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Review Article

Agri-Food Waste and Food Security: Exploring the Business Potential of Agri-Waste Functional Compounds

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Abstract:

Food security, energy crisis, reducing food losses and waste are among the significant challenges in fulfilling the dietary requirements of the rapidly growing population. The increase in population affects agricultural production on both international and national scales. Approximately one-third of crops grown traditionally suffer damage mostly as a result of natural disasters, insect and microbial assaults, nutrient deficiencies, and poor soil quality. This results in the production of large amounts of waste. A large portion of global solid waste is generated from agricultural waste. Examples of agri-waste include food processing waste, crop residues, and leaf litter weeds. Saw dust and forest trash. Improper management of agricultural waste harms the environment, poses serious threats to human health, and eventually worsens the environment. Food insecurity is rising due to population growth, inappropriate use of natural resources, waste and limited food supply. Agri-waste is enriched with essential nutrients. The recovery of essential nutrients from agri-food waste is a key solution in reducing waste, preventing excessive raw material consumption, and enhancing the business potential of agri-waste functional compounds. The present chapter highlights the likely business models to reduce food waste.

Keywords: agriculture-waste, business model, food security, nutrients

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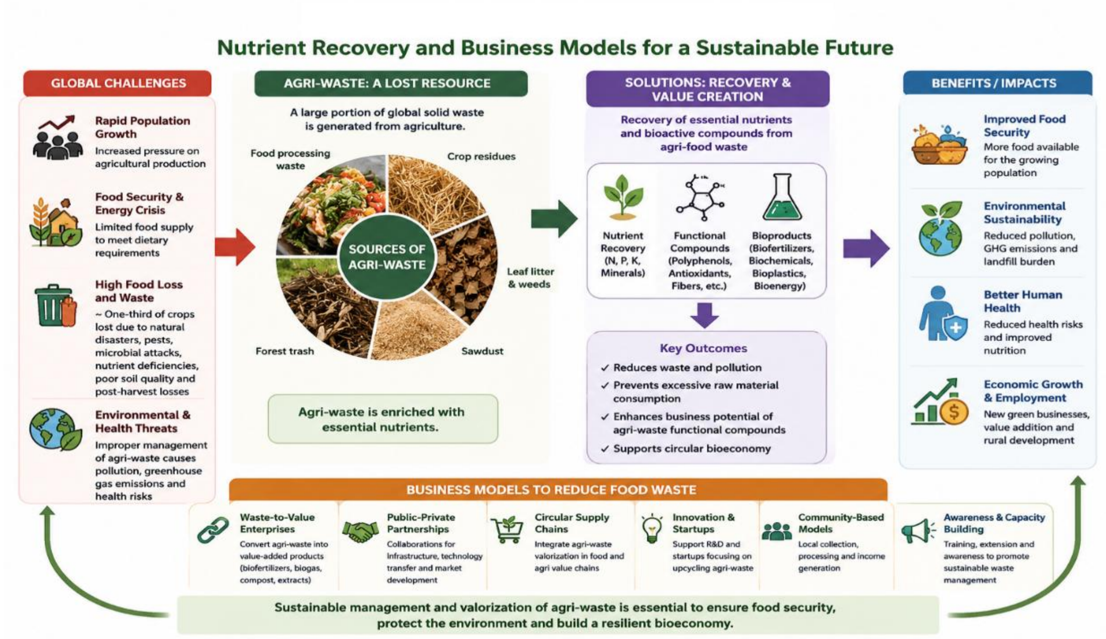
Graphical Abstract



