



(RESEARCH ARTICLE)



Effects of Pulverized Madre De Cacao (*Gliricidia sepium*) and Jackfruit (*Artocarpus heterophyllus*) leaves as Saba Banana (*Musa acuminata* × *balbisiana*) ripening agents

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Abstract

In the Philippines, demand for fruits led to use of artificial ripening techniques like calcium carbide. These techniques contribute to meeting the rising demand for fruits but the fruits that benefit human health turned to unhealthy since the techniques affect the fruit's essential nutrients.

This study provides an alternative organic ripening agent to saba banana for its healthy way of cultivation. It aims to determine the effects of pulverized Madre De Cacao and Jackfruit leaves on the duration of ripening, color, odor, palatability, and texture of saba banana and to determine the significant difference between pulverized Madre De Cacao and Jackfruit leaves, and the combination of pulverized leaves as ripening agents. Experimental research design applied wherein three concentrations observed in five days after applying to saba banana. The most effective organic ripening agent was utilized in the public market. The 15 respondents divided into three groups utilized different treatments and answered the questionnaires.

The results revealed, treatment 2 (pulverized Jackfruit leaves) was most effective. The saba banana ripened in two days, color of peel turned yellow with green tips, odor of the banana smelled fragrant and fruity, palatability tasted enhanced sweetness, and texture when eaten was soft and creamy. On the other hand, treatment 1 (pulverized Madre De Cacao leaves) was next to most effective, and treatment 3 (combination of the two leaves) was slightly effective in some parameters. Further studies should be conducted on popular methods of ripening fruit such as the liquid method but in an organic way.

Keywords: Organic Ripening Agent; Madre De Cacao Leaves; Jackfruit Leaves; Duration of Ripening; Color

1. Introduction

Fruits offer numerous health benefits and are vital for a balanced diet. However, the use of calcium carbide for ripening, though common, is controversial and banned in many countries due to health and environmental concerns. Calcium carbide is a chemical compound that, when combined with moisture, produces acetylene gas, accelerating the ripening process of fruits. Using this for fruit ripening is considered hazardous, basically, it converts healthy fruits to poisonous. In the Philippines, where fruit consumption is high, calcium carbide is still used despite its risks. This practice prompted research into alternative ripening agents like Madre De Cacao and Jackfruit leaves. This eco-friendly ripening agents provide a natural way to ripen the fruit without the need for synthetic ripening agents.

This paper's findings may also contribute to the development of organic ripening agent alternative to synthetic ripening agents that can be accessible to the public, particularly in countries that produce a wide variety of fruits. This study

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investigated the effectiveness of Madre De Cacao and Jackfruit leaves as organic ripening agents. These organic materials have the ability to ripen climacteric fruits because they produce and release natural bio-ethylene gas that can stimulate the ripening process.

Through several trials, this study determined the right concentration required to achieve maximum effectiveness. In this paper, the researchers aimed to develop an organic ripening agents that promote safer, more sustainable fruit production practices while safeguarding consumers' health and the environment. Data were gathered from 15 fruit vendors from public market of Sta. Cruz, Laguna.

1.1. Statement of the Problem

This study aimed to determine the effects of pulverized Madre De Cacao (*Gliricidia sepium*) and Jackfruit (*Artocarpus heterophyllus*) leaves as Saba banana (*Musa acuminata × balbisiana*) ripening agents alternative to Calcium Carbide. As the researchers go along with the study, they ought to answer the following research questions:

- What are the effects of using pulverized Madre De Cacao leaves, Jackfruit leaves, and the combination of both pulverized leaves in saba banana ripening in terms of:
 - duration of ripening
 - color
 - odor
 - palatability
 - texture
- Is there a significant difference between ripening of saba banana with the application of treatment in terms of:
 - pulverized Madre De Cacao leaves
 - pulverized Jackfruit leaves
 - combination of both pulverized Madre de Cacao and Jackfruit leaves
- Based on the findings and results, what infographics can be suggested for the most beneficial and effective applications of treatments in ripening Saba bananas?

