars, and minerals. thanks to their high nutritional composition, these residues are not described as "wastes" but are considered raw materials for other product formation and developments. the supply of those nutrients in raw materials offers appropriate environments for the expansion of microorganisms. These microorganisms have gotten the power to reuse raw materials with the utilization of fermentation processes. The agro-industrial residues are used for solid support in SSF developments for creating different beneficial products. It also helps for the assembly of fermentable sugars by reducing the assembly cost of the idea of food crops. Various studies were dispensed to understand the conversion of agricultural waste into sugars by using different microorganisms (Nguyen et al. 2010).

RH may be wont to produce silicon because it has 80-90% silica. Li-ion battery anodes are often synthesized from pure silicon nanoparticles. Kavitha et al. found that direct SiC is produced from direct Pyrolysis of RH, which has many uses due to the low coefficient of thermal expansion (CTE), oxidation resistance (rustproof), and excellent abrasion/wear resistance. A review by Adebisi et al. brings the spotlight on the importance of manufacturing nanosized solar grade silicon from agricultural waste, which may be a cost-effective method compared to its conventional counterparts.

Agriculture waste can be used as biosorbents for removing toxic heavy metal ions from aqueous solutions. Lightweight artifacts are often developed by incorporating raw rice husks and foam bubbles in magnesium oxysulfate cement paste. And maybe used as inner wall partitions and thermal insulating components of the building. Even if agro-food waste is used in some ways, ashes are produced as second-generation bi-product. These wastes are often not disposed of properly; instead dumped in open fields. Ashes will be harmful to any or all because of particle size. Thus, environment-friendly and cost-efficient methods are getting used to manage the ashes of agro-food wastes. Because of their high mineral content, these renewables are often converted into valuable engineering materials through various chemical, physical, and mechanical methods.

Currently, these ashes are used as resource materials to manufacture glasses and glass ceramics as they're rich in silica and lots of chemical element oxides. On the opposite hand, garbage is employed in tissue engineering, enhancing soil quality, synthesizing environment-friendly catalysts, biodiesel production, etc. Except for use in conventional waste management methods, the efficient use of second-generation agro-food waste ashes won't only provide a meaningful solution to the management of those harmful ashes but will improve the economic condition of the farmers. There is scope for plenty of progress in this field, as the inherent presence of trace elements in agro-food waste has not been vividly explored. The presence of transition metal oxides in trace amounts, in agro-food waste ashes, could be used as a resource for the synthesis of optically active materials and some elements behave as phase stabilizers.

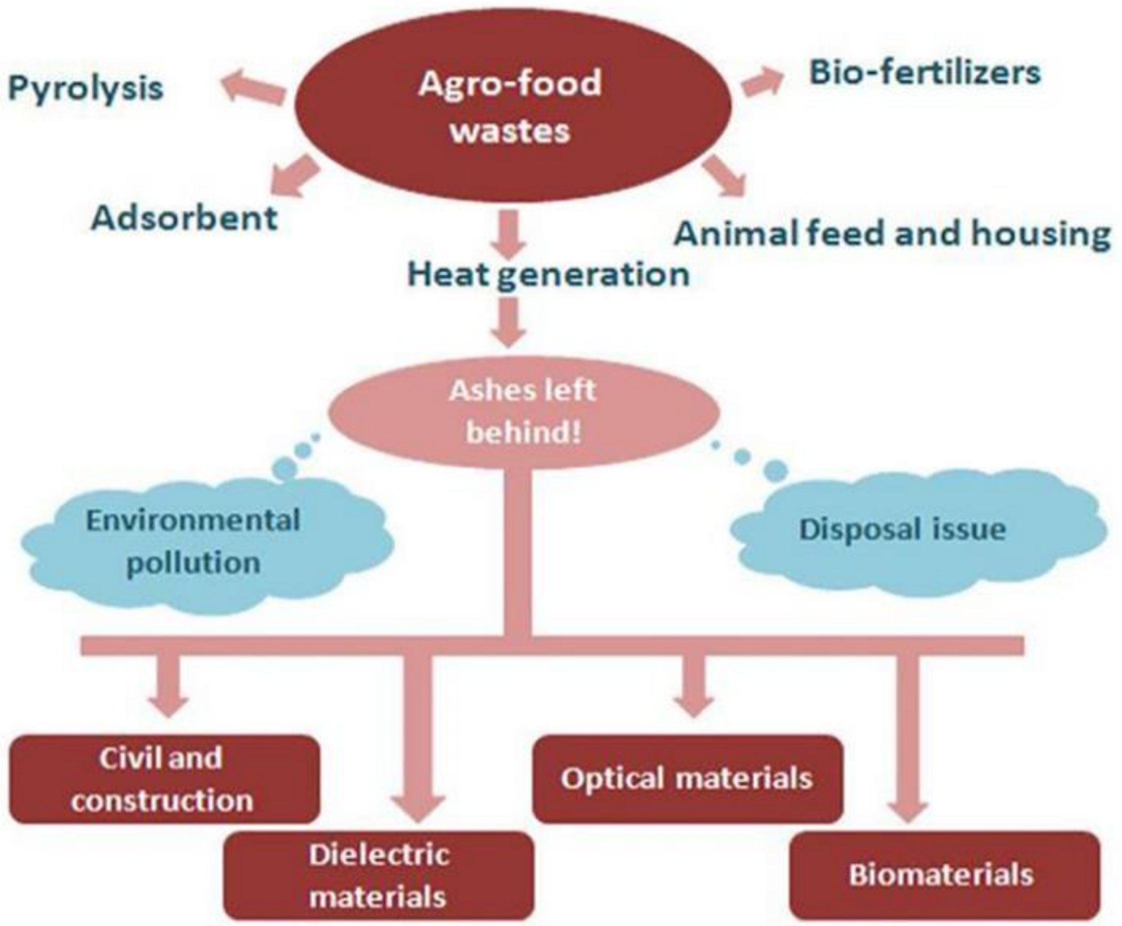

Fig 1: Applications of agro-food wastes and their ashes.

Production of huge amounts of agricultural waste has found its use in many applications. A disposal and pollution problem created by second-generation ashes needs appropriate methods for utilization, too. Staple foods such as rice and eggs, constitute a large portion of global agro-food waste content. Whereas, WS, dry SCL, groundnut shell, CC, CH, and BH are region-specific but are common to most parts of the world. So, in the present view, the focus is concentrated on common agro-food waste like RH, ES, SCL, WS, CH, PS, and their applications. The objective of this study is to provide information about the classification of various agro-food wastes and their use in the production of different value-added cost-effective materials.

