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Eco-Lumilard Candles: Sustainable Innovation Through the Utilization of Pig Lard for Eco-Friendly Illumination

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ABSTRACT

This study explores the sustainable innovation of repurposing pig leaf fat (lard), a by-product of swine farming, into eco-friendly candles known as **Eco-Lumilard Candles**. Originating from the agricultural training programs of the **Northern Mindanao School of Fisheries**, the research addresses the underutilization of pig lard by integrating it with natural beeswax and essential oils to create a renewable, cost-effective, and biodegradable illumination alternative. Through a series of development trials, the formulation was refined to enhance structural durability, scent masking, and burn performance. The final product demonstrated a competitive burn time of up to four hours, stable wick and flame behavior, ant resistance, and reduced waste pooling compared to pure lard-based and commercial candles. Evaluation methods combined statistical analysis with qualitative feedback, showing promising results in performance and acceptability. The study highlights the potential of agricultural by-product utilization for sustainable product development and provides practical insights for educational and entrepreneurial applications in local communities.

A. INTRODUCTION

The utilization of by-products of livestock production has been an area of growing interest in sustainable practices and resource management. One such by-product, pig lard, has traditionally been used in culinary applications but remains underutilized in non-food industries.

The study originates from the agricultural and educational initiatives of Northern Mindanao School of Fisheries which this institution is offering of the Animal Production (Swine) NC II program. With some locals engaged in swine production, significant amounts of pig fat or lard are often generated as by-products, which are either sold for consumption or underutilized. This scenario highlights the pressing need to adopt innovative and sustainable agricultural practices to maximize resource utilization.

The problem of underused pig fat presents both a challenge and an opportunity. As the world increasingly focuses on sustainability, there is a growing demand for practical solutions that promote eco-friendly alternatives. The idea of transforming pig fat into candles seeks to explore the potential of creating an eco-friendly candle by combining pig lard with natural beeswax. This aligns with this global trend, offering an inventive way to repurpose agricultural by-products into a value-added product. This initiative not only addresses the issue of by-product disposal but also advocates for sustainable agricultural innovation that benefits both the environment and the local community.

In the study "*Extraction and Utilization of Wax from Wastes of Poultry, Slaughterhouse, and Fish Industry*," (Chatterjee, 2022), the waste from poultry, mutton (goat), and fish, homogenized, heated,

filtered, and centrifuged to extract wax. Candles made from these waste waxes were found to be long-lasting, with goat waste wax melting less than that from chicken and fish. This study highlights the versatility of utilizing animal waste materials, which offers an eco-friendly alternative to traditional candle-making and other wax-based products. It demonstrates the feasibility of extracting valuable products from waste, much like how this research aims to utilize pig leaf fat (lard) for the production of Eco-Lumilard Candles.

However, there is a noticeable gap in the literature regarding the specific use of pig fat (lard) as a sustainable alternative in candle production. While studies such as the one mentioned above demonstrate the broader concept of using animal waste for various wax-based products, there is limited research exploring the direct application of pig lard in the production of eco-friendly candles, particularly in terms of its performance, burn time, and brightness compared to traditional paraffin or soy-based candles.

This gap is particularly important because it opens the possibility for further investigation into how pig lard, a by-product of swine farming, can be a sustainable and renewable material for the candle industry. Unlike other animal by-products such as poultry or fish waste, the use of pig lard in this context has not been sufficiently explored, and its environmental benefits, economic potential, and scalability remain largely unexamined. By bridging this gap, this study will contribute to the existing body of knowledge, offering a practical and innovative solution for reducing waste while promoting sustainability in the agricultural sector.

This research was inspired by the desire to combine the principles of sustainability and innovation in agriculture. Recognizing the potential of pig fat as a renewable resource, the study seeks to create a product that not only reduces waste but also offers economic and practical benefits. By promoting the use of Eco-Lumilard Candles, the researcher aims to showcase the transformative potential of agricultural practices when paired with creativity and resourcefulness. The project also emphasizes the role of education in fostering sustainable solutions, demonstrating how technical training and community collaboration can lead to impactful innovations.

Through this study, the Northern Mindanao School of Fisheries endeavors to lead by example, encouraging other institutions and communities to explore similar opportunities for sustainable development. The research serves as a call to action for agricultural stakeholders to embrace resource optimization and contribute to the global effort toward a greener future.

This study is intended to evaluate the performance and environmental impact of utilizing pig fat as a sustainable raw material to produce Eco-Lumilard Candles, with a focus on waste reduction.

