Chapter 7
Recycling Nutraceuticals from Agro-Industrial Residues

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Abstract Agro-industrial residues contain lignocellulose and bioactive compounds that could be recycled as enzymes, vitamins, dietary fibers, pigments, organic acids, bio-fuels, antioxidants, antibiotics, and animal feed, for example. Here we review the fermentation of agricultural waste for the production of food additives, antibiotics, antioxidants, enzymes and biosurfactants.

Keywords Agro-industrial residue · Bio fuels · Enzymes · Fermentation · Lignocellulosic waste · Organic acids · Vitamins

7.1 Introduction

Huge amount of ago-industrial residues produced every year by different food and agro-processing industries. Agro-industrial residues are exonerated surroundings devoid of following appropriate discarding system eventually ecological fault and harmful consequences on fitness of living being. Majority of these wastes are natural and unused, thus it is discharged by incineration, discarding or by land filling. Natural wastes generate diverse inconvenience with weather by raising percentage of greenhouse gases. Also, the use of fossil fuels has remarkable influences on greenhouse gases production (Bos and Hamelinck 2014). Therefore the global apprehension is to find out the improvement or alternative resources for cleaner and renewable bio-energy as agro-wastes cause a severe disposal difficulty. The juice industries produce fruit peels in huge quantity, coffee industry produce coffee pulp in vast amounts and cereal industries generate husks which are considered as waste. Globally total fiber residue wheat straw, rice straw are found about 147.2, 709.2 and

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673.3 million metric tons respectively (Belewu and Babalola 2009). But proximate study revealed that these residues are highly nutritious, thus it accomplished additional concern in quality protection (Table 7.1).

Earlier reports described that diverse categories of fruits and nuts waste for example green walnut husks, pomegranate peels, lemon peels successfully utilized as standard antimicrobials (Adámez et al. 2012). Organic compounds produced from wastes though it is a hazard to the environment, but they characterize potential resources for cultivation of mushrooms as food as well other bio-based stuff in terms of energy and fertilizers. Several agricultural residues are utilized for making animal feed. Nonetheless, these wastes have lot of variations in composition for example large quantities of carbohydrate, proteins, and minerals.

Considering presence of highly nutritious components, these residues and not described as "wastes" but as essential/optional ingredients for another produce. The accessibility of these nutrients in unrefined form such as cereal industries generate husks. A range of studies informed that various kind of fruit waste e.g. pomegranate, lemon peels and green walnut husks employed as natural antimicrobials. These nutrients in peel or husks provide suitable environments and solid support for microbial growth in SSF system for manufacturing diverse valuable goods likefermentable sugars by dropping the manufacturing charges depending on the food crops (Adámez et al. 2012; Katalinic et al. 2010).

7.2 Agro-Waste

About 1.3 billion tonnes is wasted yearly which is approximately 33% of the food manufactured globally for eating of mankind. The tubers, roots as well as fruits and vegetables, have recorded highest (40–50%) wastage rates as compared to any other food, representing (520–650 million tonnes) globally per year. Food wastage of European Union recorded 39% or 89 million tons of food waste occurs during preparation annually, whereas 367 million tons per year inedible in the European Union (Panesar et al. 2016). However, highest quantity of agro-waste dedicated for animal bedding and fodder, and diverse horticulture purpose.

7.2.1 Valorisation of Agro-Industry Wastes

According to various earlier studies performed in last decades investigating the efficient consumption of agro-waste, the prospective ingredients for manufacturing of important produce to add value. Largely agro-waste utilization have been done in agriculture rich countries as their economies are greatly dependent on agriculture. Currently, bioethanol and other liquid-fuels are industrial functioning procedure to utilize agro- waste as major starting ingredients. Largest manufacturer and exporter of sugar cane is Brazil and eventually, Brazil also the second biggest maker of

Table 7.1 Production of food grade enzymes and Applications

Enzymes	Substrate	Organisms used	Fermentation type	Activity	Industrial Applications	
					Industry	Application
Pectinase	Orange bagasse	*Thermoascus aurantiacus* 179–5	SSF	19,320 Ug-1 (PL)	Fruit Industry	Clarification of the fruit juices
	Wheat bran 10% sugarcane bagasse +90% Orange bagasse		SSF	11,600 Ug-1 (PL) 40, 180 Ug-1 (PL)		Enhanced levels of fruit juice volume when fruit pulps treated with pectinase
	Lemon pulps	*Trichoderma virde* *Aspergillus niger*	Slurry state	9.01 Uml-1		Soften the peel of citrus fruits
	Orange bagasse: wheat bran (1:1)	*Penicillium viridicatum RFC*	SSF	346.4 Ug-1 (Exo-PG) 314.4 Ug-1 (PL) 5.6 Ug-1 (Endo -PG) 71.2 Ug-1 (Exo-PG) 480 Ug −1 (PL)		Enhances the citrus oil extraction such as lemon oil
	Deseeded sunflower head with green gram husk	*Aspergillus niger DMF 27*	SMF	30.3 Uml^{-1} (Exo-PG) 18.9 Uml^{-1} (Endo-PG)	Beverages industry	Accelerates tea fermentation
		Aspergillus niger DMF 45	SSF	45.9 Uml-1 (Exo-PG) 19.8 Ug-1 (Endo-PG)		Reduces foam forming property in instant tea powders
	Orange bagasse	*Botryosphaeria rhodina MAMB-05*	SSF	32 Uml-1		Remove mucilaginous coat from coffee beans
	Orange bagasse: wheat bran (1:1)	*Thermomucor indicae_seudaticae*	SSF	120 Uml-1	Wine industry	Imparts stability of red wine

(continued)

Table 7.1 (continued)

Enzymes	Substrate	Organisms used	Fermentation type	Activity	Industrial Applications	
					Industry	Application
			SMF	13.6 Uml^{-1}		
	Orange bagasse: Molokhia Stalks (1:3)	*Penicillium pinophlilum* Hedg 3503 NRRL	SSF	3270 Ug-1 dry solid substrate		
	Orange peel	*Aspergillus niger*	SMF	117.1 ± 3.4 µmml-1 min-1-1		
	Orange peel	*Bacillus licheniformis* SHG 10		2.69 µg galactouronic acid min-1 mg 1		
	Citrus pulp and sugarcane Bagasse	*Aspergillus. Oryzae* CPQBA 394–12 DRM 01	SSF	45 ± 4 Ug-1		
	Orange peel and groundnut oil cake	*Saccharomyces cerevisae PVK4*	SMF	6285 Uml-1		
Amylase	Coconut oil cake	*Aspergillus oryzae*	SSF	3388 Ugds-1	Brewing industry	Fermentation of alcohol by converting starch to sugars
	Wheat bran	*Thermomyces lanuginosus ATCC 58157*	SSF	4.946 × 105 Ukg-1	Baking industry	Breakdown of starch into simple sugars; thereby allowing the bread to rise and impart umigat
	Wheat bran	*Bacillus* sp. PS-7	SSF	4,64,000 Ug-1 dry bacterial bran		Dough conditioning
	Potato peel	*Bacillus subtilis* DM-03	SSF	532 ± 5 Ug-1		Generates additional sugar in the bread, which improves the taste, crust color and toasting quality
	Rice bran	*Streptomyces* sp. MSC702	SMF	373.89 Iuml-1		Anti-staling effect during bread making; improves the softness and shelf-life

	Rice bran: wheat bran (1:2)			549.11 Iuml-1	Fruit and brewery industry	Clarification of beer and fruit juices
	Wheat bran 1	*Aspergillus oryzae* IIB-6	SSF	7800 Ugds-		
	Soyabean meal	*Aspergillus. oryzae S2*	SSF	22118.34 Ug-1 dry substrate		
	Rape seed cake, potato peel and feather	*Bacillus subtilis* PF1	SMF	16.39 ± 4.95 µgml-1		
	Brewery waste	*Bacillus subtilis* UO-01	SMF	9.35 Euml-1		
Laccase	Barley bran	*Trametes versicolor*	SMF	500–600 Ul-1	Wine industry	Removal of polyphenol, thereby providing stability to wines
	Banana leaf biomass	*Pleurotus ostreatus*	SSF	1.7106 Umg-1 protein		Preparation of cork stoppers of wine bottles
		Pulmonarius sajorcaju		1.6669 Umg		Reduces cork taint generally imparted to aged wine bottles
	Groundnut seeds	*Trametes hirsuta*	SSF	600–700 nkatl-1	Brewing industry	Removal of oxygen at the end of beer fermentation process
	Oat husks supplemented with combined fiber and deinking sludge	*Cerrena unicolor T 71*	SSF	178 nkatg-1 DW		Prevent the formation of off-flavors (trans 2-nonenal)
	Banana peel: mandarin peel: cantaloupe peel (5:3:2)	*Pleurotus florida NCIM 1243*	SSF	6.8 Ug-1	Fruit industry	Juice clarification
	Brewary waste	*Phanerocheate chrysosporium*	SSF	738.97 Ugds-1	Baking industry	Increase strength, stability and reduce stickiness Increase volume, improved crumb structure and softness of the product

(continued)

Table 7.1 (continued)

Enzymes	Substrate	Organisms used	Fermentation type	Activity	Industrial Applications	
					Industry	Application
Lipase	Babassu cake	*Penicillium simplicissimum*	SSF	26.4 Ug-1	Fats and oils	Production of mayonnaise and other emulsifiers,
	Wheat bran: gingelly oil cake (3:1)	*Aspergillus niger MTCC 2594*	SSF	384.3 Ug-1		Triglycerides synthesis and trans-esterification of triglycerides in non-aqueous media; specially fat production
	Palm oil mill effluent	*Candida cylindracea ATCC 14830*		20.26 Iuml-1	Milk	Production of milk with slightly cured umigat for use in milk chocolates
	Wheat bran, coconut oil cake and wheat rawa	*Aspergillus niger MTCC 2594*	SSF	628.7 Ugds-1	Cheese	Aging, ripening and general umigat characteristics
	Defatted rice bran	*Aspergillus umigates* MTCC 9657	SSF	8.13 Iuml-1		Lecithin modification
	Castor oil cake and sugarcane bagasse	*Trichoderma harzianum*	SSF	4 Ugds-1	Meat industry	Degumming during the refining of vegetable oil
	Olive oil with crambe meal	Fusarium	SSF	5.08 Ugds-1		Fat removal
	Crambe meal		SMF	3.0 Iuml-1		
	Seasame oil cake	*Candida rugosa NCIM 3462*	SSF	22.40 Ug-1		
	Palm oil industry waste	*Aspergillus niger*	SSF	15.41 IUml-1		

