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Synergistic activity of Malunggay (*Moringa oleifera*) leaves and Sodium percarbonate ($2Na_2CO_3•3H_2O_2$) as a wastewater deodorizer for pig farms

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ABSTRACT

According to the Agriculture and Consumer Health Department (2017), odor is associated with the main environmental and societal problems throughout pig farms affecting 72% of nearby residents and 30% of workers in the Philippines (Drucker et al., 2007). The synergistic activity of Malunggay (*Moringa oleifera*) leaves with Sodium percarbonate ($2Na_2CO_3•3H_2O_2$) was aimed at deodorizing pig farm wastewaters to decrease the presence of odorant compounds. Investigations were: I. Screening for peroxidase, II. Laboratory analyses for Volatile Organic Compounds (VOCs), Hydrogen sulfide (H_2S), and Ammonia (NH_3), III. Perceptual Odor Assessment of Human Panel, IV. Shelf-life determination. Screening showed that malunggay leaves contain peroxidase, an enzyme that can convert toxic materials into less harmful substances (Albuquerque et al., 2019). For laboratory analyses in the experimental and negative control groups, the Colorimetry for H_2S showed 48 mg/L and <1.0 mg/L respectively; Phenate method for NH_3 showed 124 mg/L and 121 mg/L respectively; Gas Chromatography detected no other VOC except chloroform. 32 µg/L and 17 µg/L were found, respectively. Using the 9-point Hedonic scale for perceptual odor assessment of a human panel, results showed that in terms of odor intensity, there was an 82.76% decrease in the negative control (Strongest Odor Imaginable) to the experimental (Moderate Odor). While there was an 80% decrease in unpleasantness from the negative control (Extremely Unpleasant) to the experimental (Neutral Pleasantness). After shelf-life determination, the malunggay leaves powder lasted for 8 weeks. For further validation of results, additional studies on the synergistic activity of plant peroxidases and peroxides must be conducted with various methods of application and testing.

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INTRODUCTION

Kolhe et al. (2015) reported that environmental pollution is growing due to the widespread of hazardous and odorous substances. The Agriculture and Consumer Health Department (2017) stated that odor accounts for the primary environmental and societal problem in the pig production sector.

In a study by Drucker et al. (2007), 72% of nearby residents and 30% of pig keepers are affected by odor from pig production in the Philippines. Linked to this, residents in the country's barangays have also been vocal about the adverse effects of commercial and backyard pig farms (Dorado et al., 2019). Since, due to the present odorous compounds such as NH_3, H_2S, and VOCs in released pig farm wastewater, pollution in the air, soil, ground, and surface water is instigated with a joint effect to the increase of infections and diseases. However, according to the Environmental Management Bureau (2015), only 10% of wastewater is treated in the Philippines, stating that an estimated 4,200 people die every year due to contaminated water, making it a leading concern of public health in the country.

Although pig manure is considered a fertilizer, excessive amounts can become harmful to most organisms. This is caused by the high amounts of hydrogen sulfide, ammonia, airborne microorganisms, heavy metals, volatile acids, volatile organics, p-cresol, and aldehydes it contains (Zhang et al., 2016) which can spread through the farms' wastewater, causing a detrimental effect to the environment. Moreover, according to Kravchenko (2016), nearby residents and pig farm workers have higher risks for diseases and infections. Including respiratory dysfunction caused by endotoxins and volatile acids, asthma due to the farms' presence of p-cresol, ammonium, and aldehydes, and kidney function damage due to the contaminated soil and groundwater, which inhibits copper and iron absorption when ingested by humans. Neurological effects on children and miscarriages may also form from contaminated water and diarrhea due to the potential presence of *Salmonella typhimurium*. Hence, the public and environment are at risk. Therefore, there is a demand for the production of a feasible deodorizer for pig farm wastewaters.

Peroxidase was positive in oxidizing odorant compounds (Rezazgui et al., 2015). According to Albuquerque et al. (2019), this is an enzyme with high availability that can convert toxic materials into less harmful substances. Similarly, in accord to Govere et al. (2005), deodorization using peroxidase with electron acceptors initiates the polymerization and adsorption of phenolic and odorant compounds. Palada (2017) states that malunggay leaves are widely cultivated in the Philippines and can be extensively seen in local backyards. While based on a study by Agunbiade et al. (2021), there is a 1.4082 units per mg of protein peroxidase presence which is significantly high in fully grown malunggay leaves. In support of this, purified peroxidase from malunggay leaves' activity remains at 90% at 60 °C for 30 minutes of incubation.

