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Chapter

Food Waste and Agro By-Products: A Step towards Food Sustainability

Ajita Tiwari and Roshna Khawas

Abstract

Utilization of food/agricultural waste is having challenge and necessity in day to day life. It's an important aspect for all the industries (food) for the process of modification and recovery. The main aim is to minimize deterioration and maximize utilization of food which will lead to less problems in waste management and environment pollution. In some of the meat packaging and food processing industries, waste utilization treatment has been implemented for successful and substantial processing. In need of growing demands of high nutritive and cheap price foods, requirements are getting high simultaneously with increasing world population. So, there is urgent need of nutrient recovery from wasted utilization and sources of food/feed will help to reduce the shortage of world food supplies to the coming generation.

Keywords: Innovation, agro by products, food waste utilization

1. Introduction

The organic waste generated during different unit operation from various sources including commercial and domestic kitchens, food processing plants, restaurants and cafeterias. According to FAO [1], in the food supply chain approximately 1.3 billion tonnes of vegetables, meat, fruits bakery, dairy and other food products are lost [2]. In Asian countries nearly every year amount of food waste (FW) could rise from 278 to 416 million tonnes from 2005 to 2025.

Kitchen and yard waste are the primary source of municipal solid waste (MSW). This waste can be further utilized for converting into useful products/energy generation at very low-cost rather than dumping and landfilling [3].

The process may attribute towards environmental and economic factors, such as capacity of municipal landfill; price associated with transportation of waste materials and landfilling; rules and regulation adoption for environment protection; less utilization of commercial fertilizers; more recycling of household waste and quality improvement of compost products [4]. Composting FW reduces the waste volume, kills pathogens, decreases weed germination in agricultural fields, and destroys malodorous compounds [5]. In concept of agriculture (organic), organic-grade agricultural waste compost gaining popularity due of its advantage on physical, biological, and chemical soil properties of soil [6]. Various food industries produced a large number of by-products or wastes which cause a serious disposable problem with the environment. Approximately 1.3 billion tonnes of food per year [7] for human consumption is lost or wasted globally. As the food production is resource-intensive, food wastes and losses are indirectly accompanied by impacts of environment, such as erosion of soil, deforestation, air and water pollution, as well as greenhouse gas emissions that occur in the processes of food production, storage, transportation, and waste management [8]. Domestic households generate the largest food-waste faction in the food supply chain [9]. As the food waste amount occurring high on the household level, in the food supply chain at the final stages, prevention must be taken at utmost importance to help prevent further climate change for food waste [10]. Recognition of appropriate management of waste has been implemented as essential prerequisite for sustainable development [11]. Historically, in the context of urban, removing potentially harmful substances or materials away from human settlements was the main focus of public waste management [12]. Increase in waste generation due to environmental, social and financial implications of unsustainable use of raw materials in the short and long term [13] waste management began to shift from a mere pollution prevention and control exercise, towards a more holistic approach.

This chapter presents the reasons for consumer food waste in a systematic, causes, replicable, systematic and transparent way. In this chapter it is reviewed and analyzed the observation collected from different studies which is carried out on the factors promoting or impending on consumer food waste. Food waste is generated when the unprocessed food is converted to suitable form for the human consumption, during the period of conversion of food it may lost, contaminated, discharged and degraded leading to the production of food waste. Nowadays waste management and its control are a great challenge from collection point to disposal unit and identifying of sustainable approach to solve the problem of waste management caused by the agricultural and industrial sectors, food supply chains and as well as retailers and final consumers. Some useful products for industrial purposes like biofuels or biopolymers are produced from the food waste. Fixation of carbon by composting and nutrients recovery can also be achieved and the final left out waste should be used as minimum desirable options for incineration and landfilling. The chapter reviews to provide an overview on food waste definitions, generation and reduction strategies, and conversion technologies emerging.

2. Food waste and agro by-products

Food wastes are usually organic residues produced by the processing of raw materials into food. Waste is characterized as a product that do not add value to a product whereas by-product is a secondary product obtained as a result of manufacturing of the main product, often with a market value. Many by-products require further processing before sale [14].

So, the wastes could be considered valuable by-product if appropriate technical means are available to generate value which exceeds the cost of reprocessing. Residues in this case cannot be considered as wastes but becomes a product of higher value. Utilization of food processing residues offer potential of converting these by-products to beneficial uses [15].

3. Agro by-products

Agro by-products or agro residues are mainly obtained from agricultural production, harvesting, and processing in farm areas and from agricultural processing industries such as oilseed extraction, brewery, malt production, cereal grain milling, fruit and vegetable processing. These by-products hold tremendous potential source of protein supply for animal feed and can also be converted to biofuels, bioenergy and other products in a way that produces economic value.

3.1 Types of agro by-products

The agro by-products derived from various crops play a significant role in animal nourishment. These by-products are of various types and can be classified into different groups, such as by-products from fruit and vegetable processing industry, crop waste and residue, by-products from sugar, starch and confectionary industry, by-products from distilleries and breweries, by-products from grain and legume milling industry, and oil industry. The handling and technologies used for processing of by-products are generally based on their type [16].