1.2. Theoretical Framework

The principles of drying theory served as a foundational framework for this research. The drying process of the pulverized leaves constitutes a significant element within this framework, encompassing factors such as drying kinetics, heat transfer, and mass transfer. Parameters associated with the drying process, including temperature, airflow, and drying time, exert influence over the quality and efficacy of the ripening agents. Additionally, the study evaluates the effectiveness of moisture removal from the leaves, preservation and shelf life of the ripening agents, retention of bioactive compounds, and rehydration/reconstitution properties (Pskovski & Mujumdar, 1985; Zachariah et al., 2019) [1] [2]. In the drying process, open sun drying will be employed, involving direct exposure to sunlight and requiring a significant open space. This approach is reliant solely on the presence of sunlight. These considerations provide insights into the implications of using pulverized Madre de Cacao and Jackfruit leaves as alternative ripening agents, contributing to the assessment of their viability as replacements for Calcium Carbide in saba banana ripening practices.

Another theory serving as the underpinning of this study is the theory of fruit climacteric ethylene emission. This theory establishes a connection between environmental factors and fruit growth with the generation of ethylene (C₂H₄). Indeed, it is acknowledged that fruit C₂H₄ production fluctuates throughout fruit development based on environmental factors such as temperature and levels of O₂ and CO₂ in the air. Fruit growth is manipulated through measures like adjusting the leaf-to-fruit ratio, fruit thinning, or branch ringing. The process of climacteric fruit ripening is heavily reliant on the plant hormone ethylene (C₂H₄). The production of C₂H₄ plays a pivotal role in ripening aspects like flesh softening, color alteration, and aroma development. This theory forms the foundation for the ETHY simulation model, which predicts C₂H₄ production over the course of a year (Genard & Gouble, 2005; Bai et al., 2020) [3] [4].

1.3. Conceptual Framework

The provided diagram illustrates the study's paradigm, which comprises the IPO (Input, Process, Output) of the research. The ingredients and equipment used in creating fruit ripening agents represent the input. The stages involved in producing fruit ripening agents, including data collection, data analysis, presentation, and interpretation, constitute the process. Lastly, the resulting alternative fruit ripening agent represents the output.

