




Promoting Sustainability in Utilizing Halal Food Waste in Producing Value-added Products

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Abstract. The escalating waste generation is becoming an increasingly pressing concern for many countries, including Brunei Darussalam. Every year, tonnes of leftover halal food are consigned to landfills. Landfills remain the most cost-effective and practical disposal method for the government. However, if waste is not managed judiciously, the country faces potential environmental challenges, including the overwhelming accumulation of waste in landfills. Moreover, organic waste disposal can exacerbate global warming, as methane gas is released during the anaerobic decomposition process within landfills. This paper underscores the categorization of waste and introduces the concept of value-added products derived from halal food waste. The goal is to enhance the current state of halal food waste management. Effective waste reduction can bolster halal-certified food enterprises and further the government's aspiration for a robust and sustainable economy, aligning with Goal 12 of the United Nations' Sustainable Development Goals (SDG).

Keywords: Bioproducts, Brunei, Halal Food Waste, Halal Industry, Waste Management.

1 Introduction

Millions of tonnes of halal food waste are discarded annually [1]. Estimates suggest that a supply chain wasting event accounts for one-third of the global food produced for human consumption [2], contributing to 6.8% of the world's total greenhouse gases [3, 4]. In response, the European Union (EU) has proposed the Circular Economy Package, with a target of 65 percent municipal waste recycling by 2030 [5]. In light of this, waste streams can be transformed into valuable resources by embracing a circular economy approach [6].

Waste management is one of the most pressing challenges of the 21st century. In Brunei Darussalam, food waste has emerged as a boiling concern given its distinction as the highest waste generator in ASEAN, consequently positioning the Sultanate as a leading contributor to greenhouse gas emissions per capita [7]. Landfills are overflowed with food waste, where its decomposition results in the further release of greenhouse

gases. While the contribution of halal food waste remains undetermined, the significant Muslim population in the country implies a substantial amount [8].

Hence, it is imperative for the Brunei government to initiate prompt measures to manage this concern, with a particular focus on wastes from the disposal of halal food. The halal industry should implement a comprehensive waste management programme to reduce food loss and waste (FLW). Considerations for waste reduction span across design, production, and human resources [9, 10], as well as operations, distribution, and inventory sections [11]. This paper aims to elucidate the benefits of waste management by highlighting the potential of converting waste into value-added products. This piece intends to guide the halal industry in optimizing waste management practices, emphasizing recycling and producing value-added products.

Despite the significance of waste management, there remains a noticeable gap in the halal, sustainability and waste management literature [1], especially concerning Brunei Darussalam.

2 Material and Methods

The research adopted a qualitative methodology, drawing primarily from an extensive grey and white literature review. Grey literature sources encompassed government publications from agencies such as the Department of Environment, Parks and Recreation, and the Ministry of Development. Media reports from outlets including the Brunei Times, the Scoop, and the Borneo Bulletin, as well as authoritative websites, particularly those aligned with the Ministry of Development, provided context-specific insights about Brunei. Complementing this, white literature provided a broader perspective, with relevant documents, academic journals, and conference proceedings offering depth and nuance. This study aims to provide a comprehensive understanding and enrich the prevailing discourse on the subject by collating and critically examining these diverse sources.

3 Results and Discussion

Managing food waste and manufacturing value-added goods were identified based on the review of relevant information. Under the ensuing sub-headings, the findings are discussed:

3.1 Waste Management in Brunei

Food that is edible or suitable for human consumption but has been discarded after its date of expiration, after quality has deteriorated, after decay has occurred, or after insect consumption has occurred is considered waste [12]. The subsequent waste or disposal in landfills of one-third of all food produced for human consumption causes environmental damage. Furthermore, a significant part of food waste must be managed appropriately before being burned or disposed of, or it is illicitly diverted into the unauthorised system for use as cooking oil or cattle feed, thereby causing substantial food safety

concerns [12]. Globally, the importance of food safety at each level of the supply chain is rising as a fundamental pillar of a sustainable and prosperous society [13].

