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THE STUDY OF FERTILIZER MADE FROM FOOD WASTE AND SAWDUST IN PELLET FORM AND COMPOST

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Abstract:

Fertilizers are essential in modern agriculture which improve soil health by supplying key nutrients for plant growth. Meanwhile, food waste presents a serious global issue, contributing to methane emissions from landfills and accelerating climate change. Sawdust, another abundant waste byproduct from the wood industry, also poses disposal challenges. This study explores composting and pelleting fertilizers using varying proportions of food waste and sawdust to support sustainable farming. Compost was produced by combining food waste, sawdust, dry leaves, and effective microorganisms (EM) in a bin. Key parameters monitored included pH, temperature, moisture content, as well as carbon-to-nitrogen (C:N) and carbon-to-phosphorus (C:P) ratios. Pelleted fertilizer was produced by grinding, mixing, and pelletizing the same materials. Composting results showed pH levels from 3.44 to 7.49 and temperatures between 22.4°C and 34.1°C. Moisture content declined over time. Sample A recorded the highest C:N and C:P ratios of 12:1 and 20:1, respectively. Iron and manganese concentrations remained low (0.36 mg/L and 0.59 mg/L), indicating non-toxicity. The pelleted fertilizer exhibited uniform size and shape due to the precision of the pelleting apparatus. Sample A showed the highest water stability at 88% after 10 minutes. Sample E had the highest bulk density (2.28 g/cm³), while samples A and B recorded the lowest (2.26 g/cm³). All samples displayed consistent pellet sizes in particle distribution. This study demonstrates that composting food waste and sawdust yields nutrient-rich and environmentally safe fertilizers. The results support the integration of food waste recycling into agricultural practices which promote soil fertility and environmental sustainability

Keywords:

Fertilizer, Food Waste, Sawdust, Compost, Pellet

Introduction

Nowadays, the ability of contemporary agriculture to fulfill future food needs is a concern due to the rising global population. Fertilizers have become important in modern agricultural techniques in replenishing nutrients in agricultural soils (Du et al., 2020). It is the key in enhancing soil quality by supplying necessary nutrients and minerals for plant growth, thus leading to higher productivity and better harvest results (Wan et al., 2021). Fertilizers supply critical nutrients such as nitrogen, phosphorus, and potassium that plants require for growth and development to enhanced agricultural production and yields (Ilinova et al., 2021). Fertilizers help replace soil minerals lost by continual cropping, preserving soil health and fertility over time (Kumar et al., 2023). Fertilizers can increase plant growth, allowing for several harvests per year and faster crop turnaround times (Kang et al., 2023). Fertilizers are required for intensive farming operations to fulfill the food needs of a growing worldwide population (Wang et al., 2023).

There are two main types of fertilizer which is organic (natural) and inorganic (chemical) fertilizer. Organic fertilizer fostering a holistic approach to soil health while inorganic fertilizer focusing on accelerated plant development and productivity (Zhang et al., 2020). Synthetic or chemical fertilizers are the chemical blends and additives that are produced through artificial means to provide numerous benefits to plant (Kakar et al., 2020). Overuse of chemical fertilizers can cause soil acidification, decrease soil organic matter, and general soil health degradation (Li et al., 2023). These fertilizers can contaminate groundwater with nitrates and other pollutants, posing health concerns to humans and animals (Severini et al., 2023).

Natural fertilizers can come from various sources such as plants, animals, or minerals that can add nature goodness to the soil (Yan et al., 2023). Compost is one of the ways to make fertilizer. The successful of composting process relies on the complex relationship of various microorganisms, such as bacteria and fungi, that work diligently to decompose organic matter in the soil (Yin et al., 2024). Compost is made of aerobically decomposing organic materials such as food scraps, yard trash, manure, and other biodegradable compounds. The key benefit of composting is the capacity to offer a balanced supply of important nutrients (Gao et al., 2024).

Apart from compost, fertilizer also can be made in a pellet form. Pellet fertilizers sometimes referred to as granular or pelletized fertilizers are tiny, homogeneous, and compact pellets derived from a range of nutrients and sources that might be organic, such as processed animal dung or plant leftovers, or inorganic, such as synthetic chemicals. These nutrition sources are blended into a homogeneous slurry, which is then pressed into pellet (Sarlaki et al., 2021). Pellet fertilizers are intended to give plants vital nutrients in a regulated and accurate manner (Sarlaki et al., 2021).

Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

Food waste includes all food that is thrown, lost, or uneaten along the food supply chain, from production and processing to retail and consumption (Leal Filho et al., 2024). Food waste has become an alarming issue globally toward the environment, economy, and society. Some of these issues include wastage, land occupation, environmental contamination, time and effort spent on transportation and cooking, as well as the possibility of not being able to obtain enough food in the future (Niles, 2020). Food waste has the potential to be converted into organic fertilizer either by anaerobic digestion or composting method (Sánchez, 2022).

Wood processing produces numerous wood products that are important resources for many applications and the country economic growth. Examples of wood processing byproducts include sawdust, wood chips, bark, and lignin (Zheng et al., 2023). Sawdust is another material that can be used as a fertilizer. The use of sawdust in agricultural activities not only tackle the waste management issues but also gives many benefits to farmers and gardeners (Adegoke et al., 2022; Imberti et al., 2024). Farmers can boost crop yields, reduce input costs, and contribute to the long-term viability of agricultural systems by using sawdust (Liu et al., 2024).

Literature Review

Composting

Composting is the most versatile and productive way of managing biodegradable solid wastes. It is an important agricultural practice that helps to recycle farm and agricultural waste (Oyewusi et al., 2021). Composting is a simple, low-cost procedure that allows biodegradable waste to be turned into biologically stable compounds known as compost (Tsigkou et al., 2020). It decreases the environmental effect of biowaste, allows for nutrient recycling in the soil, and contributes to the circular economy (Kunszabó et al., 2022). Composting normally requires collection of organic waste such as fruit and vegetable scraps, coffee grinds, eggshells, yard trimmings, and leaves. Then, the wastes are place in a compost bin or pile and allowed to decompose (Liu et al., 2020). During decomposition, bacteria degrade organic matter into simpler compounds, creating heat as a by-product. This heat helps to speed up the breakdown process (Chia et al., 2020).

Food Waste and Sawdust Fertilizer in Pellet Form and Compost

Studies have shown that the combination of organic waste and sawdust is beneficial for maintaining an optimal carbon-to-nitrogen ratio, thus enhancing composting process (Gurusamy et al., 2021). Organic waste is abundant in nitrogen, whereas sawdust contributes carbon, thereby fostering microbial activity. The combination significantly improves aeration, mitigates odors, and regulates moisture levels, thereby rendering the composting process more efficient (Maturi et al., 2021). Furthermore, the resultant compost enriches soil fertility and promotes environmental sustainability by reducing landfill waste (Zabbey et al., 2017).

The conventional proportion of food waste to sawdust utilized in the composting process is approximately 1 part food waste to 2-3 parts sawdust by volume or 1:2 by weight (Dimkpa et al., 2020). This ratio serves to equilibrate the nitrogen derived from the food waste with the carbon sourced from sawdust, thereby facilitating efficient composting (Dias et al., 2023). Modifications are necessary depending on moisture levels and the specific conditions of the composting process.

International Journal of Innovation and Industrial Revolution
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The pellet's nutrient profile reflects the levels of essential elements like nitrogen, phosphorus, and potassium found within it. These important nutrients are essential for the thriving of plants, since they support processes including photosynthesis, root enhancement, and the plant's overall health (Ayangbenro & Babalola, 2021). Pellets are frequently utilized to supply a regulated, slow-release source of these nutrients to the plants (Briassoulis et al., 2021).

Materials and Methods

Collection of Food Waste and Sawdust

Food waste such as vegetables, fruits, eggshells, bread, etc. was collected from a cafe, restaurant, and farmer market in Pagoh, Johor while sawdust was collected from a Furniture Technology Laboratory located at Universiti Tun Hussein Onn Malaysia (UTHM), Pagoh Campus, Johor. The collected waste was stored at the laboratory prior to be used.

Formulation of Fertilizer

The formulation of the fertilizer is the different ratio of food waste, sawdust, and effective microorganism (EM) mix to produce the fertilizer. Several formulations were tested for both pellet and compost fertilizer as shown in Table 1. The EM stock solution was added with certain amount of water to dilute the content. The solution was fermented for a few days before it can be use.