Tannase	Cashew apple bagasse	*Aspergillus oryzae*	SSF	4.63 Ug-1	Brewing	Removal of polyphenolic compounds
	Rice bran	*Aspergillus oryzae*	SSF	14.40 Ug-1 min-1	Tea	Manufacture of instant tea
	Bahera fruit powder :wheat Bran (3:7)	*Aspergillus heteromorphus* MTCC 5466	SSF	1060 Ugds-1		
	Tamarind seed powder	*Aspergillus flavus MTCC 3783*	SMF	139.3 Uml-1		
	Coffee pulp	*Penicillium verrucosum*	SSF	115.995 Ugds-1		
	Wheat bran	*Foetidus. terreus*	SSF	47.3 Umg-1		
Invertase	Red carrot jam processing residue	*S. cerevisae NRRL Y-12632*	SSF	272.5 Ug-1 dry substrate	Sweetener, sugar	Invert sugar production
	Orange peel .	*Foetidus. flavus*	SSF	25.8 IUml-1	Confectionery	Production of high fructose syrup Manufacturing of soft-centered candies
	Pressmud and spent yeast	*Saccharomyces cerevisae*	SSF	430 Umg-1		Manufacture of artificial honey
	Carrot peels	*Aspergillus. niger*	SSF	7.95 ± 0.1 Uml-1	Other	Production of alcoholic beverages, lactic acid, glycerol produced from the fermentation of sucrose
Protease	Pigeon pea waste	Bacillus sp. *JB-99*	SMF	12,430 ± 120 Uml-1	Dairy industry	Prevent coagulation of casein during cheese production
	Green gram husk	*Bacillus circulans*	SSF	32,000–73,000 Ug-1		Flavor development
	Green gram husk	Bacillus sp.	SSF	9550 Ug-1 biomass	Meat industry	Meat tenderization

(continued)

Table 7.1 (continued)

Enzymes	Substrate	Organisms used	Fermentation type	Activity	Industrial Applications	
					Industry	Application
	Potato Peel: *Imperata clyindrica* Grass (1:1)	*Bacillus subtilis DM-04*	SSF	2382 Ugds-1	Baking industry	Assures dough uniformity
	Castor husk	*Bacillus altitudinis GVC11*	SSF	419,293 Ug -1of husk		Improve dough consistency
	Wheat bran	*Pseudomonas aeruginosa*	SSF	582.25 ± 9.2 Uml-1		Gluten development
	Dal mill waste	*Fusarium oxysporum*	SSF	8.8 µgml-1		Improve texture and flavor
	Cotton seed cake	*Bacillus subtilis K-1*	SSF	1020 Uml-1		Reduce mixing time
Naringinase .	Grapefruit rind	*Foetidus. foetidus*	SSF	2.58 Uml-1	Fruit industry	Debittering of citrus fruit juices
	Rice bran	*Aspergillus niger MTCC 1344*	SSF	58.1 ± 1.6 Ug-1 dry substrate	Wine industry	Enhances the aroma in the wine
	Sugarcane bagasse+ soyabean hulls+rice straw	*Aspergillus niger*	SSF	3.02 Uml-1		Production of pruning, a flavonoid
	Orange rind	*Aspergillus niger*	SSF	13.89 Uml-1		
β-galactosidase	Whey	Kluyveromyces. marxianus MTCC 1388	SMF	1.68 Umg-1	Dairy industry	Production of low lactose/ lactose free milk
	Whey	Kluyveromyces.. *marxianus* NCIM 3551	SMF			Production of prebiotics
	Whey and parboiled rice effluent	*K. marxianus* ATCC 16045	SMF	10.4 Uml-1		Prevents crystallization of lactose
	Acid whey	Streptococcus thermophilus	SMF	7.76 Uml-1		Production of ice creams, sweetened flavor and condensed milks
	Whey	*Bifidobacterium animalis* ssp. lactis Bb12	SMF	6.80 Uml-1		Improves the scoop ability and creaminess of the product

		Lactobacillus delbruckii ssp. *bulgaricus* ATCC 11842		7.77 Uml-1		
	Cheese whey	Kluyveromyce. *marxianus* CBS 6556	SMF	21.99 Uml-1		
	Wheat bran and rice husk (1:1)	*Aspergillus oryzae*	SSF	386.6 μmoles of ONP released ml-1 min-1		
	Wheat bran	*Aspergillus tubingensis*	SSF	15,936 Ugds-1		
	Wheat Bran and whole wheat (7:3)	*Penicilium canescens*	SSF	5292 ± 111 Ug-1		
Papain					Meat industry	Tenderizing of meat
					Brewing industry	Prevents haze formation in beer; thereby resulting in shiny bright beer
					Baking industry	Breakdown gluten proteins in the dough in case of waffle and cracker production

Modified after Panesar et al. (2016)

Table 7.2 Nutraceuticals food additives used in food Industries

Additives	E-number	Properties	Sources
Tocopherol	E306	Antioxidants, vitamin E	Vegetable oils; cranberry seeds; nuts
Carotenoids (a-carotene, b-carotene, g-carotene, astaxanthin)	E160e161	Antioxidant, coloring agent, precursor of vitamin A (except astaxanthin)	Astaxanthin can be extracted from crustacean shells or algae or Obtained by fermentation of carbohydrates by Phaffia rhodozyma; Carotenes in general are extracted from vegetables (carrots, tomatoes)
Citric acid	E330	Flavoring and preservative agent	Fruits; fermentation of carbohydrates by aspergillus Niger, Candida spp., or bacillus licheniformis
Lactic acid	E270	Preservative, curing and flavoring agent	Fermentation of carbohydrates by lactic acid bacteria
Malic acid	E296	Source of extreme tartness	Fruits; fermentation of carbohydrates by aspergillus flavus
Tartaric acid	E334	Flavoring agent, antioxidant, emulsifier	Vinification lees, fruits
Fumaric acid	E297	Acidity regulator, flavoring agent, antioxidant	Fermentation of carbohydrates by Rhizopus plants (Fumaria officinalis)
Natural emulsifiers (pectins, gelatin, gum, xanthan, carrageenan, alginates)	E440e449	Stabilizers, emulsifiers	Fruits, porcine, bovine, fish, algae, microorganisms
Xylitol	E967	Sweetener	

bio-ethanol worldwide (da Silva 2016) using hydrolysis of waste further by simultaneous saccharification and fermentation (Ravindran et al. 2018). However, researchers start looking at feasible alternative to translate polysaccharides rich lignocellulose residues produced from agrowaste as a starting material for manufacturing of diverse enzymes shown in Tables 7.1 and 7.2 (Ghoshal et al. 2012; Bos and Hamelinck 2014).

7.3 Solid State Fermentation

In biotechnological method when microorganisms grow on solid insoluble object without free water or limited water, known as solid state fermentation (Bhargav et al. 2008).

Legume seeds, cereal grains and other lignocellulosic materials e.g. straws, sawdust or wood shavings, and other of plant and animal byproducts are considered as generally used raw material in solid state fermentation. The substrates are polymeric and reside as stoutly packed or hardly water soluble usually due to low cost and easily accessible but as an intense nutrients rich ingredients for microbial growth. Manufacturing of foods using fermentation technique is oldest technique. Earlier literature illustrated small quantity of water otherwise deficiency of water suggests numerous reward like simple product revival, low expenditure for whole manufacturing procedure, small size reactor, compact downstream procedure, and also diminution of need of power during agitation and autoclaving (Pandey 2003). For fruitful implementation of solid state fermentation, diverse factors such as microorganisms, solid support used, water activity, temperature, aeration, and type of fermenter utilized must be standardised prior to fermentation. Single pure cultures, individual mixed cultures or a group of mixed original microorganisms can be used in solid state fermentation. Some solid state fermentation practice, e.g., tempeh and oncom manufacturing, involve multiplication of microorganisms like fungi which needs lower water activity for fermentation using extracellular enzymes produced by fermenting fungi (Table 7.1). Fungi, bacteria and yeasts diverse microorganisms are used in solid state fermentation method. Molds are often used in solid state fermentation to get highest yield of value added produce due to generation of unsurprisingly on solid support made of lignocellulosic agro-waste. Nevertheless, bacteria and yeasts, which necessitate reasonably elevated moisture concentration in effectual fermentation, can also be utilized in solid state fermentation, with smaller yield. Solid state fermentation consists of following five steps

1. Choice of substrate.
2. Mechanical, chemical or biochemical pre-treatment of substrate by processing to perk up the entrenched nutrients accessibility as well as to diminish particle size, e.g., ground straw and cut fruits and vegetables peels to optimize the physical characteristics of the procedure. However, the expenditure of pre-treatment should be reasonable with ultimate product value.
3. Hydrolysis of main polymeric substrates, including carbohydrates and proteins.
4. Fermentation routes for exploiting degradation of commodities by hydrolysis.
5. Downstream processing for refining and quantitative analysis of finish goods.

Majority of the Asian and African countries include diverse fermented foods in their daily diet. Diverse types of active oxygen e.g. superoxide anion radicals (O^{2-}), singlet oxygen (O_2), hydroxyl radicals (OH^-) and H_2O_2 which stated that these can direct oxidative damage to living being. Therefore, these free radicals are the cause of many deadly diseases such as cancer, atherosclerosis, arthritis and emphysema (Jacobs et al. 1999). Since time immemorial solid state fermentation is found mostly in food processing application, but currently it is achieving tremendous awareness because of the mounting utilization of diverse types of organic wastes and the greater manufacturing of value-added end product (Pandey et al. 2000; Wang and Yang 2007). The hunt for sustainable and green method for bio-translation of organic wastes into important produce could replace non-renewable resources and also convert chemical method to green method in commercial scale which

emphasizes the potential of solid state fermentation. Scrupulous attention of solid state fermentation is because of its comparatively easy method which utilizes plentiful cheaper biomaterials of negligible or no pre-treatment for biotransformation, lower waste water production, capability for reproducible comparable micro-environments, suitable for microbial growth. Additionally, solid state fermentation has introduced a novel perception for bio transformation of solid organic wastes during manufacturing of purely vigorous metabolites in lab scale and large scale. Purpose of solid state fermentation in the manufacturing of diverse innate products have been extensively stated including enzymes, organic acids, biofertilizers, biopesticides, biosurfactants, bioethanol, bioflavour, animal feed, pigments, vitamins, and antibiotics. Similarly, solid state fermentation reproduce normal microbial techniques such as composting and ensiling. Thus, solid state fermentation and development of value-added goods are reviewed.