Specifically, the study sought to:

1. Measure the burn time and brightness of Eco-Lumilard Candles compared to commercial candles.
2. Identify the benefits of utilizing pig fat in candle production, focusing on resource optimization.

This innovation addresses the growing need for sustainable alternatives to commercial candles, which are derived from non-renewable petroleum sources and release harmful emissions during use. By introducing

Eco-LumiLard Candles as an eco-friendly option, the study provides a renewable, biodegradable, and environmentally safer substitute.

Moreover, the findings of this research can be integrated into the curriculum of the Animal Production (Swine) NC II program, providing students with practical knowledge and skills in sustainable practices and eco-friendly product development.

Lastly, the result of this study can raise awareness to the local swine farmers, small entrepreneurs and households of other purposes of the pig lard.

This study focused on the utilization of pig fat (lard), a by-product of swine farming, as a raw material for creating eco-friendly candles named Eco-LumiLard Candles with natural beeswax.

The scope of the research encompasses the entire process of transforming pig leaf fat, sourced from wet markets, into usable lard for candle production. The study seeks to establish a sustainable candle-making process that integrates environmentally friendly practices while addressing the underutilization of a readily available agricultural by-product. By evaluating key factors such as burn time, brightness, and overall performance of the candles, the study aims to highlight the practicality and efficiency of this innovative approach.

The limitations of this study are primarily tied to the availability and quality of raw materials. Since pig leaf fat is dependent on local swine farming practices and wet market supplies, fluctuations in its accessibility could impact the consistency of production. Additionally, the use of natural beeswax introduces variability in terms of sourcing, cost, and compatibility with pig lard.

B. METHODS

1. Project Design

The candle involves several key components that work together to create a sustainable and efficient candle. A **wick**, typically made of cotton or other absorbent natural fibers, is used to draw the melted Ecolumilard upward to sustain the flame. The Ecolumilard and wick are contained within a **heat-resistant glass container**, ensuring safety during use. These containers are usually around 40 cm in hieght and 60 cm wide. The picture is shown in Figure 1.

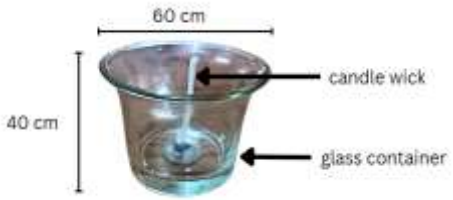

Figure 1. Eco-Lumilard Candle Container.

2. Project Development

1. **Supplies and Materials:** The supplies and materials used in this project are locally available. Table 1 shows the quantity, unit and description of the supplies and materials needed for this process.

Table 1. Supplies and Materials

Qty.	Unit	Description
2.8	kls	Pig leaf fat, dry and clean
300	g	Natural beeswax, pellets

24	pcs	Glass with lid, 40ml capacity, clear, transparent
24	pcs	Candlewick with suspender
1	pc	Sticker photo paper, waterproof, 2x2, glossy
ml	25	Essential oil, lavender

2. **Tools and equipment:** The tools and equipment used in the process are simple and can be easily accessed since the process is not critical. Table 2 will show the different tools and their function in the process.

Table 2. Tools and Their Functions.

Tools	Functions
1. Gas stove	In rendering the pig leaf, fire is needed.
2. Wooden ladle	To turn the pig leaf from time to time avoiding sticking to the pot.
3. Cooking pot with lid	Used to contain the pig leaf for rendering.
4. Measuring cup	Measures the leaf lard/oil after rendering for records purposes.
5. Scissors	Used to cut the excess wick.
6. Weighing scale	Used to measure the pig leaf fat for records purposes.
7. Stainless strainer	Used to strainer the oil to make sure oil is extracted from pig leaf fat after rendering.

3. Process Procedure

To make the candle, the pig leaf fat is rendered using a dry heat method in a very low fire making it a clearer oil and not burnt. The steps are as follows:

a. Cut into small pieces for a faster rendering process.
b. In a cooking pot, put the sliced pig leaf fat inside. Turn heat into a very low fire and turn the fat upside down occasionally to avoid burnt oil as shown in figure 2.

Figure 2. Rendering Pig Leaf Into Usable Lard.

c. Once completed, strain the pig fat to separate the oil from it. Add lemongrass leaves and essential oils such as lavender oil for an aromatic product.
d. Secure the wick in the center of the container using an adhesive or wick holder, and the mixture is

carefully poured into the container, encasing the wick.

e. Refrigerate for about 1-2 hours for solidifying or 12-24 at room temperature.
f. Label with waterproof sticker photo paper for a polished finish as shown in Figure 3.

