Value Added Products from Fruit Waste: A Systematic Review

Ebenezer Laryea[1], Oluwaseyi Omoloso[2], Dilshad Sarwar[3], Chijioke D. Uba[2], Amin Hosseinian-Far[4*] [0000-0002-2534-9044]

[1]Department of Law, University of Northampton, NN1 5PH, UK
[2]Department of Strategy and International Business, University of Northampton, NN1 5PH, UK
[3]Department of Business Systems & Operations, University of Northampton, NN1 5PH, UK
[4]Department of Business Analytics and Systems, University of Hertfordshire, AL10 9AB, UK, a.hosseinian-far@mail.com

Abstract

Food waste contains hazardous compounds that can impact the growth of plants, polluting drinking water, impacting sea life to ultimately contaminating human food consumption. With approximately 1.3 billion tonnes of food is wasted per annum, there is need to mitigate the impact of waste from the different food processing sectors. Specifically, making use of waste from the vegetable and fruit processing sectors is a significant, albeit difficult, task in food sustainability. Numerous studies have explored the potential use of discarded fruits, including their waste materials, for further industrial purposes. Also, the extraction of functional ingredients, extraction of bioactive components, and fermentation of food waste from the vegetable and fruit sector is now the subject of extensive research. This is a systematic review of a selection of a range of relevant original studies that assess the potential of upcycling food waste (particularly fruit waste) – turning food waste into ingredient item/s to produce value added consumer products. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines underpins the method applied to the identification, eligibility evaluation and final selection of relevant studies. Findings from the review show the potential of repurposing fruit waste, using different methods, into added-value material for a wide range of products such as bioethanol, biohydrogen, ethanol, fertilisers, bio-oil and sanitary pads.

Keywords: Fruit Waste, Circular Economy, Upscaling, Agro-Waste

1. Introduction, and Background

Food Waste (FW) refers to the food leftovers of households, and bioprocessing sector including the fresh produce manufacturing, and the hospitality industry (Paritosh, et al., 2017). There are various FW categorisations, nonetheless, a recognised group of such waste relate to fruit and vegetable leftovers. There has been a significant increase in demand for fruit and vegetable produce as the global population increases so does the demand for fresh produce (Balali, Yar, Dela, & Adjei-Kusi, 2020). With this growth and demand placed on requests for fresh produce there are also significant side effects which impacts the level of waste and by-products. Waste and by-products have become a significant negative impact of this growth (Chaouch & Benvenuti, 2020). Moreover, this increased level of waste which ultimately contains hazardous compounds can impact the growth of plants, polluting drinking water, impacting sea life to ultimately contaminating human food consumption (Singh & Kalamdhad, 2011). This level of waste has a fundamental issue for the environment at a global level, but also poses critical debates around symmetric availability of food for different groups of population (Sehnem, Pereira, Junior, Bernardy, & Lara, 2022).

Within agriculture and food literature, there are several instances of waste-to-value applications of food waste, and the rise in related studies can be attributed to the high cost, energy consumption, and the carbon food print associated with food production in the first place (Aschemann-Witzel, et al., 2021). However, at the same time, it is also argued that relying on food waste as an input to emerging industrial processes, places an unsustainable need for creation of such waste, and in fact has a negative feedback loop for solving the food waste problem (Pleissner, 2018).

It has become increasingly essential to ensure that the correct methods are used to remove and dispose of bio-waste which will ultimately support the necessary requirements to reduce the negative impacts on the environment. Mango, Papaya and Pineapple are considered exotic fruits which albeit very popular fruit at a global level (Evans, Ballen, & Siddiq, 2017), unfortunately have a high level of waste. Considering this, a particular focus is placed on fruit waste resulting from processing these exotic fruits in this systematic review. This review provides clarity in terms channelling food waste by-products to ultimately make a positive impact on the economic and global environment by enabling the production of valued products.

This review is structured as follows: Section 2. outlines the methodology used for identifying and extracting relevant information from original studies. Section 3. includes data and evidence extracted from the included studies. Section 4. provides a critical discussion to assess our findings against existing literature in the field. The review is concluded in Section 5.