Table 1: Formulations for Pellet and Compost Fertilizer (%)

Sample	Pellet form			Compost			
	Food waste	Sawdust	Leaves	Food waste	Sawdust	EM	Leaves
1	10	50	40	10	50	20	20
2	20	40	40	20	40	20	20
3	30	30	40	30	30	20	20
4	40	20	40	40	20	20	20
5	50	10	40	50	10	20	20

Preparation of Pellet Fertilizer

Initially, food waste was dried in an oven at 102°C to ensure free from any moisture. Next, the formulation of the fertilizer for each sample was prepared based in Table 1 for 2 kg. Then, the prepared mixture was placed in a grinder machine to grind and mix the content as well as get the right particle size. Subsequently, the mixture was placed in a pellet machine to be compressed and extruded. The machine used high pressure to push the material through a die, creating thick pellets that are all the same size and shape. After that, the pellets were screened to get rid of particles and then left to dry before further testing and analysis. Figure 2 shows the preparation of pellet fertilizer.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 23 (December 2025) PP. 111-127
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Figure 2: Preparation of Pellet Fertilizer

Physical Characterization of Pellet Fertilizer

The pellet fertilizer was physically characterized by measuring the diameter, length, water stability, bulk density and particle size distribution. The length and diameter of the pellet fertilizer was measured in mm using a digital vernier caliper. In water stability test, the pellets undergo immersion in water for certain period, during which their disintegration process is carefully monitored and quantified. Water stability was calculated using Equation 1:

$$\text{Water stability (\%)} = \frac{\text{Weight of pellets before immersion (g)}}{\text{Weight of pellets after immersion (g)}} \times 100 \qquad \text{(Eq.1)}$$

The bulk density was calculated using Equation 2:

$$\text{Bulk density} = \frac{\text{Mass of pellet (g)}}{\text{Volume of container (cm}^3\text{)}} \qquad \text{(Eq.2)}$$

The particle size distribution of the pellet was determined from sieving process. The particle retained of the pellet sample was measured using Equation 3:

$$\text{Particle retained (\%)} = \frac{\text{Weight of particle on sieve (g)}}{\text{Total sample weight (g)}} \text{x100\%} \qquad \text{(Eq.3)}$$

Preparation of Compost Fertilizer

Firstly, the formulation of the compost fertilizer for each sample was prepared based in Table 1 for 10 kg. Then, the mixture of the compost was placed in a 2 L polyethylene bin as shown in Figure 3. The compost pile should be moist but not dripping, so EM was added as needed. The compost was left in the bin for per week composting process. Periodically the compost pile should be stirred with a shovel to ensure even composting and provide oxygen for the microorganisms. The ratio of the greens and browns may need adjustment as the pile breaks down into compost. If the temperature begins to fall below thresholds, more fresh greens was needed and the compost was stirred to add oxygen back to the pile.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

Figure 3: Preparation of Compost Fertilizer

Effects of Composting Parameters

The effects of composting parameters such as temperature, pH, and moisture content toward time were investigated by measuring the parameters weekly. Changes in temperature can be used to assess the quality of organic matter and the behavior of bacteria throughout the composting period. After the compost being stored in the bin for a week, the temperature of the compost was measured by using a digital thermometer. The temperature reading was taken by inserting the tip of the digital thermometer into the compost pile. The reading was taken three times. Compost material changes during the composting process where pH level signifies the efficiency of the composing process through the breakdown of organic matter. A HQ440d benchtop multi-meter (Hach) was used to measure the pH. Moisture may speed up metabolism, which makes it crucial for microbial activity as low humidity limit microbial activity. An indicator of mature composting and decomposition at the end of the process is the decrease of moisture content. The moisture content of the compost pile is determined using Equation 4:

$$\text{Moisture content (\%)} = \frac{(w-d)}{w} \times 100 \qquad \text{(Eq. 4)}$$

Where:
w = Initial weight of sample, g
d = Weight of sample after drying g

Analysis of Iron and Manganese Concentration

The iron concentration of the compost sample solution was determined by using the FerroVer® Colorimetric method while the manganese concentration was determined using the 1-(2-Pyridylazo)-2-Naphtanol PAN method. Both iron and manganese concentration were analysed using DR 6000 UV-Vis spectrophotometer (Hach).

