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RESEARCH ARTICLE

DEVELOPMENT AND ASSESSMENT OF BANANA (*MUSA ACUMINATA*) AS A POTENTIAL INDUSTRIAL LUBRICANT

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Abstract

The detrimental impact of non-renewable petroleum fuels on the environment has prompted the quest for more sustainable and environmentally friendly alternatives. This study assessed the viability of utilizing banana peel extract as a lubricant additive. The objective was to offer the Philippines an economically viable and eco-friendly answer for their industrial and waste management requirements. A comparative analysis was conducted to assess the tribological characteristics of the lubricant derived from banana peels in comparison to conventional industrial lubricants. This evaluation involved conducting a coefficient of friction test and a pin-on-disc wear test. The oil derived from banana peels was obtained through a conventional extraction process and combined with paraffin oil in equal proportions (1:1) to produce the lubricant. The findings indicated that the standard lubricant exhibited superior tribological characteristics to the banana peel-based lubricant. The standard lubricant had an average coefficient of friction of 0.354 and a wear coefficient of 0.022, whereas the banana peel-based lubricant had respective values of 0.594 and 0.037. These findings conclude that banana peel is not a viable addition to industrial lubricants. However, additional research is required to explore more sophisticated scientific tools and technologies for assessing the tribological characteristics of lubricants derived from banana peels. Furthermore, improvements to the banana peel extraction process should be considered to create more accurate and reliable results.

Keywords: *banana (musa acuminata), industrial lubricant, experimental*

Introduction

The Philippines remained the top banana producer in 2022, according to the Department of Agriculture (2022), and the second-largest in the world in 2021, according to a recent UN Food and Agriculture Organization report. The health benefits of bananas include their ability to be consumed orally, where they can be utilized as a moisturizer and skin soother, to improve dental and hair health, and as one of the main sources of nutrients for animal feed (Rugerri, 2022). Banana peels have the potential to replace petroleum products since they are biodegradable, renewable, and non-toxic, and because bananas are produced and consumed in large amounts in the nation (Masripan et al., 2019). Furthermore, according to a study by Hikal et al. (2022), agricultural waste has caught scientists' attention and is now fascinating to investigate and use rather than being a waste that is neglected.

Conversely, lubricants assist a material in lowering heat generated during surface movement and reducing friction between adjacent surfaces (Devashree, 2022). Engines, greases, compressors, gearboxes, and transmission oils are among the applications for lubricants. However, a study by Masripan et al. (2020) discovered that using conventional lubricants led to issues with toxicity and the environment, as well as an increase in the severity of working conditions. The study also discovered that the rising cost of fossil fuels is pushing scientists to find other types of additives, such bio-lubricant. Furthermore, the prolonged lockdown during COVID-19 has an impact on manufacturing sectors as metalworking, fabrication, oil and gas, chemicals, and consumer goods (Devashree, 2022). As a result, the industrial sector's need for lubricating oil declined. However, there will be a higher need for lubricants in the industrial sector when it reopens in 2021. Furthermore, according to a study by Ali et al. (2022), many businesses have focused on improving the topological properties of contact surfaces in an effort to lessen the amount of energy wasted in combustion engines due to wear and friction. These arguments were strong enough to justify the use of nanoparticles to lubricants to enhance their performance.

Furthermore, in order to preserve Mother Earth and reduce the need for these fossil fuel resources, it is imperative to develop new renewable energy alternatives like bio-oils. Since bio-oils are derived from naturally replenishable resources, they do not pose a threat to the environment (Sadiq et al., 2022). Eco-friendly lubricants are becoming more popular as a result of the harm that non-renewable petroleum fuels do to the environment. Vegetable and synthetic oils are regarded as feasible basis stocks for bio-lubricants (Prasannakumar et al., 2022). The performance of banana peels as a lubricant alternative in many applications is of interest to the researchers. The lubricating qualities of banana peels and common lubricants will be contrasted in this experiment. This study may indicate that utilizing banana peels as lubricants could be financially advantageous for smaller businesses because it would save them money on expensive commercial lubricants. The Philippines' industrial and disposal needs are intended to be met by this project in a sustainable and economical manner.

Research Question

Specifically, this study sought to answer the following:

1. What are the key tribological properties (friction, wear reduction) of banana peel extracts or bio-oils?
2. How do banana-based lubricants perform in friction and wear tests compared to conventional lubricants under various load and speed conditions?
3. Are banana-derived lubricants compatible with common industrial materials (metals, plastics)?
4. Can banana-based lubricants contribute to a more sustainable lubrication industry by reducing reliance on petroleum-based products?