1. Introduction:

The agriculture sector plays a vital role in enhancing economic growth in both developed and developing countries. Due to the rapid increase in the world population, food production at a larger scale is the main goal of the agricultural industry. It is anticipated that the world population will reach 9.15 billion by 2050. Agriculturists succeeded in the production of a large number of food crops (Maqbool *et al.*, 2025; Sadh et al., 2018; Alexandratos and Bruinsma, 2012.)Agricultural sectors produced approximately 1300 tons of waste throughout the year. Agri-food waste and by-products are defined as the plant residues that are not used as food or feed. Plenty of seeds, husks, leaves, pulp, and stems are generated as waste (Amran et al., 2021). If agricultural food waste is disposed of without proper management, it may pose serious threats to the biotic and abiotic components of the environment. (Abd El-Fatah and, 2019;Amran et al., 2021). Degradation and the diminution of bio resources are among the major concerns due to the fast-growing population (Makris and Şahin, 2019). Agricultural waste and food by-products are enriched with functional compounds. Sustainable use of agri-waste and by-products put forward a golden opportunity to generate additional income for the pharmaceutical, cosmeceutical, nutraceutical and fertilizer industries (Ben-Othman et al., 2020). The debate on the appropriate use of natural resources and limited economic growth has been raised for over half a century. The first report on “The Limits to Growth” was published by the Club of Rome in 1972 (Meadows et al., 2018). Later on, after 15 years, a report by the World Commission on Environment and Development and Our Common Future invited new technologies to manage environmental resources (Brundtland and Khalid, 1987; Hariebrundtland, 1985). Now legislators are promoting the circular economy strategy. The circular economy strategy regulates the continuous flow of materials (technical and biological) through a value circle and the waste is reduced, reused, valorized, or recycled. (Anon, 2013); Murray et al., 2017). The relationship between bio-economy, circular economy, and sustainability is still undiscovered (Millar et al., 2019). Implementation of a circular economy strategy in the agriculture sector can navigate sustainable innovation by transforming traditional linear business models into circular ones (Lamolinara et al., 2024). Within this context, production of valuable products through the volarization of agri-food-waste and by-products has emerged as an important tactic. The goal of zero waste production can be achieved using eco-friendly and economical technologies to utilize agri-food-waste and by-products. Innovative bio-based formulations have proved to be significantly more profitable than the production of biofuel (Otles et al., 2015).

1.1: Agri-food waste is a rich source of bioactive compounds:

Valorization of agri-food waste and by-products can help to meet the modern consumer and societal demands by reducing waste generation and promoting the concept of zero hunger.

Up till now agri-food wastes have been used in the production of fuels, organic fertilizers or livestock feed. But with the advancement in green technology, modern technologies, and high-tech equipment new ideas have emerged that promote the formulation of value-added products through the efficient use of agri-food waste and by-products (table 1). Fourier transform infrared spectroscopy (FTIR) is a valuable instrument that detects the presence of functional groups present in the agri-food waste and by-products (Kachel-Jakubowska et al., 2017). Deep eutectic solvents (DES) are a revolutionary type of eco-friendly, non-toxic, and cost-effective green solvents that are derived from natural and renewable resources like glycerol or organic acid salts. This DES extracts bioactive compounds such as polyphenols from agri-food waste and by-products. Some of the value-added items include bioethanol, organic acids, functional phyto-compounds, prebiotics, etc. Figure 1 shows the valorization of agri-food waste based on its composition (Banerjee et al., 2017; Soong and Barlow, 2004).

According to the published research data, most of the fruit waste is generated by juice processing sectors and the industries involved in the production of flavored items. In comparison to edible parts of the fruit non-edible parts (peels, skin portion, twigs, etc.) are a rich source of bioactive compounds (Gorinstein, Martín-Belloso, et al., 2001; Gorinstein, Zachwieja, et al., 2001). It is reported that the peels of grapes, citrus fruits, apples, and seeds of avocado, mango, and jackfruit are rich sources of polyphenolic compounds than pulp (Soong and Barlow, 2004). Pomace (a mixture of peel, pulp, seeds and stem) is produced in a large quantity after the production of beverages by the food industry. Pomace is highly perishable, and hence, it can have negative impacts on the environment (Majerska et al., 2019). It can be used as livestock feed, biofertilizer or serve as a source of biomass for the production of biofuel. The fruit pomace is enriched with more bioactive compounds as compared to juice (Kachel-Jakubowska et al., 2017). Various studies have been conducted on the production of value-added products from fruit processing waste. Apple and berry pomace has been used as a potential ingredient to enhance the nutritional fiber, antioxidant profile, and sensory quality of bakery and dairy items (Majerska et al., 2019).