Moreover, in a study by Yuan et al. (2016), different electron acceptors with lignin peroxidase were investigated for their reduction potentiality towards odorous compounds present in pig manure such as phenol, 4-methylphenol, indole, and skatole (3-methylindole), NH_3, and H_2S. It also includes Volatile Fatty Acids (VFAs) such as $C_3H_6O_2$ (propionic acid), 2-methylpropanoic acid, 4-methylpentanoic acid, and 3-methylbutanoic acid. Among its synergy with three electron acceptors (H_2O_2, CaO_2, $2Na_2CO_3 \cdot 3H_2O_2$) or (Hydrogen peroxide, Calcium peroxide, and Sodium percarbonate), it was concluded that CaO_2 and $2Na_2CO_3 \cdot 3H_2O_2$ perform better than the H_2O_2. 4-methylphenol had a reduction percentage of 90. While the odor strength, presence of indoles and VFAs had 40-60%, 16.5 – 40%, and 25-40% reductions respectively. In a similar study, it was also concluded by Parker et al. (2012) that the use of dry powder has a potential benefit as an additive to swine barns in topical application. The same study compared the application of soybean peroxidase, calcium peroxide, and soybean peroxidase synergized with calcium peroxide. It was concluded that the synergy of the peroxidase and peroxide was the most effective treatment as it decreased 98% of 4-methylphenol emission rates in pig manure.

With these relevant data, the researcher conceptualized the use of Malunggay (*Moringa oleifera*) leaves, synergized with Sodium percarbonate ($2Na_2CO_3 \cdot 3H_2O_2$) as a powdered deodorizer for pig farm wastewaters. A series of laboratory analyses will be used to analyze the most abundant present odorous compounds in wastewater. Gas chromatography will be used to analyze VOCs, Colorimetry for H_2S, and the Phenate method for NH_3. In addition to this, a qualitative analysis of a human panel will be conducted based on a method used by Govere et al. (2005) to determine its effects in terms of odor pleasantness and odor intensity. Through the development and production of this cheap and economical product, the pig farm workers, the environment, and nearby residents will not be affected by the excessive toxic odorous compounds emitted by pig farm wastewaters.

STUDY OBJECTIVES

In this paper, the generalized objective is to determine the synergistic activity of malunggay leaves and Sodium percarbonate as a wastewater deodorizer for pig farms. The specific objectives are:

1. To determine the content in malunggay leaves that has the ability to deodorize pig farm wastewater with Sodium percarbonate.
2. To assess the reduction percentage (quantitative analysis) in the toxic compounds which cause odor intensity in pig farm wastewater.
3. To assess the qualitative analysis of odor intensity by a human panel through a 9-point Hedonic scale.
4. To observe and determine the shelf-life of the malunggay leaves powder.

MATERIALS AND METHODS

Research Design

This study used a Post test-only control group research design with negative control and experimental setup groups to determine the synergistic activity of Malunggay (*Moringa oleifera*) leaves and Sodium percarbonate ($2Na_2CO_3 \cdot 3H_2O_2$) as a wastewater deodorizer for pig farms.

Gathering and Preparation of Materials

One kilogram (1 kg) of locally available matured malunggay leaves was gathered through the houses of Tayug, Pangasinan. Sodium percarbonate was ordered from a certified laboratory supply distributor. Three liters (3L) of odorous wastewater were collected at a pig farm in San Macario, Natividad Pangasinan.

Plant Identification

The plant sample was brought to the Santa Maria campus of Pangasinan State University's (PSU) College of Agriculture in the aim of plant identification, supervised by a licensed plant botanist.