2. Materials and Methods

2.1. Study Selection

This systematic review has been conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. In order to identify relevant studies, the Science Direct and MarketLine databases were systematically searched, using the keywords of 'Fruit Waste', 'Agro-Waste', 'Agro-Fruit Waste, 'Mango', 'Pineapple', 'Coconut, 'Papaya', 'Circular Economy', and 'Upcycling'. The search was conducted to identify studies and articles that were published from 1st January 2012 up until 26th August 2022. No geographical filter was applied in relation to the place of research or publication, in order to maintain the comprehensiveness of the search. The search strategy used for the Science Direct database is outlined below:

> (“fruit waste" OR “agro-waste” OR “agro-fruit waste”) AND ("Mango" OR "Pineapple" OR "Coconut" OR "Papaya") AND (“Circular Economy” OR “upcycling”).

After the initial search, a total of 260 studies were identified. An additional 12 studies were included through other sources e.g., by reviewing the reference lists within the identified articles. Of the 271 identified studies, 54 were omitted due to unavailability of their full text. The remaining articles were screened by title and abstract, and in accordance with the inclusion and exclusion criteria, and as a result, an additional 110 studies were excluded. The remaining 107 studies entered the eligibility evaluation phase and were therefore examined by reading the full text. From the eligibility evaluation phase, 80 further studies were omitted, and 27 studies were selected for final evidence extraction. To avoid bias, both stages of screening and eligibility evaluation were conducted by 5 project team members independently, and in cases of uncertainties around inclusion or exclusion of a study, a more experienced reviewer supported to finalise the selection. The stages of study selection are outlined in the PRISMA Flow Diagram below (Figure 1.)

