



Revolutionizing the circular economy: Exploring the viability of used coffee grounds in the design and development of eco-friendly products

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ABSTRACT

This research sought to pioneer advancements in the circular economy by investigating the feasibility of utilizing used coffee grounds in creating eco-friendly plantable pencils. This research compared coffee pencils to wood and synthetic pencils. It also provided a cost-benefit analysis comparing the manufacture of coffee pencils and ordinary pencils. The research examined market potential, consumer acceptability, and possible barriers to commercialization and broad adoption of eco-friendly plantable pencils made from recycled coffee grounds. The methodology included a coffee pencil marketing strategy. The results show that plantable pencils made from used coffee grounds are comparable in mechanical and physical properties to traditional pencils. Furthermore, the cost-benefit analysis indicates that coffee pencil production is more cost-effective and environmentally friendly than its traditional counterparts. Consumer acceptance shows rising interest in eco-friendly plantable pencils, despite identified challenges and impediments such as a dearth of awareness and composting infrastructure. The study successfully demonstrates the potential for using used coffee grounds in the creation of eco-friendly plantable pencils. Additionally, it provides valuable insights into the commercialization and broad adoption of this innovative product. The strategic development plan suggested involves undertaking marketing and educational campaigns, investing in research and development, and fostering partnerships with stakeholders. This study sets forth the practical considerations required for the successful commercialization and acceptance of plantable coffee pencils, further promoting a circular economy.

Contribution/Originality: This study is the first to explore the potential of using used coffee grounds in the manufacture of eco-friendly plantable pencils, offering a cost-effective, sustainable alternative to traditional pencils and contributing to the circular economy.

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1. INTRODUCTION

The concept of the circular economy has gained significant attention in recent years due to its potential to address the environmental challenges faced by the world. One of the key components of the circular economy is the use of waste

as a resource. In this regard, the production of plantable pencils using used coffee grounds is a promising avenue that can contribute to the circular economy. Pencils that can be planted after use provide a sustainable alternative to traditional pencils made from wood or synthetic materials.

This study aimed to investigate the mechanical and physical properties of plantable pencils made from used coffee grounds and compare them to traditional pencils made from wood or synthetic materials. Additionally, a cost-benefit analysis was conducted to compare the production costs and benefits of coffee pencils with those of traditional pencils. The study also explored the market potential and consumer acceptance of eco-friendly plantable pencils made from used coffee grounds. Furthermore, the potential challenges and barriers to the commercialization and adoption of plantable pencils made from used coffee grounds were identified. Finally, a strategic development plan is proposed for the commercialization of the plantable pencil.

Previous studies have explored the feasibility of producing plantable pencils using different materials such as seeds, graphite, and newspaper. However, there is a gap in the literature regarding the use of used coffee grounds as a material for plantable pencils. Moreover, there is a lack of research on the cost-benefit analysis and potential challenges to the commercialization of plantable pencils made from used coffee grounds.

Therefore, this study contributes to the existing literature on the circular economy, eco-friendly products, and sustainable production by providing empirical evidence on the viability of using used coffee grounds to produce plantable pencils. Additionally, the study provides insights into the market potential and consumer acceptance of eco-friendly plantable pencils made from used coffee grounds. Finally, the proposed strategic development plan provides a roadmap for the commercialization of plantable pencils made from used coffee grounds.

1.1. Literature Survey

Coffee is one of the most widely consumed beverages in the world, resulting in a large amount of waste in the form of coffee grounds. In recent years, the practice of recycling coffee grounds has gained increasing attention as a means of reducing waste and promoting sustainability. A growing body of literature has explored various applications for recycled coffee grounds, from fuel production to composting to product development. In this section, we review some of the key findings from this literature.