7.3.1 Substrate for Solid State Fermentation

In SSF solid industrial waste generated from diverse manufacturing unit such as paper, textiles, agriculture, alcoholic beverages, detergent, food, and animal feed processing are utilized as solid support. Raw materials that stay on solid also have low moisture intensity which are chosen for SSF. Figure **7.1** showed diverse category of the hard support used for SSF. Many researchers utilized miscellaneous

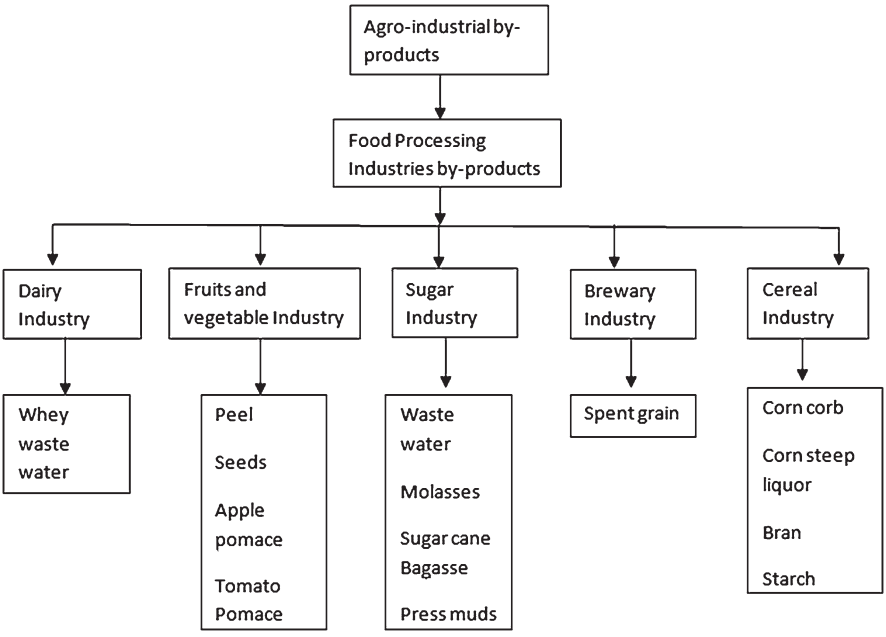

Fig. 7.1 Production of different agro-industrial by-products from different food processing industry. (Modified After Panesar et al. 2016)

ingredients considered for their study like black eyed pea (*Vigna unguiculata*), seim (*Lablab purpureus*), rice (*Oryza sativa*), peanut press cake (*Arachis hypogea*), (Sadh et al. 2017a, b, c, d). Diverse agro-industrial wastes intentionally utilized suitability for fungus immobilization delivery system for SSF (Orzuaa et al. 2009). They established few sabotage resources have superior probability using in immobilization delivery system in SSF, as they restrain large water assimilation capability, in addition to appropriate for superior multiplication rate for microbes.

7.3.2 *Utilization of Agro-Industrial Wastes Using Solid State Fermentation*

Agro wastes are utilized for generating huge commodities to add value. Figure 7.2 shows the schematic illustration of relevance from diverse raw materials. Maximum field wastes can be utilized internationally in manufacturing of biofuels, biogas in terms of heat, and power applying diverse technology. Diverse substrates have dissimilar composition and utilized in manufacturing of miscellaneous expensive stuff in terms of their composition (Table 7.2).

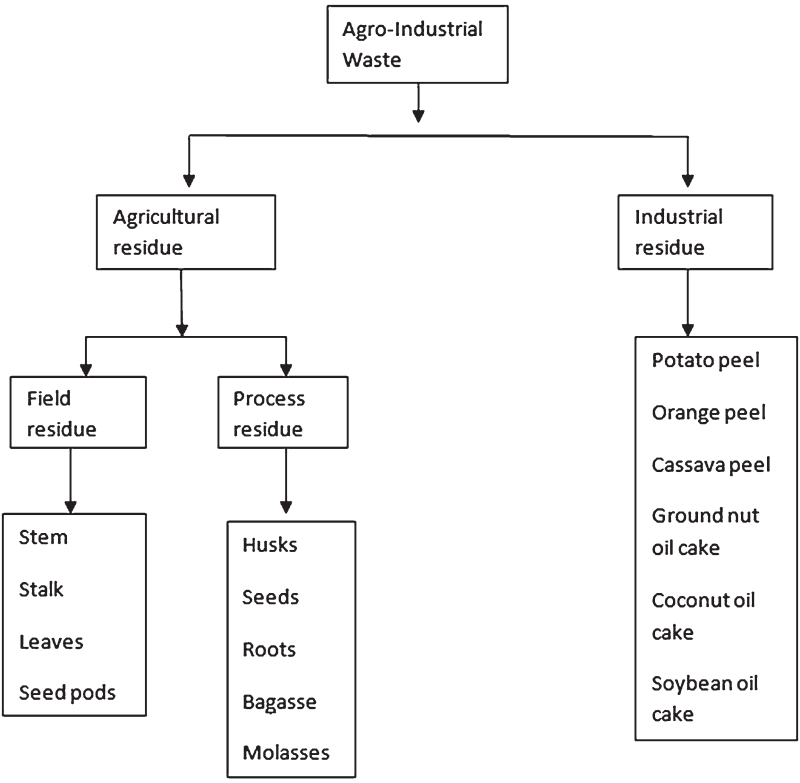

Fig. 7.2 Different types of agro-industrial waste

7.3.3 Antioxidant Properties

Antioxidants act as radical scavengers as they protect the human body from free radicals which causes numerous diseases such as asthma, anaemia, dementias, ischemia, arthritis, and aging. Lack of knowledge of composition of natural antioxidants, their application is restricted. As they are natural antioxidants therefore are safer and also have antiviral, anti-inflammatory, anti-cancer, anti-tumour, and hepatoprotective characteristics. Anti-carcinogenic and antioxidant agents was found in pineapple waste which is about 50% of the weight of pineapple, can be utilized as substrate and support in solid state fermentation. It was found that the pineapple waste after fermentation provides improved quantity of protein, fiber, phenolic and antioxidant activities too. So they recommended that the pineapple waste can be a substitute for novel advantageous stratagems (Rashad et al. 2015). Residues of various fruits and vegetables like peel is generally considered as a waste whereas various researches proved that fruits and vegetables peels though known as waste but considered as an important raw materials for the manufacturing of various food additives and pharmaceutical products (Parashar et al. 2014). Duda-Chodak and Tarko (2007)) explored the oxygen scavenging, total tannin and polyphenols in several fruits peels and seeds they found that nutraceutical content is higher in peels compared to seeds. The order of oxygen scavenging activity exits in different peels is Pomagranet> lemon> orange peel (Singh and Genitha 2014). Win et al. (2011) stated the occurrence of antioxidant activity and phenolic content in different parts of peanut and they found that maximum quantity is present in husk than other parts like hull, kernel. Field remainder like stem, leaves, and stalks were also be used for antioxidant and antimicrobial activities. A number of earlier reports revealed that the oxygen scavenging properties of numerous parts of *Argemone mexicana* and *Thuja orientalis* plants and found that compared to stem, leaf and other medicinal plant wheat, rice the fruit extracts have maximum antioxidant activity (Duhan et al. 2011a, b; Saharan et al. 2012; Saharan and Duhan 2013; Rana et al. 2014; Duhan et al. 2015a, b, 2016).

Sadh et al. (2017a, b) studied to find out the results of solid state fermentation on liberation of phenolics and subsequently the perfection of oxygen scavenging activity of *Lablab purpureus* (seim), *Oryza sativa* (rice), and their mixture using filamentous fungi, i.e., *A. awamori* and *A. oryzae* which is considered as generally recognized as safe. They found a considerable enhancement of total phenolic content level of fermented seed as well as flour with scrupulous culture as contrast to unfermented substrate. Rising total phenolic content concentration, the oxygen scavenging properties of fermented sample amplified in ethanolic extract of substrates with *A. awamori* and *A. oryzae.* Sadh et al. (2017c) used seim and rice mixture as substrate, i.e., to determine the influence of solid state fermentation on liberation of antioxidants and phenolics and also for some suitable feature. They established that fermented samples extract have high phenolic, antioxidant content and have functional properties better than the non-fermented sample as numerous biochemical alteration take place at the time of fermentation, thus fermentation has

been utilized for advancement or to alter the percentage of nutritious and anti-nutritious components of substrates, which influence the product's biochemical or functional properties.

7.3.4 Antibiotic Production

Antibiotics are generated using diverse microorganisms that carefully hinder the multiplication or destroy contaminated microorganisms at extremely small amount (Tripathi 2008). Diverse agriculture wastes are utilized for the manufacturing of different antibiotics. Oxytetracycline were produced in solid state fermentation using corn cobs, sawdust, and rice hulls as solid support and in another study groundnut shell was used as solid substrate and effectively using *Streptomyces rimosus* culture (Ifudu Ifudu 1986; Asagbra et al. 2005). Contribution of exterior energy resource was utilized for improved manufacturing of antibiotic. Due to use of low cost carbon source like of varied agro-industrial residues the price of antibiotic production was reduced. For neomycin and other antibiotics production these residues can be used as an unexpected alternative sources (Vastrad and Neelagund 2011a). Same group also reported extracellular rifamycin B production in solid state fermentation using *Amycolatopsis Mediterranean* MTCC on oil pressed cake or oil industry waste as a raw material and found maximum antibiotic activity from coconut oil cake and ground nut shell (Fig. 7.2) Vastrad and Neelagund (2011b).

7.3.5 Oncom Production

Oncom, the traditional fermented produce of Indonesia made from numerous agro-industrial residues. Among three types of Oncom the popular majority is prepared from peanut meal. Oncom kacang is popular in West Java. Tahoo oncom well known in Jakarta, made from soya bean curd solid waste following same process as kacang. Oncom ampas hunkwe is made from mungbean (*Phaseolus radiata*) solid wastes and known as (Beuchat 1986; Steinkraus 1983).