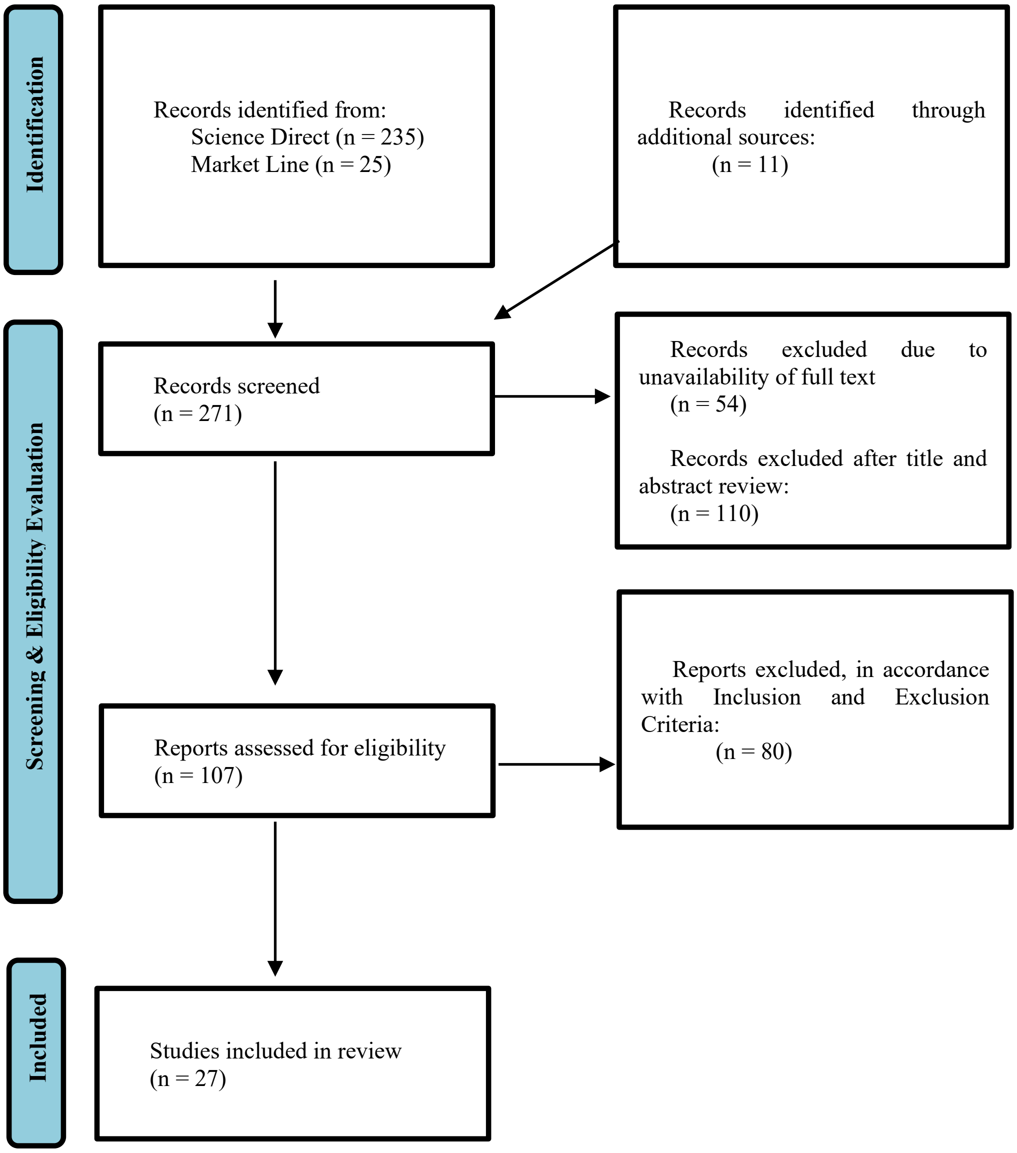

Figure 1: PRISMA Flow Diagram for Study Selection.

2.2. Inclusion and Exclusion Criteria

Criteria used to include studies are outlined below:

- Articles, reports, or studies that have reported both the waste ingredients, and the final product,
- Studies published in English,
- Studies with full text available,
- Studies that have reported on tested and marketable products.

Criteria for excluding studies were:

- Review papers of any sort,
- Studies in languages other than English,
- News articles.

3. Data Extraction and Results

To extract relevant information from the included studies, a checklist appropriate to the study aim and focus was designed. The checklist included, the first author's surname, year of publication, raw material (waste), process for converting the waste into another substance, component, or material, and an example of final product. Data extracted from the final studies are presented in Table 1.

Table 1: Collected Information from Included Studies.

Author	Year	Raw Material	Process	Added-Value Material	Example Final Product
Aili Hamzah et al. (Aili Hamzah, et al., 2022)	2022	Pineapple	Anaerobic co-digestion	Biogas	Methane Production
Banerjee et al. (Banerjee, Vijayaraghavan, Arora, MacFarlane, & Patti, 2016)	2016	Mango Peels	Extraction of Pectin	Lemon	Pectin
Kengkhetkit and Amornsakchai (Kengkhetkit & Amornsakchai, 2014)	2013	Pineapple	Biomass	Polypropylene	Natural fibre
Krishnan et al.	2020	Mango	Biomass	Biogas	Energy

(Krishnan, Agarwal, Bajada, & Arshinder, 2020)					
Gómez-García et al. (Gómez-García, et al., 2022)	2022	Melon	Bioactive	Phenolic	Natural fibre
Basak et al. (Basak, et al., 2020)	2020	Pineap-ple	Biomass	Biohythane	Energy
Ghosh et al. (Ghosh, Kar, Chatterjee, Bar, & Das, 2021)	2021	Pineap-ple	Adsorption	biomateri-als	Energy
Picha et al. (Pocha, et al., 2022)	2022	Agro (fruit) waste	Pyrolysis & hydrothermal liquefaction	Alterna-tive/green en-ergy base	Biofuel and green diesel
del Pilar Sanchez-Camargo et al. (del PilarSánchez-Camargo, et al., 2019)	2019	Mango Peel	Box-Behnken opti-mization of MP	Sunflower oil antioxidant	Alternative for MP valorisa-tion - Food anti-oxidant
Zhu et al. (Zhu, et al., 2022)	2022	Agro residue	Pyrolytic conversion of agro residues	Biochar	Energy; Soil amendment; ac-tivated soil sub-stitution
Nday-isenga et al. (Ndayisenga, et al., 2021)	2021	Straw	Microbial electrohydro-genesis & dark fermentation	Biore-sources - nu-merous	Biohydrogen
El-egbede et al. (Elegbede, Ajayi, & Lateef, 2021)	2021	Corn-cob	Microbial valorisation	Range of biotech prod-ucts (e.g., en-zymes, biofu-els	Bioethanol; biohydrogen