Analysis of C:N and C:P Ratio

The compost fertilizer was analysed for C:N and C:P ratio. The phosphorus concentration of the compost sample solution was determined using the PhosVer 3 (Ascorbic Acid) method. The nitrogen concentration of the compost sample solution was determined using the UV Screening method. The content of nitrogen and phosphorus in the fertilizer was analysed by using DR 6000 UV-V is spectrophotometer (Hach) while for carbon using COXEM SEM-EDX (EM-30AX) machine.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

Results and Discussion

Compost Fertilizer

The result for compost fertilizer includes the effects of composting parameters such as temperature, pH, and moisture content towards time as well as the concentration of iron and manganese in the compost fertilizer. Furthermore, the result for C:N and C:P ratio of the compost fertilizer is also discussed in details in the next subsection.

pH, Moisture Content, and Temperature

Figure 4(a) shows the pH value towards time for all samples. Sample A exhibited a consistent increase in pH values from week 1 to week 3 from 3.58 to 4.3, respectively before increase to 4.34 in week 4. In a similar trend, sample B demonstrated an increase in pH value from 3.74 to 4.19 from week 1 to week 4. This suggests that the metabolic activities of microorganisms influenced the process as the sample became slightly acidic (Sridhar et al., 2025). For sample C, the pH experienced a minor increase from 3.39 to 3.71 in week 1 to week 2, and slightly decrease to 3.76 in week 4. For sample E, the pH displayed a slight increase from week 1 to week 3, from pH 3.44 to 4.58, followed by a decrease to pH 3.88 on the week 4. This might be due to acid-generating microbes, particularly lactic acid bacteria that consume on carbohydrates and various substrates, yielding organic acids such as lactic acid, acetic acid, or propionic acid, which lead to acidic condition in the compost (Usmani et al., 2022). For sample D, the pH increased from 5.13 to 7.49 in week 1 to week 4, which signifies the transition from acidic to alkaline condition in sample D. An alternative possibility is denitrification, a process wherein nitrate-reducing bacteria utilize protons (H^+) throughout the transformation of nitrate (NO_3^-) into nitrogen gas (N_2), thereby resulting increased of pH (Kim et al., 2022).

Figure 4(b) shows the moisture content towards time for all samples. All samples exhibited a pattern of fluctuation in moisture content from weeks 1 to 4. The highest moisture content was attained at 40% for sample B in week 4. The lowest moisture content of 6% was attained in sample C in week 1. The optimum moisture level for composting is between 40% to 70% which plays a crucial role in assisting microorganisms to effectively decompose organic materials, guarantees ample oxygen for aerobic breakdown, keeps the compost from turning overly soggy or parched, and safeguards against nutrient depletion (Kolobeng et al., 2022). The low moisture content observed at the beginning of compost in sample C can be attributed to swift compost dehydration and limited bacterial engagement, which consequently resulted in a decline in the biological composting phenomenon (Naveed et al., 2024). The ideal moisture level for microbial engagement usually fluctuates between 50% and 70%. This range supplies ample water for microorganisms to execute their metabolic processes while ensuring adequate aeration for those that thrive in oxygen-rich environments (Meng et al., 2024).

Figure 4(c) shows the temperature towards time for all samples. Each sample demonstrate median temperature changes from 22.4 °C to 34.1 °C. For every sample, the temperature increases from week 1 to week 2, then a steady decline from week 2 week to the week 3, and increased again on the week 4. The increased of temperature is attributed to the hot weather conditions, which facilitate microbial activities. On the fourth week, the weather was sunny and the temperature rose, which increased microbial activities (Vainio et al., 2024). The temperature range for optimal microbial activity lies between 20°C and 40°C, where microorganisms such as bacteria and fungi, thrive in the 30°C to 37°C condition (Orwa et al., 2020). This temperature range raises enzyme activity and metabolic processes which enabling

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

microbes to thrive and proliferate with great efficiency. When the temperature is too low, microbial actions decrease, whereas too high can lead to enzyme denaturation that potentially causing microbes to die (Verdnik & Rieberer, 2022).