This paper is an attempt to present a comprehensive and systematic overview of ways in which agro-food waste and the second-generation ashes can be used directly. In this review, conventional and modern applications of agro wastes are discussed, following is their use as renewable resource materials for use in civil, dielectric, and the bioengineering field.

Types of agro-industrial wastes

Agricultural Residues

Figure 1 shows two different types of agro-industrial wastes, i.e., husbandry remainders and artificial remainders. Agriculture remainders can be further divided into field remainders and process remainders. Field remainders are remainders that are present in the field after the process of crop harvesting. These field remainders correspond to leaves, stalks, seed capsules, and stems, whereas the process remainders are remainders present indeed after the crop is reused into an alternate precious resource (Table 1).

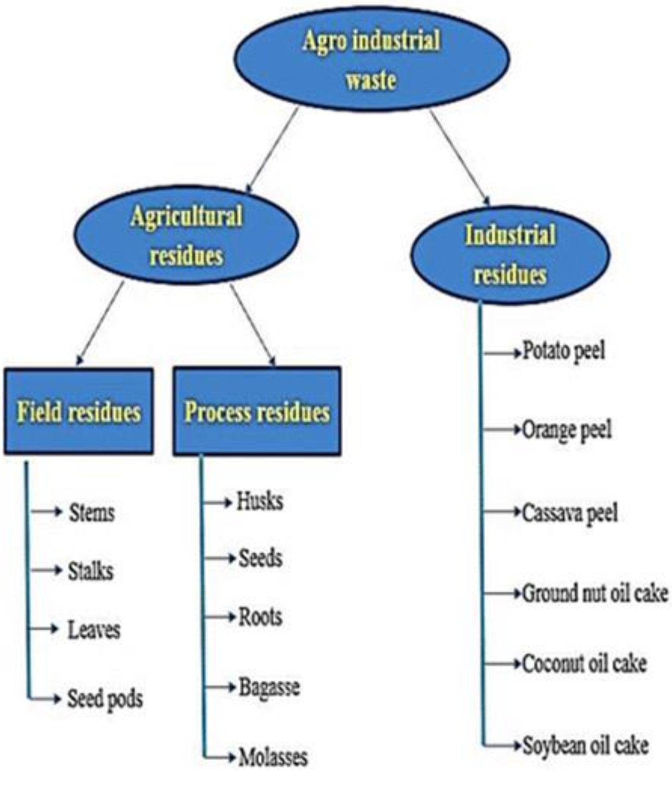

Fig 2: Agro-industrial wastes and their types

Table1: Composition of agro-industrial wastes

These remainders correspond of molasses, cocoons, bagasse, seeds, leaves, stem, straw, stalk, shell, pulp, stubble, peel, roots, etc. and used for beast feed, soil enhancement, diseases, manufacturing, and colourful

Agro-industrial wastes	Chemical composition (% w/w)						References
	Cellulose	Hemicellulose	Lignin	Ash (%)	Total solids (%)	Moisture (%)	
Sugarcane bagasse	30.2	56.7	13.4	1.9	91.66	4.8	El-Tayeb et al. (2012) and Nigam et al. (2009)
Rice straw	39.2	23.5	36.1	12.4	98.62	6.58	El-Tayeb et al. (2012)
Corn stalks	61.2	19.3	6.9	10.8	97.78	6.40	El-Tayeb et al. (2012)
Sawdust	45.1	28.1	24.2	1.2	98.54	1.12	El-Tayeb et al. (2012) and Martin et al. (2012)
Sugar beet waste	26.3	18.5	2.5	4.8	87.5	12.4	El-Tayeb et al. (2012)
Barley straw	33.8	21.9	13.8	11	_	_	Nigam et al. (2009)
Cotton stalks	58.5	14.4	21.5	9.98	_	7.45	Nigam et al. (2009)
Oat straw	39.4	27.1	17.5	8	_	_	Martin et al. (2012)
Soya stalks	34.5	24.8	19.8	10.39	_	11.84	Motte et al. (2013)
Sunflower stalks	42.1	29.7	13.4	11.17	_	_	Motte et al. (2013)
Wheat straw	32.9	24.0	8.9	6.7	95.6	7	Nigam et al. (2009) and

other processes. Huge quantum of field remainders is generated and utmost of them are underutilized.

							Martin et al. (2012)

Controlled use of field remains can enhance the proficiency of irrigation and control of corrosion. In Middle East region, wheat and barley are the major crops. In addition to this, colourful other crops like rice, lentils, sludge, chickpeas, fruits, and vegetables are also produced each over the world. Agrarian remainders are discerned on the base of their vacuity as well as characteristics that can be different from other solid energies like watercolour, wood, and housekeeper briquette (Zafar 2014).

Industrial wastes

A huge quantum of organic remainders and related backwaters are produced every time through the food processing diligence like juice, chips, meat, confectionery, and fruit diligence. These organic remainders can be employed for different energy sources. As the population increases continuously, the demand for food and its uses also increased. So, in the utmost of the countries, different diligence of food and libation have increased remarkably in that region for the fulfilment of need of food. Table 2 shows different compositions of fruit artificial wastes that constitute the different compositions of cellulose, hemicellulose, lignin, humidity, ash, carbon, nitrogen, etc. and these ingredients have implicit to biochemically digested to produce useful products like the products of biogas, bio-ethanol, and other commercially useful exemplifications. Roughly, 20 of the products of fruits and vegetables in India are going to waste every time (Rudra et al. 2015) because in India a large quantum of apple, cotton, soybean, and wheat are produced. So as the product increased in the country, it also increased the chance of waste produced from them. Also, the waste produced from food diligence contains a high value of BOD, COD, and other suspended solids. Utmost of these wastes are left unutilized or undressed, which hurt terrain as well as mortal and beast health but the composition of these

Fruit-industrial waste	**Chemical composition (% w/w)**								
	Cellulose	**Hemi-cellulose**	**Lignin**	**Ash**	**Total solids**	**Moisture**	**Total carbon**	**Total nitrogen**	**References**
Potato peel waste	2.2%	–	–	7.7%	–	9.89	1.3%	–	Weshahy and Rao (2012)
Orange peel	9.21%	10.5%	0.84%	3.5%	–	11.86	–	–	Rivas et al. (2008)
Coffee skin	23.77 (g/100 g)	16.68 (g/100 g)	28.58 (g/100 g)	5.36 (g/100 g)	–	–	C/N 14.41		Lina et al. (2014)

Table 2: Composition of fruit-industry wastes

Pineapple peel	18.11	–	1.37		93.6	91	40.8	0.99	Paepatung et al. (2009)

wastes contains a large number of organic emulsions that produced a variety of value-added products and also reduced the cost of the product as described in Table 1.