3.2 Value addition of agro by-products

Adding value to agricultural by-product makes it more desirable and enhances their economic value. Crop residue or agro by-products usually represent relatively high amounts of cellulosic material that could be returned to the soil for its future enrichment in carbon and nutrients or could be made available for further conversion to biofuels, bioenergy and other products. Such agricultural by-products can play an important role in triggering the transition of sustainable energy. There are many economic benefits that can be obtained through value-addition to agricultural by-products. These benefits include enhancing the resource use efficiency of agricultural production, increasing farm incomes and reducing the costs of production and thus increasing the profitability of farming, producing novel products, creating jobs, minimizing the disposal of the by-products into the environment to ensure improvement in environment quality [17].

3.3 Utilization of agro by-products

Earlier these agro residues were treated as waste by agriculturists and used to disposed into the surrounding environment causing pollution. However, they realized the significance of these by-products and the invulnerable costs of animal feed and fertilizers, and harmful impact to the environment and started to utilize it as animal feed. The use of crop residues is a good way of discarding materials that could otherwise be a potential health and environmental hazard. Agro by-products plays an important role in improving the nutritional status of various forms of rations and feeds of livestock as these by-products contain numerous amounts of macro and micro nutrients that are necessary for body growth and productivity [18]. There are several ways of utilizing agricultural by-products as feed for livestock, a source of fuel, and as inputs into agricultural production and rural industries [17]. The increased utilization of agricultural by-products can provide a sustainable basis for small and medium industries in a rural area and stimulate rural economic development. Harnessing crop residues as manure and bio-fertilizers, and as raw materials for producing energy and consumer products, can expand the profitability of agricultural enterprises, improve the quality of the environment and enhance energy security [19].

4. The global food supply chain: food losses and waste

The global food waste challenge concerns about over escalating emissions of Green House Gas and other impacts of environment associated with food waste [20],

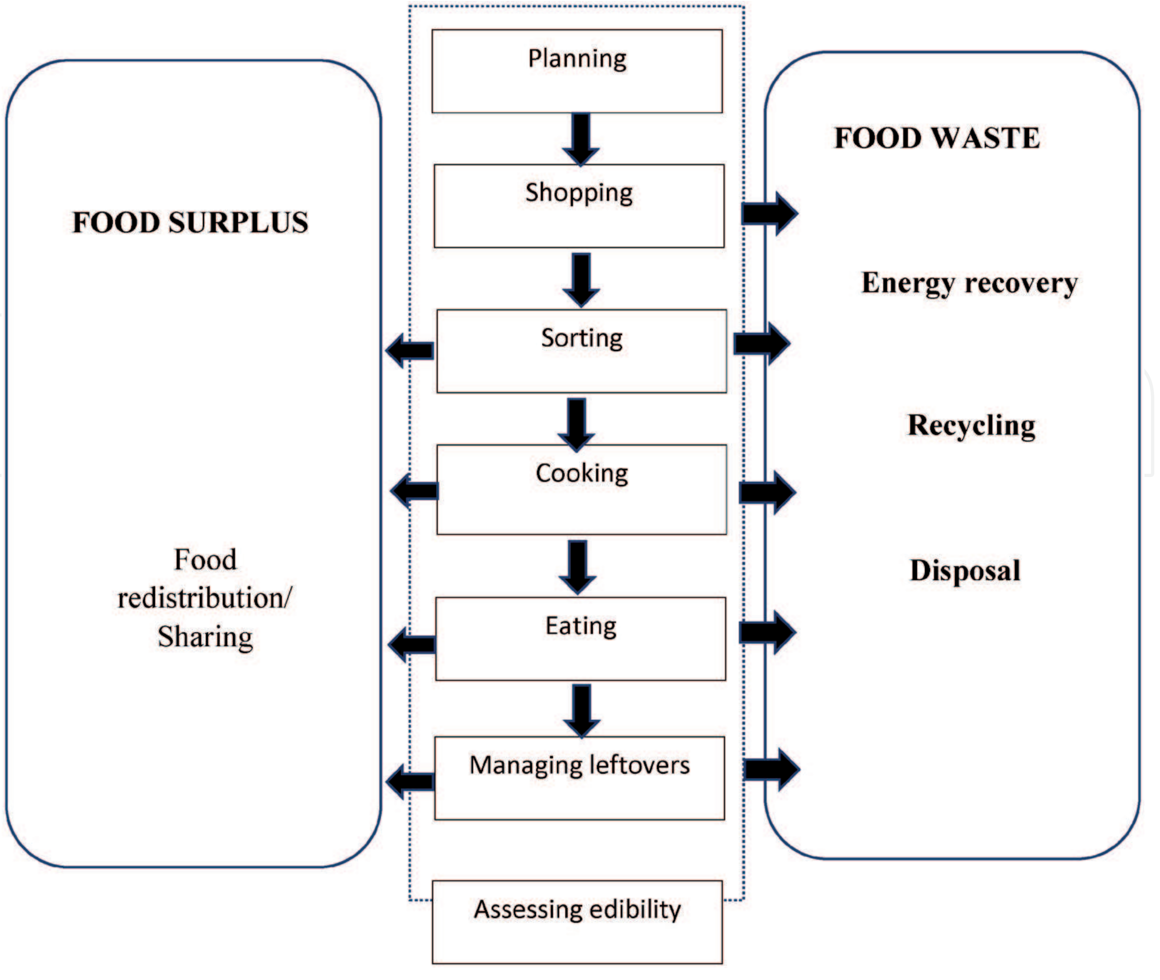

Figure 1.
Waste prevention and waste management.

