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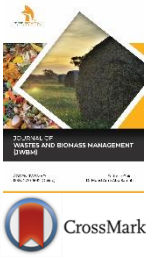

REVIEW ARTICLE

CONVERSION OF KITCHEN FOOD WASTE TO HALAL ORGANIC FERTILIZERS

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ABSTRACT

Food produced for human consumption can be wasted up to one-third of the time, causing economic, social, and environmental harm. The value of kitchen food waste is being increasingly recognised, and Brunei Darussalam ranks among the highest in the region, with a solid waste output of 1.4 kg per capita per day. However, just 11.3% of food waste is estimated to have been recycled, with the remainder ending up in landfills. In this context, the purpose of this paper is to provide recommendations for the most environmentally friendly means of disposing of kitchen food waste, with composting providing natural, halal, eco-friendly fertiliser. Thus, a two-month experiment was conducted to produce compost-based fertilizer from kitchen food waste. The nutritional value of the plant was then ascertained by fertilizing one plant of bird's eye chillies *(Capsicum frutescens* L*)* with compost-based fertilizer (CBF) and another plant with clay-based soil (CBS). The results of this study showed that almost all the macronutrients in CBF plants are in the accepted range and show good compost fertilisation. Thus, it demonstrates how composting food waste from households can aid in the management of waste reduction for sustainable and a healthy environment, and nutrient recycling in agriculture.

KEYWORDS

Brunei, Compost, Kitchen Food Waste, Halal Organic Fertilizers, Green

1. INTRODUCTION

The globe loses or wastes one-third of the food produced for human consumption each year (Ilakovac, et al., 2020; Shahrajabian, et al., 2019; Jeevahan, et al., 2021; Gustavsson, et al., 2011). Similarly, millions of tonnes of discarded halal food are released into the environment annually (Sulaiman, et al., 2014). In India, food waste is a major issue, as well as in other countries including Brunei Darussalam (herein called Brunei) (Kumari, et al., 2020). Despite having a population of only 400,000, Brunei has one of the highest rates of waste production per capita in the region. According to Brunei produces 1.4 kilogrammes (kg) of solid waste per capita every day, second only to Singapore among the ASEAN countries (Shams, et al., 2014). Unfortunately, according to ASEAN statistics from 2017, Brunei continues to be the second-highest country in terms of solid waste creation, with 1.4 kg per capita per day (Azahari, 2022).

Even according to data from 2019, the average person in Brunei produces 1.14 kg of municipal solid garbage daily, ranking the Sultanate as one of the ASEAN region's top waste producers per capita (Borneo Bulletin, 2021; Department of Environment, Parks and Recreation, 2021). The six landfills in Brunei handle 70% of the country's total rubbish, 2% of which is used to generate compost, while the remaining 40% is disposed of using various conventional techniques (Shams, et al., 2014). 2019 marked the highest waste generated at 263,669 MT in Brunei Darussalam and only 11.3% of food waste was recycled; the remainder was dumped in landfills (Kon, 2020; Borneo Bulletin, 2021; Department of Environment, Parks and Recreation, 2021).

Food wastes represent a significant environmental burden by luring pests, producing toxic fumes, and contaminating groundwater, making them purer waste streams that have the potential to cause considerable environmental harm (Okareh, et al., 2014). Food waste must be avoided from residences and institutions, including boarding schools, schools, prisons, sports complexes, industries, etc., to preserve a clean and healthy environment (Okareh, et al., 2014). Composition, a crucial component in the management of food waste, can help with these to make compost that will be used in agricultural farming (Sun-Kee and Hang-Sik, 2004; Okareh, et al., 2014).

Risse and Faucette also claimed that food waste might convert into compost, which could be useful for agricultural applications to boost output due to the compost's high carbon and nitrogen ratio (Risse and Faucette, 2009). The delayed release of nitrogen from food waste composts allows for a steady, moderate rate of plant development, which is very ideal for urban farming (Sullivan et al., 2002). Composts are more agriculturally safe than fresh wastes because they contain less phytotoxic compounds and more stable organic materials suggests a workable plan for sustainable farming (Ayuso, et al., 1996; Milinković, et al., 2019).

As a result, the country must act quickly to manage waste effectively, particularly in light of the high value of organic fractions. Therefore, by analysing the plants that used composted fertiliser, the study intends to demonstrate the value of compost fertilisers, which will ultimately minimise the amount of food waste that ends up in landfills and the amount of methane gas released as a by-product of food waste in the home. However, the only practical remedy for this problem is composting, which converts household food waste into organic fertiliser. Furthermore, organic fertilisers are crucial for the agriculture sector because they enhance the soil without endangering plants or groundwater (Min, 2015).

2. LITERATURE REVIEW

Despite having an abundance of woods, Brunei has the highest carbon dioxide emissions per person in the world, with 55% of those emissions

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originating from gaseous fuel, 28% from liquid fuel, and 13% from gas flaring (Dariah, et al., 2022). Moreover, every day 400 to 500 tonnes of waste are sent to the Sungai Paku landfill in the Tutong area (Wong, 2020). As a result, the Sungai Paku Landfill, the country's major landfill, has housed more than 90% of total waste and is expected to be full by 2030 if effective recycling procedures are not done, received rotten goods and vegetables from stores in Brunei, according to an article in the Brunei Times (Department of Environment, Parks and Recreation, 2021; Kon, 2020). Furthermore, including imports from other countries, retailers in Brunei produced up to BND 1000 worth of spoiled products per month. Hua Ho, one of Brunei's largest supermarkets, throws out 2 to 3 kg of bad products every two days, totalling 45 kg of waste every month (Dariah, et al., 2022). This level of food waste should be decreased since it may have negative effects on culture, the economy, and the environment (Haq, 2019).

Food waste is food that is fit for human consumption but has been discarded, whether due to being kept over its expiration date or being allowed to rot, lose quality, or be eaten by bugs (Sun, et al., 2021). A significant amount of food waste is inadequately processed and transported to landfills or incinerators, or it is illegally diverted into the unofficial system to feed cattle or manufacture cooking oil, resulting in significant food safety hazards (Sun, et al., 2021). More and more individuals are exploring employing environmentally friendly technology for food waste prevention and treatment to develop more sustainable global food and waste systems (Thyberg and Tonjes, 2017). Policies for sustainable food waste management are being proposed and implemented, particularly in the U.S. and Europe, China, and Saudi Arabia, and the United Kingdom (Thyberg and Tonjes, 2017; Sun, et al., 2021; Waqas, et al., 2018; Slorach, et al., 2020). Concerns about the social, environmental, and economical consequences of food waste have heightened public awareness of the problem. As a result, one potential solution to this problem is to convert this food waste into organic compost for agricultural use (Bhadwal et al., 2022).