Especially in canvas diligence, a huge quantum of reused remainders is produced after canvas birth from the seeds; these remainders are known as canvas galettes. These diligences beget air, water, and solid waste pollution because these remainders contain high attention of fat, canvas, grease, suspended solids, and dissolved solids. Canvas galettes have variabilities grounded on their substrate (Table 3). Canvas cutlet is of different types like canola canvas cutlet (CaOC), sunflower canvas cutlet (SuOC), coconut canvas cutlet (COC), sesame canvas cutlet (SOC), mustard canvas cutlet (MOC), win kernel cutlet (PKC), soybean cutlet (SBC), groundnut canvas cutlet (GOC), cottonseed cutlet (CSC), olive canvas cutlet (OOC), rapeseed cutlet (RSC) (Ramachandran et al. 2007). These bandied agro-industrial remainders are fairly cheap, containing a high quantum of ingredients that have an unlimited prospective to be consumed as indispensable substrates for fermentation.

Oil cakes	Dry matter	Crude protein	Crude fiber	Ash	Calcium	Phosphorus	References
CaOC	90	33.9	9.7	6.2	0.79	1.06	Ewing (1997)
COC	88.8	25.2	10.8	6.0	0.08	0.67	Gohl (1970)
CSC	94.3	40.3	15.7	6.8	0.31	0.11	Friesecke (1970)
GOC	92.6	49.5	5.3	4.5	0.11	0.74	Kuo (1967)
MOC	89.8	38.5	3.5	9.9	0.05	1.11	Kuo (1967)
OOC	85.2	6.3	40.0	4.2	–	–	Maymone et al. (1961)
PKC	90.8	18.6	37	4.5	0.31	0.85	Owusu et al. (1970)
SuOC	91	34.1	13.2	6.6	0.30	1.30	Brendon (1957)

Table 3: Composition of oil cakes

Solid state Fermentation (SSF)

Any biotechnological processes in which organisms grow non-soluble material or solid substrates in the absence or near absence of free water is honoured as solid-state fermentation (SSF) (Bhargav et al. 2008). Generally used substrates in SSF are cereal grains (rice, wheat, barley, and sludge), legume seeds, wheat bran, and lignocellulose accoutrements similar to straws, sawdust, or wood slices, and a wide range of factory and beast accoutrements. The composites of these substrates are polymeric and remain undoable or sparingly answerable in water but the utmost of them have low cost and are fluently accessible and represent a concentrated source of nutrients for microbial growth. Food medication by fermentation is one of the oldest styles. A critical study of the literature shows that a low quantum of water or the absence of water in SSF offers several advantages similar as easy product recovery, low cost of complete product process, lower fermenter-size, reduced downstream processing, and also reduction of energy conditions for shifting and sterilization (Pandey 2003). For the successful process of SSF, different factors like microorganisms, solid support used, water exertion, temperature, aeration, and type of fermenter used should be considered before going to start any fermentation process. The microorganisms used in SSF can do as single pure societies, mixed identifiable societies, or an institute of mixed indigenous microorganisms. Some SSF processes, e.g., tempeh and oncom products, bear picky growth of microorganisms similar to molds that need low humidity situations to carry out fermentation with the help of extracellular enzymes buried by stirring microorganisms. Table 4 shows different microorganisms like fungi, provocations, and bacteria that are used in SSF processes. Molds are constantly used in SSF for maximizing the production of value-added products as they grow naturally on solid substrates similar to pieces of wood, seeds, stems, and roots. Still, bacteria and provocations, which bear comparatively advanced humidity content for effective fermentation, can also be used for SSF, but with a lower yield. SSF is a multistep process involving the following way:

Microorganisms	Solid supports	References
Bacteria		
Amycolatopsis mediterranean MTCC 14	GOC and COC	Vastrad and Neelagund (2011a, b)
Xanthomonas campestries MTCC 2286	Potato peel	Vidhyalakshmi et al. (2012)
Pseudomonas spp. BUP6	GOC, COC, SOC, and CSC	Faisal et al. (2014)
Bacillus licheniformis MTCC 1483	Wheat straw, sugarcane bagasse, maize straw, and paddy straw	Kaur et al. (2015)
Fungi		
Aspergillus niger	Rice bran, wheat bran, black gram bran, GOC, and COC	Suganthi et al. (2011)
Aspergillus niger	Rice bran, wheat bran, black gram bran, and soybean	Kumar and Duhan (2011)

Microorganisms	Solid supports	References
Streptomyces spp.	Household kitchen wastes	Ezejiofor et al. (2012)
Aspergillus oryzae	Soybean meal (waste)	Thakur et al. (2015)
Rhizopus arrhizus and *Mucor subtillissimus*	Caorncob cassava peel, soybeans, wheat bran, and citrus pulp	Nascimento et al. (2015)
Aspergillus niger	Rice bran, wheat bran, black gram bran, GOC, and COC	Mahalakshmi and Jayalakshmi (2016)
Aspergillus terreus	Palm oil cake	Rahman et al. (2016)

Table 4: Recent studies of solid-state fermentation using different microorganisms and agro-industrial wastes

1. Selection of substrate.

2. Pre-treatment of substrate either by mechanical, chemical, or biochemical processing to ameliorate the vacuity of the bound nutrients and also to reduce the size of the factors., pounding straw and shredding vegetable materials to optimize the physical aspects of the process. Still, the cost of pre-treatment should be balanced with eventual product value.