Fruit and vegetable seeds contain a wide range of bioactive chemicals with potential applications in the neutraceutical and pharmaceutical industries.

2: Materials and Methods:

We performed a systematic literature search from 2000 to 2026 on PubMed, Scopus, Web of Science, Google Scholar and ScienceDirect. The keywords used were: agri-food waste, bioactive compounds, extraction techniques, green extraction, circular economy, and business model (Snyder, 2019).

Only original papers, review articles and book chapters published in English were included. Animal waste studies, abstracted papers and papers with limited access were not included. Titles, abstracts and full texts were screened by two independent reviewers. Disagreements were resolved by discussion or consultation with a third reviewer. The data obtained were collected in a standardized form through the collections of waste type, bioactive compounds, extraction methods, bioactivity, and business models.

A narrative synthesis methodology was used because of the heterogenity of studies. The quality assessment criteria were experimental design, protocol reproducibility and relevance. No human or animal subjects were used and so no ethical approval was needed (Snyder, 2019).

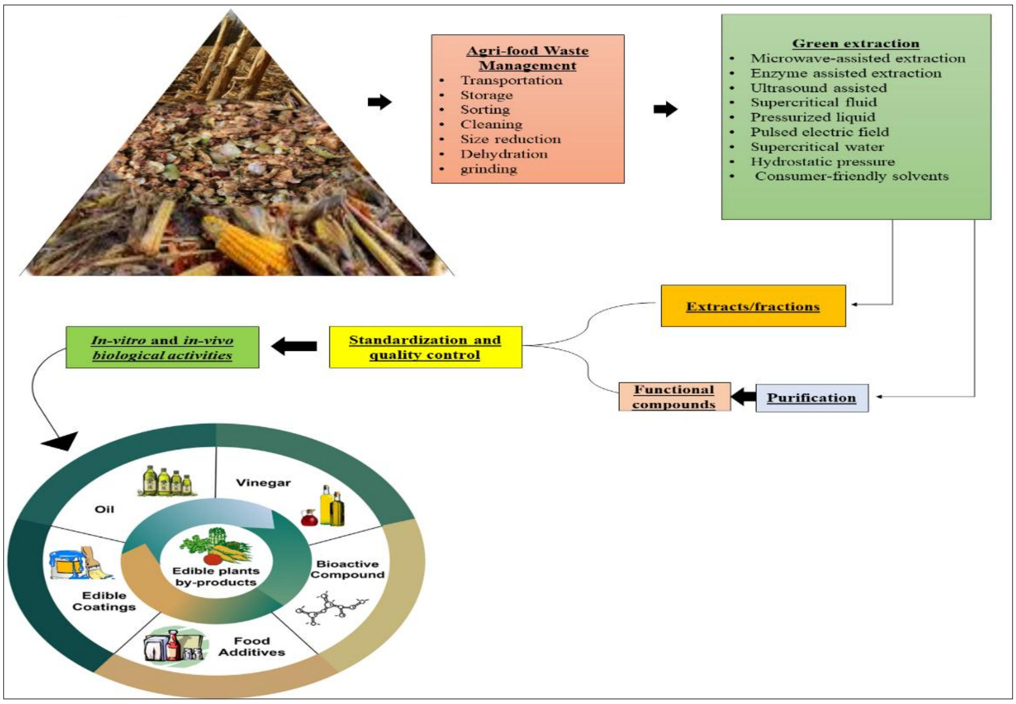


Figure 1: An integrated biorefinery model for the management of agri-food waste and by-products

3: Results and Discussion

3.1: Extraction of functional food ingredients from agri-food waste:

Nature has blessed mankind with a vast variety of plant species. To extract targeted functional compounds from agri-food waste (peels, pomace, rind, husk, etc.), it is essential to follow a standardized screening process. Industries such as food, pharmaceutical, cosmeceutical, and chemical utilize functional compounds. Numerous extraction techniques are employed to extract bioactive compounds from plant tissues, with variation in length, cost and accessibility. Functional bioactive compounds extracted from plants exhibit high selectivity in bioassays and analytical techniques. Hence provide reliable and accurate results (Azmir et al., 2013). The efficacy of conventional extraction methods is affected by heat, ionic strength of the solvents, and solubility. Maceration, Soxhlet extraction, solvent extraction and reflux extraction are some common traditional extraction methods. In the maceration extraction technique, plant sample is crushed (to enhance the surface area) and mixed in solvents, the solution is agitated and filtered to remove the impurities. Although maceration has low extraction efficiency and consumes a lot of time, but thermolabile components could be extracted by this method. Percolation is another conventional extraction method thatis more efficient than maceration. It is a continuous process that includes the use of specialized equipment known as a percolator, in which a fresh solvent changes the saturated solvent continuously. Dried plant samples are placed in the percolator mixed with boiling water and left for a few hours to macerate. Once the extraction is completed evaporation begins and the crude extract can be obtained (Azwanida, 2015; Zhang et al., 2018).

Decoction, the most common extraction method that involves the heating of crude extract at a specific temperature for a set of time to extract heat-resistant compounds. The liquid solution is set to cool and filtered. The decoction is not suitable for the extraction of heat-sensitive (volatile) compounds (Tandon and Rane, 2008). Solid-liquid extraction is an efficient and faster extraction method than percolation and maceration and it involves the use of less solvent (Wen et al., 2018). Solid-liquid extraction technique combines the dried plant sample and solvent in a heated agitated jar. Condensation of vapors back into the flask enhances the mass transfer and contact efficiency between the sample and solvent. The main drawback of solid-liquid extraction is that it cannot extract the high thermolabile compounds (Sridhar et al., 2021). Soxhlet extraction method is a widely used method for concentrating analytes and isolating functional compounds from plant matrices. It combines the principles of percolation and reflux extraction methods by continuously extracting bioactive compounds from the sample matrix using a fresh solvent. Despite this exposure to excess heat may accelerate the degradation of bioactive compounds (Luque de Castro and Priego-Capote, 2010)

Traditional or conventional extraction methods such as Soxhlet and maceration extraction have been proven as efficient methods in different studies, but they are not cost-effective and also take a lot of time and energy. Based on the limitations of conventional extraction methods, emerging green extraction techniques require less energy reduced the extraction times, solvent requirements and enhances the efficiency. For instance, extraction of grapes with ultrasound and pulsed electric fields was shown to increase the polyphenol content up to 32-33 % and reduce the energy consumption by 17.6 fold (Maza et al., 2019; Mena-García et al., 2019). Some emerging green extraction techniques are discussed below:

3.2: Ultrasound-Assisted Extraction (UAE)

Ultrasound is a sound wave, inaudible to humans, with a frequency ranging between 20 kHz and 100 kHz (Vilkhu et al., 2008). Ultrasound-assisted extraction (UAE) makes use of ultrasonic waves for extraction. UAE is cost-effective, faster and easy to employ. Sonication also facilitates effective mixing and faster energy transfer. Various bioactive compounds including flavonoids, anthocyanins and polyphenols can be extracted through UAE technique (Maza et al., 2019).

3.3: Supercritical fluid extraction (SFE):

Supercritical fluid was discovered in 1879 by Hannay and Hogarth in 1879 and has been in extraction practice. In 1964, it was used to decaffeinate coffee in the food sector. Supercritical fluid extraction uses supercritical fluid and supercritical carbon dioxide (CO_2). Supercritical carbon dioxide (CO_2) is an inert, non-toxic gas that exhibits low critical temperature i.e. 31 ^oC, SFE promotes the extraction of bioactive compounds from plant matrices at atmospheric temperature without the use of heat. Supercritical fluid exhibits properties of both gas (viscosity, diffusion, and surface tension) and liquid (density and solvation power). Hence this unique combination increases the extraction rate and yield (da Silva et al., 2016). SFE method of extraction has proven most effective in the extraction of alkaloids like pyrrolidine (Carrara et al., 2017), vinblastine (Falcão et al., 2017), olechicine (Ellington et al., 2003), caffeine (Içen and Gürü, 2010), and as well as flavonoids (Ouédraogo et al., 2018), terpenes (Favareto et al., 2017), phenolic compounds (Pimentel-Moral et al., 2019) and essential oils (Conde-Hernández et al., 2017).