7.3.6 Tempeh Production

Tempeh is very popular fermented food popular in Indonesia and Malaysia prepared domestically in home or in small scale industries. The smell and consistency of tempeh are superior. Boiled soya beans is better substrate as compared to steamed or sterilized soya bean for tempeh manufacturing. Soft tempeh is made from boiled soya bean using *Rhizopus* strains as they are capable to deteriorate the raw material based on their main nutrient components (Mak 1986). Earlier report suggested that

the employment of soya milk waste formed a superior tempeh and it also prepared from unusual solid support or raw stuff for the manufacturing of cheaper, efficient and nutritionally superior tempeh. The amount of protein in tempeh improved considerably following using soya milk residues. Therefore, soya milk residues can be utilized as an alternative substrates for manufacturing a protein-rich food for human as a replacement for thrown out. Diverse types of tempeh and tempeh kind of products are popular in Indonesia (Lim 1991).

7.3.7 Enzyme Production

Composition of agro-wastes is not consistent and when wastes are used as a raw material which helps multiplication of different microbes thus diverse products e.g. valuable enzymes produced during fermentation. Multiplication rate of fungi is improved during utilization of these agro-waste and resulted alteration of lignocellulosic agro-wastes into low complex ones through inactivation of numerous enzymes. Amylase, was utilised for debranching of polysaccharides into lower sugar components during starch maufacturing. In another study cheaper nutritious agro-wastes are used to manufacture endoglucanase and β-glucosidase in solid state fermentation (Kalogeris et al. 2003) (Table 7.1).

Corn cobs were used for phenolics manufacturing in solid state fermentation as well as enzymic action (Topakas et al. 2004). Another study cinnamoyl esterase and xylanase were produced enzymatically using corn cobs, sugarcane bagasse, coconut husk and candelilla and they found production percentage increased in the following order of substrate used candelilla stalks<coconut husks<sugarcane bagasse<corn cobs. Oliveira et al. (2017) studied optimization of lipase manufacturing using oil cakes as substrate using *Aspergillus ibericus*, and they found maximum lipase production using palm kernel oil cake (PKOC). Saharan et al. (2017) studied to fermentation of cereals to release phenolics, flavonoids, and antioxidant activity and also investigated the role of α-amylase, xylanase, and β-glucosidase enzymes in SSF. A positive correlation was observed in concentration of polyphenols and activities of enzyme. To assays α-amylase, xylanase, β-glucosidase, and lipase during fermentation of peanut press cake using *A. oryzae*, resulting a considerable improvement in enzyme activities during analysis (Sadh et al. 2017d). Table 7.1 shows several studies that have been conducted on production of various enzymes with the using agro industrial residues.

In this section the important enzymes utilized in food applications reviewed, highlighted the innovation published in past years on baked goods, dairy, brewing, wine oleochemistry and in meat processing.

7.3.7.1 Lipases

Lipases are universal triacylglycerol acylhydrolases (EC 3.1.1.3) enzymes, which naturally biocatalyze the ester bonds cleavage of triglycerides and diglycerides, monoglycerides, or glycerol are generated. Lipases are believed multipurpose biocatalysts due to numerous attractive features like their chemo-, enantio-, and regioselectivity; its strength in organic solvents; their capability to catalyze reactions such as esterification, interesterification, and transesterification reactions; and their wide range of substrate specificity (Hasan et al. 2006; Jaeger and Reetz 1998). Extra application of these enzymes in diverse segment, holding third position on the basis of sales, because the significant applications in pharmaceutical, food, detergent, cosmetics industries (Table 7.1) (Houde et al. 2004; Gerits et al. 2014).

Lipases in Oil Industry

Lipids usually exist in living beings and the cause of lipolytic enzymes in the food sector is becoming a topic in limelight. The major research fields are the variation of vegetable and animal oils to achieve emulsifying complexes, to increase dietary importance, or else to reduce the amount of caloric. Purposely, diverse strategies have been planned, like the exclusion of injurious fatty acids or the enhancement of helpful complex such as ω-3 PUFA. The application of customary emulsifiers has triggered improved attention, and this market is acknowledged to exceeding 2.5 million tons in 2017 owing to their stabilizing and conditioning features in different dairy and bakery products (Naik et al. 2014). The use of lipase-catalyzed alcoholysis reactions monoacyl glycerides is a favourite choice than usual chemical substitute, due to the latter necessitate disadvantages like the necessity of metal catalysts, higher operation temperatures (210–240 °C), less alteration production, polymerization of unsaturated fatty acids, tedious refining steps, manufacturing of colour and fragrant stuff (Van der Padt et al. 1990). Thus, an improved research endeavour has been provided in the normal production of emulsifiers. Numerous studies have accounted the capability of fresh, unrefined lipases to catalyze the manufacturing of monoacyl glycerol and diacyl glycerol. To produce monoacyl glycerol and diacyl glycerols from the media containing glycerol and oleic acid at a fixed molar ratio of 11:1 using lipase from *Penicillium cyclopium* fermentation broths was studied. Chang et al. (2014) reported for the production of DAGs using recombinant *Candida rugosa* lipase as sub-product at the time of development of fatty acid methyl esters (FAME) attaining ratios of 1, 3-DAG to 1, 2-DAG of more or less 4:6. Occasionally, the use of immobilized lipases permit circumventing restrictions usually connected with free enzymes, like their non-recovery and unstable nature, encouraging the process to sustainable and economic by reducing operational costs and recycling of biocatalyst (Kamori et al. 2000). Eariler report by Naik et al. 2014 revealed that the most encouraging conditions of enzyme-catalyzed glycerolysis by varying lipase (Fermase CALB 10000) quantity, the oil-to-glycerol molar ratio (1:5), the solvent category, accomplish monoglyceride translation about 80% after 6 h duration of

reaction. Correspondingly, Ghattas et al. (2014) utilized alginate-immobilized lipase extracted from *Rhizopus oryzae* for catalyzation up to 10 cycles of hydrolysis of olive oil to produce MAGs, DAGs, and (TAGs) from olive oil. They optimized the concentration of alginate (2% w/v), $CaCl_2$ (100 mM), and preliminary enzyme (2000 IU/mL) amounts. Previous studies (Zha et al. 2014) evaluated the capability of three immobilized lipases from *Candida antarctica*, *Rhizomucor miehei* and *Thermomyces lanuginosus* (from Novozym 435, Lipozyme RM IM, and Lipozyme TL IM respectively) to catalyze the glycerolysis of other vegetable oils such as coconut oil to achieve a correct MAG concentration at the time of two-step molecular distillations. The found that the optimum conditions are 8% enzyme, coconut oil to glycerol ratio 1:4, surfactant concentration 16% at 50º C temperature that yielded MAGs of 62.5%, DAGs of 30.4%, and TAGs of 5.8% after 5 h of reaction duration when lipase was used as biocatalyst. Ortega-Requena et al. (2014) utilized similar catalyst to accomplish polyglycerol polyricinoleate in a step in a vacuum reactor in inert atmosphere of dry nitrogen flow. In this technique circumvent the expensive conventional move concerning different steps in first step the ricinoleic acid polymerization and in the second step polyricinoleic acid esterification afterwards catalyzed by immobilized lipase extracted from *C. rugosa Rhizopus arrhizus*, *R. oryzae*, or *Mucor javanicus* (Gomez et al. 2011). Instead of the manufacturing of emulsifiers, many authors have given importance in FA modification using lipase as biocatalist to enhance the features of low nutritional value oils and accomplish health hassle of customers (Wang et al. 2012a, b). With this concern the manufacturing of low-calorie lipids controlled way containing medium-chain saturated fatty acids in the sn-1 and sn-3 positions as well as long-chain saturated or unsaturated fatty acids have been embattled in diverse study (Arifin et al. 2010). It is recognized easily when low dietary value avocado oil oils are used for etherification of capric and stearic acid with glycerol (Arifin et al. 2010; Caballero et al. 2014). This reaction is suitable for the commercial manufacturing of margarines. They found that interesterification is the process to to generate trans-free shortening and margarines with suitable characteristics in terms of melting, crystallization, textural and organoleptic characteristics (Zhao et al. 2013; Pande et al. 2012). The possibility of lipases has been exploited to manufacture esters with prominent odours and high molecular weight to extend the stability period. Due to the presence of meticulous organic acid and alcohol, post esterification different sensory properties can be identified. Li et al. (2014a, b)) reported 80% translation of butter oil using of immobilized *T. lanuginosus* lipase after 2 days (Li et al. 2014a, b). The same lipase for improvement of kojic acid esterfification yield and lipophilicity of ricinoleic acid was utilized by El-Boulifia et al. (2014).

Lipases in Bakery

Hitherto, mixture of several additives emulsifiers and enzymes has been believed to enhance the feature of baked products. Lipases also act crucial function during baking, as the lipid percentage of wheat grain create till 3–4%, that might be diminished

to 1–2.5% post milling (Schaffarczyk et al. 2014). Therefore, the lipolytic enzymes addition might be regarded as precious for repairing, when conventional bread emulsifiers, diacetyl tartaric esters of monoglycerides (DATEM) was used. These entail immense storage space and shipping difficulties due to maintenance of lesser temperatures to circumvent caking, and their weight effectiveness is 10 times lesser as compared to the product when lipase (Novozymes 2003) is used as emulsifier. Another study when commercial lipase, Lipopan 50-BG was used, produced a very dense gluten complex that yielded a reduced volume of loaf (Martinez-Anaya and Jimenez 1997). Colakoglu and Özkaya (2012) used second generation lipases and observed that lipases generated altered structure of gluten proteins and starch which provide superior dough steadiness and a less soft and sticky as compared to application of DATEM, probably due to elevated affinity of outline amylose - lipid complexes. Presently, Lipopan Xtra, the third generation of bakery lipases also studied to achieve better compliance useful in miscellaneous flours, causing the development of the gluten network and improvement in wall thickness, to diminish cell density (Stojceska and Ainsworth 2008). Many earlier studies revealed that utilization of lipases along with novel emulsifiers e.g. inulin, confirmed health beneficial effects, providing the appropriate rheological features also better cake crumb with a dense homogeneous cell structure (Rodriguez-Garci et al. 2014).