Screening for Peroxidase

The screening for peroxidase was conducted at AGS Diagnostic center with the help of a qualified scientist based on a method used by Mitsch et al. (2020) through the preparation of 1% guaiacol solution and hydrogen peroxide. 50 grams of malunggay leaves were powdered, 10 to 20 grams were added to an Erlenmeyer flask, and an extract was collected. The extract was placed in test tubes, added with distilled water, 1% guaiacol solution, hydrogen peroxide, and shaken well. An intensive and rapid brown-reddish tissue coloring of the solution indicates a high peroxidase activity. A spectrophotometer at 420 nm was used to measure the changes in light absorption. The test was replicated 3 times.

Table 1. Spectrophotometric Reading

Malunggay Leaf Extract (Peroxidase Test)			
	1st	2nd	3rd
1st Replication	X	X	X
2nd Replication	X	X	X
3rd Replication	X	X	X

Legend: Where X is the result of spectrophotometric reading.

Formulation of Product

One kilogram (1 kg) of matured malunggay leaves was sundried for 1-2 days until it became dehydrated, then powdered using a blender. The powder was then sifted, weighed 13.5g, and mixed with 9g of Sodium percarbonate (111:166 malunggay leaves powder to Sodium percarbonate ratio).

Pig Farm Wastewater Treatment

A 2-group division of 3 liters of collected pig farm wastewater (1 experimental plus 1 negative control) was used to analyze and compare. The negative control group comprised 1.5 liters of untreated pig farm wastewater. At the same time, the experimental group was composed of 1.5 liters of pig farm wastewater. The wastewater was divided into 500 ml and distributed into 3 1-liter beakers. Then, the samples were treated with 4.5g malunggay powder and 3g Sodium percarbonate each. (13.5g malunggay powder and 9g Sodium percarbonate overall). The powder was mixed with 100 ml water to activate deodorizing properties and filtered using cheesecloths into 250 ml Erlenmeyer flasks and added to the wastewater. The experimental group setups were mixed rapidly for at least 1 minute and slowly for 10 minutes. Experimental group setups were left for 2 hours. Both groups were divided and placed in sanitized 1000 ml PET bottles and 40 ml VOA vials each and sent via courier to the CRL Environmental Corporation.

Laboratory Analyses

For the quantitative and chemical analyses on the reduction percentage of pig farm wastewater toxic and odorant compounds, Gas Chromatography (GC) analysis for VOCs, Colorimetry for H_2S content, and Phenate method for NH_3 content on the treated and not treated pig farm wastewater was conducted at the CRL Environmental Corporation. The 2 setup results were compared.

Table 2. The Experimental setup for the laboratory analyses on the pig farm wastewater

Experimental Setup	
Odor-causing and toxic compounds	Pig farm wastewater
Volatile Organic Compounds	X
Hydrogen sulfide	X
Ammonia	X

Legend: Where X is the result of the laboratory tests.

The experimental setup consists of 40 ml of treated pig farm wastewater for the VOC test, 500 ml for H_2S content, and 500 ml for NH_3 content.

Table 3. The Negative Control setup for the laboratory analyses on the pig farm wastewater

Negative Control Set-up	
Odor-causing and toxic compounds	Pig farm wastewater

Volatile Organic Compounds	X
Hydrogen sulfide	X
Ammonia	X

Legend: Where X is the result of the laboratory tests.

The negative control setup consists of 40 ml of untreated pig farm wastewater for the VOC test, 500 ml for H_2S content, and 500 ml for NH_3 content.

Perceptual Odor Assessment of Human Panel

Upon experimentation, the deodorizing potentiality was assessed through perceptual odor interpretation of 6 human panels (nearby residents and pig farm workers) based on a method used by Govere et al. (2005) through a wafting method. The odor intensity and pleasantness estimates were determined using a 9-point Hedonic scale. The weighted average mean from the experimental and negative control wastewater samples was compared using the following formula:

$$\frac{\text{Total mean}}{\text{No. of respondents}} = \text{Weighted average mean}$$

Figure 1. The formula for the computation of the weighted average mean

Table 4. 9-point Hedonic Scale for human panel

SCORE	Frequency of Use									TW/ WM	RANK
	NOI (9)	ODL (8)	WO (7)	N (6)	MO (5)	O (4)	SO (3)	VSO (2)	SOI (1)		
Odor Intensity	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X
WEIGHTED AVERAGE MEAN					X					X	X

Legend: Where NOI-No Odor Imaginable; ODL-Odorless; WO-Weak Odor; N-Neutral; MO-Moderate Odor; O-Odorous; SO-Strong Odor; VSO-Very Strong Odor; SOI- Strongest Odor Imaginable. Where X is the odor intensity of qualified human panels for the qualitative differences of experimental and negative control wastewater samples and =X is the total mean.