Methodology

Materials and Equipment

Banana Peels:

- Ripe bananas (varying ripeness for comparison)
- Drying oven or dehydrator
- Grinder (e.g., mortar and pestle, blender)
- Sieve (optional, for size control)

Extraction and Processing:

1. Solvent(s) for extraction (e.g., ethanol, water, vegetable oil) depending on chosen extraction method
2. Distillation apparatus (optional, for solvent removal)
3. Filtering materials (e.g., filter paper, cheesecloth)
4. Heating mantle or hot plate (for solvent evaporation)

Analysis and Testing:

- Analytical balance
- Viscometer (for measuring viscosity)
- Tribological testing equipment (e.g., pin-on-disk tester) for measuring friction and wear properties
- Spectroscopy equipment (e.g., FTIR) for chemical characterization (optional)
- Biodegradability testing equipment or collaboration with a lab specializing in biodegradation studies

Banana Peel Extraction and Banana peel-based Lubricant Production

Typically, lubricants contain 90% base oil (most often petroleum fractions, called mineral oils) and less than 10% additives. In this experiment's case, the researchers will be utilizing paraffin oil as the base oil together with extracted banana peel oils as the additive, to form the lubricant. However, the lubricant concoction ratio that the investigators seek to administer in this experiment is set to 50% paraffin oil and 50% extracted banana peel oil. This is mainly influenced by an experiment by Masripan et al. (2019) wherein the researchers involved were able to prove that the level of banana peel content could influence the tribological properties of the paraffin oil, which was the base oil used. Furthermore, it was also stated that the effectiveness of the tribological properties improves directly proportional to the level of banana peel content utilized, making it favorable for the investigators of this research to concoct the lubricant from a high banana peel additive content.

Killeen (2021), stated the following for the procedures for extracting banana peel oil. Take note that a portion of the original procedure was modified due to the lack of proper materials and instruments:

1. Slice seven banana peels into medium pieces. Afterwards, blend for 10 minutes or until desired texture.
2. Using a pot, boil the blended banana peels for 1 hour at low to medium heat in Ethanol. Then filter the extract in a jar. This crude extract is considered dirty, containing a diverse mix of aqueous and non-polar moieties, cell debris, and other insoluble. Add salt to the extract to aid the separation process.
3. In a separate jar, mix vinegar, baking soda, dish soap, and water to create a homemade water-based cleaner in place of hexane. This mixture is essential for washing the crude extract and discarding the unwanted molecules.
4. Mix the homemade water-based cleaner with the banana peel extract and leave it to stand for 24 hours to phase out and form 2 layers.
5. Once the layers are formed, withdraw the banana oil which can be discovered at the top layer of the aqueous mixture. Use a syringe in the process. The banana oil extracted will then serve as the additive for the lubricant

6. To complete the procedure, mix the banana peel oil extract with paraffin oil in a ratio of 1:1. This mixture will facilitate the desired outcome of producing a lubricant with paraffin as the base oil and banana peel extract as the additive.

Lubricants Tribological Properties Evaluation

With the complete product, the researchers will then proceed with comparing the effectiveness of banana peel-based lubricant with standard lubricants and record the data created through tabulations. This study will measure the two tribological properties of lubricants mainly, the friction and wear. The researchers will execute traditional methods and procedures in evaluating the required data.

The researchers will execute a simple coefficient of friction experiment for the friction test. This experiment is necessary to calculate the friction coefficient of the lubricants and determine which of the lubricants was able to reduce more friction between an object and the surface.

1. The test utilized Rasmussen's (2022) simple friction coefficient test procedure:
2. Apply the lubricant to be tested on a block of wood.
3. Position the block of wood at one edge of the flat slab.
4. Slowly lift the slab until the block slides at the other end of the slab.
5. Measure the exact height of the slab at which the block of wood slipped. Also, calculate the length of the flat slab.
6. With the Pythagorean theorem, calculate for the adjacent given the hypotenuse (length of the slab) and opposite (height of the slab).
7. Afterwards, divide the height of the slab by the calculated adjacent to obtain the friction coefficient. Repeat the test with the same lubricant and block/platform until 5 trials are completed.
8. Now, repeat the whole process but with a different lubricant and block/platform.

For the wear test, the researchers will execute a simplified version of the pin-on-disc experiment which is a widely known test for obtaining the wear coefficient. This method is necessary to approximately determine which of the lubricants was able to reduce more wear between two surfaces.