Lipases in Dairy Industry

In cheese Lipolytic enzymes can hydrolyze milk fat and permit the maintenance of flavour or by making cheese ripening process faster. Thus, the incorporation of lipases is highly accurate for low molecular weight FAs which generate a strong as well spicy flavour, while that lipase catalyzing the hydrolysis of high molecular weight triglycerides grows a mild taste and flavour (Ferreira-Dias et al. 2013). In continuation, yeast lipase isolated from the digestive juice of *Sporidiobolus pararoseus* strain application in the mozzarella cheese-manufacturing practice formed a favourable cheese flavor (Mase et al. 2011; Mase et al. 2013). In composition of powdered babyfoods, fatty acids positions are not specific in the TAG configuration. Pancreatic lipase can hydrolyze the saturated fat if the position of saturated fatty acids at the sn-1,3 to release fatty acids, eventually cause constipation symptoms due to engagement of calcium soap in the intestine (Xu 2000).

In this circumstance, industrial structured lipids generated from Betapol, as milk fat alternative vegetable oils is permitted in Europe and Asia. Zou et al. 2014 have utilized an immobilized lipase extracted from *R. miehei* (Lipozyme RM IM) at the time of formulation the alternative human milk fat supplemented with medium-chain fatty acids delivering by acidolysis reaction of *Cinnamomum camphora* seed oil and oleic acid, optimizing the time, temperature, enzyme concentration and substrate concentration.

Lipases in Other Sectors

Lipolytic enzymes was generated with a huge deliberation to concentrate and/or transform fish oil-derived ω-3 fatty acids, like eicosapentaenoic and docosahexaenoic acids, which are extensively used as ingredients for functional food or nutritional supplements. They are traditionally accomplished by extraction using physical methods depending on temperature, pH etc. therefore concerning unexpected chemical reactions e.g. geometric isomerisation, polymerization and degradative oxidation which results in the production of bad odour. Thus, the application of lipases with ω-3 selectivity was planned by means of gentle processing conditions, size reduction of agro-wastes by lowering energy utilization, and improved features of the end products (Nalder et al. 2014). The application of these enzymes has also been anticipated in meat product preparation, due to the hydrolytic action contributes to incorporate an appropriate aroma of dry-cured meat produce for example like smoked-cured bacon, dry-cured ham and duck (Yang et al. 2005; Xu et al. 2008; Huang et al. 2014a, b). Ultimately, many reports stated about the utilization of lipases, incorporated in enzyme cocktails at the time of brewing procedure to transform white wine flavours and ensuring outstanding mouthfeel (Yu et al. 2011; Jiang 2010) or to obtain a creamy savour of coffee beverages and buttery consistency of toffees and caramel.

7.3.7.2 Amylases

The importance of starch, as polysaccharide chiefly made of amylose and amylopectin, in the diet of human being has encouraged a powerful investigation attempt to translate to diverse food ingredients such as glucose syrups, starch hydrolysates, fructose, cyclodextrins and maltodextrin derivatives (Souza et al. 2010). Although acidic hydrolysis has been traditionally used but the enzymatic catalysis has become appropriate alternative. Alteration of starch into oligosaccharides reasonable and environmentally responsive manner amylases has been used. Amylase can be classified into three types (1) hydrolytic α-Amylase (EC 3.2.1.1) that normally work on the cleavage of inner α-1,4- glycosidic linkages in starch to yield glucose and maltose. (2) α-1, 4-glucan linkages in non reducing ends is catalyzed by β-Amylase (EC 3.2.1.2) to convert polysaccharide chains to yield consecutive maltose units. (3) γ-Amylase (EC 3.2.1.3) directed to cleavage the non-reducing end of amylose and amylopectin to generate glucose after infringement of α-1, 6-glycosidic bonds and the last α-1,4-glycosidic linkages. Amongst the three classes, α- and $_{\beta}$-amylases are the favourite substitute for industrial application in the bakery goods, beverages, and in brewing (Table 7.1).

Amylases in Bakery

All the baked food products e.g. bread, cake, biscuits, crackers, cookies, etc., are made of cereal flour and starch is the major content of flour. Starch acts as gelling agent, thickener, water binder and emulsifier. Thus, the occurrence of α-amylases in

cereal doughs is not desirable. In baking method the hydrolysis of starch to take place to yield small dextrins that can later be digested by yeasts at fermentation. In this technique, duration of fermentation are reduced to get and less viscous dough's are achieved, to get better final textures and superior loaf volumes (Patel et al. 2012). Another critical challenge of the bread is staling, that can be speeded up on the basis of both the baking practice and the storage period. Generally, this disadvantage is related to the recrystallization of the gelatinized amylopectin (AP) arrangement, which cause decrease of its shelf life. Grewal et al. (2015) have studied how mutagenic α-amylase manipulates the retrogradation of AP. The use of differential scanning calorimetry approved ultimately an outstanding hang-up of crumb set whilst the extent of hydrolysis was greater than 20%, due to a greater percentage of unit chains with a degree of polymerization lesser than 9 is identified, therefore hampering the small external AP chains to get double helices. An equivalent tendency was distinguished by Sozer et al. (2011) analyzed the effects of α-amylase incorporated to cakes, though they exhibited inferior staling rates as compared to bread, perhaps due to the superior ratios of sugar and shortening. Another interesting features of amylases is their probability to modify the fine starch structure of. Starch is divided in three main categories: (A) quickly digestible starch where part digested in less duration about than 20 min gradually (B) digestible starch require between 20 min and 2 h, and (C) resistant starch cannot be digested (Englyst et al. 1992). As the rapidly digestible starch produce a fast enrichment with postprandial glucose and insulin intensity in the bloodstream (Miao et al. 2014), the utilization of mutagenic amylases has been planned for enhancement of the quantity of gradually digestible starch from 11% to 20%. Sanz-Penella et al. (2014) pointed out the utilization of α-amylases to produce better quality bread devoid of visible transformation in the glycemic index. Nonetheless the main attempt for the use of amylases in baking is dealth with yeast-leavened doughs, the manifestation of frozen doughs or "ready-to-bake" limit the employment of chemical leaveners with indefinite effects when amylases are utilized. Patel et al. (2012) reported that the accumulation of additives like ascorbic acid and fungal α-amylases led to worsen dough viscosity, which exhibit growth during baking. Comparable satisfactory results of TPA analysis in terms of hardness, resilience, chewiness, cohesiveness and springiness were stated if these enzymes were applied in a mixture with lipases and proteases in gluten-free doughs (Martinez et al. 2013).

Amylases in Brewing

During brewing composition of wort is significantly exaggerated using the particular raw ingredients such as malt, adjunct, hops and yeasts. Though the malt has been conventionally prepared using barley, sorghum. It has also been used in lager beer manufacturing as a brilliant ingredient because of its cheaper price and appropriateness for manufacturing of beers of gluten-free in nature (Owuama 1997; Schnitzenbaumer et al. 2013). However, the superior gelatinization temperature > 70º C and the deficiency of amylolytic enzymes endanger its widespread submission (Ogbonna 2011). Thus, the accumulation of amylolytic exogenous enzymes which could sustain the reason for the use of sorghum as essential

ingredient in countries when barley is not particularly cultivated (Schnitzenbaumer et al. 2013).

On the other hand accumulation of amylolytic enzymes has been confirmed as it is appropriate for manufacturing of light lager beers and carbohydrate-free in nature of lesser viscosity (Serna-Saldivar 2010). As the amylolytic enzymes modify substances made of fermentable sugars in wart, therefore leads to elevated ethanol percentage in beers. Higher maltose and glucose content linked with highest ethanol manufacturing and rates was found between 48 and 96 h for maltose and 72 and 120 h for glucose respectively, possibly due to osmotic stress based on glucose (Espinosa-Ramírez et al. 2014). Furthermore, the accumulation of these enzymes has also positively exaggerated the shelf life of opaque beers, as confirmed by Nsogning et al. 2015. One substitute for the consumption of amylolytic exogenous enzymes in brewing yeast is the establishment of amylase-encoding genes. Many authors have assured about the improvement using genetically engineered strains (Liu et al. 2008; Liu et al. 2009; Zhang et al. 2008; Wang et al. 2012a, b). Exceptionally, acetaldehyde generation in storage involve a pungent aroma that should be circumvent. Therefore, the plan demanding disorder of the ADH_2 gene encoding alcohol dehydrogenase projected collectively through the endorsement of glutathione synthesis, in a typically non-enzymatic defence structure extensively used by the brewery industry next to staling of beer, also an enhancement of amylolytic enzyme action (Wang et al. 2010). Wang et al. (2010) expressed gene encoding glutamyl cysteine synthetase uaing the organisms *Saccharomyces cerevisiae* GSH1 and the *Saccharomycopsis fibuligera* ALP1 gene encoding α-amylase in the brewing yeast strain aim the α-acetolactate synthase and alcohol dehydrogenase genes. In the fermentation media the amount of glutathione enhanced till 33%, while the α-amylase activity allowed after 5 days using roughly 50% of the starch leads to 30% upgrading of the stability index of flavor, approximately 80% lesser amount of remaining sugar, and 60% and 30% diminution of diacetyl and acetaldehyde concentration respectively. Amylolytic enzymes have been used not only in the beer industry, but also in other fermentation practices for the formulation of rice wine popular in China. The conventional manufacturing practices comprise raw rice pretreatment concerning elevated energy and labour expenses and generation of huge quantity of wastewater (Gohel and Duan 2012). Therefore, the application of enzymatic extrusion in the brewing of Chinese rice wine has been designed by Li et al. (2014a, b)), on the basis of optimizing amylase proportion, barrel temperature, and moisture percentage.