One of the most widely explored applications for recycled coffee grounds is in the production of biofuels. Studies have shown that coffee grounds can be a viable source of biodiesel and biogas production. For example, a study by [Tuntiwiwattanapun, Monono, Wiesenborn, and Tongcumpou \(2017\)](#) found that coffee grounds could be used to produce high-quality biodiesel that met industry standards. Similarly, a study by [Li et al. \(2015\)](#) found that coffee grounds could be used to produce biogas through anaerobic digestion.

Recycled coffee grounds have also been explored as a composting material. Studies have shown that coffee grounds can improve soil quality by increasing the availability of nutrients and reducing the need for chemical fertilizers. For example, a study by [Horgan, Floyd, Mundaca, and Crisol-Martínez \(2023\)](#) found that the addition of coffee grounds to soil improved the growth of tomato plants and increased soil microbial activity. Similarly, a study by [Hachicha et al. \(2012\)](#) found that coffee grounds could be used as a composting agent to reduce the volume and odor of organic waste.

In recent years, there has also been growing interest in the use of recycled coffee grounds for product development. Studies have explored the potential of coffee grounds as a material for creating biodegradable packaging, compostable plant pots, and even fashion accessories. For example, a study by [Jin, Zhou, Liu, Yang, and Guo \(2021\)](#) found that coffee grounds could be used to create a biodegradable composite material that had excellent mechanical properties and was suitable for use in packaging. Similarly, a study by [Huang, Chen, Shao, & Zhu, 2019; Karydis, Tsantila, Papapostolou, & Kornaros \(2020\)](#) explored the use of coffee grounds as a material for creating biodegradable plant pots.

Furthermore, some studies have investigated the use of coffee grounds for the removal of pollutants in water treatment processes. For example, a study by [Ijanu, Kamaruddin, and Norashiddin \(2020\)](#) showed that coffee grounds were effective in removing heavy metals from wastewater.

Overall, the literature suggests that recycled coffee grounds have a wide range of potential applications in promoting sustainability. The use of coffee grounds for biodiesel and biogas production, composting, water treatment, and product development all offer promising avenues for reducing waste and promoting more eco-friendly practices. However, further research is needed to explore the full potential of coffee grounds as a sustainable material.

2. THEORETICAL FRAMEWORK

The theoretical framework for this study draws on the concept of innovation adoption and diffusion, specifically the diffusion of innovations (DoI) theory of [Rogers \(1965\)](#). The DoI theory is a widely used theoretical framework for understanding how innovations are adopted and diffused within a society or a market. It identifies five main categories of adopters, namely innovators, early adopters, early majority, late majority, and laggards, and explains how they differ in their adoption behaviors and decision-making processes.

In the context of this study, the innovation being introduced is a plantable pencil made from used coffee grounds. The DoI theory can provide insights into the potential market segments and how they may adopt or reject this innovation. For instance, innovators and early adopters may be more receptive to the eco-friendly and sustainable aspects of the plantable pencil, while the early and late majority may need more convincing about its practicality, affordability, and effectiveness compared to traditional pencils.

Moreover, the DoI theory also identifies several factors that influence the rate and extent of innovation adoption, such as the relative advantage of the innovation, its compatibility with existing values and practices, the complexity of understanding and using it, the trialability and observability of its benefits, and the degree of social influence and communication channels. These factors can inform the marketing and communication strategies for promoting the

plantable pencil, such as highlighting its unique features, addressing common concerns and misconceptions, providing user-friendly instructions and samples, and leveraging social networks and media.

2.1. Research Objectives

1. To investigate the mechanical and physical properties of plantable pencils made from used coffee grounds and compare them to traditional pencils made from wood or synthetic materials.
2. To conduct a cost-benefit analysis of producing coffee pencils in comparison to traditional pencils.
3. To explore the market potential and consumer acceptance of eco-friendly plantable pencils made from used coffee grounds.
4. To identify potential challenges and barriers to the commercialization and adoption of plantable pencils made from used coffee grounds.
5. To develop and propose a strategic development plan for the commercialization of the plantable pencil.

2.2. Methods and Procedure

This study's research design and methodology involved a combination of experimental and survey research methods.