Market-line (MarketLine, 2020)	2020	Apple, Avocados, Citrus fruits, Asparagus, Mangoes	Blending and then extracting Lipid Molecules	Lipid	Plastic packaging reduction, fresh produce waste reduction
Market-line (MarketLine, 2018)	2018	Fibre from Banana tree stems	Unknown	Unknown	Sanitary pads
Orejuela et al. (Orejuela, et al., 2020)	2020	Mango By-products	Oil/Butter Extraction	Deep eutectic solvents (DES)	Mango seed oil and butter; natural colorants from: pressed seed (orange), mango peel (green) and mango pulp (light yellow); mango peel flour; ground seed (cotyledon); lip balm; moisturizing cream.
Neenu et al. (Neenu, et al., 2022)	2022	Pineapple	Acid Hydrolysis	Biomass waste	Nano paper for food packaging applications
Wang et al. (Wang, et al., 2022)	2022	Mango Seed	Adsorption	Bio sorbents	Heavy metal recovery/ removal from (waste)water
Ahmed et al. (Ahmed, et al., 2021)	2021	Watermelon Seeds	Pyrolysis	Biochar	Pb (II) removal from water/wastewater
Atub et al. (Atub, Othman, Yusop, Khan, & Zakria, 2021)	2021	Palm Oil Fuel Ash Waste	Simple and single-step chemical activation method	Graphene	"POFA derived graphene (PDG) nanosheets

Muru-ganantham et al. (Muruganantham, Wang, & Liu, 2022)	2022	Mango Peel	Facile Carbonization	NS-MPC	Battery Anode
Luna-Avelar et al. (Luna-Avelar, et al., 2021)	2021	Mango peel (MP) and mango seed (MS), and microalgal residue biomass (MRB)	Anaerobic digestion (AD)	Biogas	Energy
Siddiqui et al. (Siddiqui, et al., 2022)	2022	All fruit waste	Black soldier fly larvae (BSFL	Higher value biomass	Animal feed
Jacqueline et al. (Jacqueline, et al., 2022)	2022	Pomegranate peel (PP)	Catalytic microwave preheated co-pyrolysis	Biomass	Bio-oil/Bio-char
Jahid et al. (Jahid, Gupta, & Sharma, 2018)	2018	Banana, Papaya, Pineapple and Mango Peels	Enzymatic hydrolysis and fermentation	Bioethanol	Bioethanol
Gunarathne et al. (Gunarathne, et al., 2019)	2019	Coconut waste	Bio based process	Coconut Milk	Coconut Milk
Mota et al. (Mota, da Boa Morte, Cerqueira eSilva, & Chinalia, 2020)	2020	Rambutan fruit peels	Lypholization	Ethanol	Sunscreen
Schmidt et al.	2021	Coconut shells	Homogenisation	Cement	Concrete

(Schmidt, et al., 100047)					

4. Discussion

The systematic review process employed in this study has culminated in the selection of a range of relevant papers which assess the extent to which agricultural waste (particularly fruit waste) can be upcycled as an ingredient item to produce value added consumer products. The studies included in Table 1, each represent a researched assessment of how different kinds of fruit waste can be upcycled. In populating Table 1, the research team has focused mainly on studies which reported the upcycling of selected specific fruit wastes such as coconut shells, pomegranate peels, pineapple peels, as well as mango seeds and peels. In addition to these, the research team have also included papers on the upcycling of other fruit and agricultural wastes may provoke some interest in other wastes which can be upcycled.