Amylases in Other Sectors

Damaging incidence of both starch soluble and insoluble present in sugarcane cause injurious effect during processing of sugarcane e.g. highly viscous and blockage in the filters, therefore declining the attaining quality of the sugar (Eggleston et al. 2010). Therefore, the function of α-amylases was planned to diminish these difficulty, enthralling into explanation that the action is robustly exaggerated by the

feature such as the pH, calcium content, temperature, or degrees Brix (Eggleston et al. 2013). Maize starch was utilized by Cole et al. (2015)), in a media of model juices and syrups, estimating presentation of industrial α-amylases from *B. licheniformis* at miscellaneous stages of the sugarcane processing. An additional application of these enzymes is in the alteration of rice starch, as these constituents are used more and more in the manufacturing of infant formulations, bakery and breakfast cereal products (Zavareze et al. 2009). The enhanced significance in the development products that are gluten-free as a result of the increasing percentage of celiac disease infected people (Kurppa et al. 2010) have extra importance in enzymatically tailored rice flour. The aptness of rice flour customized with amylolytic enzymes from *A. niger* they have established *A. oryzae* to make a cereal cream, instantaneous milk powder, and purified sugar were taken with a good acceptance in sensory analysis (Martins Ferreira et al. 2014). In the advancement of novel application of amylases developing requirements in food safety have made positive impact. Thus, Gronqvist et al. (2014) have efficiently considered for the application of α-amylase extracted from *Bacillus amyloliquefaciens* in time-temperature integrators for confirmation of pasteurization criterion for fish burgers.

7.3.7.3 Hemicellulases

Enzyme-catalyzed hemicellulose hydrolysis reactions provide properties for example gentle working situations or the deficiency of poisonous deprivation commodities. Diverse hemicellulolytic enzymes have been defined (Table 7.3), although xylanases and endoglucanases are most useful (Kumar et al. 2008; Kuhad et al. 2011). In the last decades, these enzymes have prompted commercial importance in various sectors such as brewing, baked goods, animal feed, and or their manufacturing has been improved by development of fungal and bacterial strains suitable in to *Clostridium*, *Cellulomonas*, *Thermomonospora*, *Trichoderma*, and *Aspergillus genera* (Kuhad et al. 2011) (Table 7.1).

Hemicellulases in Bakery

Traditionally, xylanases have been added as a constituent of enzyme combination, along with other oxido-reductases and many other hydrolytic enzymes like amylases and lipases, to convert flow behavior and textural quality of doughs (Collins et al. 2006;), even though some authors have also reported their favourable properties when incorporated separately (Valeri et al. 2011). The main purpose of xylanases in wheat flour along with hemicellulases, catalyze the cleavage, permiting superior bread features on the basis of dough machinability, structure of crumb and firmness (Shrivastava et al. 2013). Furthermore, these enzymes transform water-insoluble hemicellulose into soluble form, allowing the bridge between water and dough, which leads to diminish the dough firmness, more uniform crumbs and greater loaf volume (Butt et al. 2008). Though xylanases is being added frequently

Table 7.3 Hemicellulases and peptidases

Sl no.	Hemicellulose	E. No.
1.	Endo-1,4-β-D-glucanase	EC 3.2.1.4
2.	Endo-1,4-β-xylanase	EC 3.2.1.8
3.	β-glucosidase	EC 3.2.1.21
4.	β-xylosidase (xylan-1,4-$_{\beta}$-xylosidase,	EC 3.2.1.37
5.	α-Arabinofuranosidase (α-L-arabinofuranosidase,	EC 3.2.1.55
6.	Acetylxylan esterase	EC 3.1.1.72
7.	Feruloyl esterase	EC 3.1.1.73
8.	Exo-1,4-$_{\beta}$-D-glucanase	EC 3.2.1.91
9.	Arabinanase (arabinan endo-1,5- α L-arabinanase,	EC 3.2.1.99
10.	α -glucuronidase (α -glucosiduronase,	EC 3.2.1.139
	Peptidase	
1.	Amino peptidase A	(EC 3.4.11.7)
2.	Amino peptidase B	(EC 3.4.11.6),
3.	Carboxypeptidase A	(EC 3.4.17.1),
4.	Carboxypeptidase B	(EC 3.4.17.2),
5.	Chymotrypsin	(EC 3.4.21.1),
6.	Papain	(EC 3.4.22.2),
7.	Pepsin	(EC 3.4.23.15),
8.	Subtilisin	(EC 3.4.21.62),
9.	Thermolysin	(EC 3.4.24.27),
10.	Plasmin	(EC 3.4.21.7),
11.	Trypsin	(EC 3.4.21.4)

to wheat flour bread dough but in rye bread making xylanase is extensively added globally. In this regards Banu et al. (2011) estimated the influences of variables like pH, enzyme concentration, and fineness modulus of flour to accomplish better texture in the final loaf.

The improvement of a competent bread manufacturing procedure encourages exploration of mutant yeasts, containing xylanases genes were determined. Therefore, Zhan et al. (2014) incorporated xylanase-expressing gene in *Kluyveromyces lactis* and established a development in sensory properties and bread size. The superior chearacteristics results because xylanases eliminate the arabinoxylans which is water insoluble persistent during the gluten development, which further leads to a elastic and steady dough arrangement (Sorensen et al. 2004; Ortiz Escobar and Hue 2008).

On the contrary, it has been hypothesized that the survival of these enzymes is important to activate an enhancement of arabino xylooligo saccharides in bread (Polizeli et al. 2005; Van Haesendonck et al. 2010), with established health beneficial effect. New development in bakery product manufacturing is decided to enhance the quality of prebaked bread. Generally, four different environmental factors are important for storage of prebaked breads such as at room temperature, refrigeration

temperature, frozen temperature, and modified atmosphere (Barcenas and Rosell 2006a, b). The choice of the type of storage depends on shelf-life differences ranging few days to few months. Further explicitly, freezing storage results reducing loaf volume, moisture, flavor but modifications, and improvements in firmness of crumb (Barcenas and Rosell 2006a, b). The effect of storage at low temperature on the superiority of prebaked French bread was investigated by Lopes Almeida and Chang (2014) at varied concentration of hemicellulases produced by *A. niger* or *B. subtilis* were incorporated, additionally with other enzymes gluco-lipases, hexose-oxidases. Shelf-life expansion of prebaked rolls was achieved from 7 to 65 days devoid of considerable diminution in sensory characteristics.

Hemicelluloses in Brewing

Sukumaran et al. (2005) reported the advantages of extraction of glucanases from microbial source in alcoholic fermentation to produce beer and wine. Accumulation of glucanase has been established to reduce the viscosity of wort and circumvent filter blockage as they catalyze the glucan hydrolysis (Bamforth 2009). Additionally, the presence of hemicellulases has been help to remove color and clarification of must, producing a better ultimate wine feature and strength (Pinelo et al. 2009; Itu and Rapeanu 2011). Earlier study by Gambuti et al. (2007), Kelebek et al. (2007) established a positive correlation among the existence of macerating enzymes and color of wine as well as phenolic substances. Similar behavior was defined by Puertolas et al. (2009), to compare the enzymatic and physical (pulsed electric fields) healing for the separation of phenolic complexes during Cabernet Sauvignon vinification. An additional significant features to believe in vinification practices is the growth of a appropriate aroma, that is associated with occurrence of volatile notes recovered from grapes and flavourless non-volatiles, odourless glycoconjugates, known as glycosidic predecessor (Loscos et al. 2010; Pogorzelski and Wilkowska 2007). They can be chemically or enzymatically hydrolyzed and latter being mainly most suitable process circumvent for the development of unnecessary flavours, because of the alteration of aglycone structure (Hernandez-Orte et al. 2009). In this case, the utilization of β-D-glucosidase authorize the cleavage of glycosidic bond devoid of altering the aglycone, therefore being gorgeous to apply in flavour improvement of musts, juices, and wines (Wang et al. 2013).

Hemicellulases in Other Sectors

The most conventional utilization of hemicellulases consign to their utilization in extraction olive oil (Sharma et al. 2015), due to this the procedure bear an important consequences on the feature of the end product.

Even though expected approach for extraction on the basis of application of pressure followed by centrifugation has been ordinary (Vaz-Freire et al. 2008) diverse restrictions regarding the yields during extraction have additional employment of

microbial or enzyme-catalyzed procedure (Najafian et al. 2009). Thus, extracellular hemicelluloses is being incorporated to destroy the oil bearing cell walls and better oil extraction without rancidity and better aroma (Najafian et al. 2009). This technique is applied to other variety of oils such as pumpkin seed oil. A blended application of microwave along with enzyme cocktail to attain 64.17% of oil followed by optimization of factors such as enzyme percentage (1.4%), temperature (44º C), time (66 min), and power of microwave radiation (419 W) was done. The extracted oil exhibited elevated oxidation stability possibly because of the superior antioxidant activities (Jiao et al. 2014). Similarly, the mixture of sonication and pH manupulation methods in addition of enzyme produced a multi fold improvement of lycopene separation from tomato peel (Konwarh et al. 2012; Cuccolini et al. 2013). Lycopene a carotenoid pigment having confirmed good antioxidant and anticarcinogenic activities (Kuhad et al. 2011). Same way β-carotene or chlorophyll separation was the objective in enzyme-catalyzed system (Ozkan and Bilek 2015).

Proteases

Protease known as peptidases, peptide bond hydrolases, or proteolytic enzymes, is one of the very demanding enzyme for food industries (Sawant and Nagendran 2014). These enzymes, also can be classified as exopeptidases or endopeptidases, based on the position where the cleavage is made (near the end or middle of polypeptide chains). Further, they are described as amino peptidases or carboxy peptidases when the peptide bonds is cleavaged at the N- or C-terminus, and some typical examples are shown in Table 7.3 (Tavano 2013). Though few enzymes are frequently achieved from plants or animal origin, present global needs induce the commercial manufacturing on the basis of microbial development, since it necessitate a superior biochemical variety and microorganisms can be hereditarily customized to increase the intensity of enzyme (Table 7.1) (Rao et al. 1998).

Application of Proteases in Bakery

Proteases have an imperative function in making baked goods (Gaenzle et al. 2008) as they certify superior dough consistency and superior bread texture (Goesaert et al. 2005). In this regards, one of the most important application is in gluten-free commodities. Currently, celiac disease activated in about 1% of the European and American population, due to the presence of gluten in food (Rao et al. 1998). Nevertheless, the gluten networks positively influence carbon dioxide maintenance throughout dough fermentation and due to its visco-elastic nature, as an unusual arrangement have to be improved to sustain these features. As earlier assured, rice flour is considered as excellent option for making gluten-free bread, its healing with enzymes, such as amylolytic and proteolytic enzymes, has been established to be valuable in terms of ultimate loaf quality. These enhancement rely on the deteriorating of the disulfide bonds exists in the gluten protein, therefore declining the gluten network (Katsube-Tanaka et al. 2004). Gathering of proteases extracted from

B. amylo liquefaciens (Protin SD-NY10) and *B. licheniformis* and papain concerned a diminution in time of mixing and dough texture and better consistency and pore unformity (Hatta et al. 2015). Their study confirmed that deterioration of the subunits of glutelin was requisite to fabricate the homogeneous network of tiny protein combined in rice (Table 7.1).