A well-controlled waste recycling system is necessary, whether for human consumption or animal feed, in order to guarantee the value-added product is secure and safe for ingestion. Food waste reduction is unquestionably a big job that includes many people [13]. More and more people are considering using environmentally friendly technology to handle and avoid food waste to strengthen global food and waste systems [14].

Anaerobic digestion, landfilling, incineration, and composting are described and compared in the majority of earlier studies on organic or food waste management alternatives [15, 16, 17]. In certain studies, the comparison also considers animal feed [18, 19, 20]. Some studies also cover the benefits of preventing food waste on the environment. As an example, Gentil et al. [21] predicted that a food waste stream could be decreased by 20%, but they did not explain how or how much it would cost. Another preventive trial by Salhofer et al. [22], contrasted prevention with charitable donations; however, the efficacy of the measure was not assessed. In addition, instead of considering other options, Schneider [23] evaluated donated food based on its emissions related to production.

The operational aspect of waste management in Brunei comprises door-to-door garbage collection and disposal. The Department of Environment, Parks and Recreation (DEPR), Ministry of Development of Brunei, maintains a list of registered garbage collectors on its website. The general public can also use the nation's waste collection facilities, which contractors chosen by the DEPR run.

However, in Brunei, landfill is the only more accessible and affordable disposal option—and the most widely used one [24]. Unfavourable environmental effects result from releasing industrial food organic waste into the environment. Brunei has one of the region's most outstanding food waste rates, despite its small population of approximately 400,000 people. According to Shams, et al. [24], Brunei ranks second among ASEAN countries with an average daily production of 1.4 kg of solid trash per person. But, according to estimates, only 11.3% of food waste has been recycled, and only 2% was utilized to make compact, leaving the remaining 70% to be disposed of in landfills [25].

After examining several papers and articles, Laurent et al. [16, 17] found a pattern in studies contrasting various waste management techniques. Thermal treatment, composting, and landfilling were the least desirable options. The preferred method was anaerobic digestion. Nevertheless, not all research adhered to this pattern. Laurent et al. [16] came to the conclusion that the success requires the local infrastructure.

The al-Qur'anic explanation of the *halalan thayyiban* principle forms the foundation of the halal food sector. A component of the holistic concept is Shariah-compliant guidelines for the production and consumption of food. Islam also teaches fundamental dietary habits like refraining from overindulging and being charitable to our neighbours and loved ones [26]. The current halal standard and criteria in Brunei, which follow the *halalan thayyiban* principle, may overlook critical factors that should be considered, particularly in the management of waste. In contrast, the guideline for MS1500:2019 and MMPHC (D) in Malaysia has added waste management as a need for *thayyiban* management [27].

Using waste energy technology, 99% of waste was recycled in Sweden, whereas just 11.3% of Brunei's waste was recycled [28]. Therefore, a shift in waste management is necessary for the industry to achieve the objective of environmental conservation. The question is which waste management strategy from the numerous options should be adopted to obtain environmental benefits. This study aimed to understand the many food waste management options available to the industry. The main objective was to provide more detailed information about implementing zero-waste or waste-reduction practices that produced value-added products.

3.2 Type of Waste

Food waste makes up 36% of Brunei's garbage, while paper, plastic, metal, glass, wood, and textiles comprise a substantial portion of the remaining 55% [24]. According to other research, the four main waste kinds in Brunei dumped at the Sungai Paku Engineered Landfill are around 32% food waste, 29% plastic, 11% green waste, and 10% paper [25, 29]. The majority of the residual garbage, including nonrecyclables and non-reusables items, is dumped in the engineered landfill at Sungai Paku despite the country's strong encouragement to use the 3Rs - Reduce, Reuse, and Recycle - to manage waste. Jais [27] asserted that diverse waste forms require careful handling and management, particularly in halal-certified companies. Waste management is a component of thayyiban management in the halal assurance system. Table 1 lists the different waste types.