Sample identifiers were withdrawn, and the odor intensity of the samples was evaluated. NOI, or No Odor Imaginable, is the highest score, and SOI, or Strongest Odor Imaginable, is the lowest.

Table 5. 9-point Hedonic Scale for human panel

SCORE	Frequency of Use									TW/ WM	RANK
	EP (9)	MP (8)	P (7)	SP (6)	N (5)	SUP (4)	U (3)	MU (2)	EU (1)		
Odor Pleasantness	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X =X	X
WEIGHTED AVERAGE MEAN					X					X	X

Legend: Where EP-Extremely Pleasant; MP-Moderate Pleasant; P-Pleasant; SP-Slightly Pleasant; N-Neutral; SUP-Slightly Unpleasant; U-Unpleasant; MU-Moderate Unpleasant; EU-Extremely Unpleasant. Where X is the odor pleasantness of qualified human panels for the qualitative differences of experimental and negative control wastewater samples and =X is the calculated results.

Sample identifiers were withdrawn, and the odor pleasantness of the samples was evaluated. EP, or Extremely Pleasant, is the highest score, and EU, or Extremely Unpleasant, is the lowest.

Shelf-life Determination

Malunggay leaves powder was stored at a temperature (20℃ to 25℃) and humidity similar to pig feed storage sites. The shelf-life determination was observed and remarked on by the researcher on a weekly basis to evaluate the quality change (appearance and odor) until the powder showed signs of deterioration.

Table 6. Indicators for the deterioration of malunggay leaves powder

Characteristics	Normal	Indicators of Deterioration
Appearance	Mold-free greenish color	Discoloration or formation of molds
Odor	Fine mild, and peppery smell	Foul smell or loss of fine mild, and peppery smell

Table 7. Observation of malunggay leaves powder at room temperature, similar to pig feed storage sites

Room Temperature (20℃ to 25℃)		
Date of Observation	Appearance	Odor
1st Observing Week	X	X
2nd Observing Week	X	X
3rd Observing Week	X	X
4th Observing Week	X	X
5th Observing Week	X	X
6th Observing Week	X	X
7th Observing Week	X	X
8th Observing Week	X	X
9th Observing Week	X	X
10th Observing Week	X	X

Legend: Where X is the researcher's observation.

Analysis of Data

Data upon the deodorization of pig farm wastewater was collected. The results of the screening for peroxidase; laboratory analyses such as the gas chromatography test, phenate method, and colorimetry; and perceptual odor assessment of human panel utilizing the 9-point Hedonic scale were gathered. The collected data was analyzed, and conclusions in the study were drawn.

RESULTS AND DISCUSSION

Plant Identification

After submission of the plant sample at PSU Sta. Maria campus, the licensed plant botanist identified and certified that the sample was malunggay leaves scientifically recognized as *Moringa oleifera*.

Screening for Peroxidase

The peroxidase activity test based on a method used by Mitsch et al. (2020) conducted at AGS Diagnostic center with the help of a qualified scientist showed results of a reddish tissue coloring indicating peroxidase activity in the plant sample.

Table 8. Results of Spectrophotometric Reading

Malunggay Leaf Extract (Peroxidase Test)					
	1st	2nd	3rd	Date of Analysis	Analyst
1st Replication	0.183	0.192	0.202	Aug. 10, 2021	A. C. Franza
2nd Replication	0.200	0.197	0.193	Aug. 10, 2021	A. C. Franza
3rd Replication	0.156	0.152	0.155	Aug.10, 2021	A. C. Franza

Table 8 shows that upon the use of a spectrophotometer at 420 nm, it is confirmed that peroxidase was present in the malunggay leaf extract. To support this, according to Rai et al. (2017), there is a high presence of peroxidase in malunggay leaves based on an evaluation of the plant's antioxidant potential and biochemical analysis. Similarly, based on a study by Agunbiade et al. (2021), peroxidase presence is significantly high in the matured or fully grown leaves of malunggay.