Composting is one of the most difficult yet simplest ways to make your home eco-friendlier by reducing rubbish and providing a rich supplement for your plant soil. In other terms, composting is a biological process that converts organic biodegradable waste into a sanitary, humus-rich product (compost) that may be used as a soil supplement and organic fertiliser (Popkin, 1995; Ouédraogo, et al., 2001). Compost absorption into soil provides a foundation for soil microbial feeding and hence enhances their activity (Bastida, et al., 2008). Soil microorganisms' activities release nutrients such as nitrogen, phosphorus, and sulphur into the soil, making them available to plants (Gliessman, 2014). Composting aids in the stabilisation of the soil aggregate framework, improving soil structure, porosity, and density. This reduces soil runoff and erosion, resulting in a healthier plant root environment (Saison, et al., 2005). Compost improves soil water retention and plant water availability, reduces evaporation, and reduces nutrient leaching. It also functions as a long-term slow-release fertiliser and avoids plant diseases (Hepperly, et al., 2009; Arthur, et al., 2010).

In their study, said that food waste used to make compost is particularly beneficial for organic cabbage, cauliflower, and radish production in subtropical settings since the compost from food waste can boost soil fertility (Kumari et al., 2020). Compost treatment boosted leaf relative water content and decreased electrolyte leakage in all plants, resulting in improved cabbage, cauliflower, and radish health and greater yields. In other research, compost had a substantial impact on lettuce growth, production, and nutritional quality because compost provided nutrients required by plants (Masarirambi, et al., 2010; Aggelides and Londra, 2000). Silva and Menezes also contend that the ability to compost to stop Nitrogen-soil deterioration (in the short term) and raise Phosphorus and Potassium soil content throughout that period of culture makes it the most efficient method of supplying plant nutrients (Silva and Menezes, 2007).

As a result, this research is extremely beneficial for improving waste management by nutrient recycling or composting kitchen food waste into halal organic fertiliser, as well as the key to eco-farming practices. Keeping foregoing in mind, the current study was designed to evaluate the performance of Bird's Eye Chilli (BEC), scientifically known as Capsicum frutescens L, for plant visual assessment and nutrient analysis to demonstrate that halal organic fertilisers derived from composting material are safe to use and efficient.

3. Research Method

3.1 Material Selection

Organic food waste collected from the author's residences was incorporated into the composition. It is critical to realise that not all foods have the same caloric and nutritional value (Aldaco, et al., 2020). Hence, when making judgments, it is critical to consider the nutritional value of food waste (Bradshaw, 2018). Green vegetables, eggshells, and banana peel were among the leftover food waste that was chosen for composting. To reduce the excess moisture, garden soil and dry leaves are added to the compost also it will speed up the composting process and keep the unpleasant odour at bay (Hamid, et al., 2019; Sulaiman, et al., 2022). Furthermore, organic waste such as kitchen garbage, leaves, vegetables, fruits, dry leaves, and garden soil are chosen since they rot quickly and are organically destroyed (Dewi, 2020).

3.2 Carbon and Nitrogen Sources

Composting requires greens and browns as the primary supply of composting materials, which are also known as carbon and nitrogen sources. Green trash was the primary source of composting materials. Greens and browns are necessary for the composting process. Greens are kitchen waste, whereas browns are items like dry leaves, sawdust, shredded paper, and soil (Hamid, et al., 2019). Table 1 shows the carbon and nitrogen sources that will be used in the composting process.

Table 1: List of Carbon and Nitrogen source

Greens (High in Nitrogen -N)	Browns (High in Carbon – C)
Leftover green vegetables	Dry leaves
Banana peels	Garden soil
Eggshells	Paper towel

3.3 Compost Production

The composting container of choice has been a plastic basket with holes, as shown in Figure 1, to allow air into the compost since bacteria in aerobic systems require oxygen to continue respiring. It is also a good idea to keep the compost in a closed container. The basket will shield the compost from the weather while also maintaining a consistent inside temperature. Furthermore, the basket's lid keeps out unwanted odours and prevents other animals from interfering with the process.

Figure 1: Plastic basket for compost production

The compost mixtures were blended to adapt and maximise the input substrate in the composting container (Aldaco et al., 2020). To prevent the container from blowing up, the input combinations were allowed to decay and were only opened once every two weeks to stir and let the gas escape and ventilation was to improve the aeration of the composting process (Abdullah, et al., 2021; Hamid, et al., 2019). As a result of the rotting, this allows for aerobic biological breakdown and change (Aldaco, et al., 2020). Warm temperatures will allow the compost's bacteria to perform more effectively, thus the container was placed in a warm location. Finally, the liquid was drained from the container and refilled every two weeks, to ensure that the aerobic decomposition of composted food waste occurs (Waqas, et al., 2018; Abdullah, et al., 2021). Last but not least, compost can be created using a sifting process based on post-treatment. Figure 2 depicts the properties of mature and sifted compost, which has a lovely soil-like scent and a dark brown colour.

Figure 2: Mature and Sifted Halal Composted Fertilizer (Source: Rahim, et al., 2022; Sulaiman, et al., 2022)

3.4 Experimental Layout on Bird's Eye Chilli (*Capsicum Frutescens* L)

The experiment was set up using two BEC plants after two months of fermentation. The mature and sifted halal composted fertiliser was named compost-based fertiliser (CBF) and was ready to be applied to one of the BEC plants, whereas the other BEC plant received no halal composted fertiliser and was only grown with clay-based soil (CBS). Because compost is an organic fertiliser for plants, it must contain the nutrients that plants require (Chew, et al., 2018).