Figure 3. Pig Oil To Lard To Ready To Use Candle.

4. Project Timeframe

In the process of creating a Pig Lard Candle involves a series of steps to transform pig leaf fat to an eco-friendly product. With a blend of careful preparation, simple assembly, and creative finishing touches, the entire process is simple yet challenging. Below is the detailed timeframe to guide you through each phase of the project. The table below will show the details of the project timeframe.

Table 3. Timeframe of the Project

Day	Preparation of Purchase Request of Raw Materials	Purchasing Raw Materials and Supplies	Processing of Candles			
			Rendering	Packing	Cooling and Solidifying	Labelling
1-5	/					
6-9		/				
10			/	/		
11-12					/	
13						/

5. Project Cost

The total expenses incurred in this project, based on the cost of supplies and materials, determined the overall cost of the complete outputs. Table 4 shows the summary of supplies and materials used in this project.

Table 4. Summary of Expenses

Unit	Item Description	Qty	Unit Cost	Total Cost
kls	Pork leaf fat	2.8	50.00	140.00
g	Natural beeswax, pellets	300	45.36/100g	136.08
pcs	Mini candle glass, 40ml	24	10.42	250.00

	capacity with lid			
pcs	Candle wick, 25cm	24	2.00	48.00
pc	Sticker photo paper, A4, glossy, waterproof	1	9.80	9.80
ml	Essential oil, lavender	25	259.20/30ml	216.00
Total				799.88

The total expenses are ₱799.88 for a total of 24 glasses of candles with 40 ml capacity output resulting in ₱33.32 amount per piece, while the commercial candles of same packaging and capacity are around ₱44.00 - ₱50.00 each. It only shows that the output of this project is relatively cheaper than the commercial one.

3. Operation and Testing Procedures

The process of this project took the researcher to do it more than once as every innovation needs to be polished to ensure that the final product is safe, functional, and meets the desired quality standards.

First Attempt

- **Material Details**: Pure pig lard was extracted from ***pork chop*** and used without additives. A ***recycled wick*** was employed.
- **Performance**: The candle burned for approximately an hour, since the wick is reused, flickering ***is observed*** and soot formation is absent. A wax pool formed easily when lighted and the candle ***softened*** at room temperature, leading to decreased usability.
- **Disadvantage**: The natural ***pig odor was prominent***, and ***ants were attracted*** to the candle after two weeks of testing. Its structural stability was poor due to liquefaction.
- **Second Attempt**
- **Material Details** : Pig lard was extracted from ***pig leaf fat***, scented ***with lavender oil and lemongrass extract***, and decorated with lemongrass leaves. A ***new wick with a suspender*** was used.
- **Performance**: The burnt time is the same with the first attempt, with a ***stable wick*** and no soot. Wax pool formation remained very noticeable, and the candle ***softened*** at room temperature after use.
- **Improvement**: The lemongrass extract masked the natural odor approximately 20%, and ants were no longer attracted to the candle and it has the whiter appearance of candles.
- **Third Attempt**
- **Material Details**: Pig lard was extracted from ***pig leaf fat*** combined with ***lavender essential oil*** and ***beeswax***. The addition of beeswax provided structural fortification. A new wick with a suspender was used for optimal performance.
- **Performance**: The total burn time during testing lasted up to 4 hours, ***with a stable wick*** and no soot formation. ***Wax pool formation was minimal***, indicating improved wax longevity.
- **Enhanced Features**: ***Odor masking reached 50%,*** effectively suppressing the natural pig odor. The addition of beeswax significantly improved durability, as the candle ***retained its solid state*** at room temperature and solidified immediately after each use.

- **Outcome**: This attempt demonstrated the best overall performance, showing ***no signs of liquefaction***, ***improved scent masking***, and structural resilience. It was also ***ant resistant***.

4. Evaluation Procedure

The study follows a systematic process to ensure its external validity and assess its overall impact. The procedure involves controlled testing to compare the performance of Eco-Lumilard Candles with commercial candles and pure pig lard.

Key parameters for evaluation of burn time included total burn time, wick performance, and flame stability. Brightness is measured using a light meter mobile application, soot production and wax pool formation is also observed. Other factors such safety, solid state durability and the ease of lighting is also evaluated.