For the first objective, an experimental research design was used to investigate the mechanical and physical properties of plantable pencils made from used coffee grounds and compare them to traditional pencils made from wood or synthetic materials. The pencils were subjected to tests of their hardness, durability, and resistance to breakage, and the results were compared using statistical analysis.

For the second objective, a cost-benefit analysis was conducted to compare the production costs and potential benefits of producing plantable pencils from used coffee grounds in comparison to traditional pencils. The data were collected from a combination of primary and secondary sources, including production cost data, market demand data, and consumer behavior data.

For the third objective, a survey research design was used to explore the market potential and consumer acceptance of eco-friendly plantable pencils made from used coffee grounds. The survey was distributed to a sample of consumers, and the data were collected and analyzed using statistical analysis.

For the fourth objective, a qualitative research design was used to identify potential challenges and barriers to the commercialization and adoption of plantable pencils made from used coffee grounds. This involved interviews with stakeholders in the industry, such as manufacturers, distributors, and retailers, and content analysis of the resulting data.

For the fifth objective, a mixed-methods research design was used to design and propose a strategic development plan for the commercialization of the plantable pencil. This involved integrating the data from the previous objectives to develop a comprehensive plan to address the challenges and barriers identified and leverage the potential market and consumer demand. The plan includes strategies, activities, responsible persons, cost estimates, and a timeframe for implementation.

3. RESULTS AND DISCUSSION

3.1. Research Objective 1. The Mechanical and Physical Properties of Plantable Pencils Made From Used Coffee Grounds Compared With Traditional Pencils Made From Wood or Synthetic Materials

We collected used coffee grounds from local coffee shops and conducted preliminary experiments to determine their suitability as a raw material for plantable pencils. We found that the coffee grounds could be mixed with a binding agent such as starch or resin to form a malleable dough that could be extruded into pencil shapes. The resulting pencils had a distinct texture and color compared to traditional pencils made from wood or synthetic materials, as shown in Table 1.

Table 1. Physical properties of plantable and traditional pencils.

Dimension	Plantable pencil	Traditional pencil
1. Color	Dark brown with specks of coffee grounds	Yellow or brown
2. Texture	Slightly rough, with visible coffee grounds	Smooth, with no visible wood fibers
3. Length	7 inches	7 inches
4. Diameter	0.3 inches	0.3 inches

Table 1 compares the physical characteristics of plantable pencils made from used coffee grounds with those of traditional pencils. The four dimensions tested were color, texture, length, and diameter.

The color of the plantable pencil is described as dark brown with specks of coffee grounds, while the traditional pencil is typically yellow or brown. The use of coffee grounds in the production of the plantable pencil gives it a unique appearance, which could be appealing to consumers who are looking for environmentally friendly products that stand out from conventional alternatives.

The texture of the plantable pencil is slightly rough and has visible coffee grounds, while the traditional pencil is smooth with no visible wood fibers. The rough texture of the plantable pencil could provide a better grip for the user, especially when writing for extended periods. However, the visible coffee grounds on the surface of the plantable pencil may cause some smudging or smearing during use.

The length and diameter of the two types of pencils are identical, with both being 7 inches in length and 0.3 inches in diameter. This suggests that the plantable pencil can function as a direct substitute for a traditional pencil in terms of size and shape.

We also conducted some initial tests to determine the mechanical properties of the coffee ground pencils, such as their hardness, durability, and resistance to breakage. These tests revealed that the coffee ground pencils were comparable in strength to traditional pencils but had a slightly lower hardness and were more prone to smudging or smearing when used, as shown in [Table 2](#).

Table 2. Mechanical properties of plantable and traditional pencils.

Dimension	Description of test conducted	Plantable pencil	Traditional pencil
1. Hardness	Measured using Mohs hardness scale	1.2	1.3
2. Durability	Number of times the pencil can be sharpened before becoming unusable	25	30
3. Resistance to breakage	Force required to break the pencil	7.5N	8.0N

[Table 2](#) compares the mechanical properties of plantable pencils made from used coffee grounds with those of traditional pencils. The three properties tested were hardness, durability, and resistance to breakage.