Laboratory Analyses

The quantitative or chemical analyses on the number of odorant compounds in pig farm wastewater were conducted at CRL Environmental Corporation, and 2 groups (experimental and negative control) were compared.

Table 9. The Experimental setup for the laboratory tests on the pig farm wastewater

Experimental Setup			
Odor-causing and toxic compounds	Results	Date of Analysis	Analyst
Volatile Organic Compounds	Detected compound/s: Chloroform 32 µg/L	Sept. 17, 2021	MA G. Rodriguez
Hydrogen Sulfide	48 mg/L	Oct. 5, 2021	MA G. Rodriguez
Ammonia	124 mg/L	Sept. 24, 2021	MA G. Rodriguez

For the experimental setup, 124 mg/L NH_3 was present after the Phenate method. Colorimetry for H_2S content showed 48 mg/L; after Gas Chromatography, no other VOC was detected except chloroform. 32 µg/L was found in the experimental.

Table 10. The Negative Control setup for the laboratory tests on the pig farm wastewater

Negative Control Set-up			
Odor-causing and toxic compounds	Results	Date of Analysis	Analyst
Volatile Organic Compounds	Detected compound/s: Chloroform 17 µg/L	Sept. 17, 2021	MA G. Rodriguez
Hydrogen Sulfide	<1.0 mg/L	Oct. 5, 2021	MA G. Rodriguez
Ammonia	121 mg/L	Sept. 24, 2021	MA G. Rodriguez

For the negative control setup, 121 mg/L NH_3 was present after the Phenate method. Colorimetry for H_2S content showed <1.0 mg/L; after Gas Chromatography, no other VOC was detected except chloroform. 17 µg/L was found in the negative control.

After the tests were conducted, it was found that Chloroform, H_2S, and NH_3 were higher in the experimental setup than the negative control, indicating no reduction percentages of the treatment. However, according to Parker et al. (2012), the utilization of peroxidase and peroxides can reduce the odorous VOC emissions of pig manure. In a similar study by Maurer et al. (2017), soybean peroxidase and calcium peroxide additive synergistic activity showed a decrease in the release of gaseous compounds. This included a 21.7% and 79.8% decrease in ammonia and hydrogen sulfide respectively; 31.2% and 43.5% in indole and 3-methylindole; and percentages of 37.2, 47.7, and 39.3 decreased in VFAs specifically butyric, valeric, and 3-methylbutanoic acid. Moreover, upon the employment of malunggay leaves powder on chicken abattoir wastewater, it was concluded by Mohan et al. (2016) that the powder decreased 18% electrical conductivity, 24% oil and grease content, and 8 to 36% turbidity of the wastewater. A study by Yuan et al. (2016) also concluded that the use of peroxidase with peroxides (Sodium percarbonate being the most effective) had significance to releasing hydrogen sulfide, ammonia, and strength of odor.

Perceptual Odor Assessment of Human Panel

The synergistic activity of malunggay leaves and Sodium percarbonate as a deodorizer was estimated through the odor perception of 6 human panels (nearby residents and pig farm workers), which was based on a study by Govere et al. (2005) through a wafting method. The odor intensity and pleasantness estimates were determined using a 9-point Hedonic scale. The weighted average mean from the experimental and negative control wastewater samples was compared using the following formula:

$$\frac{\text{Total mean}}{\text{No. of respondents}} = \text{Weighted average mean}$$

Figure 2. The formula for the computation of the weighted average mean

Table 11. 9-point Hedonic scale of odor intensity by a human panel (Experimental setup)

SCORE	Frequency of Use										
	NOI (9)	ODL (8)	WO (7)	N (6)	MO (5)	O (4)	SO (3)	VSO (2)	SOI (1)	TW/ WM	RANK
Odor Intensity	0 =0	0 =0	1 =7	3 =18	2 =10	0 =0	0 =0	0 =0	0 =0	35 =5.8	MO
WEIGHTED AVERAGE MEAN	MODERATE ODOR									5.8	MO

Legend: Where NOI-. No odor imaginable; ODL- Odorless; WO-Weak odor; N- Neutral; MO- Moderate odor; O-Odorous; SO- Strong odor; VSO- Very strong odor; SOI- Strongest odor imaginable.