Trainers from the Northern Mindanao School of Fisheries and community end-users serve as evaluators, using tools such as light meters and open-ended evaluation form for quantitative feedback. Data gathering methods include focus group discussions to gather user feedback on usability and acceptability for qualitative feedback, and detailed observations of candle performance.

The methodology employed in evaluating the project combines both qualitative and quantitative approaches to ensure a thorough analysis of its performance and impact. Statistical analysis is used to measure the burn time and brightness of the candles to gain insight into user perceptions and the practical benefits of the product.

This evaluation process offers valuable insights into the performance, sustainability, and acceptability of the Eco-Lumilard Candles, ensuring that the project aligns with its objective of resource optimization.

C. RESULTS AND DISCUSSION

1. Project Description

The project revolves around creating an eco-friendly candle by rendering pig leaf fat into usable lard. This process involves heating the fat to extract its oils, which are then combined with natural beeswax, essential oils like lavender, and lemongrass extracts to form a fragrant and stable candle. A wick is secured at the center of a heat-resistant glass container, and the melted mixture is carefully poured around it. The candles are left to solidify, either through refrigeration or at room temperature, before being labeled for use.

Features/Characteristics:

Eco-friendly and sustainable: Uses locally sourced pig leaf fat as the primary ingredient, reducing waste.
Fragrance: Infused with essential oils and lemongrass for a pleasant scent.
Stability: Beeswax addition enhances structural durability, preventing liquefaction at room temperature.
Cost-effective: Significantly cheaper than commercial candles of similar packaging.
Ant-resistant: Improved formulation avoids pest attraction.
Enhanced burn performance: With a burn time of up to 4 hours, stable wick functionality, and minimal wax pooling.

2. Project Structure

The finished product is a compact and aesthetically pleasing candle housed in a transparent, heat-resistant glass container. The container, which comes with a fitted lid, ensures safety and portability. Each candle is labeled with waterproof glossy sticker photo paper for a polished and professional appearance.

Features, Dimensions, and Specifications:

Container: Clear glass, 40ml capacity. Dimensions approximately 40 cm in height and 60 cm wide.

Wick: Made of cotton with a suspender for optimal performance.
Materials: Combination of pig lard, beeswax, lavender essential oil, and lemongrass extract.
Design: Minimalist yet functional, with labels that are water-resistant and visually appealing.

3. Project Capabilities and Limitations

The Eco-Lumilard Candle project showcases a range of innovative capabilities while also presenting certain limitations that stem from resource availability and processing requirements. Among its strengths, the candles are eco-friendly and sustainable, made from pig leaf fat—a locally sourced byproduct that reduces waste.

The project achieves a burn time of up to 4 hours, with stable wick performance, minimal soot formation, and reduced wax pooling. Enhanced durability is achieved through the addition of beeswax, ensuring the candles remain solid at room temperature without liquefying after use.

Furthermore, the incorporation of lavender essential oil and lemongrass extract effectively masks the natural pig odor by up to 50%, while the improved formula resists ant attraction, making the product more practical and reliable. These candles are also cost-efficient compared to commercial alternatives, with polished, aesthetic designs that include glossy waterproof labels.

However, the project faces limitations. The availability and quality of pig leaf fat are tied to local swine farming practices and wet market supplies, creating potential fluctuations in raw material accessibility that may affect production consistency.

Additionally, the reliance on natural beeswax introduces variability in terms of sourcing, cost, and its compatibility with pig lard during the formulation process. The structural integrity and performance of the candles are also influenced by environmental conditions during cooling and solidification.

Despite these challenges, the Eco-Lumilard Candle remains distinctively different from other products by combining resource optimization, affordability, and sustainability into a functional and appealing design.

4. Project Evaluation

Table 5. *Burn Time*

ANOVA - Burn Time

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p
Welch	Candle Type	5.733	2.000	2.867	1.549	0.276
	Residuals	13.200	7.208	1.831		

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	4.600	0.548	0.245	0.119
Eco-Lumilard	5	4.800	0.447	0.200	0.093
Pure Pig Lard	5	3.400	1.673	0.748	0.492

The table 5 shows the ANOVA results and descriptive statistics for the burn times of the three candle types: Commercial, Eco-Lumilard, and Pure Pig Lard. The ANOVA result indicates no statistically significant differences in burn times among the candle types with F=1.549 and p=0.276.

The descriptive statistics reveal that Eco-Lumilard candles have the highest mean burn time of 4.8 hours and the lowest variability with CV = 0.093, making them the most consistent. Commercial candle follow with a mean burn time of 4.6 hours and moderate variability with CV = 0.119. On the other hand, Pure

Pig Lard candles exhibit the shortest mean burn time of 3.4 hours and the highest variability with CV = 0.492, indicating inconsistent performance.