3.5 Nutrient Analysis

Compost, as an organic fertiliser for plants, must be nutrient-dense. Plants require a large number of macronutrients, which include nitrogen, phosphorus, potassium, calcium, magnesium, and sulphur. The plant of Bird's Eye Chilli (BEC) from both CBF and CBS were sent for analysis to the Soil Science and Plant Nutrient Unit, Department of Agriculture and Agrifood, Ministry of Primary Resources and Tourism, Brunei Darussalam to determine the content of the organic fertilizer. The content of Nitrogen (N), Potassium (K), Magnesium (Mg), Calcium (Ca), Phosphorus (P) and Iron (Fe) were measured for the nutrient analysis.

4. Findings and Discussion

4.1 Observation Analysis

The visual evaluation of the plant's appearance serves as the basis for the observation analysis. As a result, the development of the bird's eye chilli was studied, and it was found that, as seen in Figure 3, the plant developed with CBF performed better and contained more nutrients than the chilli grown with CBS. In a study on the production and quality of leafy vegetables cultivated with organic fertilisers, a group researchers found that vegetables grown with organic fertilisers grew better and produced a greater overall yield than those planted with chemical fertilisers (Xu et al., 2005).

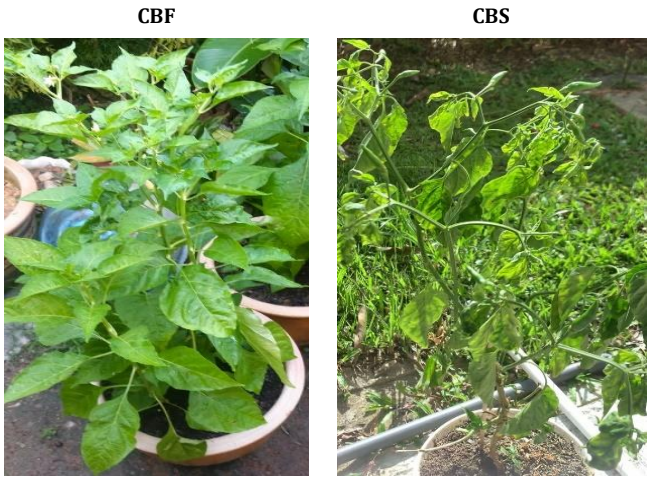


Figure 3: Comparison of visual observation of Bird's Eye Chilli Plants (Source: Rahim, et al., 2022; Sulaiman, et al., 2022)

The plant with CBS in Figure 3 visually displays symptoms of nutrient deficiency, such as twisting, cupping, and crinkling distorted or misshaped leaves (Uchida, 2000; McCauley, et al., 2009). This happens because of a calcium deficiency that can be brought on by either an extremely high or low pH in the root zone. The organic fertiliser created from a residual bone meal can be used in the soil to provide calcium as a treatment. As shown in Figure 3, organic fertiliser made from leftover food can give plants more nutrients, as is also shown.

4.2 Morphological Characterization

Morphological characterization was basically done based on external and apparent qualities, such as damage-free fruit, size, and colour, which are appreciated when evaluating BEC quality, also length and width of leaves (LL and LW) were selected to observe the growth and quality of plants (Coulibaly, et al., 2011; Oyekanmi, et al., 2008; Okeleye, et al., 2006; Bosland and Votava, 2000; Kumari, et al., 2020). In the current investigation, only the LL and LW of BEC leaves were determined using a measuring scale. The BEC leaves range in size from tiny to medium and has a long, lanceolate or oval form, measuring 5 to 10 centimetres (cm) on average. The alternately arranged, smooth-surfaced, dark-green leaves have a lighter-green underside that is slightly matted. BEC are shrub-like plants with smooth-edged leaves and red or green berries.

With the help of a measuring scale, Figure 4 shows the LL and LW of BEC leaves from the CBF pot, which is 12.3 cm in length and 5.7 cm in width. Meanwhile, Figure 5 shows the LL and LW of BEC leaves from the plant with CBS, which recorded 6.1cm in length and 4.4cm in width. A prior study found that the LL ranged from 6.25 to 11 cm and the LW from 4.1 to 8.3 cm (Santhosa, et al., 2019). Similarly, after implanting organic fertilisers in onions, the plant's leaf length rises over time due to the administration of compost to the soil, which raises the soil's biological potential and subsequently affects plant productivity (Bhadwal, et al., 2022). Both plant LL and LW are considered in their normal range compared with other studies.

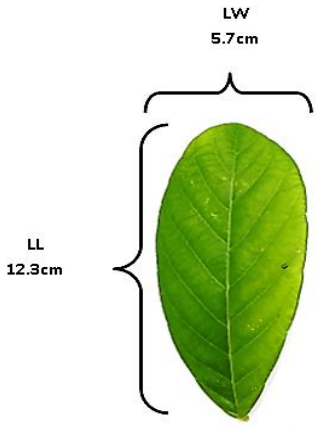


Figure 4: BEC Leaf with CBF sampling

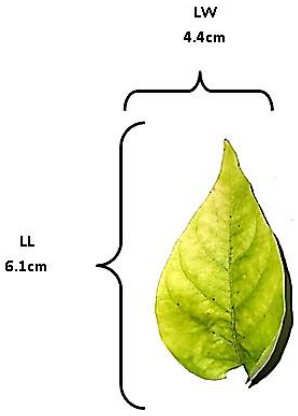


Figure 5: BEC leaf from CBS sampling

Until they reach maturity and appear above the foliage, the fruits remain upright (Chatterjee, et al., 2012). In their study, a group researchers noted that fruit lengths varied from 0.85 to 2.85 cm and fruit diameters from 0.79 to 2.65 cm (Santhosa, et al., 2019). Furthermore, the fruits elongate, are

usually upright, short and thin, up to 5cm x 1cm in size, green to cream and yellow when immature, orange to red when ripe, and the fruit wall is smooth and exceedingly pungent (Grubben and O.A., 2004). Meanwhile, some researchers discovered that fruit length varied significantly (p=0.05) among cultivars, with 9.88cm being the longest and 3.2cm being the shortest (Nkansah et al., 2011). Figure 2 depicts the fruits in an upright position, small and narrow in size, and green in colour.