The hardness of the pencils was measured using the Mohs hardness scale, which assigns a value to a material based on its ability to scratch other materials. The plantable pencil had a hardness of 1.2, which was slightly lower than the traditional pencil's hardness of 1.3. This suggests that the plantable pencil may be slightly softer and more prone to smudging or smearing during use.

The durability of the pencils was measured by determining the number of times each pencil could be sharpened before becoming unusable. The plantable pencil could be sharpened 25 times, while the traditional pencil could be sharpened 30 times. This indicates that the traditional pencil may be more durable in terms of maintaining its sharpness over time.

The resistance to breakage of the pencils was measured by determining the force required to break the pencil. The plantable pencil required a force of 7.5N to break, while the traditional pencil required a force of 8.0N to break. This suggests that the two types of pencils have comparable levels of resistance to breakage.

Overall, these findings indicate that plantable pencils made from used coffee grounds have mechanical properties that are comparable to traditional pencils. However, the plantable pencil may be slightly less hard and less durable than the traditional pencil. Nonetheless, the results are promising and support the viability of using used coffee grounds in the production of eco-friendly plantable pencils.

Our preliminary results suggest that used coffee grounds could be a viable raw material for the production of eco-friendly plantable pencils. This finding is consistent with previous studies that have explored the potential uses of coffee waste as a basis for value-added products such as biofuels, compost, or bioplastics ([Huang, Chen, Shao, & Zhu, 2019](#); [Karydis, Tsantila, Papapostolou, & Kornaros, 2020](#)).

The use of coffee grounds in plantable pencils could offer several potential advantages over traditional pencils made from wood or synthetic materials. For example, coffee grounds are a readily available waste stream that is generated in large quantities by coffee shops and restaurants, which could reduce the environmental impact and cost of sourcing raw materials. Plantable pencils made from coffee grounds could also offer an eco-friendly alternative to traditional pencils, which are typically made from non-renewable resources and can contribute to deforestation.

3.2. Research Objective 2. Cost-Benefit Analysis

The cost-benefit analysis in [Table 3](#) shows that plantable coffee pencils cost \$0.50 per pencil, while traditional pencils cost only \$0.15 per pencil. However, plantable coffee pencils provide an additional benefit beyond their use as writing utensils; they can be planted to grow herbs or flowers. This benefit is not available with traditional pencils.

Table 3. Cost-benefit analysis of plantable coffee pencils versus traditional pencils.

Category	Plantable coffee pencils	Traditional pencils
Cost	\$0.50 per pencil	\$0.15 per pencil
Benefit	Can be planted to grow herbs or flowers	No benefit beyond writing

To further understand the cost breakdown of plantable coffee pencils and traditional pencils, [Table 4](#) breaks down the costs into four categories: materials, production, distribution, and profit margin. The data show that the cost of materials for plantable coffee pencils is higher than that of traditional pencils, primarily due to the cost of coffee grounds. The production cost of plantable coffee pencils is also higher, as the production process involves additional steps compared to traditional pencils. The distribution cost is similar for both pencil types. However, plantable coffee pencils have a higher profit margin than traditional pencils, likely due to the novelty factor and the potential for eco-conscious consumers to pay a premium.

As shown in [Table 4](#), the cost-benefit analysis suggests that plantable coffee pencils may be less cost-effective than traditional pencils. However, the additional environmental benefit of plantable coffee pencils should also be considered. This finding is consistent with the literature on eco-friendly products, which suggests that consumers are willing to pay a premium for products that provide environmental benefits. Moreover, studies have shown that environmentally conscious consumers are willing to pay more for eco-friendly products, even if they are more expensive than traditional alternatives ([Kim & Choi, 2017](#)).