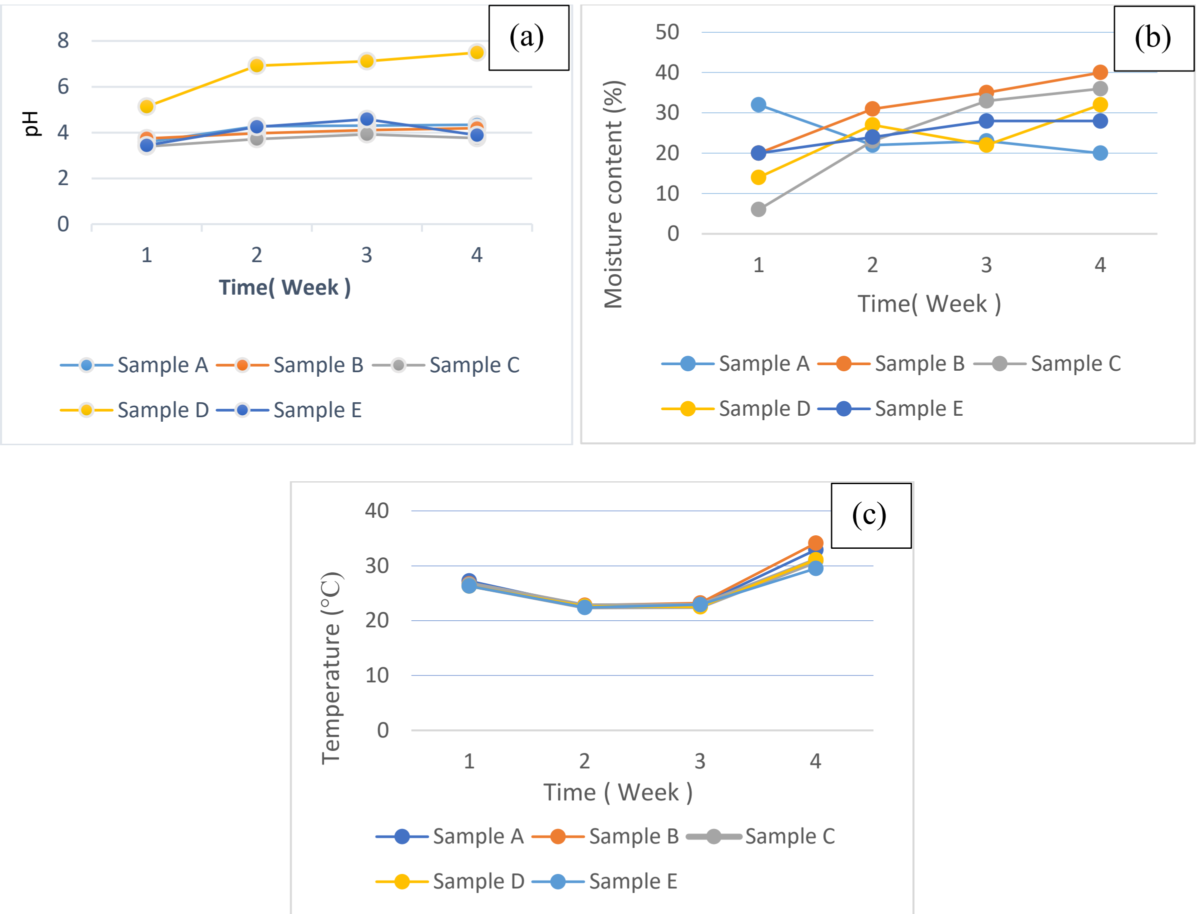

Figure 4: (a) pH, (b) Moisture Content, and (C) Temperature towards Time

Concentration of Iron and Manganese

Table 2 shows the concentration of iron and manganese in each of the compost sample. The highest iron concentration of 0.36 mg/L was observed in sample E while the lowest of 0.19 mg/L was in sample A. The suitable range for iron levels in compost is between 0.5 mg/l to 5 mg/l (Tiu et al., 2022). Exceeding the limit of 5 mg/l can make the compost unsuitable for application since it could be toxic to plants. The adverse effects include damage upon their root systems, impede the absorption of essential nutrients, and disrupt normal growth processes (Kalita et al., 2024). For manganese analysis, the highest concentration attained in sample A with 0.59 mg/L, whereas sample E recorded the lowest manganese concentration of 0.43 mg/L. The suggested manganese concentration is between 0.5 mg/l to 1 mg/l. Manganese is integral in supporting plant health yet, excessive levels can cause harm, while inadequate amounts may lead to deficiencies (Ali et al., 2024).

Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

Table 2: Concentration of Iron and Manganese in Compost Samples

Compost sample	Iron concentration (mg/L)	Manganese concentration (mg/L)
A	0.19	0.59
B	0.35	0.48
C	0.34	0.49
D	0.32	0.46
E	0.36	0.43

C:N and C:P Ratio

Table 3 shows the C:N and C:P ratio of the compost samples. Carbon is denoted as C which serves as an energy source while nitrogen is denoted as N which is necessary for the formation of cellular structures, and P is phosphate that is vital in enhancing plant performance and facilitating root development. The maximum C:N ratio of 12:1, was observed in sample A. The lowest C:N ratio of 2:1 was recorded in sample C. Low C:N ratio signifies that the compost sample rich in nitrogenous materials, which may lead to the release of excess ammonium (ammonia odor), whereas higher C:N ratio suggests that the compost still has excess carbon, leading to slower nutrient release (Tolve et al., 2021).

The C:P ratio reveals the highest of 20:1 in sample A while the lowest of 2:1 in sample D. In sample A, high C:P ratio of 20:1 can be attributed to the food waste which may content a greater quantity of carbon in comparison to phosphorus. In sample D, the low C:P ratio of 2:1 is a result of the food waste, which yields a higher concentration of phosphorus in relative to carbon, thereby resulting in a lower ratio.

The quantity of food waste has a direct influence on the equilibrium of carbon and phosphorus within the compost. These results show that the ratios of C:N and C:P obtained are not within the optimal values of 20:1 to 30:1(Ahme et al., 2024). In compost, the C:P ratio shows how carbon (C) and phosphorus (P) are proportioned. The ideal C:P ratio for composting typically within the range of 25:1 to 30:1, as this establishes a favorable balance conducive to effective decomposition. If the ratio is higher or lower than the ranges, microbial activity may become compromised, thereby adversely influencing the composting procedure (Idoko et al., 2025).

Table 3: C:N and C:P ratio of Compost Samples

Sample	Weight of food waste (kg)	Ratio	
		C:N	C:P
A	1	12:1	20:1
B	2	4:1	4:1
C	3	2:1	5:1
D	4	3:1	2:1
E	5	5:1	3:1

Pellet Fertilizer

The result for pellet fertilizer includes the diameter, length, water stability, bulk density and particle size distribution that are discuss in details in the next subsection.

Length and Diameter of Pellet

Table 4 shows the length and diameter of pellet for each sample. The measurements reveal minimal variation between each sample. Only the length measurement of 1.5 cm exhibited

International Journal of Innovation and Industrial Revolution
IJIREV
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Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

inconsistency for sample A that is due to the irregular cutting by the pelletizing machine (Blank & Obernberger, 2024). The irregularity from the machine is usually due to obstruction of pellets that need to be manually removed. Other than that, the diameter measurements present no issues, as all samples uniformly exhibited a diameter of 0.6 cm. In terms of measurement, samples B, C, D, and E consistently have the same length of 1.4 cm each.

Table 4: Length and Diameter of Pellet for Each Sample

Sample	Length (cm)	Diameter (cm)
A	1.5	0.6
B	1.4	0.6
C	1.4	0.6
D	1.4	0.6
E	1.4	0.6

Water Stability

Table 5 shows the water stability of pellets for each sample. After 5 minutes, it is apparent that sample C demonstrates the highest water stability with 87.5%, whereas sample A records the lowest water stability with 60%. Sampel C signifying long-term stability when immersed in water after 5 minutes. However, after 60 minutes, sample A recorded the highest water stability of 88% and sample E recorded the lowest water stability of 54.5%. Sample E present a lower long-term stability measurement, suggesting more rapid disintegration in comparison to the other samples (Nath et al., 2024). Samples A showcase a remarkable resilience throughout the test and uphold the form significantly better after 60 minutes compared to just 5 minutes. Sample C begins with a robust presence but tends to crumble considerably after 60 minutes, suggesting a reduced stability over time. Samples D and E also exhibit a decline in stability after 60 minutes, indicating a vulnerability to water damage as time progresses. The preference for high water stability arises from its ability to preserve the material's integrity and functionality throughout time, even when it encounters moisture (Lee et al., 2022). This characteristic protects the pellets against loss, upholds structural integrity, and enhances overall performance. In contrast, low water stability accelerates the degradation of the material, resulting in reduced efficiency and potential damage to the pellets (Kim, 2021).