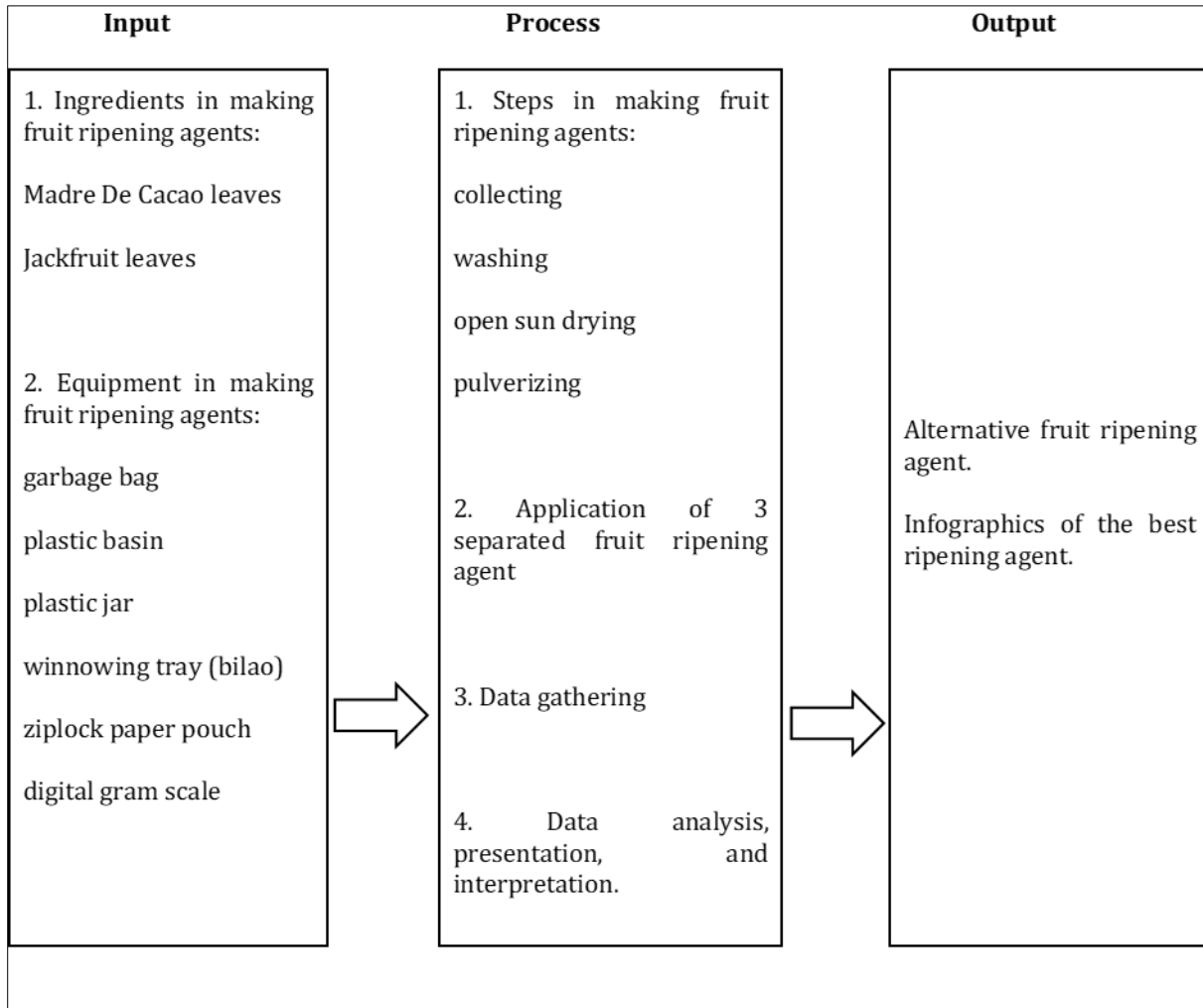


Figure 1 Conceptual framework

1.4. Significance of the Study

The researchers believed that the findings of the study helped determine the effects of pulverized Madre De Cacao leaves and Jackfruit leaves as alternative ripening agents for Calcium Carbide. Furthermore, the gathered information will be beneficial to the following:

1.4.1. Fruit vendors

The study's findings can significantly impact fruit vendors, who play a crucial role in the supply chain. The information gathered can help vendors enhance the quality and safety of their fruits, leading to increased customer satisfaction.

1.4.2. Farmers

The goal of this research is to reduce farmers' reliance on Calcium Carbide, thereby mitigating potential health and environmental risks associated with its usage. Additionally, utilizing locally available plant materials like Madre De Cacao and Jackfruit leaves can offer cost-effective alternatives for farmers, reducing their dependency on synthetic chemicals and promoting sustainable agricultural practices.

1.4.3. Community

The study's results can have positive implications for the broader community. The use of Calcium Carbide as a ripening agent has raised concerns due to potential health risks and adverse effects on consumers. Exploring alternative options such as Madre De Cacao and Jackfruit leaves, which are likely safer and more environmentally friendly, can lead to improved food safety and reduced exposure to harmful substances. This research contributes to promoting healthier practices in the food industry, ultimately benefiting consumers' well-being.

1.4.4. Environment

One significant advantage of investigating natural ripening agents is the potential positive impact on the environment. By examining the feasibility of Madre De Cacao and Jackfruit leaves as alternatives, this study promotes sustainable and eco-friendly practices within the food industry. Using organic ripening agents can help reduce chemical pollution, protect ecosystems, and contribute to a healthier environment.

1.4.5. Laguna University

The institution where the study was conducted, Laguna University stands to benefit in several ways. The research contributes to the university's academic reputation and showcases its commitment to promoting sustainable and innovative practices. The findings can also serve as a basis for further research and collaboration with other institutions, creating opportunities for interdisciplinary studies and knowledge exchange.

1.4.6. Future Researchers

The study's findings will serve as a valuable resource for future researchers interested in exploring natural ripening agents. It provides a foundation for further investigations and experiments, potentially leading to the development of new and improved ripening techniques. The research outcomes can inspire and guide future studies in related areas, helping advance scientific knowledge and contribute to the development of safer and more sustainable practices in the food industry.

1.5. Scope and Limitation of the Study

This study focused on examining the effects of pulverized madre de cacao and jackfruit leaves, as well as the combination of both pulverized leaves, on the duration of ripening, color, odor, palatability, and texture as ripening agents for saba bananas. Additionally, the study aimed to identify any significant differences among the three (3) treatments. Moreover, fifteen (15) selected fruit vendors from the public market of Sta. Cruz, Laguna, participated as respondents in the study. The researchers employed validated survey questionnaires for data collection during the second semester of the academic year 2022-2023.