High-pressure extraction is also known as pressurized fluid extraction, pressurized solvent, improved solvent, and accelerated solvent extraction. It maintains the liquid state of the solvent above its boiling point by using high pressure. High-pressure extraction reduces the solvent volume extraction time and offers excellent reproducibility. Researchers have extracted various bioactive compounds carotenoids, phenolic compounds, pectin and flavonoids using high-pressure extraction (H. W. Huang et al., 2013; Khan et al., 2019).

3.4: Microwave-assisted extraction:

Electromagnetic radiations with frequencies ranging between 300 MHz – 300 GHz are termed as microwaves. Microwaves are composed of magnetic and electric fields that oscillate perpendicular to each other. Its heating principle depends on the dipole rotation and ionic conduction mechanisms. Microwave-assisted extraction is a novel extraction technique that uses microwave radiation to extract soluble compounds into a fluid from natural sources (H. W. Huang et al., 2013). Microwave radiation generates heat by providing resistance of the medium to the ion flow during ionic conduction. Hence, in this way, microwave radiation induces changes in molecular orientation. Microwave-assisted extraction (MAE) uses mass gradients and heat to obtain a high yield. The Microwave extraction consists of three steps: the first step is the penetration of plant material in the solvent, the second is the breakdown of bioactive components by electromagnetic waves and the final step is the transportation of solubilized components from the insoluble matric to bulk solution. Afterwards, the separation between the residual solid and liquid phases are conducted (Vasudev et al., 2019). MAE extracts various functional compounds like polysaccharides (Ekezie et al., 2017), essential oils (Lal et al., 2021), terpenes (Sánchez-Ávila et al., 2009), isoflavone (Rostagno et al., 2007), flavonoids (Göktürk Baydar et al., 2007), and saponins (Chen et al., 2007)

3.5: Enzyme-Assisted Extraction (EAE)

In traditional extraction methods, the functional phytochemicals present in plant matrices are linked either with polysaccharide-lignin network by hydrophobic or hydrogen bonding or they are dispersed throughout the cell cytoplasm, therefore these are not accessible for extraction using a solvent (Ekezie et al., 2017). Pre-treatment with enzymes has been suggested as an innovative and effective way to improve the yield. Enzyme-assisted extraction (EAE) can be employed as a pre-extraction or extraction method to extract functional compounds. The bioactive compounds are released with destruction of plant cell wall (Nadar et al., 2018). Various enzymes such as pectinase (Štambuk et al., 2016), cellulase (Danalache et al., 2018), hemicellulose (Dal Magro et al., 2016), amylase (Huynh et al., 2014) and glucosidase (Paolucci-Jeanjean et al., 2000) are used in EAE. Functional compounds such as polyphenols (Dal Magro et al., 2016), anthocyanins (Swer et al., 2016), oleoresins (Pinelo et al., 2008), flavonols (Nagendra Chari et al., 2013), terpenes (Benucci et al., 2017), carotene (Hardouin et al., 2016) can be extracted via EAE approach.

3.6: Pulsed Electric Field Extraction (PEFE)

Pulsed electric field extraction enhances extraction efficiency by destroying membrane structures leads to an increase in mass transfer and hence also reduces the extraction time. When an electric field is employed to the cells electric potential is generated that forms gaps in vulnerable areas and enhances permeability (Niu et al., 2020). PEFE is cost-effective and energy-efficient approach for various industries (food, pharmaceutical, biotechnological, etc.) PEFE can extract flavonoids (Redondo et al., 2018), anthocyanins (Medina-Meza and Barbosa-Cánovas, 2015), proteins (Rajha et al., 2014) and carbohydrates (Yan et al., 2017). Polyphenols (EI Kantar et al., 2018).