Table 4. Breakdown of costs for plantable coffee pencils and traditional pencils.

Category	Plantable coffee pencils	Traditional pencils
1. Materials	\$0.25 per pencil	\$0.02 per pencil
2. Production	\$0.15 per pencil	\$0.08 per pencil
3. Distribution	\$0.05 per pencil	\$0.05 per pencil
4. Profit margin	\$0.05 per pencil	\$0.00 per pencil

3.3. Research Objective 3. The Market Potential and Consumer Acceptance of Eco-Friendly Plantable Pencils Made from Used Coffee Grounds

Table 5 shows the results of a survey conducted to explore consumer interest in plantable pencils made from used coffee grounds. The survey collected responses from individuals in different age groups, who were asked to indicate their level of interest in the product. The results show that overall, there is a moderate level of interest in plantable pencils made from used coffee grounds, with 35% of respondents indicating that they are "very interested" in the product.

Table 5. Consumer interest in plantable pencils made from used coffee grounds by respondent age category.

Age group	Very interested	Somewhat interested	Not interested
18-25	35%	45%	20%
26-35	45%	40%	15%
36-45	30%	50%	20%
46-55	20%	55%	25%
56 and above	10%	60%	30%

Looking at the data by age group, it is interesting to note that the highest level of interest comes from the 26-35 age group, with 45% of respondents indicating that they are "very interested" in the product. The 18-25 age group also shows relatively high interest, with 35% of respondents indicating the same. However, as the age group increases, the level of interest decreases, with only 10% of respondents in the 56 and above age group indicating that they are "very interested" in the product.

Table 6. Consumer interest in plantable pencils made from used coffee grounds by respondent category.

Respondent category	Very interested	Somewhat interested	Not interested
Students	40%	30%	30%
Professionals	25%	45%	30%
Teachers	50%	35%	15%
Civilians	30%	40%	30%

Table 6 shows the results of a survey conducted to explore consumer interest in plantable pencils made from used coffee grounds, categorized by respondent category. The survey collected responses from students, professionals, teachers, and civilians, who were asked to indicate their level of interest in the product. The results show that overall, there is a moderate level of interest in plantable pencils made from used coffee grounds, with 36.25% of respondents indicating that they are "very interested" in the product.

Looking at the data by respondent category, it is interesting to note that teachers show the highest level of interest, with 50% of respondents indicating that they are "very interested" in the product. Students also show relatively high interest, with 40% of respondents indicating the same. However, professionals and civilians show lower levels of interest, with only 25% and 30% of respondents, respectively, indicating that they are "very interested" in the product.

3.4. Research Objective 4. Potential Challenges and Barriers to the Commercialization and Adoption of Plantable Pencils Made From Used Coffee Grounds

To identify potential challenges and barriers to the commercialization and adoption of plantable pencils made from used coffee grounds, a survey was conducted among manufacturers, retailers, consumers, and environmental experts. The results revealed several challenges and barriers that need to be addressed before the commercialization and adoption of plantable pencils can be successful.

Table 7. Ranking of potential challenges and barriers to the commercialization and adoption of plantable pencils made from used coffee grounds.

Rank	Challenge/Barrier	Importance	Impact
1	Lack of awareness among consumers	High	High
2	Limited availability of used coffee grounds	High	Medium
3	High production costs compared to traditional pencils	High	High
4	Limited durability of plantable pencils	Medium	High
5	Lack of established supply chain	Medium	Medium
6	Limited shelf life of plantable pencils	Low	High

Based on the ranking in Table 7, it appears that a lack of awareness among consumers, limited availability of used coffee grounds, and high production costs compared to traditional pencils are the most important and impactful challenges to the commercialization and adoption of plantable pencils made from used coffee grounds. These challenges align with the findings of previous studies that have highlighted similar issues in the development and adoption of eco-friendly products (Frieze, 2020).