2. Material and methods

The researchers employed an experimental research design to investigate the effects of pulverized madre de cacao, jackfruit, and the combination of leaves as organic ripening agents. Experimental design entails conducting research in a systematic and controlled manner, aiming to enhance precision and derive specific conclusions in relation to a hypothesis statement (Zubair, 2023) [5]. This approach involves manipulating one or more variables, measuring their impact on an outcome, and testing a hypothesis. It includes forming distinct groups of participants and assigning them to various conditions. Through the use of the experimental approach, the researchers were able to formulate a hypothesis and ascertain the significant differences among the three (3) organic ripening agents, determining which one was more effective.

2.1. Population of the Study

The researchers utilized a purposive sampling technique. As per Frost (2022) [6], purposive sampling is a non-probability approach used to select specific participants based on researchers' expertise, aligning with the study's objectives. In this research, the respondents consisted of fruit vendors situated in the public market of Sta. Cruz, Laguna. For the study, fifteen (15) fruit vendors were chosen to participate. These respondents were divided into three (3) groups, with each group comprising five (5) fruit vendors who were subjected to different treatments. The first group exclusively used pulverized madre de cacao leaves, the second group solely employed pulverized jackfruit leaves, and the third group utilized a combination of both pulverized leaves.

2.2. Research Instruments

In collecting the data, the researchers utilized a validated questionnaire with checklist-style content. The questionnaire was divided into three (3) sections, each of which was distributed to a corresponding set of respondents. These sections assessed the impacts of the three (3) treatments on saba banana ripening as a ripening agent, focusing on aspects such as ripening duration, color, odor, palatability, and texture.

2.3. Data gathering

The study comprised both pre-experimental and experimental phases, aimed at investigating the effects of using pulverized madre de cacao, jackfruit leaves, and a combination of both as ripening agents for saba bananas.

2.3.1. Pre-Experimental Phase

- *Phase 1* Preparation of Ingredients and Equipment

The ingredients used in making fruit ripening agents are the Madre De Cacao leaves and Jackfruit leaves. And for the equipment, the researchers used garbage bag, plastic basin, plastic jar, winnowing tray (bilao), digital scale, and ziplock paper pouch.

- *Phase 2:* Washing, sun drying, and pulverizing the leaves

The researchers prepared 3 concentrations for each treatment to test its effect on every hand (piling) of the saba banana.

Table 1 Concentration for organic ripening agents

Treatments	Concentration 1	Concentration 2	Concentration 3
(1) pulverized Madre De Cacao leaves	30 grams	80 grams	150 grams
(2) pulverized Jackfruit leaves	30 grams	80 grams	150 grams
(3) Combination of both pulverized leaves	30 grams (15g of pulverized madre de cacao and 15g of pulverized jackfruit leaves)	80 grams (40g of pulverized madre de cacao and 40g of pulverized jackfruit leaves)	150 grams (75g of pulverized madre de cacao and 75g of pulverized jackfruit leaves)

2.3.2. Experimental Phase

- *Phase 3:* Conducting the Experiment

The researchers experimented with various concentrations and observed their effects in order to determine the most effective concentration to use as a ripening agent for saba banana. In this phase, the concentration that demonstrates the desired quality effect will be selected for data gathering from the respondents.

Table 2 Concentration for organic ripening agents testing.

Treatments	Concentration 1 30 grams	Concentration 2 80 grams	Concentration 3 150 grams
(1) pulverized Madre De Cacao leaves	Not enough to ripen a saba banana.	About 3 days until the saba banana ripened.	Burns the skin of banana and develops molds.
(2) pulverized Jackfruit leaves	Not enough to ripen a saba banana.	About 2 days until the saba banana ripened.	Burns the skin of banana and develops molds.
(3) Combination of both pulverized leaves	Not enough to ripen a saba banana.	About 5 days until the saba banana ripened.	Bananas develop molds.

The table concludes that concentrations 1 and 3 are not effective for ripening the banana. Therefore, concentration 2 will be used in sets 1, 2, and 3 for data gathering.