Table 1. Type of Waste

No	Type of Waste	Details
1	Liquid waste	Waste that is liquid or semi-solid in consistency. The sewage system receives wastewater immediately. Before entering the sewage system, blood and animal faeces are treated. Waste management companies dispose of used oil and fats.
2	Solid Waste	Non-organic waste that cannot be recycled.
3	Bulk Size waste	Large-scale solid waste that must be transported using specialist equipment.
4	Organic waste	Waste derived from food waste and biodegradable
5	Recyclable waste	Waste in the form of glass, paper and cans can be recycled. It generates extra revenue for the establishment.
6	Hazardous waste	Chemical and biological waste such as cleaning supplies, pest control chemicals, and infected carcasses (for slaughterhouses). This requires a specialized waste disposal method.
7	Non-Halal compliant waste	Waste that is confirmed to be Haram, or suspected to be Haram or contaminated with Haram ingredients. Discarded the material through the Sertu process.

Source: [41]

3.3 Value-added Product from Halal Food Waste

Halal is a term that refers to what the Shariah permits or allows. Regarding food, the word "halal" denotes that both the meal itself and the trading or commerce procedure involved are permitted or authorized by Islamic law, and Muslims are allowed to consume the food.

As a result, value-added products from food waste can be described as finished goods that utilise halal waste materials, process them according to Islamic law, and then generate goods.

Because of this, a carefully regulated system of recycling waste for human use or as animal feed is required to guarantee that the product is secure and safe to eat. Undoubtedly, eliminating food waste is a large task involving many people [13]. More and more people are looking into using ecologically friendly technology to treat and prevent food waste to create more robust food and waste systems throughout the world [14].

From a life cycle perspective, the environmental alternative of the waste management method in the case of food waste usually takes precedence over the environmental choice [16], and this is dependent on local conditions. For example, the European Waste Framework Directive (WFD) creates a hierarchy prioritising waste management and prevention. Guidelines mainly pertaining to food waste can also be found in the Netherlands, known as the Moerman ladder [30]. Another instance is the Food Recovery Hierarchy in the United States [31] and the UK’s Food Waste Pyramid, which were developed by the Feeding the 5000 Alliance to assist food businesses in minimising waste. All these hierarchies of waste reduction have been tabulated in Table 2.

Table 2. Food Waste Hierarchy

Waste Management Hierarchy	European Waste Framework Directive	Food Waste Pyramid	Food Recovery Hierarchy	Moerman Ladder
Highest	Prevention Re-use and preparation for re-use Recycle	Reduce Feed people in need Feed livestock	Source reduction Provide food for the needy Feed animals Industrial use	Prevention Use as food for humans Conversion into food for humans Utilise in animal feed Industrial raw materials
	Recovery	Compost & 100% Composting renewable energy		Processing to create a co-fermentation fertiliser Composting as a method of processing to provide fertiliser Utilise for renewable energy sources
Lowest	Disposal	Disposal	Incineration or Landfill	Burning as waste Dumping

Adapted from: [44]

Based on the table, the halal industry could convert food waste into animal feed. Halal animal feeds are gaining market shares in many Muslim countries [32]. Muslims adore meat, and they can only consume meat that are being slaughtered in accordance with Shariah. Even the al-Jallalah animal contaminated with tainted animal feed will undergo a procedure called *al-Istibra'*, a quarantine that goes from filth to purity [33]. Therefore, the animal feed on which they grow and live is also essential per Islamic jurisprudence [34].

Animal feed production necessitates blending plant and animal raw materials with certain components from the pharmaceutical and other sectors. Its natural constituents are inexpensive and easily accessible, but because they include elements of doubt and Haram, they cause Muslims great anxiety. Muslims throughout the world have, therefore, started to emphasise the value of Halal and Thayyib's integrity in creating animal feed and to voice concerns about the present growth of Halal [34].

Thus, it is about time for the halal industry in Brunei to utilize food waste and convert it into value-added products such as animal feed. For instance, Golden Corporation Sdn Bhd was the first company in Brunei to produce Fish Meal where the excess and unmarketable fish are reprocessed into value products. At the same time, the company also makes its aquatic feed for consumption in its shrimp farms and acts as a feed to aqua farmers. This production has helped in reducing marine wastage and pollution [35].