3. Hydrolysis of primarily polymeric substrates, e.g., polysaccharides and proteins.

4. Fermentation process for exercising hydrolysis products.

5. Downstream recycling for sanctification and quantification of end products.

Utmost the Asian and African countries used different fermented foods as a part of their diet regularly. Different forms of actuated oxygen like free and non-free revolutionaries similar to superoxide anion revolutionaries ($O2^-$), hydroxyl revolutionaries (OH), and H2O2 and singled oxygen (O2), independently, reported that these can lead to oxidative injury to living organisms. So, these species produced a significant part in multitudinous conditions similar to cancer, emphysema, atherosclerosis, and arthritis (Jacobs et al. 1999). SSF has been substantially employed from ancient times for the processing of foods, but currently, it's gaining a lot of attention due to the adding use of different types of organic wastes and the larger product of value-added products (Pandey et al. 2000; Wang and Yang 2007). The hunt for sustainable and green processes for bioconversion of organic waste into precious products could substitute non-renewable materials and transfigure chemical processes into cleaner practices in the artificial sector highlights the eventuality of SSF. The particular interest in SSF is due to its fairly simple process that uses abundant low-cost biomaterials with minimum or no pre-treatment for bioconversion, lower wastewater generation, and the capacity for bluffing analogous micro-environments, favourable to microorganism growth (Singhania et al. 2009). Further, SSF has opened a new paradigm of bioconversion of organic solid wastes through the product of biologically active metabolites both at the lab and artificial scale. The operation of SSF in the product of different bio-products has been extensively reported including enzymes, organic acids, biofertilizers, biopesticides, biosurfactants, bioethanol, aroma composites, beast feed, colours, vitamins, and antibiotics. Also, SSF simulates natural microbiological processes similar to composting and ensiling (Thomas et al. 2013). Thus, solid-state fermentation and its effect on the conformation of value-added products by this process are reviewed and put forth for discussion.

Substrate used for solid state fermentation

Solid waste from different diligence like food, beer and wine, husbandry, paper, fabrics, soap, and beast feed diligence are used as a substrate for SSF. Substrates that remain solid also contain low humidity situations which are preferred for SSF. Figure 2 shows some of the substrates used for SSF. Several experimenters used different substrates designed for their study like rice (Oryza sativa) (Sadh et al. 2017a), seem (*Lablab purpureus*) (Sadh et al. 2017b, c), black-eyed pea (Vigna unguiculata) (Chawla et al. 2017), peanut press cutlet (Arachis hypogea) (Sadh et al. 2017d). Orzuaa et al. (2009) studied ten agro-industrial wastes used for their felicitousness as fungus immobilization carriers for SSF. The plant that some of the waste materials have better eventuality for use as immobilization carrier in SSF, because they contain high water immersion capacity, and are respectable as the good growth rate of microorganisms.

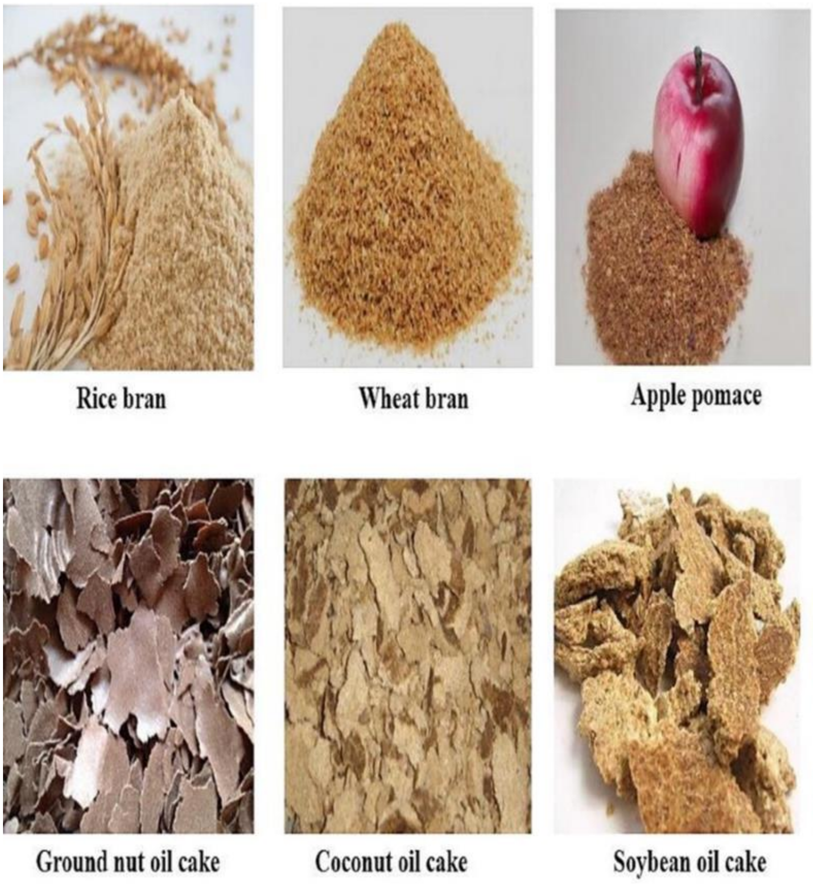

Fig 3: Substrates used for solid state fermentation

Utilization of agro-industrial wastes using solid state fermentation

Agricultural wastes are used to produce large value-added products. Figure 3 shows the schematic representation of operations from different substrates. Utmost of the field wastes can be used worldwide by the product of biofuels, biogas in place of heat, and power through different technologies. Different substrates have different compositions and are used in the product of different precious products on the base of their composition. Some of the precious products are described below.

Antibiotic products

Antibiotics are substances that are produced by different microorganisms that widely inhibit growth or kill other microorganisms at veritably low attention (Tripathi 2008). Different agrarian wastes are used for the product of different antibiotics. Different studies were carried out by using agro-industrial waste and produced antibiotics. Ifudu (1986) used sludge cobs, sawdust, and rice shells as a raw material for the production of antibiotics, i.e., oxytetracycline. Algebra et al. (2005) successfully produced oxytetracycline with SSF by consuming groundnut shells as a raw material with a strain of Streptomyces rimosus. Yang and Swei (1996) and Tobias etal. (2012) also supports the product of oxytetracycline by using agro-waste.

The cost of antibiotics products was significantly dropped by using low-cost carbon sources from various agrarian remainders. These reminders can be used as a remarkable cover for the construction of neomycin and other antibiotics (Vastrad and Neelagund 2011a). Vastrad and Neelagund (2011b) studied the product of extracellular rifamycin B by using solid-state fermentation with the help of Amycolatopsis Mediterranean MTCC 14 with the help of canvas-pressed cutlet as a raw material, which is also regarded as agro-industrial waste. Among the different agro-industrial wastes, two of them, i.e., coconut canvas cutlet and ground nutshell, showed the maximum antibiotic product. The force of external energy sources was used for the enhanced production of antibiotics.