From the reviewed studies, there is a considerable focus on getting energy out of the fruit waste. Three of the studies, outline processes and activities the lead to the generation of biogas as a by-product for methane (Aili Hamzah, et al., 2022), and energy production (Krishnan, Agarwal, Bajada, & Arshinder, 2020) (Luna-Avelar, et al., 2021). Two other included studies also focused on the production of energy from the fruit waste, yet the value-product in these articles were not necessarily biogas (Basak, et al., 2020) (Ghosh, Kar, Chatterjee, Bar, & Das, 2021). Historically, there have been several attempts to recover energy from waste materials. Municipal solid waste (MSW) is an instance of these attempts for generating refused-derived fuel (Reinhart, Podder, & Bolyard, 2022), although inefficient traditionally, many endeavours have been provided to optimise the process.

From our Systematic Review, it is also evident that some attempts are being made on producing carbon-based products out of fruit wastes. In two studies (Zhu, et al., 2022) (Ahmed, et al., 2021), processes for obtaining biochar from the waste are outlined. In another piece of research (Muruganantham, Wang, & Liu, 2022), carbon is produced out of pineapple peels to be used as Sodium Ion batteries. Availability of Lithium as key material required for manufacturing lithium-based batteries is critical (Egbue, Long, & Kim, 2022), thus research and innovation in the field of Sodium Ion batteries as an alternative is like to gain further attention by many manufacturers. In another study, the process for converting palm oil to graphene was presented (Atub, Othman, Yusop, Khan, & Zakria, 2021).Considering the high carbon content on organic waste, producing carbon-based value-added materials is a sensible practice.

Our study has also revealed other diverse material outputs created from fruit and vegetable wastes. Bioethanol (Jahid, Gupta, & Sharma, 2018), coconut milk (Gunarathne, et al., 2019), biomass (Jacqueline, et al., 2022) (Neenu, et al., 2022), organic cement from coconut shells (Schmidt, et al., 100047), bio sorbents (Wang, et al., 2022), lipid (MarketLine, 2020), enzymes (Elegbede, Ajayi, & Lateef, 2021), biohydrogen (Ndayisenga, et al., 2021), Phenolic (Gómez-García, et al., 2022), Biohythane (Basak, et al., 2020), nature-based Polypropylene (Kengkhetkit &

Amornsakchai, 2014), and citrus oil (Banerjee, Vijayaraghavan, Arora, MacFarlane, & Patti, 2016) where the other examples of by-products from our study. Such diversity of final waste-derived products in our study is in-line with the reported results of other similar systematic reviews (Magama, Chiyanzu, & Mulopo, 2022).

Over the last decade, the publication of systematic reviews of methods and applications of upcycling fruit waste has been on the rise. The upward trajectory of systematic reviews in this area has been fuelled, in large part, by the universal embrace of the United Nations Sustainable Development Goals (UNSDG's) and the need for industries to reduce and repurpose waste (Caldera, Jayashinge, Desha, Daws, & Fergusen, 2022). The UNSDGs challenge business to make their processes more sustainable by doing more and better with less through upcycling and industrial symbiosis. Taken in its most basic form, upcycling is defined as the reuse, repair or repurposing of waste material to avoid conventional endpoint disposal. Whilst research studies and applications are on the rise in this area, the concept of upcycling, and the opportunities it presents businesses to enhance their sustainability credentials and expand their revenue streams remains somewhat of a niche practice (Caldera, Jayashinge, Desha, Daws, & Fergusen, 2022).

Findings from the review show the potential of repurposing fruit waste through bioscience into several bioeconomy products such as bioethanol, biohydrogen, ethanol, fertilisers, bio-oil and sanitary pads. As global population is projected to grow 9.7 billion people by 2050 (Sadigov, 2022), these products generated from fruit waste can play a key role in replacing finite fossil resources. This presents an opportunity for several businesses in the fresh produce manufacturing sector, as well as in hospitality and food sectors to adopt new business models to capitalise on the upcycling of the fruit waste that they generate from their day-to-day operation, potentially leading to new revenue streams and equally important, contribute to solving global sustainability challenges.