3.7: Sustainable business model to reduce agri-food waste: Approximately 147.2 MMT (million metric tonnes) of fiber sources and 89 million tonnes of agriculture and agro-industrial waste are generated globally at post-harvest, pre-harvest and food processing stages. Agri-waste food generates 22% of the greenhouse. To solve this problem the United Nations has added food wastage to the 2030 agenda for sustainable development under Sustainable Development Goal 12 (Shen et al., 2019; Tonini et al., 2018). Now a days business models are known as a crucial aspect of the success of any organization. Business models serve as a blueprint for how a company operates and generates revenue. Since 1990's the interest of scientists and professionals has been increasing in business models (Magretta, 2002). Entrepreneurs use business models in the new economy and e-commerce to increase efficiency, profitability and sustainability (Magretta, 2002; Scherhaufer et al., 2018). Globally agri-food waste is among the major challenges that impact the environment, economy and human negatively. Shen et al. (2019) presented a sustainable business model to reduce agri-food waste in the retail chain. They observed the effect of five different business models for both types of profit (local restaurants, alternative food services local offices, residential communities as well as Food Net ethnic group) and non-profit (OProSS Charity). The results revealed that the reduction in agri-food waste loss requires the maintenance of regional logistics and e-commerce. For a successful business model, it is important to understand the regional consumer behavior and lifestyle. A circular economy model and reduction in agri-food waste can be achieved through collaboration between suppliers and consumers.

3.8: Business models to reduce, reuse and recycle agri-food waste and by-products:

3.8.1: Local restaurants

Local restaurants require precise inventory control to produce cost-effective and good-quality food. For small businesses negotiating rates with suppliers may be more complex. Despite they offer a more customizable menu as compared to high stores. Hence, they can tailor their menus based on the product information available (Senanayake et al., n.d.).

3.8.2: Alternative food service providers

Alternative food service providers (caterers) who deliver food to workplaces must manage their costs to address the main concern of the consumers. Just like local restaurants, product information platforms can help to reduce the cost of these businesses (Goggins, 2018).

3.8.3: Local offices or residential communities

Local offices or residential communities are the small families who visit markets once a week or more frequently. The majority of the people in local offices are women who work with limited time for grocery shopping. They could benefit from using online information platforms to buy groceries to purchase food items. The online platforms ensure the quality of food because the agricultural products from chain stores are certified, inspected, and kept at optimal temperatures (Shen et al., 2019).

3.9: Food Net ethnic community

The FoodNet ethnic community in central Taiwan includes Muslims from Malaysia and Indonesia with strict dietary requirements. Due to limited resources and language barriers, they face difficulty in finding suitable food. Providing online product information in English on a platform can help FoodNet members access affordable and edible food options (Matondang et al., 2020; Shen et al., 2019).

3.10: OProSS Charity

The OProSS Charity is the only non-profit organization. It is dedicated to helping the underprivileged in South Africa. They buy discounted food supplies that are close to expiration and sell them to college students at a reduced price. The profits are used to support the underprivileged. This initiative not only helps students save money on food but also reduces food waste (Shen et al., 2019).

3.11: Biobased integrated business model:

Bio refinery, an integrated bio-based business, uses various strategies to convert biological waste materials into marketable goods and energy such as food, fuel, chemicals, etc. The main aim of bio refinery is the sustainable production of value-added products from bio-waste (de Jong and Jungmeier, 2015). Garcia-Bernet and Daboussi (2016) focused on environmental biorefineries that only accept agricultural byproducts as inputs. The implementation of such sustainable programs depends on strategic alliances between various stakeholders both inside and outside the value chains.

3.11: Agricultural cooperative business model:

A cooperative business model is a business in which an independent group of people who have come together voluntarily to address their needs and goals in the areas of culture, society and economics. (International Co-operative Alliance, 2018) *(International Cooperative Alliance | ICA, n.d.)*. Typically, agricultural cooperatives are established within a particular industry (fruits, cereals, wine, etc.).