Application of Proteases in Dairy

Development of milk products is significantly affected by the action of protein degrading enzymes. Exclusively, plasmin was recognized as the chief endogenous protease present in buffalo milk, that positively modify the flavour and consistency of milk products. During the hydrolytic exploitation of the proteins can sustain the development of strong aromas in cheese, their presence in pasteurized milk could turn into upsetting due to gelation (Ismail and Nielsen 2010). Thus, the extent of hydrolysis should be cautiously guarded to accomplish the required consistency and aroma. Normally, cheese is formed due to the enzymatic coagulation, release of amino acids is stated as consistent due to the enhancement of cheesy flavor (McSweeney 2004). Distinguishing protein degrading enzymes such as chymosin and pepsin present in milk rennet, which attack on the k-casein's Peptide bond, diminution of coagulation of milk protein (Ripolles et al. 2015; Majumder et al. 2015). In this regards, it is significant to manage the proportion of pepsin and chymosin in rennet extracted in diverse supply.

Various proteases is expected as potential rennet alternative in halal, authentic vegetarian products, and they are deliberately used to generate novel aroma and consistency (Feijoo-Siota et al. 2014). The protein hydrolysis reaction is because of the continued existence of microorganisms for protease-manufacturing as present in particularly Camembert cheese (Aizawa et al. 2009). Five different proteases have been known all through ripening (chymosin, pepsin, plasmin, metalloproteinase, and aspartylprotease) (Tavano 2013). The improvement of accurate flavour in this cheese variety is challenging and dependent on the cautious accumulation of exogenous proteases (Wroblewska et al. 2004; Singh et al. 2003). Proteolytic enzymes are utilized for improvement of dairy allergens also, to hydrolyse that allergens up to molecular weights 3 kDa necessitates an insignificant allergenic prospective (Bogh et al. 2015). Some essential allergens are milk proteins such as caseins, lactalbumin, and lactoglobulin (Sharma et al. 2001).

Application of Proteases in Other Sectors

Several papers and patents stated that the purpose of use of proteases in meat industry is due to the enhancement of softness. In this case, the end users acceptance for red tender texture meats promotes analysis of stratagem connecting stiffness diminution (Polkinghorne et al. 2008). Similarly, Ryder et al. (2015) confirmed feasibility of proteases extracted from fungy and bacteria to hydrolyze myo-fibrillar and tissue proteins from connective tissue at altered temperature as well as pH values

during post-mortem aging of meat. Another exceptional use of proteases is in the brewing. For example, one of commonly popular liquors in China (MouTai flavored) engages a complex impulsive fermentation, where a variety of proteases can be establish. Therefore, Huang et al. (2014a, b)) identified the appropriateness of a novel protease produced by SSF using *Aspergillus hennebergii* to extend a right liquor aroma as well as to alleviate microbial fermentation.

7.3.7.4 Other Enzymes

Another group of important enzymes claim an immense awareness in food industry are lipoxygenases (e.g. linoleate oxygen oxidoreductase, EC 1.13.11.12) (Kim and Oh 2013). Lipoxygenase can be established in plants, animals, fungi, algae, bacteria and coral. Though the distinctive industrial resources are soybean and fava bean flour that generally catalyze to produce fatty acids hydroperoxides by oxidation of polyunsaturated fatty acids in presence of oxygen radical. Oxygen radicals are capable to oxidize sulfhydryl of proteins and pigments in Carotenoids to hydroxyacids therefore they are used for bleaching in bakery products (Kang et al. 2010). As a results, their possibility to reduce mixing time and advance dough raising and foaming has been described (Patel et al. 2015). Their commercial expansion has been superior for farming by using *Penicilliumor Aspergillus* species. Their industrial application is largely committed in food conservation eliminating pathogens like *Campylobacter jejuni,Listeria monocytogenes, Salmonella infantis*, *Staphylococcus aureus* etc. (Rombouts et al. 2003).

Moreover, lipoxygenase expected to catalyze glucose elimination from dehydrated eggs or from wines, during gluconic acid manufacturing, to extend the shelf life of dairy goods, to eliminate air from fruit juices, to prevent rancid flavour development in mayonnaises (Wong et al. 2008; Bankar et al. 2009; Schmidtke et al. 2012). Other enzymes such as asparaginases, $_{\beta}$-galactosidases, laccases, and transglutaminases are responsible in different food production were highlighted. The effect of asparaginases have been studied and found to have develop carcinogens acrylamide during baking due to Maillard reactions between asparagine and carbon sources and therefore the use of asparaginase was restricted (Anese et al. 2011). If protein cross-linking reaction is catalyzed by transglutaminases (EC 2.3.2.13) it was reported that foaming, gelation function, solubility and emulsifying proficiency of protein can be altered (Giosafatto et al. 2012; Kieliszek and Misiewicz 2014). Hydrolytic enzymes β-galactosidases extracted using fungy and yeast from *Aspergillus* molds and *Kluyveromyces* yeasts have been utilized either in free form or in immobilized form for lactose elimination from milk and milk products (Wong et al. 2013; Messia et al. 2007).

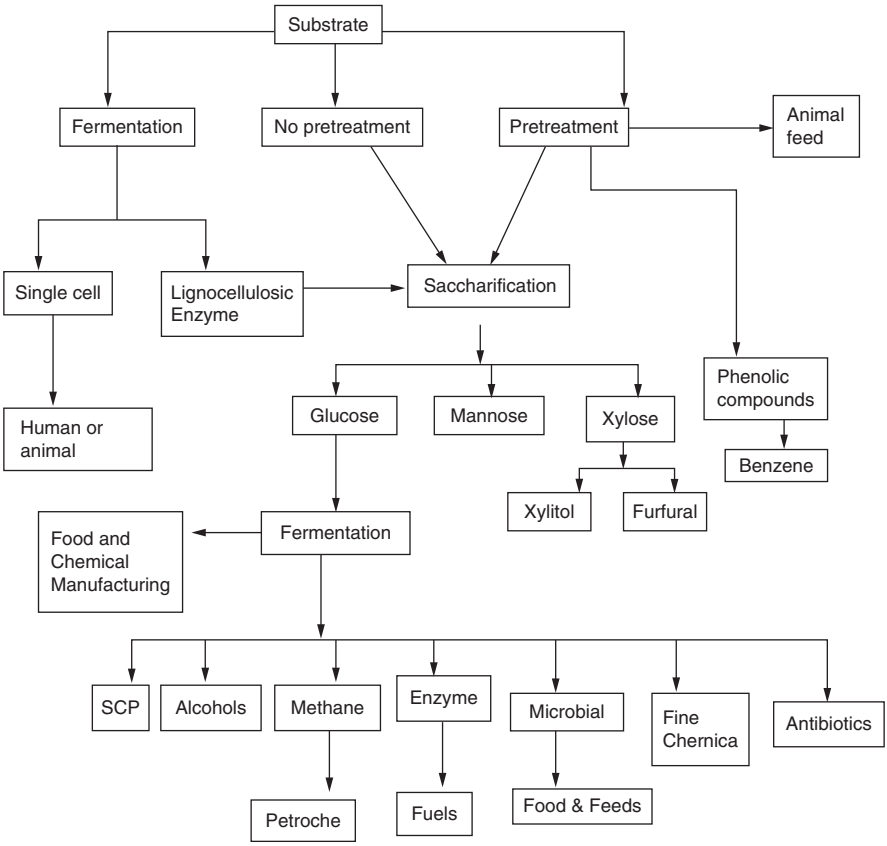

Fig. 7.3 Application of different agro-industrial substrates

7.4 Other Application of Solid State Fermentation

Some other functional advancement by SSF are also summarized here (Fig. 7.3).

7.4.1 Single Cell Protein Production

Mondal et al. (2012) studied the cultivation of single cell protein (SCP) utilizing fruit wastes like cucumber and orange peels using *S. cerevisiae* in SSF. They established that as cucumber peel generated in higher quantity and the protein amount as evaluated in the orange peels is higher. Therefore it was recommended that

cucumber and orange peel can be translated to SCP by means of appropriate microbes. The final products achieved after transformation of agro- wastes are cheaper and nutritionally restricted to elevated protein percentage.

7.4.2 Manufacturing of Poly (3-Hydroxybutyric Acid)

The citrus fruits are utilized to manufacture fruit juice, and jams all over the world commercially. Thus citrus processing industries also produced a massive quantity of waste as peel residue or in other form but the citrus wastes can be utilized in SSF as they include huge quantity of carbohydrates. Orange peel waste was utilized for the manufacturing of Poly (3-HB) as a single carbon source after easy pretreament process as Orange peel has potential to utilize as underutilized agro-waste(Sukan et al. 2014).

7.4.3 Biosurfactant Production

Bacterial strain isolated in the oil polluted location as these bacterial strains have the capability to manufacture valuable or helpful products for human being. Saravanan and Vijayakumar (2014) isolated *Pseudomonas aeruginosa* PB3A and used for manufacturing of bio-surfactant using oil industry waste like defatted sunflower, castor, peanut cake, barley and rice bran. They utilized as a carbon rich substrate for fabrication of bio-surfactant using *P. aeruginosa* strain.

7.4.4 Xanthan Production

Xanthan, a exo-polysaccharides and important food additives, generated using *Xanthomonas* species. Therefore manufacturing of xanthan from cheaper diverse agro-waste is a precious advancement (Vidhyalakshmi et al. 2012). Vidhyalakshmi et al. 2012 yielded maximum xanthan by SSF on potato peels using following microbes *X. campestries (*2.87 g/50 g), *X.citri (*2.90 g/50 g), *X. oryzae* (1.50 g/50 g), and *X. musacearum*. (0.50 g/50 g).

7.5 Immobilization of Nutraceuticals

Ten agro-industrial wastes with physio-chemical treatment in SSF were studied for their suitability as immobilization delivery system by Orzuaa et al. (2009). Finally, they reported that among ten agro-wastes, *Citrus aurantifolia*, *Malus domestica*,

Citrus sinensis, and *Cocos nucífera* have extreme possibility as immobilization media in SSF. These agro-industrial wastes can be utilized further for economical benefit environmental-friendly way for waste management as well.