Table 11 shows the 9-point Hedonic scale of the human panel in terms of odor intensity of the experimental setup. After evaluation, 3 human panels ticked N, 2 ticked MO, and 1 ticked WO. The weighted average mean indicates a score of 5.8 or "Moderate Odor." Comments in the evaluation form include that the *odor cannot be smelled at a distance.*

Table 12. 9-point Hedonic scale of odor pleasantness by a human panel (Experimental setup)

SCORE	Frequency of Use										
	EP (9)	MP (8)	P (7)	SP (6)	N (5)	SUP (4)	U (3)	MU (2)	EU (1)	TW/ WM	RANK
Odor Pleasantness	0 =0	0 =0	0 =0	1 =6	4 =20	1 =4	0 =0	0 =0	0 =0	30 =5	N
WEIGHTED AVERAGE MEAN	NEUTRAL									5	N

Legend: Where EP- Extremely pleasant; MP- Moderate pleasant; P- Pleasant; SP- Slightly pleasant; N- Neutral; SUP- Slightly unpleasant; U- Unpleasant; MU- Moderate unpleasant; EU- Extremely unpleasant.

Table 12 shows the 9-point Hedonic scale of the human panel in terms of odor pleasantness of the experimental setup. After evaluation, 4 human panels ticked N, 1 ticked SUP, and 1 ticked SP. The weighted average mean indicates a score of 5 or "Neutral Odor Pleasantness." Comments in the evaluation form include the *wastewater not smelling too pig farm-like*.

Table 13. 9-point Hedonic scale of odor intensity by a human panel (Negative Control setup)

SCORE	Frequency of Use									TW/ WM	RANK
	NOI (9)	ODL (8)	WO (7)	N (6)	MO (5)	O (4)	SO (3)	VSO (2)	SOI (1)		
Odor Intensity	0 =0	0 =0	0 =0	0 =0	0 =0	0 =0	0 =0	0 =0	6 =6	6 =1	SOI
WEIGHTED AVERAGE MEAN	STRONGEST ODOR IMAGINABLE									1	SOI

Legend: Where NOI-. No odor imaginable; ODL- Odorless; WO-Weak odor; N- Neutral; MO- Moderate odor; O-Odorous; SO- Strong odor; VSO- Very strong odor; SOI- Strongest odor imaginable.

Table 13 shows the 9-point Hedonic scale of the human panel in terms of odor intensity of the negative control setup. After evaluation, all 6 human panels ticked SOI for odor intensity. The weighted average mean indicates a score of 1 or "Strongest Odor Imaginable." Comments in the evaluation form include the *wastewater being a cause of nausea*.

Table 14. 9-point Hedonic scale of odor pleasantness by a human panel (Negative Control setup)

SCORE	Frequency of Use									TW/ WM	RANK
	EP (9)	MP (8)	P (7)	SP (6)	N (5)	SUP (4)	U (3)	MU (2)	EU (1)		
Odor Pleasantness	0 =0	0 =0	0 =0	0 =0	0 =0	0 =0	0 =0	0 =0	6 =6	6 =1	EU
WEIGHTED AVERAGE MEAN	EXTREMELY UNPLEASANT									1	EU

Legend: Where EP- Extremely pleasant; MP- Moderate pleasant; P- Pleasant; SP- Slightly pleasant; N- Neutral; SUP- Slightly unpleasant; U- Unpleasant; MU- Moderate unpleasant; EU- Extremely unpleasant.

Table 14 shows the 9-point Hedonic scale of the human panel in terms of odor pleasantness of the negative control setup. After evaluation, all 6 human panels ticked EU for odor pleasantness. The weighted average mean indicates a score of 1 or "Extremely Unpleasant Odor." Comments in the evaluation form include that the *wastewater sample gives a very strong canal-like and pig manure odor*.