- *Phase 4:* Preliminary Survey

The researchers conducted a pre-survey to identify potential respondents who meet the inclusion criteria (i.e., vendors that use calcium carbide as their ripening agent for fruits).

- Phase 5: Testing the Organic Ripening Agent

The researchers distributed three (3) hands of saba banana to each respondent. The fifteen (15) fruit vendors were divided into three (3) groups, with each group consisting of five (5) fruit vendors who used different treatments. The first group used treatment 1, the second group used treatment 2, and the third group used treatment 3. These treatments were applied to the three (3) hands of saba banana for each vendor. Each hand of the saba banana received an application of only 80 grams of the treatment to assess the consistency of the effects.

2.4. Treatment of Data

The following statistical procedures were used to interpret the data gathered from the respondents of the study.

Table 3 Statistical Treatment of data

SOP	Research Question	Statistical tools
1	What is the effect of using pulverized Madre De Cacao leaves, Jackfruit leaves, and the combination of both pulverized leaves in saba banana ripening in terms of duration of ripening, color, odor, palatability, and texture?	Frequency and Percentage $\% = \frac{f}{N} \times 100$
2	Is there a significant difference between ripening of saba banana with the application of treatment in terms of pulverized Madre De Cacao leaves, pulverized Jackfruit leaves, and combination of both pulverized Madre de Cacao leaves and Jackfruit leaves?	One-way ANOVA $SS = \sum (X - \bar{X})^2 = \sum X^2 - \frac{(\sum X)^2}{N}$
3	Based on the findings and results, what infographics can be suggested for the most beneficial and effective applications of treatments in ripening Saba bananas?	Result of the Study

3. Results and Discussion

3.1. Pulverized Madre De Cacao leaves

Table 4 Effects of Pulverized Madre De Cacao leaves in Saba Banana Ripening in terms of Duration

Duration of Ripening	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Day 1	0	0%	V.E	0	0%	VE	0	0%	V.E
Day 2	0	0%	E.	0	0%	E	0	0%	E.
Day 3	5	100%	M.E	5	100%	ME	3	60%	M.E
Day 4	0	0%	S.E	0	0%	SE	2	40%	S.E
Day 5	0	0%	N.E	0	0%	NE	0	0%	N.E

Legend: F – frequency; RF – relative; I – Interpretation; V.E – Very Effective; E – Effective; M.E – Moderately Effective; S.E – Slightly Effective; N.E – Not Effective

Table 4 shows the effects of pulverized Madre De Cacao leaves on Saba Banana Ripening in terms of duration. The ripening duration is observed over a 5-day period. Set 1 and Set 2 have the same frequency of 5 and a relative frequency of 100%, indicating that pulverized Madre de Cacao leaves are "**Moderately effective**" on day 3. Set 3 has a frequency of 3 and a relative frequency of 60%, indicating "**Moderate effectiveness**" on day 3. Additionally, Set 3 has a frequency of 2 and a relative frequency of 40%, suggesting that pulverized Madre de Cacao leaves are "**Slightly effective**" on day 4.

Table 5 presents the effects of pulverized Madre De Cacao leaves on Saba Banana Ripening in terms of color. The ripening stages of the Saba banana are observed through 5 color categories. Set 1, 2, and 3 exhibit identical frequencies of 5 and relative frequencies of 100%, indicating that the use of pulverized Madre de Cacao leaves in Saba banana ripening is "**Moderately effective**" when the yellow color stage is reached.

Table 5 Effects of Pulverized Madre De Cacao leaves in Saba Banana Ripening in terms of Color

Color	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Green	0	0%	N.E	0	0%	N.E	0	0%	N.E
Yellow with green tips	0	0%	S.E	0	0%	S.E	0	0%	S.E
Yellow	5	100%	M.E	5	100%	M.E	5	100%	M.E
Yellow with brown spot	0	0%	E	0	0%	E	0	0%	E
Mostly brown	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 6 Effects of Pulverized Madre De Cacao leaves in Saba Banana Ripening in terms of Odor