Table 1: Functional ingredients present in agri-food waste and by-products

Types	**fruit/ vegetable/ crop**	**functional compounds**	**bioactivity**	**Reference**
Pomace	Orange	pectin oligosaccharides, pectin, chlrogenic acid, ferulix acid, caffeic acid, *p*-coumaroyl-quinic acid *p*-coumaric acid Sinapic acid. isorhamnetin, rhamnetin glycoconjugates, kaempferol (−)-Epicatechin, Procyanidin B2	Prebiotic, dietary fiber, hypochlosterlemic	Click or tap here to enter text. Wang et al., 2020
			Cardiotonic, antimicrobial, antioxidant, anti-carcinogenic, anti-inflammatory	(Barreira et al., 2019;Lavelli and Corti, 2011)
	Apple	Cyanidin-3-*O*-galactoside, oleanolic acid, ursolic acid, Phlorizin, Phloretein	Anticancer, anti-inflammatory, cardioprotective, antidiabetic and neuroprotective potential, Anti-microbial, anti-inflammatory Anti-diabetic, anti-obesity,	(Liang et al., 2021) (Antika et al., 2017; L. Huang et al., 2015)
	Beetroot	Ferulic acid, p-Hydroxy-benzoic acid Vanillic acid, Protocatechuic acid Caffeic acid, Catechin epicatechin rutin	Mitigate oxidative stress, hepato-protective	(Vulić et al., 2014)
Peel	Grape	Catechin, epicatechin, quercetin-3-O-glucuronide	antihyperlipidemic, cardiovascular protection, and cancer prevention	(Göktürk Baydar et al., 2007; Štambuk et al., 2016)
	Citrus fruits	Pectin, Gallic acid, chlorogenic acid ferulic acid, coumaric acid, caffeic acid Catechins, epicatechins, Hesperidin Naringenin, Quercetin, Kaempferol	Dietary fiber, maintains blood glucose levels, and anticancer potential	(Montenegro-Landívar et al., 2021; Omoba et al., 2015; Tocmo et al., 2020)
	Banana	Epigallocatechin, epigallocatechin gallate, Gallocatechin	Anti-oxidant	(Chueh et al., 2019)
	Mango	(+)-Catechin, syringic acid, (-)-epicatechin benzoic acid, epicatechin gallate, o-coumaric acid (-)-epigallocatechin gallate, p-coumaric acid procyanidin A2, procyanidin B2,procyanidin B1 Myricetin, kaempferol 3-glucoside, Rutin Isorhamnetin, trans-resveratrol, quercetin 3-glucoside, gallic acid, quercetin-3-o- lucopyranosid cinnamic acid	Anticancer, antioxidant	(Coelho et al., 2019)
	Melon	4-Hydroxybenzoic acid, coumaric acid, chlorogenic acid, vanillin	antioxidant	(Al-Sayed and Ahmed, 2013)
	Pomegranate	Punicalagin, granatin B, tellimagrandin I, Casuarinin, granatin A, pedunculagin, Punicalin, corilagin, gallagic	Antioxidant, antimicrobial, anti-inflammatory	(Nema et al., 2022;Akhtar et al., 2015)