Tables 11 and 13 indicated an 82.76% decrease in odor intensity, while tables 12 and 14 indicated an 80% decrease in odor unpleasantness. These show significant differences in the odor intensity and pleasantness of the two group setups regarding odor perception. In support of this, in a study by Govere et al. (2005), upon the odor evaluation of pig manure after its addition of horseradish peroxidase and peroxide, it concluded a 50% strength decrease of odor unpleasantness. Since, in terms of odor intensity, out of the 100 units (strongest odor imaginable), the untreated sample resulted in 34 units, while the treated sample resulted in 18 units. In terms of odor pleasantness, results indicated a reduction from the untreated (-6 units) to the treated (-3 units). This was in basis to the range -11 to 11 units or most unpleasant to most pleasant odor. Yan et al. (2016) also indicated that the use of Sodium percarbonate synergized with lignin peroxidase reduced odor intensity by 55.9% through an odor detector.

Shelf-life Determination

Table 15. Observation of malunggay leaves powder at room temperature, similar to pig feed storage sites

Room Temperature (20℃ to 25℃)		
Date of Observation	Appearance	Odor
Week 1 (Aug. 30, 2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 2 (Sept. 6, 2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 3 (Sept. 13,2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 4 (Sept. 20,2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 5 (Sept. 27,2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 6 (Oct. 4, 2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 7 (Oct. 11, 2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 8 (Oct. 18, 2021)	No change. (Mold-free greenish color)	No change. (Fine mild, and peppery smell)
Week 9 (Oct. 25, 2021)	Changed. (Mold-free with slight discoloration)	Changed. (Less peppery smell)
Week 10 (Nov. 1, 2021)	Changed. (Mold-free with discoloration)	Changed. (Foul smell)

Table 15 shows that from week 1 to week 8, Malunggay (*Moringa oleifera*) leaves powder stored at a storage temperature (20℃ to 25℃) and humidity similar to pig feed storage sites had no sign of deterioration or change in its physical appearance and odor. While week 9 showed a mold-free with slight discoloration and less peppery smell, and week 10 showed a mold-free with discoloration and foul smell, indicating quality changes.

In support of this result, in the article of Out et al. (2013), similar to the study of Ismawati et al. (2019), the quality of different malunggay products can last for 8 weeks at room temperature while keeping its phytochemical compounds.

Figure 3. *1st Observing Week*

Figure 4. *2nd Observing Week*

Figure 5. *3rd Observing Week*

Figure 6. *4th Observing Week*

Figure 7. *5th Observing Week*

Figure 8. *6th Observing Week*

Figure 9. *7th Observing Week*

Figure 10. *8th Observing Week*

Figure 11. *9th Observing Week*

Figure 12. *10th Observing Week*

Conclusion and Recommendation

Conclusions

Derived from the findings that were obtained, the following conclusions have been drawn:

1. Peroxidase activity is present in malunggay leaves.
2. The presence of NH_3, H_2S, and VOCs, specifically chloroform, was higher in the experimental than in the negative control, and there was no reduction percentage.
3. The treatment of pig farm wastewater created significant differences in the qualitative measures after the 9-point Hedonic scale. Odor intensity had an 82.76% decrease, and odor unpleasantness had an 80% decrease based on a human panel compared to the negative control.
4. The shelf life of malunggay leaves powder lasted about 8 weeks at room temperature, similar to pig feed storage sites.

Recommendations

In consideration towards improving the quality of the paper, the succeeding recommendations were enumerated:

1. The researcher suggests that peroxidase content in malunggay leaves should be quantitatively analyzed.
2. The researcher suggests that the moisture content of malunggay leaves should be determined.
3. The researcher suggests conducting other methodologies in treating pig farm wastewater.
4. The researcher suggests determining the best treatment ratio for the pig farm wastewater.
5. The researcher suggests assessing the differences in odor intensity of wastewater after 24, 48, and 72 hours of on-farm testing and evaluation to improve the result of the observation of human panels.

6. The researcher suggests conducting the treatment in multiple pig farm facilities to improve the accuracy and reliability of the results.
7. The researcher suggests comparing the treatment to existing deodorizing methods in pig farms.
8. The researcher suggests developing a product such as hydrogel and sprays to add to pig farm sewages
9. The researcher suggests developing a deodorizer for wastewater flocculation.
10. The researcher suggests determining the microbial content before and after wastewater treatment.
11. The researcher suggests using other quantitative methods to measure the wastewater's odor intensity and pleasantness, such as the dynamic olfactometry analysis.
12. The researcher suggests lengthening the shelf-life of the product.

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