as a priority waste stream, food waste is identified by growing number of policies (national and regional) [21–23]. In high range the food amount wasted in the global food supply chain (FSC) that could have otherwise been used to feed people food security is constantly pressing global issue and raises questions about it [24].

4.1 The waste hierarchy

The aim of the waste hierarchy is to recognize the problem and to generate the suitable environment friendly product from the waste. As shown in **Figure 1**, 'prevention' is the most favorable and disposal is the least favorable activity in the waste management 'pyramid'. It has been advised to consider the social and economic impacts as well as the environmental, the waste hierarchy, as a framework, primarily focuses on delivering the best environmental option by the European Waste Framework Directive (European Parliament Council, 2008).

5. Concepts in waste management and sustainability

An overview of these concepts is provided in the sections below:

5.1 Sustainable production and consumption

According to the United Nations Environmental Program [25] Sustainable Consumption and Production (SCP) defines "production and use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations". In this context, the SCP is seen to approach strategy implementing for achieving sustainable development, economy encompassing, environment and society with the use of both social innovation and technologies.

Framework of SCP policies includes growth of economy without damaging environment, fulfilling basic human requirements, and avert the rebound effect. SCP illustrate the phenomenon of negative impacts from growing consumption outweigh and the benefits of efficient and improved technologies. It is an integrated approach, involves both the supply and demand (goods and services), by reducing the adverse situation of production and consumption [26]. On the sustainable production side, some examples are prevention from pollution, cleaner production, efficient for ecosystem, and productivity towards greenery [27]. SCP on the consumption side, connects product and the producer with the consumer, allowing more sustainable choices to be made. Some traditional examples are eco-labeling, management in supply chain, minimization in waste, recycling, sustainable procurement and resource efficiency measures [28].

5.2 Avoidable and unavoidable food waste

WRAP defines avoidable food waste as food no longer wanted, thrown away. Avoidable food is composed of material that was, edible, at some point prior to disposal, even though a proportion is not edible at the time of disposal due to deterioration.

Avoidable food waste includes foods or parts of food that are considered edible by the vast majority of people. Unavoidable food waste is described as waste arising from food that is not, and has not been, edible under normal circumstances. This includes parts of foods such as fruit skin, apple cores and meat bones.

5.3 Waste prevention and waste management

Sinclair Knight Merz Enviros (SKM Enviros) explains waste prevention are the activities that avoids generation of waste, for instance, food surplus reduction, whereas waste management as shown in **Figure 1**, includes the activities which deals with food waste once it has been generated, such as composting and anaerobic digestion.

6. Fermentation processes

Chemical transformation of product into value added products is the process known as Fermentation which is one of the oldest methods used for product transformation through microorganisms. Fermentation processes are mostly done in three types/methods such as solid state, sub merged and liquid fermentation. Selections of the fermentation process are product specific. To obtained bioactive compounds of industrial interest from various substrates such as wastes, solid state and sub-merged fermentation processes are used [29].

6.1 Solid state fermentation

Solid-state fermentation (SSF) is the fermentation procedure in which development of microorganisms takes place on solid substrates in the absence of open liquid [30]. It focuses to attain the maximum nutrient attention from the substrate for fermentation by using the microbes such as fungi or bacteria. SSF further classified on the basis of seed culture used for fermentation is pure or mixed. In pure culture SSF, specific strains are used whereas, in with the mixed culture, different types of microorganisms are used for fermentation.

6.2 Sub merged/liquid fermentation

Submerged fermentation (SmF) is the type of fermentation in which the substrate is liquefied or put off in a water source. In industrial processes for high yield, low cost, and contamination SmF is mostly used. However, SmF has some disadvantages like physical space and energy or water requirements etc. [31]. Because of some advantageous SmF produced enzymes has been used over past of century as compared to SSF. Ease of process control and sterilization this fermentation process is easier to plan by researchers [32]. Pectinase, an enzyme production from fungi has been described by Favela-Tores et al. [33] using SmF. Pectinases are a gathering of related proteins engaged with the breakdown of pectin from an assortment of plants. Pectinases have various commercial as well as industrial importance.

6.3 Uses of fermentation for the production of bioactive/value added compounds

To elevate functional and nutritional values of the substrate to large extent SSF is a remarkable tool [34, 35]. For solid state fermentation several types of solid substrates generated from agro waste have been used which is contains of high nutritive value in terms of proteins, fibers, and minerals, respectively [36].