Another instance is Gold Coin (B) Feedmill Sdn Bhd, founded in 2013 and has successfully manufactured animal feed on its own for local use [36]. Despite Brunei having an animal feed industry, the self-sufficiency rate has declined from 42.43% in 2021 to 39.7% in 2022. The importation of livestock feed also increased from 98,678 metric tonnes in 2021 [36] to 106,354 metric tonnes in 2022 [37].

3.4 Brunei Vision Goal 3 – Dynamic and Sustainable Economy

By 2035, the nation hopes to have implemented Wawasan Brunei 2035, also known as Brunei Vision 2035. Brunei aspires to become recognised for its highly educated and skilled labour force that satisfies international standards; its high standard of living, which is among the top ten worldwide; and its dynamic and sustainable economy, with a Gross Domestic Product (GDP) that is among the top ten globally [38].

Brunei's primary source of income and exports is the oil and gas sector. The third goal of Wawasan Brunei 2035 is to make the country a high-income, developed nation based on knowledge and technology. It also seeks to increase private sector engagement while bolstering the state sector's role in achieving the country's economic potential [39]. This action is taken to ensure that the economy will continue to function sustainably for future generations. Therefore, the diversification of the economy should be considered one of the most important concerns for the growth of the country's economy. In order to diversify the economy, one of the potential options is to reduce the amount of wasted food and then transform it into goods that have added value.

3.5 SDG Goal 12 – Responsible Consumption and Production

Growing urbanisation, declining natural resource availability, and an expanding global population mean more people to feed with less water, farmland, and rural labour. In order to satisfy the projected increases in water, energy, and food demands, a shift toward more sustainable production and consumption methods is required. Approximately 690 million people worldwide suffer from malnutrition, while one-third of the food produced is lost or squandered. Farmers must increase food production to sustainably feed the globe while reducing detrimental environmental consequences such as soil, water, nutrient loss, greenhouse gas emissions, and ecosystem degradation. People must be encouraged to transition to nutrient-dense, safe meals that have a low impact on the environment.

Food loss and waste (FLW) is a topic so important that the United Nations (UN) included it in its list of Sustainable Development Goals (SDGs) in order to fulfil its 2030 Agenda. SDG Goal 12 - Ensure sustainable production and consumption patterns - emphasises food waste in the following targets:

12.3 - Reduce food losses throughout the production and supply chains, including post-harvest losses, and cut down on the amount of food wasted per person globally by 2030 at the retail and consumer levels.

12.5 - The creation of garbage should be significantly reduced by the year 2030 by the use of prevention, reduction, recycling, and reuse.

12.6 – Promote the incorporation of sustainability information into the reporting cycles of multinational and large corporations and encourage them to adopt sustainable practises.

The triple global problems comprising pollution, biodiversity loss, and climate change are fundamentally caused by unsustainable production and consumption patterns. These crises and the associated environmental deterioration threaten the success of the SDGs and human well-being. If current development trends continue, the Earth's finite capacity will become insufficient to sustain the lifestyles of both present and future generations. Altering how people engage with the natural world is essential to achieving a sustainable future. As the world develops strategies to generate a new circular economy, reduce waste and pollution, and enhance resource efficiency in the aftermath of the pandemic, governments and all members of society should seize the opportunity to collaborate.

At the Sustainable Development Goals Summit on September 18, 2023, at the United Nations Headquarters in New York, United States of America, Brunei presented their pledges to the Sustainable Development Goals that will have a transformational impact. This was stated by Yang Berhormat Dato Seri Setia Dr Haji Mohd Amin Liew bin Abdullah, Minister at the Prime Minister's Office and Minister of Finance and Economy II in his national statement delivered during the Leaders' Dialogue which deliberated on scaling up further enhance the progress in Goal 12 (Responsible Consumption and Production) by exploring ways to achieve economic, social, and environmental equity by making collective actions towards sustainability such as strengthening legal and institutional frameworks to ensure sustainable management and efficient use of resources and creating economic opportunities from the green and circular economy model [40].