4.3 Nutrient Analysis

The results shown in Table 2 indicate that CBF obtains the most important macronutrients needed by a plant, such as nitrogen, magnesium, calcium, phosphorus, and iron. Given that it offered some amounts of the nutrients needed for growth, compost is also claimed to be significant in increasing the growth and yield of all plants (Abd El-Baky, et al., 2019). After that, the halal organic fertilisers made from leftover halal food are enough to replace the nutrients needed for plants to thrive on their own. It can also be applied as supplementary fertiliser to help plants grow healthier naturally. Microorganisms decomposed food waste, producing microbial fertilisers with a variety of nutrients that can improve soil quality and crop performance (Sun, et al., 2021).

Table 2: Nutrient Analysis of Bird's Eye Chilli Plants

Identification	CBF	CBS	Acceptable Range
Total Nitrogen – N %	4.27	1.19	3.5-5.0
Total Potassium – K %	1.96	2.16	3.0-5.5
Total Magnesium – Mg %	1.00	0.182	0.25-1.2
Total Calcium – Ca %	1.70	0.206	1.0-3.5
Total Phosphorus – P %	0.318	0.204	0.3-0.6
Total Iron – Fe ppm	177	181	60-300

Source: Data Analysis

Nitrogen, a crucial component in plant growth that is present in all plant cells, plant proteins, hormones, and chlorophyll, has been discovered in CBF in Table 2 within the allowed range, indicating that the growth of the plant is unaffected. The amount of magnesium in the CBF samples is likewise within acceptable bounds, which aids in phosphorus absorption and controls the absorption of other nutrients. The level of total calcium in CBF is optimal, which is necessary for healthy roots, the production of new roots and root hairs, and the growth of leaves. The adequate amount of phosphorus in CBF promotes early root and plant growth and speeds up maturity. Last but not least, total iron is sufficient in CBF which will regulate and promote growth as it is a constituent of many compounds. Moreover, Souri et al. (2019) also discovered that using organic fertilisers on pepper (capsicum annuum) increased soil nutrient profiles.

Therefore, based on observation and nutrient analysis, it is reasonable to introduce or advise turning kitchen trash into halal organic fertiliser. To reduce waste, all halal food can be composted, including leftover fruits, vegetables, bread, processed foods, dairy products, eggshells, tea bags, coffee grounds, and animal-based products in small quantities, like meat, sausages, cheese, small chicken bones, small nutshells, and single-use items labelled as "biodegradable" or "compostable." Composting organic waste is a useful amendment for improving the sustainability of the soil and crop yield (Galsim, et al., 2021).

However, Table 2 also reveals that there was a deficiency in total potassium, which will impact the plant's vigour, vitality, and health and make it less able to fend off infections as well as grow slowly and have underdeveloped roots systems (Kabata-Pendias, 2010; Abd El-Baky, et al., 2019). In other words, the plants are unable to fend against disease attacks because of a potassium deficit. One of the BEC diseases brought on by fungi is leaf curl which attacks the BEC plants with CBS (Barrera, et al., 2008; Sanago, 2003). Thus, the use of organic fertilisers is recommended since it increases the number of microorganisms that have a specific effect on protecting plants from pathogens such as nematodes and soil-borne insects, as well as providing plant growth hormones such as auxins (Agbede and Ojeniyi, 2009).

Therefore, macro- and micronutrients are crucial for the healthy growth and development of crops. The growth of plants is greatly influenced by the ideal concentration. It is advised to use NPK or urea fertilisers instead of this halal organic compost fertiliser because it lacks adequate potassium levels. To be more precise, balanced inorganic fertiliser should be applied at a rate of 100 kg N, 80 kg P2O5, 50 kg K2O, 20-25 t FYM ha-1, as well as a foliar spray of 10 gm urea l-1, before blooming to ensure that the plant receives the right nutrition (Chatterjee, et al., 2012).

In order to meet demand, plants will eventually need more nutrients, such as NPK (Fernández-Delgado, et al., 2022). However, inorganic fertilisers have adverse environmental effects when crops are chemically fertilised excessively or inappropriately. Emissions of greenhouse gases, eutrophication of surface waters, and excessively rapid plant nutrition are some adverse impacts (Coskun, et al., 2017; Liang, et al., 2013; Walling and Vaneeckhaute, 2020). Contrarily, some advantages of organic fertilisers include the progressive release of nutrients that are safe for plants and an increase in organic carbon in the soils (Sharma, et al., 2019). As a result, the need to move from inorganic to organic fertilisers is becoming more urgent.

As previously mentioned, the total potassium in CBF samples is extremely low. Unfortunately, potassium helps plants resist disease and is crucial for producing high-quality fruit. Additionally, a crucial ingredient for plant growth is potassium which aids in the exchange of water, oxygen, and carbon dioxide within plants as well as the flow of nutrients and water throughout plant tissue (Mikkelsen, 2008). Therefore, research and development (R&D) is required to enhance the quality of halal organic fertilisers and reach the optimum level that is needed in the acceptable range to minimise the use of chemical inputs as well as prevent inappropriate chemical fertilisation on crops. Thus, incorporating seaweed meal, composted bracken, wood ash, and coffee grounds into the composting fertiliser could increase its potassium concentration (Richard, 2020).

Furthermore, according to a study, as there is no specific legislation in place in Brunei to control industrial air emissions, administrative orders, a code of conduct, and management good faith are primarily used to enforce the law (Dariah et al., 2022). Therefore, the government needs to emphasise the importance of waste and pollution management, especially concerning water and air pollution in all sectors. However, it makes sense to incorporate the composting of food waste as part of waste management in policy since doing so might minimise the amount of garbage transported to landfills and cut back on harmful carbon emissions.

The COVID-19 pandemic outbreak in 2020 also showed that this country's important resource sectors can grow in the future (Dariah, et al., 2022). Current government policies encourage foreign direct investment in the sectors of primary resources and production for food security. This will aid Brunei Darussalam in achieving economic sustainability, under Vision 2035 (Dariah, et al., 2022). As His Majesty proposed in a speech during the inauguration of Majlis Ilmu in honour of His Majesty's 72nd birthday, composting domestic waste encourages people to engage in home gardening or urban farming; "*Agriculture, it needs to be explored by anyone. It is not limited to those who own hundreds of hectares of newly planted land, but people can also plant in the courtyards of their homes or in pots to produce, such as vegetable trees and peppers likewise. ... We must also contribute to greening the earth. The green earth is a symbol of sustenance*" (Pelita Brunei, 2018).