4.1. Limitations

To search and identify relevant studies, only the Science Direct, and MarketLine databases were searched. A more comprehensive search plan can be conducted on other relevant resources management systems and repositories, including Scopus and Web of Science. Additionally, one of the exclusion criteria for study selection was omission of articles written and published in languages other than English. This limits the comprehensiveness of the search.

5. Conclusion

In this systematic review, reported results of 27 selected articles that had assessed development and manufacture of valuable by-products from fruit waste, were extracted. The added-value materials, and sectors, or products that use the converted material are very diverse, ranging from Carbon, and Graphene for manufacturing nano-sheets or battery anodes in sodium ion batteries, to lipids being used for manufacturing bio-compostable packaging materials. Nonetheless, the viability of the introduced upcycling value chains in the existing studies require further investigation i.e. to: a) examine the availability of the fruit and vegetable wastes for the emerging supply chain, and avoidance of unnecessary pressures for the creation of more waste, b) conduct market analyses to analyse the cost-effectiveness and the desirability of the final manufactured value-added product within the market, and c) thoroughly and systemically scrutinise the environmental and social impacts of the newly introduced value chain.

References

Ahmed, W., Mehmood, S., Núñez-Delgado, A., Ali, S., Qaswar, M., Shakoor, A., . . . ChenD. (2021). Enhanced adsorption of aqueous Pb(II) by modified biochar produced through pyrolysis of watermelon seeds. *Science of The Total Environment, 784*, 147136.

Aili Hamzah, A. F., Hamzah, M. H., Mazlan, M. I., Che Man, H., Jamali, N. S., Siajam, S. I., & Show, P. L. (2022). Optimization of subcritical water pre-treatment for biogas enhancement on co-digestion of pineapple waste and cow dung using the response surface methodology. *Waste Management, 150*, 98-109.

Aschemann-Witzel, J., Bizzo, H. R., Doria Chaves, A. C., Faria-Machado, A. F., Gomes Soares, A., de Oliveira Fonseca, M. J., . . . Rosenthal, A. (2021). Sustainable use of tropical fruits? Challenges and opportunities of applying the waste-to-value concept to international value chains. *Critical Reviews in Food Science and Nutrition*, 1-13.

Atub, M., Othman, M. H., Yusop, M. Z., Khan, I. U., & Zakria, H. S. (2021). Facile and economical, single-step single-chemical method for conversion of palm oil fuel ash waste into graphene nanosheets. *Applied Materials Today, 25*, 101193.

Balali, G. I., Yar, D. D., Dela, V. G., & Adjei-Kusi, P. (2020). Microbial Contamination, an Increasing Threat to the Consumption of Fresh Fruits and Vegetables in Today's World. *International Journal of Microbiology*.

Banerjee, J., Vijayaraghavan, R., Arora, A., MacFarlane, D. R., & Patti, A. F. (2016). Lemon Juice Based Extraction of Pectin from Mango Peels: Waste to Wealth by Sustainable Approaches. *ACS Sustainable Chem. Eng., 4*(11), 5915–5920.

Basak, B., Saha, S., Chatterjee, P. K., Ganguly, A., Chang, S. W., & Jeon, B. (2020). Pretreatment of polysaccharidic wastes with cellulolyticAspergillusfumigatusfor enhanced production of biohythane in a dual-stage process. *Bioresource Technology, 299*, 122592.

Caldera, S., Jayashinge, R., Desha, C., Daws, L., & Fergusen, S. (2022). Evaluating Barriers, Enablers and Opportunities for Closing the Loop through 'Waste Upcycling: A Systematic Literature Review. *Journal of Sustainable Development of Energy, Water and Environment Systems, 10*(1).

Chaouch, M. A., & Benvenuti, S. (2020). The role of fruit by-products as bioactive compounds for intestinal health. *Foods, 9*(11), 1716.

del PilarSánchez-Camargo, A., Gutiérrez, L., Vargas, S. M., Martinez-Correa, H. A., Parada-Alfonso, F., & Narváez-Cuencaa, .. (2019). Valorisation of mango peel: Proximate composition, supercritical fluid extraction of carotenoids, and application as an antioxidant additive for an edible oil. *The Journal of Supercritical Fluids, 152*, 104574.