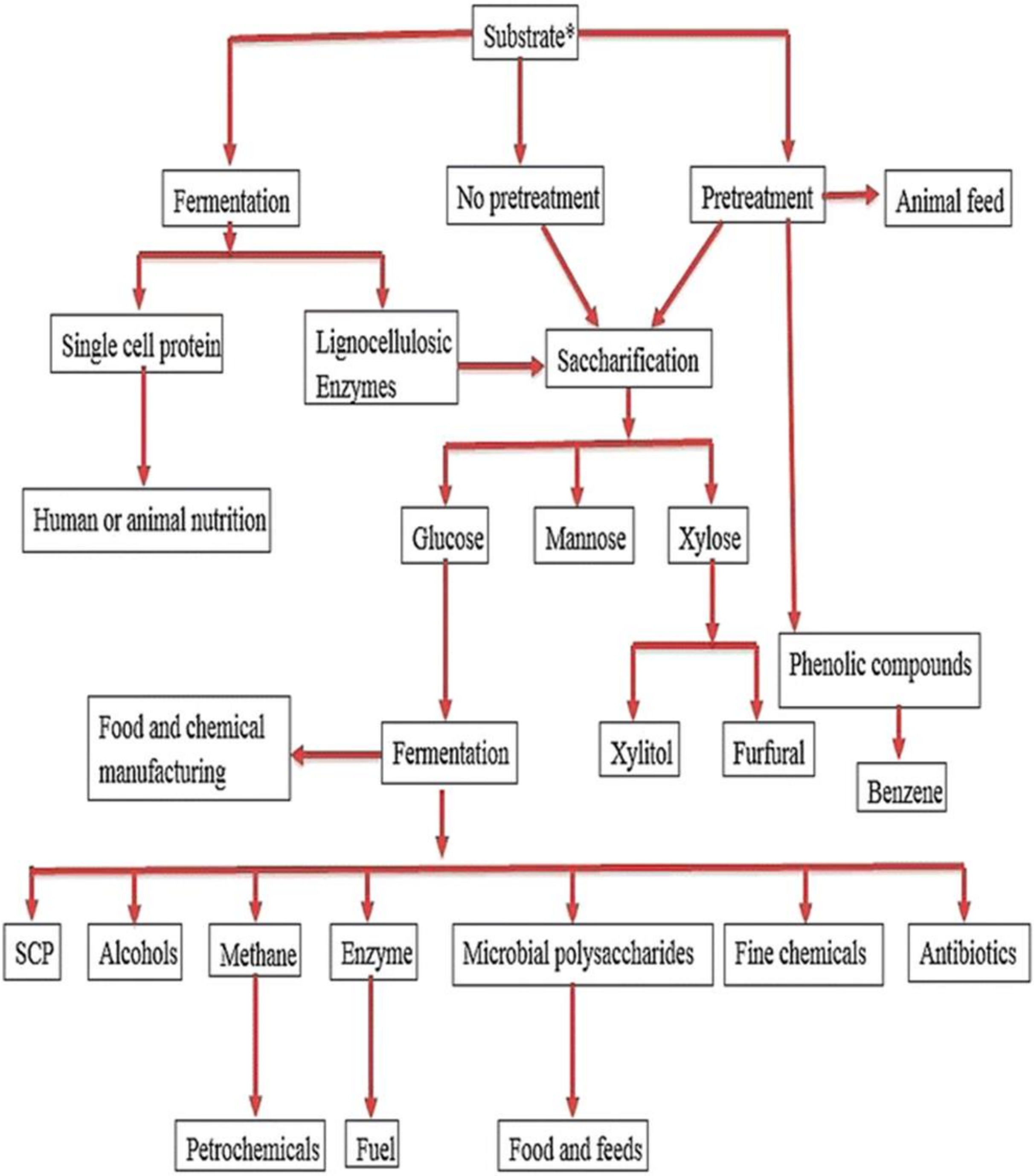

Fig 4: Schematic representation of applications of different substrates

Bio energy production

Bio-fuels remain significant because they're used as cover for fossil energies. Former studies revealed the product of biofuels from positive agro-industrial remainders like rice straw, sweet potato waste, sawdust, potato waste, sludge stalks, sugarcane bagasse, and sugar beet waste (Duhan et al. 2013; Kumar et al. 2014, 2016). In 2011, over the world bioethanol product increased as shown by the product of 85 billion litres of bioethanol (Avci et al. 2013; Saini et al. 2014). With the help of agrarian remainders, it supports dropping the deforestation by reducing our dependence on timber woody biomass. In addition, field remainders have small crop time which reduces the redundant constantly offered to bioethanol products (Limayema and Ricke 2012).

Numerous inquiries have completed the timber of ethanol from accoutrements having the lignocellulosic composition (Cadoche and Lopez 1989; Bjerre et al. 1996). Najafi et al. (2009) also studied the product of bioethanol from colourful agrarian remainders attained from different agrarian crops. Saini et al. (2014) bandied colourful agrarian wastes for the product of bioethanol for the alternate- generation. They concentrated on the use of the lignocellulosic composition of different agro-industrial wastes. They concluded that the biofuels are useful druthers of colourful fossil energies like petrol and diesel. On the base of their discussion and review of colourful approaches for biofuel products, it's easily shown that the lignocellulosic-deduced biofuels are cost-effective as well as eco-friendly and indispensable sources of energy for the forthcoming future. Another study for the product of biogas by using colourful husbandry remainders from different sources as well as two weeds, i.e., Typha Angustifolia. and Eichornia crassipes Solms was carried out by Paepatung et al. (2009).

In utmost of developing countries, fast growth in population, as well as their rapid-fire development in industrialization, causes the high demand for low-priced energy sources by using provident agrarian remainders. A large quantum of needed waste is available in these countries for the production of biofuels. Mushimiyimana and Tallapragada (2016) produced bioethanol from vegetable waste in a fermentation fashion with the help of incentive Saccharomyces cerevisiae. They used common vegetable waste like potato peel, carrot peel, and onion peel. Bioethanol products could be the stylish alternate for the consumption of agrarian remainders. The use of banana stem as a substrate for bioethanol products is a good alternative in India because of the huge vacuity of the banana mock stem as a waste. Ingale et al. (2014) produced bioethanol by using the banana mock stem as a substrate with the treatment of Aspergillus ellipticus and Aspergillus fumigatus. Maiti et al. (2016) used agro-industrial waste for the production of butanol by using Clostridium beijerinckii. The maximum butanol, i.e.,11.04 g/ l was produced after 96 h of fermentation from the agro-industrial waste bounce assiduity wastewater (SIW). So, the use of affordable and ecological agrarian waste for the production of precious biofuels is a better pathway for the fulfilment of the demand of energy through limited coffers.