4.4 Soil Analysis

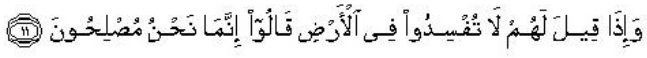
Soil sampling was performed in CBF for the organic matter (OM). The OM was a viable option for agroecosystem sustainability (Camacho Barboza, et al., 2014; Bassan, et al., 2014; Zanin, et al., 2016). OM composting is one of the most well-known and well-established procedures for organic waste stabilisation and sanitation by rapid aerobic decomposition under controlled circumstances (Maucieri, et al., 2019). This results in a product called compost (Martínez-Blanco, et al., 2013). It helps to improve soil composition, nutrient retention, aeration, soil moisture-holding capacity, and water infiltration since the OM content of CBF is relatively rich (15.1%) (Deksissa, et al., 2008; Asfaw, 2022). In essence, OM can be applied to crops to improve their defence mechanisms or to make up for nutrient deficits (Leauthaud, et al., 2021).

4.5 Islamic Perspective on Composting

At least seven different types of organic waste, including crop leftovers, sewage sludge, food processing wastes, industrial organic waste, wood production waste, and municipal trash, can be used to increase soil fertility and tilth (Mendoza, 1989). Muslims should therefore make embracing the idea of composting a major priority. Composting, which is the superior method of garbage disposal, is completely consistent with the Islamic commandment to care for the environment. Additionally, applying compost was crucial for improving the growth and productivity of all plants since compost offered a portion of the nutrients needed for growth and yield (Aggelides and Londra, 2000).

Composting is also beneficial for the planet, which humanity is obligated

to protect and preserve as one of the greatest blessings that Allah subhanahu wa Ta'ala (SWT) has given us. Therefore, organic waste such as food scraps should be collected and processed into compost, a type of artificial fertiliser that is particularly beneficial to plants (Dewi, 2020). Additionally, recycling organic waste through the process of generating compost benefits the environment and people (Wardhana, 1995). Even in the surah al-Baqarah, verse 11 exhorts believers to safeguard the planet and its ecosystem.



Translation: When it is said to them: "Make not mischief on the earth," they say: "Why, we only Want to make peace!" (Al-Qur'an, 2:11)

Islam promotes the concept of humanity as a trustee (Khalifah) of the world, which will be called into question on the Day of the Resurrection, as stated in Al-Quran, Surah Al-An'am verse 165. As a trustee, humanity must protect and maintain the environment. Even Mendoza stated that it is time to act and should not wait until all resources, such as water, are polluted and lands are so poor that they are barren, unproductive, and sick soil, requiring the application of not only NPK but also all micronutrients, and future generations will no longer be able to enjoy nature and organic production (Even Mendoza, 1989).

Furthermore, the meaning of the two verses below is that it is mankind's responsibility to protect all types of plants, with no abuse, exploitation, or carelessness, as well as by using organic foods and fruits, foods and fruits free of insecticide and herbicide, and used foods that are recyclable, reusable, or compostable. For example, excessive fertiliser use and the discharge of industrial waste in natural settings without treatment can harm natural resources such as water and vegetation, as well as soil fertility (Salem, et al., 2012).

And they strive throughout the land (causing) corruption, and Allah does not like corrupters. (Al-Qur'an, 5:64)

Do not seek to spread corruption in the land, for Allah certainly does not like the corruptors. (Al-Qur'an. 28:77)

Furthermore, the issue of crop purity should not be raised because the source of compost has no bearing on crop purity or the permissibility of ingesting the crop. Furthermore, according to associating the halal principles would support sustainable agriculture (Rezai et al., 2015). To ensure food safety and environmental friendliness, Halal aspects must be practised from the beginning of agriculture till the cultivation phases. Even according to the principle of madhab Hanafi and Dhahiriyah, the trade of organic fertilizer from manure is allowed as the materials use to preserve the earth from destruction (Mukhlishin and Saipudin, 2017). Madhab of Hanafi highlighted:

"They stated: It is allowed to trade oil exposed with najs and use it, unless for consumption. As it is allowed to trade waste, which is blended with dirt and used it, as well as animal droppings or fertilizers that considers as najs. It is the corpse, untanned skin of the corpse, pig, and wine that are forbidden to trade." (Al-Jaziri, 1972).

5. Conclusion

Food waste is a major issue all around the world. Food waste composting may reduce pollution and be useful to organic vegetable or crop development. Organic fertilisers created from waste materials such as food scraps from households are tested for sustainability in this study. The scenarios are based on the aerobic composting process and the conversion of food waste into organic fertilisers. The study thus provides a framework for recycling organic waste and demonstrates the feasibility of producing fertiliser from organic food waste. The current study's findings demonstrated that compost made from food waste has a good impact on waste management and encourages nutrient recycling in the backyard or urban farming.

To reach the goal set by the United Nations' Sustainable Development Goal (SDG) Goal 13, waste management is expected to be able to cut per capita food waste at the retail and consumer level in half by 2030. Given Islam's emphasis on personal cleanliness at all times, composting can help prevent food waste at home, keep the environment clean, and cultivate self-discipline and knowledge of the environmental harm that food waste causes. In all aspects of life, Islam condemns wasting any resources, including money, time, energy, food, and wealth. Additionally, eliminating food waste is critical to achieving sustainability.

As a result, private sector participation in mass media advertising (radio, television, and print media) is critical. For example, cigarette advertisements are usually accompanied by the phrase "Excessive smoking is detrimental to health." Similarly, in agricultural chemicals, this might be implemented by marketing "Chemical fertilisers and pesticides are poison that can hurt you and the environment if used incorrectly." Furthermore, public awareness campaigns about the negative impacts of chemical fertilisers, not just their yield-increasing effects, should be launched. Similarly, organic waste recycling or composting organic waste should receive equal campaign or advertisement time across all media platforms.

This should begin with the family, the fundamental unit of society. Waste should be sorted into biodegradable and nonbiodegradable categories for proper disposal. Composting biodegradable garbage in the backyard is an option. Composting also saves us money by avoiding the need for a private waste truck and saves governments money by avoiding the purchase of expensive chemical fertilisers, saving us money, time, energy, and food. This is done so that plants can benefit from the compost's high-nutrient fertilisers, which provide a nutritional boost to fruits and vegetables.