		acid, ellagic acid, caffeic acid, catechin, gallocatechin, luteolin, kaempferol, p-coumaric acid, gallic acid		
	Carrot	chlorogenic acid	anti-oxidant, anti-bacterial, anti-cancer, lipid metabolism, anti-inflammatory	(Wang et al., 2022)
	Garlic	Caffeic acid, ferulic and di-ferulic acids, p-coumaric	antioxidant	(Kallel et al., 2014)
	Onion	Protocatechuic acid, Kaempferol, quercetin 3,4′-diglucoside, quercetin-3-glucoside, Quercetin	antioxidant	(Celano et al., 2021)
	Potato	Caffeic acid, ferulic acid, chlorogenic acid, Carbohydrate, protocatechuic acid, gallic acid	Anti-inflammatory, anti-oxidant, anti-bacterial, anti-fungal	(Friedman et al., 2017; Ogutu and Mu, 2017; Wu et al., 2012)
	Spinach	Caffeic acid, rutin, ferulic acid	Hepatoprotective, antioxidant	Montenegro-Landívar et al., 2021; Ou and Kwok, 2004)
	Tomato	Procatchoic acid, Caffeic acid, catechin, vanillic acid, gallic acid	Antidiabetic, Diabetes, anti-cancer, anticancer and cardioprotective	(Elbadrawy and Sello, 2016)
Leaves, stalks, flowers, hush, bran	Broccoli	Chlorogenic acid, Glucoiberin, Neochlorogenic acid, Kaempferol Quercetin, Glucoraphanin, Glucobrassicin, Gluconasturtiin, 4-Methoxy-glucobrassicin, Sinapic acid, Neoglucobrassin,	Cardioprotective, Antioxidant, anti-cancer, cardiovascular disease	Ares et al., 2015; Thomas et al., 2018)
	Cauliflower	Sinapic acid, Kaempferol glycosides, Quercetin Ferulic acid, Bioactive peptides from protein Hydrolysate,	Chemopreventive, anti-hypertensive, Antioxidant, anti-obesity	Amofa-Diatuo et al., 2017; Gonzales et al., 2014; Xu et al., 2016)
	Beetroot	Phenolic acid	Antioxidants, Anti-hypertensive	Lasta et al., 2019)
	Wheat bran	Phenolic compounds	antioxidant	J. Wang et al., 2008)
	Rice husk	Flavonoids, Glycosides, carotenoids	Anticancer, antioxidant	Perretti et al., 2003)
Seeds	Plum	Bioactive peptides	Antihypertensive, antioxidant	Medina and Barbosa, 2015)
	Jackfruit	Polyphenols, Carotenoids	Anti-oxidant	Lal et al., 2021)
	Mango	Polyphenols, Alkylresorcinol, flavonols, gallotannins, xanthones, phytosterols, sito-sterol, tocopherol		Berardini et al., 2005; Coelho et al., 2019; Torres-León et al., 2016)
	Avocado	Polyphenols, carotenoids	anticancer	(W. Wang et al., 2010)
	Citrus	phenolic acids gallic acid, caffeic acids, deacetylnomilin, nomilin limonene, ichangin, obacunone		(El Kantar et al., 2018; Russo et al., 2014, 2015)

Waste and byproduct flows are produced during production. One member does not have the resources to invest in a valorisation infrastructure or to collect enough byproducts to make a valorisation pathway feasible on their own. Nonetheless, a cooperative composed of farmers can attain a certain magnitude and amass an adequate amount of byproducts (Coop de France, 2017). Cooperatives have an interest in making their byproducts more valuable for reasons related to the economy, environmental and society.

Conclusion and future prospective:

Agri-food waste is a potential source of biomass and is recognized as a rich source of nutrition and functional compounds. Despite, agri-food waste is posing serious threats to the economy, environment and human health. This viewpoint presents a practical solution to environmental and economic–issues. This chapter focuses on the role of agricultural waste in sustainable development, emphasizing its potential to generate bioactive compounds that can improve daily life, support human health, and cost-effectively reduce environmental pollution. Bioactive chemicals can replace a significant portion of the waste generated during the processing of fruits and vegetables. The agri-food waste from a variety of fruits and vegetables waste can be used to make a functional food that mitigates the requirement of artificial ingredients to enhance food quality. This method helps in lowering environmental pollution in addition to improving human health by avoiding possible health hazards related to artificial additives. Utilizing agri-food waste for phytochemical recovery becomes essential when following the circular economy's tenets. Utilizing green, eco-innovative valorization technology can make the production of functional food ingredients and nutritional supplements more economically feasible, health-promoting, and efficient in waste minimization. It is crucial to improve and optimize the process of isolating, extracting, processing, and producing bioactive chemicals from agricultural and food waste using sustainable–methods. The focus is on managing agricultural and food waste effectively and utilizing it in various sustainable ways to recover valuable bioactive products, promote a circular economy, gain socio-technical acceptance, and create a greener environment.

Author Contributions:

ZM conceptualized the review and drafted the manuscript; **NR and AZ.**Supervised, and reviewed the manuscript; **NM. RS and SI** critically reviewed the manuscript and helped with the structure

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Declaration on the Use of Artificial Intelligence (AI):

The authors declare that any artificial intelligence (AI)-assisted technologies used during the preparation of this manuscript were employed solely to improve language, grammar, readability, or formatting. All scientific content, including the study design, data collection, analysis, interpretation of results, and conclusions, was conceived, verified, and approved by the authors. The authors accept full responsibility and accountability for the accuracy, originality, and integrity of the manuscript.

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