Oncom product

Oncom is an indigenous fermented product from Indonesia made from several agrarian wastes. There are three types of oncom. The most well-known is that made from peanut press- cutlet (a waste product from peanut canvas recycling manufactories). This is oncom kacang and popular in West Java (Van Veen et al. 1968; Beuchat 1986). The alternate type is oncom yahoo which is popular in Jakarta. It's prepared from the solid wastes of tahoo, a soya bean curd. Its medication is analogous to that for oncom kacang. The third type is made from the solid wastes of mungbean (Phaseolus Radiata) bounce flour (Hunkwe), and is called oncom amps hunk (Steinkraus 1983).

Tempeh product

Tempeh is a type of fermented food used in the utmost of the developing as well as developed countries. Especially in Indonesia and Malaysia tempeh is made at home collectively or in small diligence. The aroma and texture of the fermented products, i.e., tempeh are superior compared to the fermented product. The use of boiled soya sap in tempeh products showed better results as compared to the use of steamed or autoclaved fashion. Boiled soya beans also gave a soft product as tempeh (Mak 1986).

Rhizopus strains are used for the product of tempeh as they can degrade the raw material grounded on their composition. Some experimenters suggested that the application of soya bean milk waste produced better tempeh and it also made an indispensable substrate or raw material for the production of cost-effective as well as nutritionally enhanced tempeh. These studies also showed that the protein content of tempeh bettered significantly after using soya bean milk wastes. Therefore, soya bean milk wastes can be used as a cover of raw material for making a protein-rich mortal food rather of being thrown out. Various kinds of tempeh and tempeh-suchlike products are available in Indonesia (Lim 1991).

Product of poly (3-hydroxybutyric acid)

Citrus fruits are consumed all over the world for different artificial purposes like fruit juice, and logjams. So these types of diligence also produced a colossal quantum of waste as a peel residue or in other forms but these citrus wastes can be used in fermentation as they contain a large quantum of carbohydrates. Sukan et al. (2014) used orange peel waste for the product of Poly (3-HB). Their results showed that orange peel has a rich and unutilizedagro-industrial waste. They reported the first time the product of Poly (3HB) using orange peel as a single carbon source with a veritably simple-treatment system.

Biosurfactant production

Utmost of the bacterial species are planted in canvas defiled spots and these bacterial species can produce useful or salutary products for humanity. Saravanan and Vijayakumar (2014) insulate a bacterial strain i.e., Pseudomonas aeruginosa PB3A from canvas- defiled point. They used the strain for the product of biosurfactant by using agro-waste similar to castor canvas, sunflower canvas, barley bran, peanut cutlet, and rice bran. They used these wastes as a rich indispensable carbon source for the product of biosurfactant by using insulation. aeruginosa strain.

Xanthan production

Xanthan is a type of exopolysaccharide, produced from Xanthomonas species. Xanthan is used as food complements. So, the product of xanthan from agro-waste is a precious approach as a cost-effective product. Vidhyalakshmi et al. (2012) carried out a study on the product of xanthan from different agro-industrial remainders. They produced xanthan by SSF with the help of. tapestries, X. citri, X. oryzae, and. musacearum. The loftiest xanthan was produced by. citri on potato peels, i.e.,2.90 g/ 50 g followed by2.87 g/ 50 g,1.50 g/ 50 g, and0.50 g/ 50 g by. tapestries, X. oryzae, and. musacearum, independently.

The single-cell protein production

Mondal et al. (2012) studied the product of single-cell protein (SCP) from fruit wastes. They used cucumber and orange peels as the substrate for the product of SCP with the help of. cerevisiae by using submerged fermentation. The plant that cucumber peels produced a larger quantum of protein as compared to the orange peels. So it was suggested that these fruit wastes can convert into SCP by using suitable microbes. The products attained from the bioconversion of agro-industry wastes are provident and nutritionally contained a high content of protein.

Fig 5: Applications of agro-industrial wastes

Antioxidant products

Antioxidants are known as radical scavengers because they cover the mortal body from free revolutionaries that beget several conditions including ischemia, asthma, anemia, the aging process, madness, and arthritis. Because of the lack of knowledge about the molecular composition of natural antioxidants, their use is limited. Natural antioxidants tend to be safer and they also have antiviral, anti-inflammatory, anti-cancer, anti-tumor, and hepatoprotective parcels (Nigam et al. 2009).

SSF can be used to enhance the antioxidant exertion of different substrates with the use of microorganisms. Antioxidants, as well as anti-cancer agents, were also produced with pineapple waste as a substrate for SSF. Pineapple waste included the external peel and the central part of the fruit and it contains about 50 of the total fruit weight. The experimenters concluded from their results that the fermented pineapple wastes have increased quantum of protein content, fiber content, phenolic content, and antioxidant conditioning too. So, they suggested that the waste from pineapple can be a volition for new salutary strategies (Rashad et al. 2015).

The residue of different fruits and vegetables similar to fruit and vegetable peels is generally known as waste or residue. But numerous experimenters concentrated on these peels and got good results. So, these wastes are considered a precious raw material for the product of various pharmaceutical products (Parashar et al. 2014). Duda-Chodak and Tarko (2007) delved into the antioxidant parcels, total polyphenols, and tannin content of seeds and peels of some named fruits. The plant from their study that the peels of named fruits have maximum scavenging exertion and also got high polyphenol contents in the peels as compared to the named seeds.

Orange peel uprooted with different detergents exhibits variable antioxidant conditioning (Hegazy and Ibrahium 2012). Singh and Genitha (2014) find the maximum chance of antioxidant exertion in pomegranate peel among the bomb and orange peel. A study on peanut fragments like their skin, housing, raw, and cooked kernel was carried out by Win et al. (2011). They estimated the parcels of antioxidants and redounded that the exertion of antioxidants, as well as phenolic composites of peanut skin, were maximum than the other corridor of peanut housing, cooked, and raw kernel. Field residues like stem, leaves, and stalks were also used for antioxidant and antimicrobial conditioning. Several experimenters studied the antioxidant parcels of several stem excerpts, splint excerpts, and fruit excerpts of Argemone mexicana and Thuja orientalis (Duhan et al. 2011a, b; Saharan et al. 2012; Saharan and Duhan 2013) admixture of several medicinal shops, wheat fragments, rice (Rana et al. 2014; Duhan et al. 2015a, b, 2016) and plant high antioxidant exertion in excerpts of these shops.