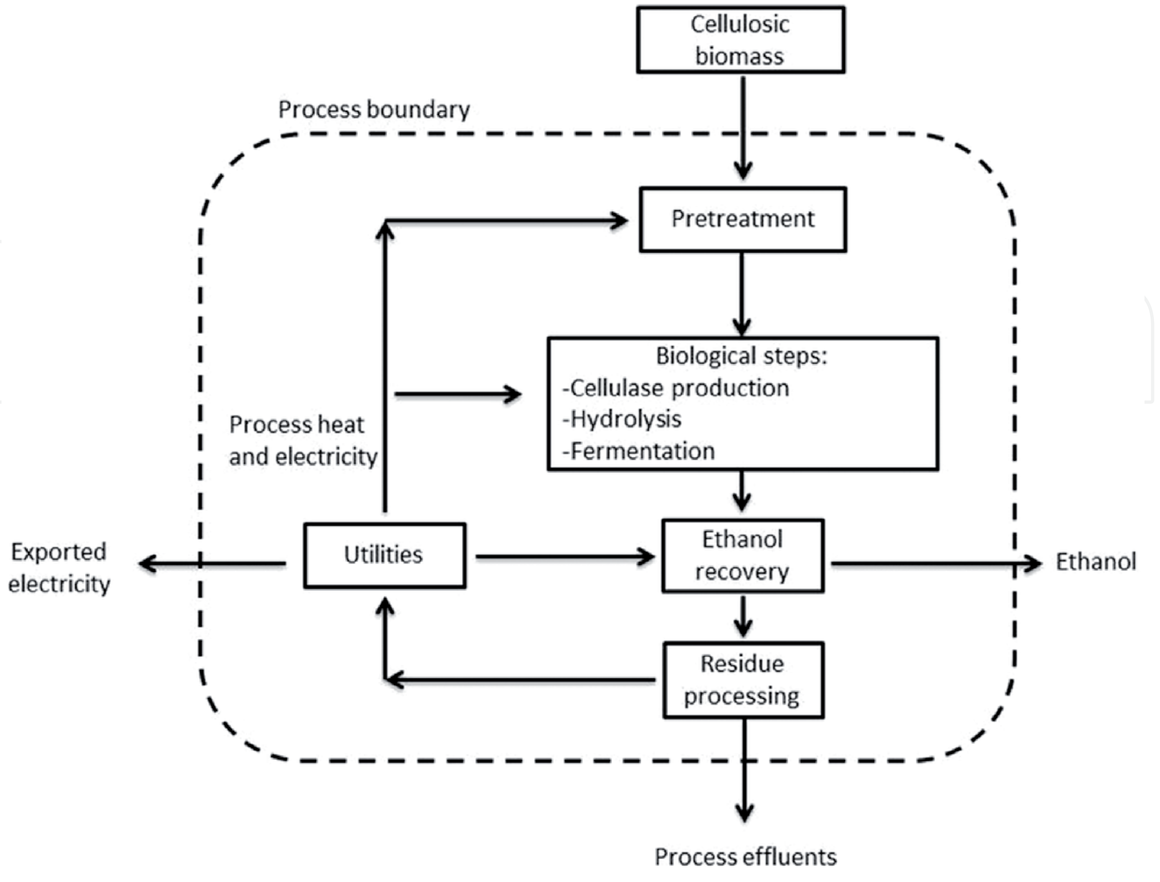

Figure 2.
Industrial waste and by-product streams via fermentation.

Figure 2 shows the outline of food industries waste through fermentation for production of various bioactive compounds. Real fact is that in human as well as animal diet these macro and micro molecules have tremendous value, therefore solid-state fermentation is an effective approach to improve their digestibility and bioavailability [37, 38]. Functional properties are the significant properties that define the pivotal phenomena of food, which are essentially used in food application [39, 40]. Also, the functional properties of food are always correlated with intrinsic components such as fats, proteins and starch, respectively.

From processing setups of the agro-industry especially the food industry produces a huge volume of wastes that are generally obtained [41]. The composition, quantity, and quality of wastes depend on the raw materials as well as the processing steps. Different type of wastes like date syrup, wheat straw, orange peel, and bran, rice straw and bran, banana, sugarcane bagasse and potato peel, soybean waste, apple pomace, oil press cakes, dairy waste, marine waste, brewery waste, food waste, etc. are produced by various types of food industries. Appropriate applications i.e., fermentations used for biotransformation of these wastes into valuable products having low cost and high nutritive value. Undeniably, use of wastes not only excludes the dumping problems but also resolves the pollution-related problems. Therefore, extra governing endorsements, as well as principal funds, are essential to bring these value-added products in the commercial market. The valorization of agro-industrial by-products to beneficial substances may not only provide future dimension to researchers but also decrease the existing environmental hazards.

7. Technologies for renewable energy generation from food/agricultural waste

Currently in many countries food waste are incinerated together with other combustible municipal wastes or landfilled for possible recovery of energy. However, due to these two approaches environment and economy of the countries are more stressed. Due to its composition of organic and nutrient-rich content, theoretically FW can be utilized as a useful resource for biofuel production through various processes of fermentation. It has attracted increasing interest in the production of biogas, hydrogen, ethanol and biodiesel as final products. Therefore, this section reviews all the food waste fermentation technologies for renewable energy generation.