Due to the absence of a pin-on-disk tribometer, the test utilized a modified version of the pin-on-disc test to evaluate the wear coefficient of the lubricants. The following is the procedure of the experiment:

1. Measure and record the diameter of the eraser to be used before starting the test
2. Coat the same eraser with the chosen lubricant and put it vertically over a fixed cardboard piece.
3. Apply a fixed amount of force (such as the weight of a small object) to the top of the eraser to create constant pressure.
4. Slide the eraser back and forth in a linear motion over a set time of 5 mins and a sliding distance of 10 cm.
5. Inspect the eraser for any wear or damage, then measure its diameter.
6. With the formula: (diameter before test - diameter after test) / sliding distance, calculate the wear coefficient
7. Repeat the test with the same eraser and lubricant to complete the 5 trials.
8. Reproduce the whole procedure but with a different lubricant and eraser of the same type. By comparing the wear and damage to the eraser for different lubricants, the researchers will be able to determine which lubricant provides the best protection against wear.

In comparing the lubricants' effectiveness, the researchers will tabulate data based on the yield of the aforementioned tests. These experiment procedures are necessary to compare the variables in terms of their effectiveness. The researchers will administer 5 trials for each test, both for assessing the banana peel-based lubricant and standard lubricant, before proceeding to compare and interpret the data.

Results

Table 1. *Banana Peel-Based Lubricant's Tribological Properties*

	Banana peel-based lubricant	
	Friction	*Wear*
Trial 1	.630	.040
Trial 2	.589	.035
Trial 3	.618	.038
Trial 4	.540	.036
Trial 5	.595	.035
Ave	.594	.037

Table 2. *Standard Lubricant's Tribological Properties*

	Standard lubricant	
	Friction	*Wear*

Trial 1	.354	.020
Trial 2	.377	.022
Trial 3	.346	.023
Trial 4	.370	.023
Trial 5	.322	.022
Ave	.354	.022

Conclusion

The study's findings demonstrate that the standard lubricant outperforms the banana peel-based lubricant in terms of its effectiveness. With the hypotheses having been rejected, it can be inferred that banana peel-based lubricant is not a viable substitute for lubricants, particularly in the industrial setting. Nevertheless, it is crucial to consider the potential limitations and gaps in this study. Given the most effective extraction process and thorough tribological properties evaluation, the banana peel-based lubricant has the potential to become a viable option for industrial use, even surpassing standard industrial lubricants. However, based on the current research, the most probable application for the banana peel-based lubricant is in household settings. Despite being unsuitable for industrial applications, it may have potential use in households or for minor, trivial, or temporary machinery issues. In conclusion, the research suggests that whilTe the banana peel-based lubricant may not be a substitute for standard industrial lubricants at present, with further research and development, it could become a feasible option. Nevertheless, for now, it is advisable to stick with standard lubricants for industrial purposes, while considering banana peel-based lubricants for minor or temporary machinery problems in domestic settings.

To improve the extraction process of banana peels for lubricant production, it is recommended that more advanced tools are utilized. In this project, a simple pot was used for boiling, but a pressure cooker would be more appropriate as it would lessen the evaporation of ethanol. Additionally, materials such as a centrifuge and separatory funnel that could significantly aid the extraction process were absent and should be considered for future studies. Some other mixtures like hexane, could also possibly be administered to maximize the yield of banana peel extraction. Apart from the limitations in equipment, future researchers should also explore and consider more methods and techniques for extracting banana peel oil. In assessing the tribological properties of the lubricants, more advanced apparatus should be used for wear and friction tests. The use of a tribometer and other advanced scientific instruments could significantly help with arriving at accurate results. More credible and reliable experimental methods should also be applied to future projects. The friction coefficient test and wear test that was used in this project were simplified versions of the original, utilizing traditional/budget materials and processes that are far inferior to what is considered conventional. Therefore, it is recommended that future studies incorporate more advanced and reliable equipment and methods for both the extraction process and tribological properties evaluation of banana peel-based lubricants. By doing so, the results obtained would be more accurate and credible and may contribute to the development of a more viable banana peel-based lubricant appropriate for industrial utilization. This could, in turn, positively impact the Philippine environment and economy as a whole, as bananas would gain its use as an effective and sustainable lubricant additive, suitable even for heavy industrial applications.

Recommendations

1. Explore formulating banana-based lubricants with additives to improve specific properties (e.g., viscosity modifiers, extreme pressure additives).
2. Investigate the compatibility of banana lubricants with common industrial materials.
3. Conduct comprehensive tribological testing using industry-standard equipment to compare the performance of banana lubricants to conventional lubricants under various load and speed conditions.
4. Analyze the chemical composition of banana lubricants using techniques like Fourier-Transform Infrared Spectroscopy (FTIR) to understand the relationship between composition and performance.
5. Develop strategies for utilizing or disposing of leftover banana peel residues after lubricant extraction in a sustainable manner.
6. Collaborate with researchers in tribology, materials science, and sustainability to leverage expertise and accelerate research progress.

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