Sadh et al. (2017a, b) conducted a study to find out the effect of solid-state fermentation on the release of phenolics and latterly on the enhancement of antioxidant exertion of Lablab purpureus (seim), Oryza sativa (rice), and their combination using GRAS filamentous fungi, i.e., A. awamori and. Oryza. They observed a significant increase in TPC position after the fermentation of seed and flour with named strains as compared to the non-fermented substrate. With the increase in TPC position, the antioxidant exertion of fermented samples was also increased in an ethanolic excerpt of all the substrates, awamori and Oryza.

Sadh et al. (2017c) used a combination of substrates, i.e., rice and feel to find out the effect of solid-state fermentation on the release of phenolics, antioxidants, and some other functional parcels. From their study, it was verified from the uprooted analysis of fermented samples that they've high phenolic, antioxidant, and functional parcels than the-fermented bones as numerous biochemical changes do during fermentation, so fermentation has been used to ameliorate or converted the proportion of nutritional and antinutritive ingredients of substrates, which affect product’s parcels similar as biochemical or functional.

Enzyme production

Agro-industrial wastes consist of variable composition that supports the growth of microorganisms as a result of fermentation producing different valuable enzymes. These wastes are used as raw materials. The growth rate of fungi is enhanced by the use of these substrates which resulted in the conversion of lignocellulosic substrates into less complicated bones by demeaning the action of several enzymes. One of the important enzymes, i.e., amylase, was used in bounce processing diligence for the declination of polysaccharides into sugar factors (Nigam and Singh 1995; Akpan et al. 1999). Kalogeris et al. (2003) studied varied agricultural wastes for the production of different cellulolytic enzymes similar to endoglucanase and β-glucosidase by solid-state civilization. They used a thermophilic fungus strain, i.e., Thermoascus aurantiacus. They suggested that the agrarian wastes or by-products are low-cost nutrition sources for solid-state civilization to produce endoglucanase and β-glucosidase. Topakas et al. (2004) used sludge cobs for the product of phenolics with solid-state fermentation in addition to coupling enzymic treatment. They also studied enzymatic products similar to cinnamoyl esterase products and xylanase products. Food diligence waste like peel, seed, canvas galettes, and field remainders similar to rice bran and wheat bran are also used for amylase and Glucoamylase products. awamori in solid-state fermentation was also reported (Ellaiah et al. 2002; Negi and Banerjee 2009; Suganthi et al. 2011). Likewise, the product of α-amylase by Aspergillus niger MTCC 104 employing solid-state fermentation has been reported (Duhan et al. 2013; Kumar et al. 2013a, b). Buenrostro et al. (2013) used four agro-industrial by-products similar to sugarcane bagasse, sludge cobs, candelilla stalks, and coconut cocoons for the product of ellagitannins, an enzyme used for biodegradation of ellagic acid product and ellagitannins. They plant the loftiest product in sludge taxicabs followed by sugarcane bagasse, coconut cocoons, and candelilla stalks. The product of lipase enzymes and their optimization was carried out by Oliveira et al. (2017) using canvas galettes as the substrate from agro-industrial waste. They used Aspergillus ibericus as the product of lipase. The loftiest lipase product was planted in win kernel canvas cutlet (PKOC). Also, Saharan et al. (2017) carried out a study to know the effect of fermentation on phenolics, flavonoids, and free radical scavenging exertion of generally used cereals and also studied the part of α-amylase, xylanase, and β-glucosidase enzymes in the release of polyphenols and antioxidants during solid-state fermentation of cereals. Results showed a positive correlation between polyphenols and enzyme conditioning. Also, various enzymatic assays were performed similarly to α-amylase, xylanase, β-glucosidase, and lipase during the fermentation of the peanut press cutlet. oryzae, performing in a significant improvement of enzyme conditioning in all assays (Sadh et al. 2017e). The table shows several studies that have been conducted on the construction of various enzymes with the use of agro-industrial remainders.

Substrates	**Enzymes**	**Microorganisms**	**Source**
Papaya waste	α-Amylase	*A. niger*	Sharanappa et al. (2011)
Groundnut oil cake (GOC)	Lipase	*C. rugosa*	Rekha et al. (2012)
Wheat bran and orange peel	Pectin methyl esterase	*P. notatum*	Gayen and Ghosh (2011)
Linseed oil cake (LOC)	Lipase	*P. aeruginosa*	Dharmendra (2012)
Orange peel	α-Amylase	*A. niger*	Sindiri et al. (2013)
Coconut oil cake (COC)	α-Amylase	*A. oryzae*	Ramachandran et al. (2004)
Rice bran	α-Amylase	*Bacillus* sp.	Sodhi et al. (2005)
Corn bran	α-Amylase	*Bacillus* sp.	Sodhi et al. (2005)
Rice bran, wheat bran, black gram bran, and soybean	α-Amylase	*A. niger*	Akpan et al. (1999)

Substrates	Enzymes	Microorganisms	Source
Fruits peel waste	Invertase	*A. niger*	Mehta and Duhan (2014)

Table 5 Studies on production of enzymes by microorganisms using agro-industrial wastes

Immobilization carrier production

Orzuaa et al. (2009) studied teenager-industrial wastes including lime peel, orange peel, apple pomace, pistachio shell, wheat bran, coconut cocoon, etc. They studied the felicitousness of various afro-industrial wastes as an immobilization carrier for SSF. Before continuing the study, they characterized the agro-industrial wastes with physio-chemical treatment. Eventually, Orzuaa et al. (2009) concluded that out of teenager-industrial wastes, four of them including Citrus aurantifolia, Malus Domestica, Citrus sinensis, and Cocos nucífera have inordinate eventuality as immobilization carriers for SSF. These agro-industrial wastes can be used further for provident advantage as well as an environmental-friendly way for waste operation.

Utilization of eggshell waste

Eggshell has a $CaCO3$ in large amounts with presence of trace elements. In present day, eggshell has many direct or after chemical treatment applications. It is used as an adsorbent to purge hazardous pollutants. Elimination of wastewater containing dyes poses a huge problem as it has high solubility in water. Tsai *et al.* studied the potential of calcified Eggshell (CES) and its ground eggshell powder (ESP) for the adsorption of cationic basic blue 9 and anionic acid orange 51 from aqueous solution by varying the agitation speed, initial dye concentration, adsorbent mass and temperature. It was concluded that eggshell waste could be used as an adsorbent for the removal of anionic dye.

Further, Abdel-Khalek *et al*. 75 found that industrial waste ES could be used as an adsorbent for methylene blue (MB) and Congo red dyes. The effect of eggshell in binding of three different dyes, methylene blue, bromophenol blue, and methyl orange from their aqueous solutions has also been studied. In conclusion to that, eggshell can be used as an effective adsorbent for removal of anionic and cationic dyes.