7.1 Production of ethanol

The rapid global demand for the for the ethanol which has wide application in industries is increasing day by day. The main purpose of ethanol is to produce ethylene which is the main raw materials for the production of polyethylene and other plastics that is the reason for the high demand i.e. more than 140 million tonnes per year. Even the bioethanol has gained interest that is produced from cheap feedstocks [42, 43]. The source of bioethanol is the waste from starch and cellulose rich crops, e.g. sugar cane, rice and potato [44]. With the help fermentation in presence of *Saccharomyces cerevisiae* starch undergo breakdown resulted in the conversion of glucose by commercial enzymes and finally production of ethanol. In case of cellulose the breakdown due to hydrolysis is more difficult. If the FW contain large number of cellulose feedstocks than hydrolysis will become difficult, that is why, for the production of ethanol use of abundant and cheap wastes such as municipal, lignocellulosic and food waste has been explored as alternative substrates [45, 46].

7.2 Production of hydrogen

Hydrogen in the form of compressed gas gives high energy yield (142.35 kJ/g) which can also be produced from FW. The production of hydrogen is associate with the food waste containing higher amount of carbohydrate. The production rate of 0.9 to 8.35 mol H_2/mol hexose is generated from thee food waste according to recent studies [47]. The production of H_2 is influenced by many factors such as process configurations, pre-treatments and the composition of FW.

7.3 Production of methane

Methane is used as a fuel for ovens, homes, water heaters, automobiles, turbines, and other things. Because of its low cost, the production of methane via anaerobic processes is a good approach for management of waste, low production of residual waste and its utilization as a renewable energy source [48, 49]. In addition to biogas, a nutrient-rich digestate produced can also be used as soil conditioner or fertilizer. [50] investigated two-stage anaerobic digestion of fruit and vegetable wastes, in which 95.1% volatile solids (VS) conversion with a methane yield of 530 mL/g VS was achieved. [51] FW was converted to methane using a 5-L continuous digester fed with an organic loading rate (OLR) of 7.9 kg VS/m^3, resulting 70% VS conversion with a methane yield of 440 mL/g VS. [52] the methane production capacities of about 54 different fruit and vegetable wastes ranged from 180 to 732 mL/g VS depending on the origin of wastes.

7.4 Production of biodiesel

Biodiesel is synthesized through direct transesterification/acid catalyst using alkaline FW converted to fatty acids and biodiesel via various oleaginous microorganisms [53–56]. Many yeast strains produce microbial oil and then it can be used as the substitute of plant oils due to their similar fatty acid compositions. It also can be used as raw material for the production of biodiesel [57]. It has been found that the potential of FW hydrolyzate as culture medium and nutrient source in microalgae cultivation contributes for production of biodiesel [58].

In terms of prevention and concern towards economic and environment, management of FWs is utmost urgent and important to be implemented. The bioconversion of FW is economically viable for the conversion of biodiesel, ethanol, hydrogen, and methane. However, problems associated with FW in terms of transportation/collection should also be monitored. Nevertheless, the low or no cost of food waste along with the environmental benefits considering the waste disposal would balance the initial high capital costs of the biorefineries.

7.5 Production of bioactive compounds by fermentation of food waste

Bioactive and compounds are the two words which gives the term "Bioactive compounds". Scientifically, the meaning of this term is several molecules that have some biological activity.

These compounds are naturally present lesser content in plants and food stuffs, they are phytochemicals [59] and potentially able to growth in metabolism for the betterment of human health. Bioactive compounds are extremely heterogeneous class of compounds includes plant growth factors, alkaloids, mycotoxins, food-grade pigments, antibiotics, flavonoids and phenolic acids etc. with dissimilar chemical structures (hydrophilic or lipophilic), specific to ubiquitous distribution in nature, significant amount present in foods and in human body, efficient against oxidative species and possess the potential biological action [60, 61].

Through various food industries a large number of by-products or wastes are produced worldwide due to which it leads to environmental degradation. So, nowadays many approaches and new techniques are introduced for the use of the wastes, because these by-products are an excellent source of various bioactive components and beneficiary for human health. The composition of these wastes mainly depends on the waste source/type. Approximately half of the waste produced from food processing factories is lignocellulosic in nature. The dissimilar types of waste produced by food industries can be fortified by various processes. One of the oldest approaches is fermentation and carried out in three types of processes, that are carried out such as solid state, submerged and liquid fermentation used for product transformation into value added products through microorganisms [34].