3.6 Recommendations

Brunei has yet to introduce policies or programs specifically targeting halal food waste management. The term 'halal' refers to products (food and non-food) prepared and processed in accordance with Islamic dietary laws. As a Muslim country, Brunei emphasizes halal practices across all facets of life, including waste management. As mentioned at the beginning part of the paper, food waste poses a challenge for many nations, including those of Muslim majority populations. Gradually, more and more countries are recognizing the importance of sustainable waste management, including halal food waste. While Brunei might benefit from policies that explicitly address halal food waste, general waste management strategies and heightened environmental awareness can also influence the reduction in food waste that complies with halal principles.

The following actions can be adopted in Brunei or any other countries facing similar challenges related to food waste:

1. **Education and Awareness:** Spread knowledge among the public, companies, and religious communities about decreasing food waste and how it links with the halal values of not wasting resources. Educational programmes can be operated through various channels, including mosques, schools, and media outlets to encourage responsible disposal methods.
2. **Halal Certification for Waste Management Facilities:** To ensure that Islamic principles do the treatment and disposal of halal food waste, introduce or expand halal certification criteria to waste management facilities.
3. **Encourage Food Redistribution:** Form alliances with non-profit groups to reroute extra halal food from establishments and occasions to those in need, reducing food waste and helping the less fortunate.
4. **Public and Private Sector Collaboration:** Encourage cooperation between the government, the commercial sector, and NGOs to provide halal-compliant, sustainable waste management solutions.
5. **Research and Innovation:** Enhancing halal food waste management research and innovation can create fresh methods and procedures. This may entail investigating effective waste-to-energy systems, waste minimization techniques, and enhanced waste collection techniques.
6. **Waste-to-Energy Projects:** Investigate the practicality of waste-to-energy programmes to reduce the negative effects of garbage disposal on the environment and convert food waste into energy that can be used.
7. **Food Waste Tracking and Analysis:** Implement mechanisms to monitor and track food waste at various supply chain points. This information can be used to monitor the success of waste reduction efforts and pinpoint areas that need improvement.
8. **Composting:** Composting is a practical method for reducing food waste and encouraging sustainability. Halal food scraps can be composted to create organic fertilizer for landscaping or farming. Composting facilities can be used, or families might be urged to compost their organic waste.
9. **Biogas Generation:** Anaerobic digestion, which transforms organic waste into biogas and fertilizer, is another alternative for controlling halal food waste. Using

biogas can lessen fossil fuel dependency by generating power or using it for cooking. One option is building biogas facilities or encouraging companies to use this technology.

10. **Segregation and Collection:** Implementing an effective waste segregation system is crucial. The many sorts of waste, including food waste, should be disposed of in separate bins by households, businesses, and organizations. Specialized collection services or facilities can be established to ensure that halal food waste is correctly disposed of and collected.
11. **Regulatory Framework:** Implementing rules and recommendations, especially for managing halal food waste, can offer a framework for ethical behaviour. Government institutions might collaborate with religious authorities to guarantee that waste management procedures adhere to Islamic ideals.

It is essential to note that these recommendations are general and may require adjustments to suit Brunei's specific context and needs. When formulating and implementing waste management regulations to address food waste, Brunei should take into account cultural and religious factors to ensure alignment with halal values.

4 Conclusion

This paper set out to broaden the understanding of many stakeholders in the industry about the significance of effective waste management and the potential to produce value-added products from waste. In the long term, the paper aspires for more industry participants to judiciously manage waste and commit to transforming food waste into value-added products, thereby generating additional revenue. In conclusion, findings from this study also implicitly advocate for adopting a zero-waste approach within businesses. This principle is paramount for all companies and food enterprises, including Brunei. Consequently, it is hopeful that the insights from this research will assist relevant stakeholders in devising strategies, promoting zero-waste practices, and enhancing environmental consciousness across businesses.