Table 6. *Wick Performance*

ANOVA - Wick Performance

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p
Welch	Candle Type	2.533	2.000	1.267	1.834	0.230
	Residuals	10.400	6.854	1.517		

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	4.800	0.447	0.200	0.093
Eco-Lumilard	5	4.200	0.837	0.374	0.199
Pure Pig Lard	5	3.800	1.304	0.583	0.343

The table 6 shows the descriptive statistics for the wick performance of the three candle types: Commercial, Eco-Lumilard, and Pure Pig Lard. The Commercial candles shows the highest mean wick performance at 4.800 and the most consistent results, with a coefficient of variation of 0.093. Eco-Lumilard candles follow with a mean wick performance of 4.200 and moderate variability with CV = 0.199, while Pure Pig Lard candles have the lowest mean performance at 3.800 and the highest variability with CV = 0.343, reflecting inconsistency.

The ANOVA results indicate no statistically significant differences in wick performance across the three candle types, with an F-value of 1.834 and a p-value of 0.230.

Table 7. *Flame Stability*

ANOVA - Flame Stability

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p
Welch	Candle Type	4.933	2.000	2.467	NaN	NaN
	Residuals	14.400	NaN	NaN		

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	5.000	0.000	0.000	0.000
Eco-Lumilard	5	4.400	0.894	0.400	0.203
Pure Pig Lard	5	3.600	1.673	0.748	0.465

The table 7 shows the ANOVA results and descriptive statistics for the flame stability across three types of candles: Commercial, Eco-Lumilard, and Pure Pig Lard. The ANOVA analysis was limited since Commercial candle exhibited zero variance, rendering statistical comparisons incomplete. The sum of squares for the candle types is 4.933, with a mean square of 2.467, while the residuals have a sum of squares of 14.400. However, due to the zero variance in Commercial candles, key metrics like the degrees of freedom, F-value, and p-value could not be computed, leaving the statistical significance of the differences inconclusive.

The descriptive statistics provide that the Commercial candles have the highest mean flame stability of 5.000 with no variability, reflecting perfect consistency. Eco-Lumilard candle follow with a mean flame stability of 4.400 and relatively low variability with SD = 0.894, CV = 0.203, indicating stable performance. Pure Pig Lard candles show the lowest mean flame stability of 3.600 and the highest variability with SD = 1.673, CV = 0.465, reflecting inconsistency.

Table 8. *Brightness*

ANOVA - Brightness

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	4.400	0.894	0.400	0.203
Eco-Lumilard	5	3.800	0.447	0.200	0.118
Pure Pig Lard	5	2.800	0.837	0.374	0.299

The table 8 shows the ANOVA results and descriptive statistics for the brightness levels of three candle types: Commercial, Eco-Lumilard, and Pure Pig Lard. The ANOVA analysis shows a marginally significant difference in brightness, with an F-statistic of 4.160 and a p-value of 0.063, suggesting potential variability across groups.

The descriptive statistics indicate that Commercial candles have the highest mean brightness of 4.400 but are the least consistent with SD = 0.894. Eco-Lumilard candles offer more stable performance with a lower variability of SD = 0.447, CV = 0.118 and a mean brightness of 3.800, while Pure Pig Lard candles have the lowest brightness of 2.800 and the highest variability with CV = 0.299.

Table 9. *Soot Production*

ANOVA - Soot Production

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	4.000	1.732	0.775	0.433
Eco-Lumilard	5	4.600	0.894	0.400	0.194
Pure Pig Lard	5	4.000	1.225	0.548	0.306

The table 9 shows the ANOVA results and descriptive statistics for the soot production across three candle types. The ANOVA reveals no significant differences in soot production with F = 0.459, p = 0.648, suggesting that variations are likely due to chance. Most variability occurs within groups, as indicated by the residuals' sum of squares of 21.200.

Eco-Lumilard candles have the highest mean soot production of 4.600 with the lowest variability of CV = 0.194, reflecting consistency. Both Commercial and Pure Pig Lard candles have a mean of 4.000, but Commercial candles show the highest variability of CV = 0.433, while Pure Pig Lard candles have moderate variability of CV = 0.306. Eco-Lumilard candles stood out for their consistency despite slightly higher soot production.