8. Future perspectives

Agricultural industries generate a huge amount of wastes and by-products during production, handling and processing of agricultural products. Disposal of these wastes has a serious financial and ecological concern due to its detrimental environmental effects [62]. Therefore, to discover alternative methods of recycling and reprocessing of these wastes is a significant target taken into consideration globally. These wastes and by-products represent huge potential which have not been fully exploited, causing a loss of economic opportunity. There is thus need to identify the reasons for underutilization of agricultural by-products so that they can be addressed through suitable strategies and policy interventions. Part of the reason for the underutilization of agricultural by-products is due to lack of awareness about their properties and potential economic benefits. Proper research and studies need to be carried out on assimilating different value-added product manufacturing process. Value addition of by-products generates economic value as it facilitates the process of economic diversification by opening up new agricultural market and providing alternatives to low-cost commodity production, by offering new perspectives for the management of resources and by providing economic opportunities and environmental benefits. Markets for agricultural by-products are essential for their commercialization, value addition and efficient utilization. The lack of markets for the by-products restricts the use of crop residue to produce biofuels. So, there is a need to establish markets and to keep operational expenses of its value addition low enough to encourage the production and utilization of value-added products. These by-products also represent potential solutions to the problems of animal nutrition. Technologies needs to be developed for better utilization considering factors, such as characteristics of individual wastes and the environment in which they are produced, reprocessed and utilizied, such technologies need to convey products that are safe not only for animal feed use, but also from the point of view of human feeding.

The proper utilization of agricultural wastes and by-products has the potential to support entire industries, increase income and valuable employment opportunities, develop rural areas and solve the problem of waste and environmental pollution.

9. Conclusion

The world Population is increasing rapidly with the decreasing trend of natural resources are at the same time. Raising concerns over the security of global food due to the disparity between food wastage and food poverty, highlights the moral and social food waste dimensions. This chapter suggests that the first step towards a more sustainable resolution of the growing food waste issue is to adopt a sustainable production and consumption approach and tackle food surplus. The distinction between food surplus and food waste on one hand, and avoidable and unavoidable food waste on the other, are crucial in the process of identifying the most appropriate options for addressing the food waste challenge. This study proposes the food waste hierarchy as a framework to identify and prioritize the options for the minimization and management of food surplus and waste throughout the food supply chain. The proposed food waste hierarchy aims to challenge the current waste management approach to food waste, contribute to the debate about waste management and food security, and influence the current academic thinking and policies on waste and food to support more sustainable and holistic solutions.

Preventing food waste in agriculture and food processing requires improved infrastructure and technological solutions in harvesting, storage, transport and distribution, supported by large-scale investment and local policies. Waste management policies should be integrated and aligned with the wider policies on food, agriculture, food standards, food poverty alleviation and sustainable production and consumption.

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References

[1] FAO. Towards the future we want: End hunger and make the transition to sustainable agricultural and food systems. Food and agriculture organization of the United Nations Rome; 2012.

[2] Melikoglu, M., Lin, C. S. K. and Webb, C. 2013. Analyzing global food waste problem: pinpointing the facts and estimating the energy content. *Cent. Eur. J. Eng.,* 3(2), 157-64.

[3] Eriksen, G., Coale, F. and Bollero, G. 1999. Soil nitrogen dynamics and maize production in municipal solid waste amended soil. *Agron. J.* 91, 1009-1016.

[4] Hansen, T., Bhander, G., Christensen, T., Bruun, S. and Jensen, L. 2006. Life cycle modeling of environmental impacts of application of processed organic municipal solid waste on agricultural land (EASEWASTE). *Waste Manag. Res.,* 124, 153-166.

[5] Jakobsen, S. 1995. Aerobic decomposition of organic wastes 2. Value of compost as fertilizer. *Resour. Conserv. Recy.,* 13, 57-71.

[6] Iglesias-Jimenez, E. and Alvarez, C. 1993. Apparent availability of nitrogen in composted municipal refuse. *Biol. Fert. Soils,* 16, 313-318.

[7] Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R. and Meybeck, A. 2011. Global food losses and food waste. *Food and Agriculture Organization of the United Nations, Rom.* http://www.fao.org/docrep/014/mb060e/mb060e00.pdf (accessed 23.08.2017).

[8] Mourad, M. 2015. France moves toward a national policy against food waste. https://www.nrdc.org/sites/default/files/france-food-waste-policy-report.pdf (accessed 23.08.2017).

[9] BIOIS, 2010. Preparatory Study on Food Waste across EU 27. European Commission (DG ENV) Directorate C-Industry. Final Report. ISBN: 978-92-79-22138-5.

[10] Parfitt, J., Barthel, M. and Macnaughton, S. 2010. Food waste within food supply chains: quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological* Sciences 365, 3065-3081. http://rstb.royalsocietypublishing.org/content/365/1554/3065 (accessed 23.08.2017).

[11] UNEP, 2011. Decoupling Natural Resource Use and Environmental Impacts from Economic Growth. *United Nations Environment Programme, Paris*.

[12] Wilson, D.C., Rodic, L., Scheinberg, A., Velis, C. and Alabaster, G. 2012. Comparative analysis of solid waste management in 20 cities. *Waste Manag. Res.,* 30 (3), 237-254.

[13] Stern, N. 2006. Stern Review: The Economics of Climate Change. HM Treasury, London.

[14] Castro-Munoz, R., Barragan-Huerta, B. E., Fila, V., Denis, P. C. and Ruby-Figueroa, R. 2017. Current role of membrane technology: From the treatment of agro-industrial by-products up to the valorization of valuable compounds. *Waste biomass Valorization.,* 9, 513-529.