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References

1. A. Sulaiman, N. Othman, A. S. Baharuddin, M. N. Mokhtar and M. Tabatabaei, "Enhancing the Halal Food Industry by Utilizing Food Wastes to Produce Value-added Bioproducts," *Procedia - Social and Behavioral*, vol. 121, pp. 35-43, 2014.
2. J. Gustavsson and e. al., "Global food losses and food waste," The Food and Agriculture Organization of the United Nations, 2011.
3. Food and Agriculture Organisation, "Food Wastage Footprint & Climate Change," Food and Agriculture Organisation of the United Nations, 2015.
4. The World Bank, "Total greenhouse gas emissions (kt of CO₂ equivalent)," 2016.

5. European Commission, "Proposal for Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste.," European Commission, 2015.
6. P. C. Slorach, H. K. Jeswani, R. Cuellar-Franca and A. Azapagic, "Energy Demand and Carbon Footprint of Treating Household Food Waste Compared to its Prevention," *Energy Procedia*, vol. 161, pp. 17-23, 2019.
7. J. Kon, "Making use of food waste," Borneo Bulletin, 2022. [Online]. Available: <https://borneobulletin.com.bn/making-use-of-food-waste/>. [Accessed 12 February 2023].
8. M. S. A. Talib and M. H. Zulfakar, "Sustainable halal food supply chain management in a small rentier halal market," *Arab Gulf Journal of Scientific Research*, 2023.
9. L. Sang, W. Khairuzzaman, R. Abdul, H. Boon and J. Yew, "Sustaining customers's loyalty: A survey of a coating resins manufacturer," *J. Sci. Ind. Res.*, vol. 72, pp. 387-392, 2013.
10. G. Kannan, D. Selladurai and S. Karthi, "Swaging process for productivity improvement in the manufacture of spindles," *J. Sci. Ind. Res.*, vol. 72, pp. 681-684, 2013.
11. M. Manzouri, M. N. Ab-Rahman, C. R. C. M. Zain and E. A. Jamsari, "Increasing Production and Eliminating Waste through Lean Tools and Techniques for Halal Food Companies," *Sustainability*, vol. 6, no. 12, pp. 9179-9204, 2014.
12. W. Sun, M. Shahrajabin and Q. Chend, "Organic Waste Utilization and Urban Food Waste Composting Strategies in China - A Review.," *Notulae Scientia Biologicae*, vol. 13, no. 2, pp. 1-16, 2021.
13. F. Cappelletti, A. Papetti, M. Rossi and M. Germani, "Smart strategies for household food waste management," *Procedia - Computer Science.*, vol. 200, pp. 887-895, 2022.
14. K. Thyberg and D. Tonjes, "The Environmental Impacts of Alternative Food Waste Treatment Technologies in the U.S.," *Technology & Society Faculty Publications*, vol. 3, 2017.
15. A. Bernstad and J. la Cour Jansen, "A life cycle approach to the management of household food waste - a Swedish full-scale case study," *Waste Manag.*, vol. 31, pp. 1879-1896, 2012.
16. A. Laurent, I. Bakas, J. Clavreul, A. Bernstad, M. Niero, E. Gentil, M. Hauschild and T. Christensen, "Review of a LCA applications to solid waste management systems - Part 1: lessons learned and perspectives," *Waste Manag.*, vol. 34, pp. 573-588, 2013a.
17. A. Laurent, J. Clavreul, A. Bernstad, I. Bakas, M. Niero, E. Gentil, T. Christensen and M. Hauschild, "Review of LCA applications to solid waste management systems e Part II: methodological guidance for a better practice," *Waste Manag.*, vol. 34, pp. 589-606, 2013b.
18. S. Lee, K. Choi, M. Osako and J. Dong, "Evaluation of environmental burdens caused by changes of food waste management systems in Seoul, Korea," *Sci Total Environ.*, vol. 387, pp. 42-53, 2007.
19. S. Menikpura, J. Sang-Arun and M. Bengtsson, "Integrated solid waste management: an approach for enhancing climate co-benefits through resource recovery," *J. Clean. Prod.*, vol. 58, pp. 34-42, 2013.
20. T. Vandermeersch, R. Alvarenga, P. Ragaert and J. Dewulf, "Environmental sustainability assessment of food waste valorization options.," *Resour. Conservation Recycl.*, vol. 87, pp. 57-64, 2014.

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