Eggshell surface has been modified to improve its quality as an adsorbent. Akazdam *et al.* used eggshell treated with NaOH to study its effectiveness as and adsorbent for MB and acid orange 7. It was observed that, around 75% MB could be removed using NaOH treated eggshell. El-Kemery *et al.* modified the calcined eggshell (CES) by depositing sol-gel titanium dioxide nanoparticles and obtained a novel hybrid nano-bio-sorbent, namely TiO2-CES. Conclusion was that TiO2-CES could be used for the absorbent of acid red nylon 57 dye from aqueous solution. The experiment conclude hat a low adsorbent dosage was enough for removal of 99.89% of dyes.

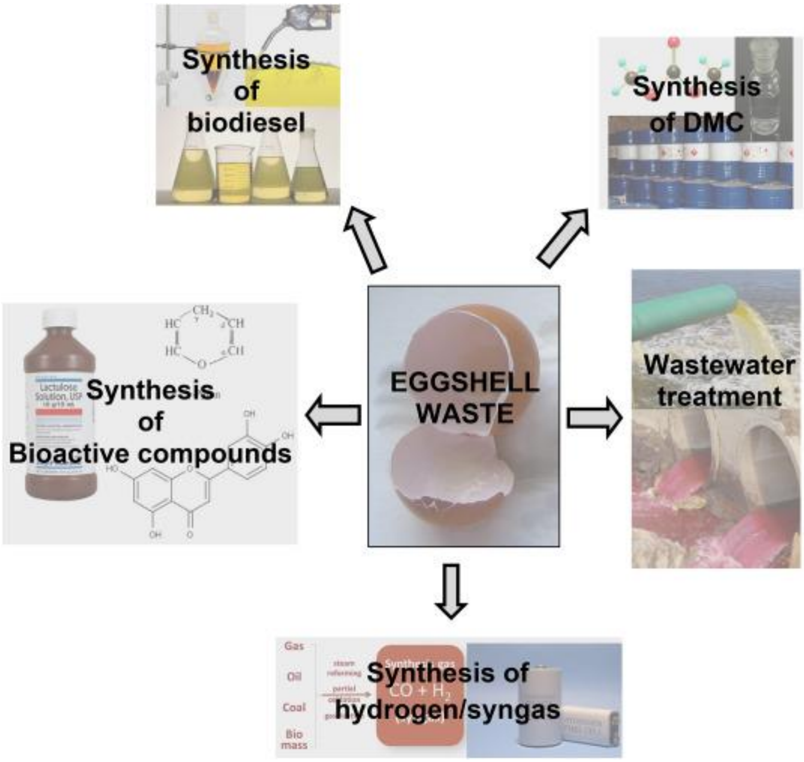

Fig 6: Utilization of eggshell

It is observed that eggshell can be used for removal of heavy metals from water. Jai *et al.* used CES for the removal of heavy metals like Cd, Cr, and Pb from waste water. Conclusion was that CES results in complete removal of Cd, as well as 99% removal of Cr. A number of studies have reported that eggshell can be useful in removal of Pb from water and soil. The ability of eggshell membrane (ESM) for removal of Cr4+ ions from aqueous solution has been reported. Under optimum conditions, maximum removal of 81.4% has been achieved. Angelis *et al.* synthesized the hydroxyapatite from eggshell waste and studied its potential as an adsorbent for Ni2+ removal from its aqueous solution. It was observed that the maximum adsorption capacity was far ahead of other waste derived adsorbents.

Consumption of water with high boron content is reported to be harmful to all living beings. Al-Ghouti and Khan found that eggshell membrane (ESM) can adsorb 97% of boron; hence, it can be used as an adsorbent for removal of boron from water. Zhang *et al.* utilized ESM as solid-phase extraction adsorbent for the removal of As5+. It was observed that, under optimized conditions, ESM was able to extract As5+ with highest adsorption capacity of 3.9 μg−1. Chen *et al.* investigated the esterification of carboxylic groups on ESM with methanol. The results showed that the arsenate sorption capacity of methyl esterified eggshell membrane (MESM) was 200 times better than the bare eggshell. Furthermore, eggshell can also be used for removal of Cu and Hg.

Eggshell powder and seashell powders have been used as coating materials on Teflon and nylon substrate by using plasma spray deposition.99,103 These food-derived coating materials are naturally bioactive and biocompatible. Polymers (Teflon and nylon) have also been used for implantation purposes due to their better corrosion resistance, better mechanical properties, and better wear resistance.104 Ostrich ES find use in the fabrication of zinc calcium phosphate coatings on titanium surface by using two-step thermo-chemical deposition methods.105 This method efficiently produced zinc brushite coating after the fabrication of zinc HA, which also showed bioactivity with the precipitation of bone-like appetite precipitation of bone-like appetite, as discussed in subsequent sections.

Concluding Reflections

A large quantum of agro-food waste is being generated due to an adding demand for food. Agro-food wastes have long been used in various traditional operations like breast feed, heat generation in small-scale diligence, composting diseases, and different ménage operations. With advances in processing technology, these wastes are being used to induce value-added accoutrements like-oils, actuated carbon, Energy feasts, and high-grade silica. These operations affect the creation of ashes as a secondary by-product. Agro-food waste ashes (second-generation products) have lately been used to make value-added engineering materials like bioactive spectacles and glass pottery, and dielectric and optic materials. The application of these agro-food waste ashes provides a practical and terrain-friendly way to convert them into value-added materials. These value-added materials could also replace conventionally synthesized mineral-grounded products. This approach could also give an effective result to the agro-food waste operation problem.

Future Scope

Agro-food wastes contain several major and minor organic ingredients. Different physical conditions and processing parameters affect the essence and metalloid oxide content present in the agro-food wastes. Using the green chemistry route these ingredients can be converted into different value-added materials. Alternate-generation by-products of agro-food wastes could also be used in various medical, civil, and engineering operations. Still, expansive exploration is needed for the large-scale use of these renewable and sustainable coffers. So, grounded on the operation, these can be named, uprooted and converted into various value-added accoutrements, which can find Operations in the medical and engineering fields. Careful selection of wastes and processing ways can therefore affect the generation of multiple value-added materials. The generation of value-added accoutrements using advanced and environmentally feasible physical, chemical and mechanical styles can reduce operation and terrain affiliated problems and also pave the way for new start-ups and diligence.

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