[15] Kathirvel, P. 2017. Bioconversion of fruit peel into value-added products. *International Conference on advances in biotechnology.,* 2(5), 71.

[16] Ajila, C. M., Brar, S. k., Verma, M., Tyagi, R. D., Godbout, S. and Valero, J. R. 2012. Bio-Processing of agro-byproducts to animal feed. *Critical Reviews in Biotechnology.,* 32(4), 382-400.

[17] Ayoo, C. and Bonti-Ankomah, S. 2020. Economic impacts of value addition to agricultural byproducts. Simpson, B. K., Aryee, A. N. A. and Toldra, F (Eds.) *Byproducts from agriculture and fisheries: adding value for food, feed, pharma, and fuels.* Chichester-UK: Johns Wiley & Sons Ltd. (Pp 685-698).

[18] Shamsi, I. H., Hussain, N. and Jiang, L. 2012. Agro-industrial by-products utilization in animal nutrition. Gupta, S. K (Ed) *Technological innovations in major world oil crops.* New York-USA: Springer. (Pp 209-220).

[19] Ayoo, C., Bonti-Ankomah, S. and Aryee, A. N. A. 2020. Constraints to value addition to agricultural byproducts. Simpson, B. K., Aryee, A. N. A. and Toldra, F (Eds.) *Byproducts from agriculture and fisheries: adding value for food, feed, pharma, and fuels.* Chichester-UK: Johns Wiley & Sons Ltd. (Pp 685-698).

[20] Garnett, T., Wilkes, A., 2014. Appetite for Change. Social, Economic and Environmental Transformations in China's Food System.

[21] EPA, 2012. Putting Surplus Food To Good Use. Washington DC

[22] Defra, 2011. Government Review of Waste Policy in England 2011. London.

[23] Government of South Australia, 2010. Valuing Our Food Waste. South Australia's Household Food Waste Recycling Pilot. Adelaide.

[24] Stuart, T., 2009. Waste. Uncovering the Global Food Scandal. Penguin, London.

[25] UNEP, 2008. Planning for Change. Guidelines for National Programmes, Paris.

[26] Greening, L.A., Greene, D.L. and Difiglio, C. 2000. Energy efficiency and consumption - the rebound effect e a survey. *Energy Policy,* 28, 389-401.

[27] Almeida, C.M.V.B., Bonilla, S.H., Giannetti, B.F. and Huisingh, D. 2013. Cleaner production initiatives and challenges for a sustainable world: an introduction to this special volume. *J. Clean. Prod,.* 47, 1-10.

[28] Tukker, A., Cohen, M.J., Hubacek, K. and Mont, O. 2010. The impacts of household consumption and options for change. *J. Industrial Ecol*, 14 (1): 13-30.

[29] Subramaniyam, R. and Vimala, R. 2012. Solid state and submerged fermentation for the production of bioactive substances: A comparative study. *Int. J. Sci. Nat.*, 3, 480-486.

[30] Bhargav, S., Panda, B. P., Ali, M. and Javed, S. 2008. Solid-state fermentation: An overview. *Chem. Biochem. Eng.*, 22, 49-70.

[31] Knob, A., Fortkamp, D., Prolo, T., Izidoro, S. C. and Almeida, J. M. 2014. Agro-residues as Alternative for Xylanase Production by Filamentous Fungi. *Biol. Res.,* 9, 5338-53773.

[32] Vidyalakshmi, R., Paranthaman, R. and Indhumathi, J. 2009. Amylase production on submerged fermentation by Bacillus spp. *World J. Chem.,* 4, 89-91.

[33] Favela-Torres, E., Volke-Sepulveda, T. and Viniegra-Gonzalez, G. 2006. Hydrolytic Depolymerising Pectinases. *Food Technol. Biotechnol.,* 44, 221-227.

[34] Chawla, P., Bhandari, L., Sadh, P. K. and Kaushik, R. 2017. Impact of Solid-State Fermentation (Aspergillus oryzae) on Functional Properties and Mineral Bioavailability of Black-Eyed Pea (*Vigna unguiculata*) Seed Flour. *Cereal Chem.,* 94, 437-442.

[35] Sadh, P. K., Duhan, S. and Duhan, J. S. 2018. Agro-industrial wastes and their

utilization using solid state fermentation: A review. *Bioresour. Bioprocess.*

[36] Sadh, P. K., Saharan, P. and Duhan, J. S. 2017. Bio-augmentation of antioxidants and phenolic content of *Lablab purpureus* by solid state fermentation with GRAS filamentous fungi. *Res. Effic. Technol.,* 3, 285-292.

[37] Oloyede, O. O., James, S., Ocheme, B. O., Chinma, C. E. and Akpa, V. E. 2016. Effects of fermentation time on the functional and pasting properties of defatted *Moringa oleifera* seed flour. *Food Sci. Nutr.,* 4, 89-95.