Hence, regulating food raw materials such as vegetables and plants could guarantee that the food we make is halalan thayyiban as we handle and manage the process of ingredients from 'farm to fork'. As a result, eating Halalan Thayyiban food can help us maintain our health because it is beneficial to our bodies, minds, and souls.

Limitations and Further Research

This study was limited to the bird's eye chilli plants and nutrient analysis of selected macronutrients. Future research could include nutrient analyses of micronutrients in plants such as zinc (Zn), copper (Cu), iron (Fe), and manganese (Mn) to assess the nutrient level that halal organic fertilisers can produce, soil pH, and electrical conductivity (EC), as well as experiments on different types of plants. Aside from that, the study might be further by examining various compost fertilisers made from selected food waste from university cafeterias or restaurants. Future studies should also investigate how knowledgeable stakeholders, such as policymakers and the general public, are about food waste.

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References

Al-Qur'an.

Abd El-Baky, M., Youssef, R., Abd El-Rheem, K.M., and Enstar, M.E., 2019. Influence of Compost and Potassium Fertlization on Yield Quantity and Quality and Nutritional Status of Lettuce Plants. Journal of Basic Sciences and Applied Research, 5 (2), Pp. 1-5.

Abdullah, N.H., 2021. Food Waste as Alternative Natural Fertilizer for Okra Plants (Abelmoschus Esculentus L.). International Journal of Nanoelectronics and Materials, 14, Pp. 43-50.

Agbede, T., and Ojeniyi, S., 2009. Tillage and poultry manure effects on soil fertility and sorghum yield in southwestern Nigeria. Soil Tilage Res., 64, Pp. 209-215.

Aggelides, S., and Londra, P., 2000. Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and a clay soil. Bioresource Technology, 71 (3), Pp. 253-259.

Aldaco, R., 2020. Food waste management during the COVID-19 outbreak: a holistic climate, economic and nutritional approach. Science of the Total Environment, 742, Pp. 1-13.

Al-Jaziri, A., 1972. al-Fiqh 'ala al-Mazahib alArba'ah Juz 2. Beirut: Dar al-Fikr.

Arthur, E., Cornelis, W.M., Vermang, J., Rocker, E.D., 2010. Amending a loamy sand with three compost types: impact on soil quality. Soil Use and Management, 27 (1), Pp. 116-123.

Asfaw, M.D., 2022. Effects of animal manures on growth and yield of maize (Zea mays L.). Journal of Plant Science and Phytopathology, 6, Pp. 033-039.

Ayuso, M., Pascual, J.A., Garcia, C., and Hernandez, T., 1996. Evaluation of urban wastes for agricultural use. Soil Science and Plant Nutrition, 42 (1), Pp. 105-111.

Azahari, I., 2022. Efforts underway to tackle growing waste issue. [Online] Available at: https://borneobulletin.com.bn/efforts-underway-to-tackle-growing-waste-issue/#:~:text=The%20management%20of%20waste%20soil,particularly%20for%20the%20Brunei%20River. [Accessed 27 December 2022].

Barrera, J.A., 2008. Physiological behaviour and quality traits during fruit growth and ripening of four Amazonic hot pepper accessions. Journal of the Science of Food and Agriculture, 88 (5), Pp. 847-857.

Bassan, A., Sambo, P., Zanin, G., Evans, M., 2014. Rice hull-based substrates amended with anaerobic digested residues for tomato transplant production. Acta Horticulturae, 1018, Pp. 573-581.

Bastida, F., 2008. Application of fresh and composted organic wastes modifies structure, size and activity of soil microbial community under semi-arid climate. Applied Soil Ecology, 40 (2), Pp. 318-329.

Bhadwal, S., 2022. Prepared compost from food waste effectively increased onion production under sub-tropical conditions. Discover Sustainability, 3, Pp. 39.

Borneo Bulletin, 2021. No time to waste. [Online] Available at: https://borneobulletin.com.bn/no-time-to-waste/ [Accessed 23 September 2022].

Bosland, P.W., and Votava, E., 2000. Peppers, vegetables, and spices. New York: CABI Publishing.

Bradshaw, C., 2018. Waste law and the value of food. Journal of Environment Law, 30 (2), Pp. 311-331.

Camacho Barboza, J., Zanin, G., Ponchia, G., and Sambo, P., 2014. Use of anaerobic digested residues in open field horticulture in the Veneto Region, Italy. Acta Horticulturae, 1018, Pp. 133-138.

Chatterjee, R., 2012. Quality Bird's Eye Chilli Production: A Retrospective. International Journal of Bio-resource and Stress Management, 3 (3), Pp. 412-414.

Chew, K.W., 2018. Food waste compost as an organic nutrient source for the cultivation of Chlorella vulgaris. Bioresource Technology, November, 267, Pp. 356-362.

Coskun, D., Britto, D., Shi, W., Kronzucker, H., 2017. Nitrogen transformation in modern agriculture and the role of biological nitrification inhibition. Nature Plants, 3 (6), Pp. 1-10.

Coulibaly, O., 2011. Consumers' perceptions and willingness to pay for organically grown vegetables. Intl. J. Veg. Sci., 17 (4), Pp. 349-362.

Dariah, A.R., Abdullah, R., Hidayat, A.R., Matahir, F., 2022. Sustainable Economic Sectors in Indonesia and Brunei Darussalam. Sustainability, 14, Pp. 3044.

Deksissa, T., Short, I., Allen, J., 2008. Effect of soil amendment with compost on growth and water use efficiency of Amaranth. Durham, s.n.

Department of Environment, Parks and Recreation, 2021. Waste Management in Brunei Darussalam. [Online] Available at: http://www.env.gov.bn/SitePages/Waste%20Management%20in%20Brunei%20Darussalam.aspx [Accessed 27 December 2022].

Dewi, I.K., 2020. Trash management policy based on participation of the society. Jurnal Hukum Volkgeist, 5 (1), Pp. 104-114.

Fernández-Delgado, M., 2022. Liquid fertilizer production from organic waste by conventional and microwave-assisted extraction technologies: Techno-economic and environmental assessment. Science of the Total Environment, Pp. 806.