7.6 Food Additives from Plants or Lignocellulosic Biomass

Lignocellulosic waste is probably extremely valuable resources for manufacturing and revival of numerous produce as raw material for food industry utilization, The resources include carbohydrates, proteins, lipids, amino acids, phenolic constituents and organic acids etc. (Ghoshal 2020). Several nutraceuticals, such as phenolic complex isolated from agrowaste lignocellulosic residues such as grape skin extract, carotenoids acquired from plants such as paprika extract, lycopene extracted from tomato skin and algae among others which can be utilized for other food product manufacturing as natural additives instead of artificial chemical additives (Table 7.2). Unusual property of barley husks antioxidants studied by De Abreu et al. (2011a, b) to stop rancidity of polyunsaturated fatty acids and also to extend the shelf life of cod liver oil by preventing oxidation. The lipid oxidation rate reduced with increasing antioxidant concentration though the major attractive result was that they were very efficient than chemical antioxidants like BHA and BHT in reducing oxidation reactions,

Antioxidant and antimicrobial properties of different spice extract from *Brassica nigra, Cinnamomum cassia*, *Origanum vulgare and Syzygium aromaticum* were studied by Krishnan et al. (2014). They evaluated the effect of spices in raw chicken meat stored at 4 °C for 15 days and also compared with positive control chemical antioxidant BHT and they were successful in diminishing microbial growth and lipid oxidation using spice extract in raw chicken. Thus applications of natural extract incorporated active packaging films were given priority to provide better oxidative potency and to protect sensory quality of meat, fish, chicken, and butter products. They developed brewery filtrate incorporated active packaging films to enhance the oxidative stability in beef stored at refrigerated conditions and 80% lipid oxidation was reduced. The heat stability of few nutraceuticals additives from beer, was studied and it was found that at 100-200º C along with antioxidant characteristics, they also acts as antimicrobial agent when incorporated into food, thus escalating the shelf life of processed foods. In another study Pereira De Abreu et al. (2011a, b) incorporated barley husks antioxidants in LDPE films and their effect on lipid oxidation in frozen blue shark (Prionace glauca) and frozen cod (Gadus morhua) and frozen swordfish (Xiphias gladius) were evaluated. In similar study by Romano et al. 2014 anticipated the incorporation of fructo-oligosaccharides in methylcellulose-based films as antimicrobial agents.

7.7 Food Additives from Lignocellulosic Biomass Produced Biotechnologically

Lignocellulosic agro-waste is considered to supply an economic resource of sugars that can be fermented with usual chemical or natural food additives to a variety of produce. The initial deliberation in achieving natural food additives from lignocellulosic residue after fermention is how to degrade lignocellulosic agro-waste materials to cellulosic, lignin, and hemicellulose sugars. Natural food additives extracted biotechnology are also have significance because of temporary set of laws, customer declare for normal constituent, and global awareness pertaining to sustainable development. Nonetheless, biotechnology based conduit and separation practice for natural add-mixture should be optimized to obtain a relation using low cost agro-industrial residue as substrate, with the final product yield, the application of microbes, and also the refining process. Novel bio-technology based processes are being comprehensive to realize diverse food additives which are presently formed industrially following chemical synthesis path. Natural additives for food processing and nutraceuticals isolated from plant sources e.g. astaxanthin, lactic acid, and xylitol can be recovered by fermentation with varied carbon sources with the suitable microbes, whereas like antioxidants are separated straight from fruits or other agro-industrial residues.

Xylitol, the polyalcohol, achieved by degradation of xylose, and can be utilized as sugar alternative in food industry due to its high sweetening index, gum and teeth protection characrterics, and suitable for diabetics. As xylose has the similar sweetening index as sucrose but low caloric value, with no carcinogenicity, but have a tremendous laxative effect. Xylitol is produced as an intermediate by using D-xylose catalyzed by xylose reductase extracted from *Debaryomyces hansenii* yeast. Some authors have studied the xylitol manufacturing using hemicellulosic low-cost carbon resources like sugars isolated from lignocellulosic residues (Rafiqul et al. 2015). Astaxanthin, the red-orange carotenoids is isolated from crustaceans or from variety of yeasts or microalgae biotechnologically (Liu et al. 2014). Astaxanthin is considered as significant biological antioxidants with encouraging nutritional property and clinical remedial for healing of diabetes, cancer, and ocular degeneration; improvement of immune system and preventing swelling. Furthermore, astaxanthin can be utilized as natural additive in foods to provide attractive red-orange color to foods like salmon flesh. Earlier reports projected on the utilization of lignocellulosic remainder to produce astaxanthin. Wood waste after acid hydrolysis in mild treatment conditions hydrolyzed followed by neutralization and treatment with charcoal to remove inhibitors finally enrichment using nutrients to use as culture media for growth of red yeast *Phaffia rhodozyma* to generate astaxanthin. One of the important food additive is lactic acid synthesized using synthetic chemicals or produced naturally in biotechnological path (Colakoglu and Özkaya 2012; Wang et al. 2010, 2012a, b; Gohel and Duan 2012; Li et al. 2014a, b; Eggleston et al. 2010). It is utilized to preserve pH in carbonated drinks, control acidity in cheeses, and as preservatives in olives and processed vegetables. In the form of calcium lactate it is utilized to metabolize hexoses (glucose, sucrose, or galactose) by lactic acid bacteria in the

homo (e.g. *L. delbrueckii*, *L. rhamnosus*, and *L. jensenii*) or hetero fermentative (e.g., *Lactobacillus brevis)* path. Another path lactic acid bacteria (e.g., *Lactobacillus pentosus*) transform pentoses (e.g., xylose) instead of hexoses into lactic acid via pentose pathway. In this path lactic acid bacteria convert first D-or L-pentoses into lactate and acetate to produce intermediate D-xylulose 5-phosphate with conversion yield of 0.6 using winary snip as carbon source.

In this method hemicellulosic vines, hoots are first acid hydrolyse with sulfuric acid sugars, followed by neutralization and addition of nitrogen and then other minor nutrients, are sterilized prior to fermentation with *L. pentosus*. Another path lactic acid can be produced by simultaneous saccharification and fermentation using alfalfa fibers with pretreatment of liquid hot water (LHW) and non-LHW in homo or hetero fermentative *lactobacilli* strains (Eggleston et al. 2013).

Other acidulants used in food processing are ascorbic acid, citric acid, fumaric acid, and malic acid. Malic acid is a four carbon dicarboxylic acid frequently used as acidulant to enhance the taste of beverage or other food. *Saccharomyces cerevisiae* is used commonly to convert glucose to L-malic acid in four different metabolic pathways. *Aspergillus flavus* can also be used to generate L-malic acid with better yield as compared to *S. cerevisiae* without manufacturing of aflatoxin. Some reports are available for metabolic conversion of *S. cerevisiae* after genetic engineering to enhance yields of malic acid. Diverse substrate for example molasses, starchy materials, and hydrocarbons have been exploited as raw material for industrial citric acid manufacturing (Vidhya and Neethu 2009). About 99% of citric acid is produced globally by surface or submerged culture via biotechnological processes (Torrado et al. 2011). For citric acid manufacturing *Aspergillus niger* can be used in orange peel and cane molasses mixture as carbon source biotechnologically (Hamdy 2013). *Candida* and *Bacillus licheniformis* can also be used to produce citric acid. Fumaric acid, the four-carbon unsaturated dicarboxylic acid, is extensively used as food acidulant for beverage and can be generated biotechnologically using agro-industrial carbon sources. *Rhizopus oryzae*, the mycelial fungi, can be used as microorganisms to generate fumaric acid and chitin concurrently in same process. Fumaric acid fermentation consists of three steps, such as seed culture making, cultivation of fungal biomass in inert gas nitrogen environment.

β-carotene, ascorbic acid natural antioxidants are resource of natural vitamins can be produced in SSF using agroindustrial residues as food additives (Sharma and Ghoshal 2020a, b). Thus natural antioxidants diminish fatty acid oxidation rate also enrich the food products. Some culture of lactic acid bacteria generate diverse types of exopolysaccharides (EPS), which enhance rheology and improve textural properties of fermented food products (Trabelsi et al. 2015). EPS are generated by bacteria either by extracellular or intracellular method.

Lactic acid bacteria can generate bacteriocins, the generally recognized as safe (GRAS) additives. Bacteriocins (e.g. *Bacillus subtilis*, *E. coli*, and *Pseudomonas aeruginosa*) are imperative for maintaining the proportion of pathogenic and spoiling microbes in foods and feed (Muthalagu and Sinthyak 2015).

Certain lactic acid bacteria (*Lactococcus lactis*) can produced excess amount of B vitamins, folate (B11), riboflavin (B2), and cobalamin (B12), to supplement food stuff. Lactic acid bacteria metabolites are used as preservative in cereal processing

as it is a dependable substitute to reduce fungal contamination at the time of pre or post harvest, with added benefits throughout the processing of cereals, to improve cereals products marketing. Microbial polysaccharides e.g. dextran, pectin, xanthan gum, gellan gum are the by-product of fruits can be used as food additives such as emulsifiers, gelling agents, texturizers, stabilizers, thickeners approved by the US FDA for food application. The majority of industrial gelatin about 41% of the produce globally is chiefly from pigskin. Fish gelatin is a substitute to mammalian gelatin for application in diverse food and pharmaceutical purposes (Schmidt et al. 2015). Other gelling, thickening and stabilizing polysaccharides such as alginate, carrageenan, and agar can be extracted from algae are widely used in food processing.

7.8 Conclusion

Most of the agro-waste residue are nutraceutical and natural bioactive enriched composition. They contain significant proportion of carbohydrates, proteins, lipids, minerals, and simple sugars, consequently, they are regarded as "raw material" instead of "wastes" in diverse industrial processes. Therefore presence of such beneficial nutrients in these residues recommended appropriate circumstances for abundant growth of diverse beneficial microbes. The microorganisms have favourable effect for recycling the same waste as substrate for their multiplication during fermentation process. The agro-industrial wastes can be utilized as solid hold up in SSF method for manufacturing of variety of important valuable composite. The application of agro-wastes residues as starting ingredients not only can assist to decrease the manufacturing cost also means of recovery of waste and its value addition by creating the environment eco-friendly as well.

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