Table 5: Water Stability of Pellets for Each Sample

Sample	Water stability (%)		Physical state of the pellets after immersion
	5 minutes	60 minutes	
A	60	88	

Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

B	71.43	87.5	
C	87.5	56	
D	77.8	55.6	
E	77.8	54.5	

Bulk Density

Table 6 shows the bulk density of pellets for each sample. Sample E exhibits the highest bulk density with 2.28 g/cm^3 while sample A and B had the lowest bulk density with 2.26 g/cm^3. This indicates that the pellets possessed quite similar density. The minimal variance in bulk density (merely 0.02 g/m^3) suggesting the slight differences in their composition or production methods, yet it is unlikely that this will influence their overall functionality. High bulk density indicates that the pellet is compact and weighty relative to its volume, whereas low bulk density signifies that the pellet is lighter and had high air gaps within the particles (Rezaei et al., 2024). High bulk density is advantageous for energy storage (like with fuel pellets), while lower bulk density is preferable for applications such as composting, where the circulation of air and moisture plays a crucial role. A low bulk density is typically favored for pellets because it renders them lighter, facilitates handling, and promotes enhanced airflow (Pathirana et al., 2024).

Volume 7 Issue 23 (December 2025) PP. 111-127
DOI 10.35631/IJIREV.723008

Table 6: Bulk Density of Pellet for Each Sample

Sample	Bulk density (g/m³)
A	2.26
B	2.26
C	2.27
D	2.27
E	2.28

Particle Retained

The particle retained for each sample was 100%. This finding suggests that the utilization of a pellet machine results in a consistent pellet size across all samples. The uniform retention values imply that all samples exhibit equivalent efficacy in retaining particles under the specified testing conditions (Bastiaansen et al., 2024). Comparing the properties of compost and pellet fertilizers provides a clearer understanding of the overall quality and suitability for agricultural use. Compost with optimal C:N and C:P ratios supply slow-release nutrients, improves soil structure, and supports microbial activity, making it ideal for long-term soil health, organic farming, and improving degraded soils. Pellet fertilizers, by contrast, contain more concentrated and consistent nutrients, offering faster availability and easier application suited to commercial production or precise nutrient management. Mature, stable compost can complement pellets by adding organic matter and gradual nutrient release, while nutrient-rich pellets can compensate for compost's lower nitrogen or phosphorus content. Together, these fertilizers form a more complete strategy that enhances soil quality, sustainability, and crop productivity.

Conclusion

Fertilizer made from food waste and sawdust in pellet form and compost was successfully produced in this study. The variations of food waste and sawdust content in the pellet form and compost resulted in difference of physical properties of the pellet fertilizer and chemical properties of compost fertilizer as well as the effects in composting parameters. Optimum pH, moisture content, and temperature of 7.49, 40%, and 34.1°C, were obtained in samples D, B, and B, respectively. All samples exhibited fluctuations in pH levels, which were significantly influenced by microbial activity. The highest concentration of iron and manganese are within the permissible limit for all sample with 0.36 mg/L and 0.59 mg/L. The most ideal C:P ratios was achieved for samples A with 20:1. The physical properties of the produced pellet revealed homogeneity of the pellet diameter across samples which shows consistent machine performance. Apart from that, the bulk density values exhibited only slight variability among samples, with sample E presenting the highest density of 2.28 g/cm^3 and sample A the lowest density of 2.26 g/cm^3. Additionally, all samples demonstrated uniform particle retention of 100%, indicating consistent pellet size and efficient performance of the pelletizing process. Sample A exhibited the highest water stability of 88% after a duration of 60 minutes, indicating superior resistance to aqueous degradation. Conversely, sample E demonstrated low stability of 54.5%, suggesting a tendency for more rapid disintegration in water. The findings of this study indicate that the incorporation of food waste and sawdust into contemporary agricultural practices holds significant potential for improving soil fertility and fostering environmental sustainability.

Volume 7 Issue 23 (December 2025) PP. 111-127
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