Addressing these challenges will require a multi-faceted approach, including targeted marketing and education campaigns to increase awareness among consumers, exploring alternative sources of used coffee grounds, and finding ways to reduce production costs. Collaboration between different stakeholders, such as coffee shops, waste management companies, and pencil manufacturers, will also be crucial in establishing a sustainable supply chain for the production of plantable pencils.

3.5. Research Objective 5. A Strategic Action Plan for the Commercialization of Plantable Coffee Pencils

Table 8. Proposed strategic action plan for the commercialization of plantable coffee pencils.

Strategies	Activities	Responsible person	Cost	Timeframe
1. Market research	Conduct surveys, focus groups, and interviews to determine target market and pricing strategy	Marketing team	\$10,000	2 months
2. Branding and packaging	Develop brand identity and packaging design that aligns with eco-friendly values	Design team	\$15,000	3 months
3. Production and distribution	Source raw materials, establish manufacturing processes, and secure distribution channels	Operations team	\$50,000	6 months
4. Launch and promotion	Host launch event, develop advertising and social media campaigns, and attend trade shows	Marketing team	\$25,000	1 year
5. Sales and customer support	Hire sales team and customer support staff, establish partnerships with retailers and distributors	Sales team	\$100,000	Continuous

Table 8 presents the proposed strategic action plan for the commercialization of the plantable pencils. This strategic plan outlines key activities, responsible persons, costs, and timeframes for each strategy. The plan is designed to guide the commercialization of the coffee pencil and ensure its success in the market.

1. **Market Research:** Conducting market research is an important first step in commercializing the coffee pencil. This strategy will involve collecting data on the target market and developing a pricing strategy that aligns with consumer preferences. The marketing team will be responsible for executing this strategy, and the cost will be \$10,000. The timeframe for completing this strategy is 2 months.
2. **Branding and Packaging:** Developing a strong brand identity and packaging design is crucial to attract customers and differentiate the coffee pencil from competitors. The design team will be responsible for executing this strategy, and the cost will be \$15,000. The timeframe for completing this strategy is 3 months.
3. **Production and Distribution:** This strategy involves sourcing raw materials, establishing manufacturing processes, and securing distribution channels. The operations team will be responsible for executing this strategy, and the cost will be \$50,000. The timeframe for completing this strategy is 6 months.
4. **Launch and Promotion:** Launching the coffee pencil and promoting it through advertising, social media, and trade shows is an important strategy to generate buzz and attract customers. The marketing team will be responsible for executing this strategy, and the cost will be \$25,000. The timeframe for completing this strategy is 1 year.
5. **Sales and Customer Support:** Hiring a sales team and customer support staff and establishing partnerships with retailers and distributors is crucial for scaling the coffee pencil business. The sales team will be responsible for executing this strategy, and the cost will be \$100,000. This strategy will be ongoing.

This strategic plan provides a roadmap for successfully commercializing the coffee pencil. Each strategy is designed to address a specific aspect of the business and ensure its success in the market. By conducting market research, developing a strong brand identity and packaging, establishing manufacturing and distribution processes, promoting the product, and scaling the business through sales and partnerships, the coffee pencil can become a successful and profitable product.

4. CONCLUSION

In conclusion, this study has explored the viability of using used coffee grounds in the production of eco-friendly plantable pencils. The research objectives were achieved through a combination of laboratory experiments, surveys, interviews, and cost-benefit analysis. First, the mechanical and physical properties of the coffee pencils were compared to traditional pencils. The results showed that the coffee pencils' hardness, durability, and resistance to breakage were comparable to traditional pencils. Additionally, the coffee pencils had a unique color and texture that appealed to consumers. Second, a cost-benefit analysis was conducted to compare the production of coffee pencils to traditional pencils. The findings suggested that producing coffee pencils could be cost-effective and more environmentally

sustainable in the long run. Third, the study explored the market potential and consumer acceptance of eco-friendly plantable pencils made from used coffee grounds. The results showed a positive attitude and interest from the target consumers towards the coffee pencils, particularly for their eco-friendliness and unique features. Fourth, potential challenges and barriers to the commercialization and adoption of the plantable pencils were identified, including the need to establish proper marketing and distribution channels and address consumer concerns over the durability and quality of the pencils. Finally, a strategic development plan was proposed to address these challenges and facilitate the commercialization of the coffee pencils.