Galsim, F., Golabi, M., Kim, Y., Iyekar, C., 2021. Comparative effects of composted organic waste and inorganic fertilizer on nitrate leachate from the farm soils of northern Guam. International Soil and Water Conservation Research, 9 (1), Pp. 87-102.

Gliessman, S.R., 2014. Agroecology: The ecology of sustainable food systems. 3rd ed. Boca Raton: CRC Press.

Grubben, G., and O.A., D., 2004. Plant Resources of Tropical Africa 2. Vegetables. Wageningen, Netherlands: PROTA Foundation.

Gustavsson, J., 2011. Global food losses and food waste. [Online] Available at: www.fao.org/docrep/014/mb060e/mb060e00.pdf [Accessed 10 November 2022].

Hamid, H.A., 2019. Development of Organic Fertilizer from Food Waste by Composting in UTHM Campus Pagoh. Journal of Applied Chemistry and Natural Resources, 1 (1), Pp. 1-6.

Haq, Z., 2019. Food India wastes can feed all of Bihar for a year, shows govt. study. [Online] Available at: https://www.hindustantimes.com/india-news/food-india-wastes-can-feed-all-of-bihar-for-a-year-shows-govt-study/story-qwV3C9YnJAoXn83b3htmsK.html#:~:text=That%27s%20more%20than%20the%20national,states%2C%20for%20a%20whole%20year.&text=Haq%2C%20New%20Delhi-, [Accessed 29 December 2022].

Hepperly, P., 2009. Compost, manure and synthetic fertilizer influences crop yields, soil properties, nitrate leaching and crop nutrient content. Compost Science & Utilization, 17 (2), Pp. 117-126.

Ilakovac, B., Cerjak, M., and Voca, N., 2020. Why do we waste food? In-depth interviews with consumers. Energy Sources, Part A: Recovery, Utilization and Environmental Effects.

Jeevahan, J., 2021. Waste into energy conversion technologies and conversion of food wastes into the potential products: a review. International Journal of Ambient Energy, 42 (9), Pp. 1083-1101.

Kabata-Pendias, A., 2010. Trace elements in soils and plants. Boca Rotan, Florida: CRC Press.

Kon, J., 2020. Brunei highest waste generator in ASEAN. [Online] Available at: https://borneobulletin.com.bn/brunei-highest-waste-generator-in-asean-2/#:~:text=Brunei%20Darussalam%20generates%20around%201.15,mainly%20ends%20up%20at%20landfills. [Accessed 27 December 2022].

Kumari, N., 2020. Compost from the food waste for organic production of cabbage, cauliflower, and radish under sub-tropical conditions. International Journal of Recycling of Organic Waste in Agriculture, 9, Pp. 367-383.

Leauthaud, C., 2021. Production and use of homemade dry manure-based tea in fertigation systems in North Africa. Renewable Agriculture and Food Systems, 37, Pp. 245-256.

Liang, B., Zhao, W., Yang, X., and Zhou, J., 2013. Fate of nitrogen-15 as influenced by soil and nutrient management history in a 19-year wheat-maize experiment. Field Crops Research, 144, Pp. 126-134.

Martínez-Blanco, J., 2013. Compost benefits for agriculture evaluated by life cycle assessment. A review. Agron. Sustain. Dev., 33, Pp. 721-732.

Masarirambi, M.T., Hlawe, M.M., Oseni, O.T., and Sibiya, T.E., 2010. Effects of organic fertilizers on growth, yield, quality, and sensory evaluation of red lettuce (*Lactuca sativa L.*) 'Veneza Roxa'. Agriculture and Biology Journal of North America, 1 (6), Pp. 1319-1324.

Maucieri, C., Barco, A., and Borin, M., 2019. Compost as a Substitute for Mineral N Fertilization? Effects on Crops, Soil and N Leaching. Agronomy, 9, Pp. 193.

McCauley, A., Jones, C., Jacobsen, J., 2009. Plant Nutrient Functions and Deficiency and Toxicity Symptoms. [Online] Available at: https://mtvernon.wsu.edu/path_team/Plant-Nutrient-Functions-and-Deficiency-and-Toxicity-Symptoms-MSU-2013.pdf [Accessed 1 November 2022].

Mendoza, T.C., 1989. Nutrient Recycling: The Key to Eco-Farming Practice. Los Banos, Laguna, SEAMEO Regional Center for Graduate Study and Research in Agriculture (SEARCA), Pp. 67-80.

Mikkelsen, R., 2008. Managing Potassium for Organic Crop Production. Better Crops, 92 (2), Pp. 26-29.

Milinković, M., 2019. Biopotential of compost and compost products derived from horticultural waste—Effect on plant growth and plant pathogens' suppression. Process Safety and Environmental

Protection, 121, Pp. 299-306.

Min, T.L., 2015. Production of Fertilizer using Food Wastes of Vegetables and Fruits, s.l.: Universiti Malaysia Sarawak.

Mukhlishin, A., Saipudin, 2017. Sistem Jual Beli Pupuk Kandang Prespektif Imam Syafi'i dan Imam Hanafi (Studi di Kampung Sulusuban Kecamatan Seputih Agung). Jurnal Mahkamah, 2 (2), Pp. 327-350.

Nelson, D., and Sommers, L., 1983. Total Carbon, organic carbon, and organic matter. In: A. Page & e. al, eds. Method of Soil Analysis: Part 2 Chemical and Microbiological Properties. 2nd ed. Madison (Washington): ASA and SSSA, Pp. 539-579.

Nkansah, G., Ofosu-Budu, K., and Ayarna, A., 2011. Growth and yield performance of bird eye pepper in the forest ecological zone of Ghana. Journal of Applied Biosciences, 47, Pp. 3235-3241.

Okareh, O.T., Oyewole, S.A., and Taiwo, L.B., 2014. Conversion of food wastes to organic fertilizer: A strategy for promoting food security and institutional waste management in Nigeria. Journal of Research in Environmental Science and Toxicology, 3(4), Pp. 066-072.

Okeleye, K.A., Adeoti, A.Y.A., and Tayo, T.O., 2006. Farmers participatory rice variety selection trials at Ibogun Olaogun, Ogun State, Nigeria. Intl. J. Trop. Agr., 24, Pp. 643-649.