Egbue, O., Long, S., & Kim, S. D. (2022). Resource Availability and Implications for the Development of Plug-In Electric Vehicles. *Sustainability, 14*(3), 1665.

Elegbede, J. A., Ajayi, V. A., & Lateef, A. (2021). Microbial valorization of corncob: Novel route for biotechnological products for sustainable bioeconomy. *Environmental Technology & Innovation, 24*, 102073.

Evans, E. A., Ballen, F. H., & Siddiq, M. (2017). Mango production, global trade, consumption trends, and postharvest processing and nutrition. In *Handbook of Mango Fruit* (pp. 1-16). Chichester: John Wiley & Sons.

Ghosh, I., Kar, S., Chatterjee, T., Bar, N., & Das, S. K. (2021). Removal of methylene blue from aqueous solution using Lathyrus sativus husk: Adsorption study, MPR and ANN modelling. *Process Safety and Environmental Protection, 149*, 345-361.

Gómez-García, R., Sánchez-Gutiérrez, M., Freitas-Costa, C., Vilas-Boas, A. A., Campos, D. A., Aguilar, C. N., . . . Pintado, M. (2022). Prebiotic effect, bioactive compounds and antioxidant capacity of melon peel (Cucumis melo L. inodorus) flour subjected to in vitro gastrointestinal digestion and human faecal fermentation. *Food Research International, 154*, 111045.

Gunarathne, D. S., Udugama, I. A., Jayawardena, S., Gernaey, K. V., Mansouri, S. S., & Narayana, M. (2019). Resource recovery from bio-based production processes in developing Asia. *Sustainable Production and Consumption, 17*, 196-214.

Jacqueline, P. J., Muthuraman, V. S., Karthick, C., Alaswad, A., Velvizhi, G., & Nanthagopal, K. (2022). Catalytic microwave preheated co-pyrolysis of lignocellulosic biomasses: A study on biofuel production and its characterization. *Bioresource Technology, 347*, 126382.

Jahid, M., Gupta, A., & Sharma, D. K. (2018). Production of Bioethanol from Fruit Wastes (Banana, Papaya, Pineapple and Mango Peels) Under Milder Conditions. *Journal of Bioprocessing & Biotechniques, 8*(3), 1000327.

Kengkhetkit, N., & Amornsakchai, T. (2014). A new approach to "Greening" plastic composites using pineapple leaf waste for performance and cost effectiveness. *Materials & Design, 55*, 292-299.

Krishnan, R., Agarwal, R., Bajada, C., & Arshinder, K. (2020). Redesigning a food supply chain for environmental sustainability – An analysis of resource use and recovery. *Journal of Cleaner Production, 242*, 118374.

Luna-Avelar, K. D., Barrena, R., Font, X., Sánchez, A., Santos-Ballardo, D. U., Germán-Báez, L. J., & Valdez-Ortiz, A. (2021). A preliminary assessment of anaerobic co-digestion potential of mango and microalgal residue biomass using a design of experiments approach: Effect of thermal, physical and biological pretreatments. *Food and Bioproducts Processing, 128*, 143-152.

Magama, P., Chiyanzu, I., & Mulopo, J. (2022). A systematic review of sustainable fruit and vegetable waste recycling alternatives and possibilities for anaerobic biorefinery. *Bioresource Technology Reports*, 101031.

MarketLine. (2018). *Success Case Study: Saathi Pads - Disrupting the Feminine Hygiene Sector with an Eco-Friendly, Natural, and Safe Alternative*. (MarketLine) Retrieved 2022, from https://www.researchandmarkets.com/reports/4605684/success-case-study-saathi-pads-disrupting-the

MarketLine. (2020). *Footwear retailers ramp up sustainability efforts*. (Market Line) Retrieved 2022, from https://www.marketline.com/blog/footwear-retailers-ramp-up-sustainability-efforts/

Mota, M. D., da Boa Morte, A. N., Cerqueira eSilva, L. C., & Chinalia, F. A. (2020). Sunscreen protection factor enhancement through supplementation with Rambutan (Nephelium lappaceum L) ethanolic extract. *Journal of Photochemistry and Photobiology B: Biology, 205*, 111837.