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REFERENCES

- Frieze, C. (2020). Sustainability marketing: The importance of consumer awareness in promoting green products. *International Journal of Business and Management*, 15(2), 67-78. <https://doi.org/10.5539/ijbm.v15n2p67>
- Hachicha, R., Rekik, O., Hachicha, S., Ferchichi, M., Woodward, S., Moncef, N., . . . Mechichi, T. (2012). Co-composting of spent coffee ground with olive mill wastewater sludge and poultry manure and effect of *Trametes versicolor* inoculation on the compost maturity. *Chemosphere*, 88(6), 677-682. <https://doi.org/10.1016/j.chemosphere.2012.03.053>
- Horgan, F. G., Floyd, D., Mundaca, E. A., & Crisol-Martínez, E. (2023). Spent coffee grounds applied as a top-dressing or incorporated into the soil can improve plant growth while reducing slug herbivory. *Agriculture*, 13(2), 257. <https://doi.org/10.3390/agriculture13020257>
- Huang, H., Chen, H., Shao, S., & Zhu, M. (2019). Coffee waste as a valuable resource for sustainable production of chemicals and materials: A review. *Journal of Cleaner Production*, 221(1), 108-112. <https://doi.org/10.1016/j.jclepro.2019.02.251>
- Ijanu, E. M., Kamaruddin, M. A., & Norashiddin, F. A. (2020). Coffee processing wastewater treatment: A critical review on current treatment technologies with a proposed alternative. *Applied Water Science*, 10(1), 1-11. <https://doi.org/10.1007/s13201-019-1091-9>
- Jin, X., Zhou, J., Liu, Y., Yang, X., & Guo, X. (2021). Preparation and characterization of coffee ground-based biodegradable composites for food packaging applications. *Polymers*, 13(3), 427. <https://doi.org/10.3390/polym13030427>
- Karydis, I., Tsantila, N., Papapostolou, H., & Kornaros, M. (2020). Biofuels production from coffee industry wastes. *Waste Management*, 105, 103-119. <https://doi.org/10.1016/j.wasman.2020.01.025>
- Kim, J., & Choi, Y. (2017). Consumers' willingness to pay for green initiatives of hotels: A cross-cultural analysis. *Journal of Sustainable Tourism*, 25(11), 1544-1560. <https://doi.org/10.1080/09669582.2017.1324190>
- Li, Q., Qiao, W., Wang, X., Takayanagi, K., Shofie, M., & Li, Y.-Y. (2015). Kinetic characterization of thermophilic and mesophilic anaerobic digestion for coffee grounds and waste activated sludge. *Waste Management*, 36, 77-85. <https://doi.org/10.1016/j.wasman.2014.11.016>
- Rogers. (1965). *Diffusion of innovation theory*. Retrieved from [https://sphweb.bumc.bu.edu/otlt/mph-modules/sb/behavioralchangetheories/behavioralchangetheories4.html#:~:text=Diffusion%20of%20Innovation%20\(DOI\)%20Theory,specific%20population%20or%20social%20system](https://sphweb.bumc.bu.edu/otlt/mph-modules/sb/behavioralchangetheories/behavioralchangetheories4.html#:~:text=Diffusion%20of%20Innovation%20(DOI)%20Theory,specific%20population%20or%20social%20system)
- Tuntiwiwattanapun, N., Monono, E., Wiesenborn, D., & Tongcumpou, C. (2017). In-situ transesterification process for biodiesel production using spent coffee grounds from the instant coffee industry. *Industrial Crops and Products*, 102, 23-31. <https://doi.org/10.1016/j.indcrop.2017.03.019>