Ouédraogo, E., Mando, A., Zombré, N., 2001. Use of compost to improve soil properties and crop productivity under low input agricultural system in West Africa. Agriculture, Ecosystems & Environment, 84 (3), Pp. 259-266.

Oyekanmi, A.A., Okeleye, K.A., and Okonji, C.J., 2008. On-farm evaluation of rainfed lowland rice varieties at Olokose Village, Odeda, Ogun State. Nigeria J. Agron., 7, Pp. 192-196.

Pelita Brunei, 2018. Ceburi Pertanian sebagai Pemangkin Kehidupan. [Online] Available at: https://www.brudirect.com/news.php?id=58697 [Accessed 23 September 2022].

Popkin, R., 1995. Good news for waste watchers: recycling, composting show results for the future. EPA Journal, 21 (1), Pp. 188-190.

Rahim, S.M., 2022. Ehtaj - Home Kitchen Composter Device Produce Halal Eco-Friendly Fertilizer. Negeri Sembilan, AID Conference, Pp. 34-39.

Rezai, G., Mohamed, Z., and Shamsudin, M.N., 2015. Can Halal be Sustainable? Study on Malaysian Consumers' Perspective. Journal of Food Products and Marketing, 21 (6), Pp. 654-666.

Richard, 2020. How to Increase Potassium in Soil. [Online] Available at: https://www.growerexperts.com/how-to-increase-potassium-in-soil/#:~:text=Or%20by%20adding%20seaweed%20meal,them%20into%20your%20compost%20pile. [Accessed 27 December 2022].

Risse, M., and Faucette, B., 2009. Food Waste Composting: Institutional and Industrial Applications, s.l.: The University of Georgia.

Saison, C., 2005. Alteration and resilience of the soil microbial community following compost amendment: effects of compost level and compost-borne microbial community. Environmental Microbiology, 8 (2), Pp. 245-257.

Salem, M.A., Hasnan, N., and Osman, N.H., 2012. Some Islamic Views on Environmental Responsibility. Singapore, LACSIT Press.

Sanago, S., 2003. Chile pepper and the threat of wilt diseases. Plant Health Progress.

Santhosa, H., Manju, M., and Roopa, S.P., 2019. Morphological characterization of bird eye chilli grown as intercorp in arecanut plantation. Journal of Pharmacognosy and Phytochemistry, 8 (3), Pp. 2504-2507.

Shahrajabian, M.H., Sun, W., Cheng, Q., 2019. Measures to achieve a stable farming system in sustainable agriculture- a short review. Annales Universitatis Paedagogicae Cracviensis Studia Naturae, 4, Pp. 170-179.

Shams, S., Juani, R.H.M., and Guo, Z., 2014. Integrated and Sustainable Solid Waste Management for Brunei Darussalam. 5th Brunei International Conference on Engineering and Technology.

Sharma, H., Xu, C., and Qin, W., 2019. Sustainability, 10, Pp. 235-251.

Silva, T., Menezes, R., 2007. Organic fertilization of potato with manure and, or crotalaria iuncea. II. Availability if N, P and K in the soil along the crop cycle. Reviste. Brasileiria de clencia do solo, 31, Pp. 51-61.

Slorach, P.C., Jeswani, H.K., Cuéllar-Franca, R., and Azapagic, A., 2020. Assessing the economic and environmental sustainability of household food waste management in the UK: Current situation and future scenarios. Science and Total Environment, 710, Pp. 135580.

Souri, M., and Sooraki, F., 2019. Benefits of organic spray on growth quality of chilli pepper seedlings under cool temperature. Journal of Plant Nutrition, 42, Pp. 650-656.

Sulaiman, A., 2014. Enhancing the Halal Food Industry by Utilizing Food Wastes to Produce Value-added Bioproducts. Procedia - Social and Behavioral Sciences, 121, Pp. 35-43.

Sulaiman, N.S., 2022. Food Waste Conversion to Halal Organic Fertilizers. s.l., Research Synergy Press, Pp. 209-217.

Sullivan, D.M., 2002. Food Waste Compost Effects on Fertilizer Nitrogen Efficiency, Available Nitrogen, and Tall Fescue Yield. Soil Science Society of America Journal, 66 (1), Pp. 154-161.

Sun-Kee, H., and Hang-Sik, S., 2004. Performance of an Innovative Two-Stage Process Converting Food Waste to Hydrogen and Methane. Journal of the Air & Waste Management Association, 54 (2), Pp. 242-249.

Sun, W., Shahrajabain, M.H., and Chend, Q., 2021. Organic Waste Utilization and Urban Food Waste Composting Strategies in China - A Review. Notulae Scientia Biologicae, 13 (2), Pp. 1-16.

Thyberg, K.L., and Tonjes, D.J., 2017. The Environmental Impacts of Alternative Food Waste Treatment Technologies in the U.S. Technology & Society Faculty Publications, Volume 3.

Uchida, R., 2000. Essential Nutrients for Plant Growth: Nutrient Functions and Deficiency Symptoms. In: J. A. Silva & R. Uchida, eds. Plant Nutrient Management in Hawaii's Soils, Approches for Tropical and Subtropical Agriculture. Manoa: s.n., Pp. 31-55.

Walling, E., and Vaneeckhaute, C., 2020. Greenhouse gas emissions from inorganic and organic fertilizer production and use: a review of emission factors and their variability. Journal of Environmental Management, 276, Pp. 111211.

Waqas, M., 2018. Optimizing the process of food waste compost and valorising its applications: A case study of Saudi Arabia. Journal of Cleaner Production, Pp. 426-438.

Wardhana, W.A., 1995. Dampak Pencemaran Lingkungan. Yogyakarta: Andi Offset.

Wong, A., 2020. Brunei's first mass produced toilet tissue made 100% from recycled paper. [Online] Available at: https://www.bizbrunei.com/2020/08/bruneis-first-mass-produced-toilet-tissue-made-100-from-recycled-paper-enevo/ [Accessed 27 December 2022].

Xu, H., 2005. Yield and quality of leafy vegetables grown with organic fertilizations. Acta Hort, 627, Pp. 25-33.

Zanin, G., 2016. Use of organic fertilizers in nursery production of ornamental woody species. Acta Hortic., 1112, Pp. 379-386.