Table 10. ***Wax Pool Formation***

ANOVA - Wax Pool Formation

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p
Welch	Candle Type	2.533	2.000	1.267	1.418	0.307
	Residuals	16.400	6.678	2.456		

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	4.800	0.447	0.200	0.093
Eco-Lumilard	5	4.200	0.837	0.374	0.199
Pure Pig Lard	5	3.800	1.789	0.800	0.471

The table 10 shows the ANOVA results and descriptive statistics for the wax pool formation across three candle types: Commercial, Eco-Lumilard, and Pure Pig Lard. The ANOVA indicates no significant differences of F = 1.418, p = 0.307, suggesting that the variations in wax pool formation are likely due to chance. Most of the variability occurs within groups, as reflected by the residuals' sum of squares of 16.400.

The Descriptive statistics reveal that Commercial candles have the highest mean wax pool formation of 4.800 with the lowest variability of CV = 0.093, indicating consistency. Eco-Lumilard candle follow with a mean of 4.200 and moderate variability of CV = 0.199, while Pure Pig Lard candles have the lowest mean of 3.800 and highest variability of CV = 0.471.

Table 11. ***Solid State Durability***

ANOVA - Solid State Durability

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p

Descriptives - Solid State Durability

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	4.600	0.548	0.245	0.119
Eco-Lumilard	5	3.800	1.304	0.583	0.343
Pure Pig Lard	5	2.800	1.643	0.735	0.587

The table 11 shows the solid-state durability of three candle types, through descriptive statistics and ANOVA. While no significant differences were found (p = 0.126), Commercial candles demonstrated the highest mean durability with 4.600 and consistency of SD = 0.548. Eco-Lumilard candles followed with moderate performance of mean = 3.800, and SD = 1.304, and Pure Pig Lard candles displayed the lowest durability of mean = 2.800 and highest variability of SD = 1.643.

Table 12. ***Container Safety***

ANOVA - Container Safety ▼

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p
Welch	Candle Type	6.400	2.000	3.200	NaN	NaN
	Residuals	16.000	NaN	NaN		

Descriptives - Container Safety

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	5.000	0.000	0.000	0.000
Eco-Lumilard	5	4.200	1.095	0.490	0.261
Pure Pig Lard	5	3.400	1.673	0.748	0.492

The table 12 shows the container safety analysis for three candle types. Commercial candles achieved the highest safety score of mean = 5.000 with no variability, reflecting exceptional reliability. Eco-Lumilard candles followed with a mean of 4.200 and moderate variability, while Pure Pig Lard candles scored lowest of mean = 3.400 with the highest variability. The coefficient of variation further supports these trends, highlighting the consistent performance of Commercial candles.

Table 13. ***Ease of Lighting***

ANOVA - ease of Lighting

Homogeneity Correction	Cases	Sum of Squares	df	Mean Square	F	p
Welch	Candle Type	6.533	2.000	3.267	NaN	NaN
	Residuals	4.400	NaN	NaN		

Descriptives - ease of Lighting

Candle Type	N	Mean	SD	SE	Coefficient of variation
Commercial	5	5.000	0.000	0.000	0.000
Eco-Lumilard	5	4.400	0.548	0.245	0.124
Pure Pig Lard	5	3.400	0.894	0.400	0.263

The table 13 shows the ease of lighting analysis for the three candle types. Commercial candles achieved the highest mean score of 5.000 with zero variability of SD = 0.000, signifying absolute consistency. Eco-Lumilard candles followed with a mean score of 4.400 and moderate variability of SD = 0.548, while Pure Pig Lard candles scored lowest of mean = 3.400 and exhibited the highest variability of SD = 0.894.

D. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The comparative analysis of burn time, wick performance, flame stability, brightness, soot production, wax pool formation, solid-state durability, container safety, and ease of lighting across three candle types—Commercial, Eco-Lumilard, and Pure Pig Lard—revealed significant trends in performance and consistency. Commercial candles excelled in most metrics, demonstrating superior reliability, such as zero variability in ease of lighting and container safety. Eco-Lumilard candles performed competitively, often showing lower variability, particularly in burn time and soot production, suggesting a balance between performance and consistency. Pure Pig Lard candles consistently ranked the lowest across metrics, reflecting higher variability and less reliable performance. Despite these descriptive trends, most ANOVA results showed no statistically significant differences, implying the observed variations could largely be attributed to random chance due to small number of research respondents.

Recommendation

Expand the study by increasing the sample size to include a larger group of participants, ensuring broader representation and improving the reliability and validity of the results.

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