Muruganantham, R., Wang, F., & Liu, W. (2022). A green route N, S-doped hard carbon derived from fruit-peel biomass waste as an anode material for rechargeable sodium-ion storage applications. *Electrochimica Acta, 424*, 140573.

Ndayisenga, F., Yu, Z., Zheng, J., Wang, B., Liang, H., Phulpoto, I. A., . . . Zhou, D. (2021). Microbial electrohydrogenesis cell and dark fermentation integrated system enhances biohydrogen production from lignocellulosic agricultural wastes: Substrate pretreatment towards optimization. *Renewable and Sustainable Energy Reviews, 145*, 111078.

Neenu, K. V., Midhun Dominic, C. D., SaburaBegum, P. M., Parameswaranpillai, J., Kanoth, B. P., David, D. A., . . . Badawi, M. (2022). Effect of oxalic acid and sulphuric acid hydrolysis on the preparation and properties of pineapple pomace derived cellulose nanofibers and nanopapers. *International Journal of Biological Macromolecules, 209*, 1745-1759.

Orejuela, L., Arroyo, E., Gualle, A., Andino, C., Lagos, A. S., & Landázuri, A. C. (2020). Mango (Mangifera Indica L.) by-products for cosmetic, food and water treatment applications: A zero-waste and biorefinery approach with classic and new generation solvents. *AIChE Annual Meeting.* Virtual.

Paritosh, K., Kushwaha, S. K., Yadav, M., Pareek, N., Chawade, A., & Vivekanand, V. (2017). Food Waste to Energy: An Overview of Sustainable Approaches for Food Waste Management and Nutrient Recycling. *BioMed research international, 2017*.

Pleissner, D. (2018). Recycling and reuse of food waste. *Current Opinion in Green and Sustainable Chemistry, 13*, 39-43.

Pocha, C. K., Chia, S. R., Chia, W. Y., Koyande, A. K., Nomanbhay, S., & Chew, K. W. (2022). Utilization of agricultural lignocellulosic wastes for biofuels and green diesel production. *Chemosphere, 290*, 133246.

Reinhart, D. R., Podder, A., & Bolyard, S. C. (2022). A Brief History of Energy Recovery from Municipal Solid Waste. In *Energy from Waste.* CRC Press.

Sadigov, R. (2022). Rapid Growth of the World Population and Its Socioeconomic Results. *The Scientific World Journal*.

Schmidt, W., Commeh, M., Olonade, K., Schiewer, G. L., Dodoo-Arhin, D., Dauda, R., . . . Rogge, A. (100047). Sustainable circular value chains: From rural waste to feasible urban construction materials solutions. *Developments in the Built Environment, 6*, 2021.

Sehnem, S., Pereira, L. H., Junior, S. S., Bernardy, R. J., & Lara, A. C. (2022). Management of food waste in restaurants by way of circular practices. *Journal of Material Cycles and Waste Management, 24*, 1020–1036.

Siddiqui, S. A., Ristow, B., Rahayu, T., Putra, N. S., Yuwono, N. W., Nisa, K., . . . Nagdalian, A. (2022). Black soldier fly larvae (BSFL) and their affinity for organic waste processing. *Waste Management, 140*, 1-13.

Singh, J., & Kalamdhad, A. S. (2011). Effects of heavy metals on soil, plants, human health and aquatic life. *Int J Res Chem Environ, 1*(2), 15-21.

Wang, Q., Wang, Y., Yang, Z., Han, W., Yuan, L., Zhang, L., & Huang, X. (2022). Efficient removal of Pb(II) and Cd(II) from aqueous solutions by mango seed biosorbent. *Chemical Engineering Journal Advances, 11*, 100295.

Zhu, X., Labianca, C., He, M., Luo, Z., Wu, C., You, S., & Tsang, D. C. (2022). Life-cycle assessment of pyrolysis processes for sustainable production of biochar from agro-residues. *Bioresource Technology, 360*, 127601.