[38] Chi, C. H. and Cho, S. J. 2016. Improvement of bioactivity of soybean meal by solid-state fermentation with *Bacillus amyloliquefaciens* versus Lactobacillus spp. and *Saccharomyces cerevisiae*. *LWT Food Sci. Technol.*, 68, 619-625.

[39] Singh, H. 2011. Functional properties of milk proteins. *Ref. Modul. Food Sci*.

[40] Bhandari, L., Sodhi, N. S. and Chawla, P. 2016. Effect of acidified methanol modification on physico chemical properties of black-eyed pea (*Vigna unguiculata*) starch. *Int. J. Food Prop.*, 19, 2635-2648.

[41] Kumar, S. P., Kumar, S., Chawla, P. and Singh J. D. 2018. Fermentation: A Boon for Production of Bioactive Compounds by Processing of Food Industries Wastes (By-Products). *Molecules*, 23, 2560

[42] Lundgren, A. and Hjertberg, T. 2010. Ethylene from renewable resources. In: Surfactants Renewable Resources. John Wiley & Sons, Ltd. 109-26.

[43] International-Renewable-Energy-Agency. Production of bio-ethylene. IRENA- ETSAP; 2013.

[44] Thomsen, A. B., Medina, C. and Ahring, B. K. 2003. Biotechnology in ethanol production, in New and Emerging Bioenergy Technologies. In. *Riso National Laboratory, Denmark;* 2, 40-4.

[45] Jensen, J. W., Felby, C. and Jorgensen, H. 2011. Cellulase hydrolysis of unsorted MSW. *Appl Biochem Biotechnol,* 165(7-8), 1799-811.

[46] Kim, S. and Dale, B. E. 2004. Global potential bioethanol production from wasted crops and crop residues. *Biomass Bioenergy,* 26(4), 361-75.

[47] Patel, S. K. S., Kumar, P., and Kalia, V. C. 2012. Enhancing biological hydrogen production 707 through complementary microbial metabolisms. *Int. Jr. Hydrogen Energy*, 37(14), 10590-603.

[48] Morita, M. and Sasaki, K. 2012. Factors influencing the degradation of garbage in methanogenic bioreactors and impacts on biogas formation. *Appl, Microbiol Biotechnol,* 94(3), 575-82.

[49] Nasir, I. M., Ghazi, T. I. M. and Omar, R. 2012. Production of biogas from solid organic wastes through anaerobic digestion: a review. *Appl. Microbiol. Biotechnol.,* 95(2), 9-21.

[50] Viturtia, A. et al. 1989. Two-phase anaerobic digestion of a mixture of fruit and vegetable wastes. *Biolog. Wastes,* 29(3), 189-99.

[51] Lee, J. P., Lee, J. S. and Park, S. C. 1999. Two-phase methanization of food wastes in pilot scale. *Appl. Biochem Biotechnol – Part A Enzyme Eng Biotechnol*, 77– 79, 585-93.

[52] Gunaseelan, V. N. 2004. Biochemical methane potential of fruits and vegetable solid waste feedstocks. *Biomass Bioenergy,* 26(4), 389-99.

[53] Chen, Y. et al. 2009. Synthesis of biodiesel from waste cooking oil using immobilized lipase in fixed bed reactor. *Energy Convers Manage,* 50(3), 668-73.

[54] Mahmood, T. and Hussain, S. T. 2010. Nanobiotechnology for the production of biofuels from spent tea. *Afr J Biotechnol,* 9(6), 58-68.

[55] Papanikolaou, S. et al. 2011. Biotechnological conversion of waste cooking olive oil into lipid-rich biomass using Aspergillus and Penicillium strains. *J Appl Microbiol*, 110(5), 38-50.

[56] Yaakob, Z. et al. 2013. Overview of the production of biodiesel from waste cooking oil. *Renew Sustain Energy Rev*, 18, 84-93.

[57] Uckun Kiran, E., Trzcinski, A. and Webb, C. 2013. Microbial oil produced from biodiesel by-products could enhance overall production. *Bioresour Technol,* 29-50.

[58] Pleissner, D. 2013. Food waste as nutrient source in heterotrophic microalgae cultivation. *Bioresour Technol,* 137, 39-46.

[59] Martins, S., Mussatto, S. I., Martinez-Avila, G., Montanez-Saenz, J., Aguilar, C. N. and Teixeira, J. A. 2011. Bioactive phenolic compounds: Production and extraction by solid-state fermentation. A review. *Biotechnol. Adv.,* 29, 365-373.

[60] Carbonell-Capella, J. M., Buniowska, M., Barba, F. J., Esteve, M. J. and Frigola, A. 2014. Analytical methods for determining bioavailability and bioaccessibility of bioactive compounds from fruits and vegetables: A review. *Compr. Rev. Food Sci. Food Saf.*, 13, 155-171.

[61] Porrini, M. and Riso, P. 2008. Factors influencing the bioavailability of antioxidants in foods: A critical appraisal. *Nutr. Metab. Cardiovasc. Dis.,* 18, 647-650.

[62] The Government Office for Science, 2011. Foresight Project on Global Food and Farming Futures Synthesis Report C7: Reducing Waste. London.