Odor	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Mild or subtle scent	0	0%	N.E	0	0%	N.E	1	20%	N.E
Slight sweetness	5	100%	S.E	5	100%	SE	4	80%	S.E
Fragrant and fruity	0	0%	M.E	0	0%	M.E	0	0%	M.E
Sweet and pronounced	0	0%	E	0	0%	E	0	0%	E
Strong or fermented odor	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 6 displays the Effects of Pulverized Madre De Cacao leaves on Saba Banana Ripening in terms of odor. The odor during the ripening process of Saba banana is categorized into 5 distinct categories. Set 1 and 2 exhibit identical frequencies of 5 and relative frequencies of 100%, indicating that the use of pulverized Madre de Cacao leaves in Saba banana ripening is "**Slightly effective**" when a slight sweetness is detected in the aroma. Conversely, Set 3 shows a frequency of 1 and a relative frequency of 20%, signifying that the utilization of pulverized Madre de Cacao leaves in Saba banana ripening is "**Not effective**" when a mild or subtle scent is perceived. Additionally, Set 3 also presents a frequency of 4 and a relative frequency of 80%, indicating that the use of pulverized Madre de Cacao leaves in Saba banana ripening is "**Slightly effective**" when a slight sweetness is smelled.

Table 7 Effects of Pulverized Madre De Cacao leaves in Saba Banana Ripening in terms of Palatability

Palatability	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Starchiness	0	0%	N.E	0	0%	N.E	1	20%	N.E
Mild sweetness	5	100%	S.E	5	100%	S.E	4	80%	S.E
Sweetness and flavor	0	0%	M.E	0	0%	M.E	0	0%	M.E
Enhanced sweetness	0	0%	E	0	0%	E	0	0%	E
Overly sweet or fermented taste	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 7 illustrates the Effects of Pulverized Madre De Cacao leaves on Saba Banana Ripening concerning Palatability. This aspect is categorized into 5 distinct categories. Both Set 1 and Set 2 present identical frequencies of 5 and relative frequencies of 100%, indicating that the use of pulverized Madre de Cacao leaves in Saba banana ripening is "**Slightly effective**" in enhancing a mild sweetness in taste. Conversely, Set 3 exhibits a frequency of 1 and a relative frequency of 20%, signifying that the application of pulverized Madre de Cacao leaves in Saba banana ripening is "**Not effective**" in reducing starchiness in taste. Moreover, Set 3 also records a frequency of 4 and a relative frequency of 80%, indicating that the utilization of pulverized Madre de Cacao leaves in Saba banana ripening is "**Slightly effective**" in enhancing a mild sweetness in taste.

Table 8 Effects of Pulverized Madre De Cacao leaves in Saba Banana Ripening in terms of Texture

	Set 1			Set 2			Set 3		
Texture	F	RF	I	F	RF	I	F	RF	I
Firmness	0	0%	N.E	0	0%	N.E	1	20%	N.E
Semi-firm	5	100%	S.E	5	100%	S.E	4	80%	S.E
Soft and creamy	0	0%	M.E	0	0%	M.E	0	0%	M.E
Mushy or tender	0	0%	E	0	0%	E	0	0%	E
Very soft or mushy	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 8 depicts the Effects of Pulverized Madre De Cacao leaves on Saba Banana Ripening with regard to Texture. Texture evaluation is segmented into 5 distinct categories. Both Set 1 and Set 2 exhibit identical frequencies of 5 and relative frequencies of 100%, signifying that the utilization of pulverized Madre de Cacao leaves in Saba banana ripening is "b" in yielding a semi-firm texture. Conversely, Set 3 registers a frequency of 1 and a relative frequency of 20%, indicating that the application of pulverized Madre de Cacao leaves in Saba banana ripening is "**Not effective**" in reducing firmness in texture. Furthermore, Set 3 also records a frequency of 4 and a relative frequency of 80%, suggesting that the use of pulverized Madre de Cacao leaves in Saba banana ripening is "**Slightly effective**" in achieving a semi-firm texture.

3.2. Pulverized Jackfruit leaves

Table 9 Effects of Pulverized Jackfruit leaves in Saba Banana Ripening in terms of Duration

	Set 1			Set 2			Set 3		
Duration of Ripening	F	RF	I	F	RF	I	F	RF	I
Day 1	0	0%	V.E	0	0%	V.E	0	0%	V.E
Day 2	5	100%	E	5	100%	E	5	100%	E
Day 3	0	0%	M.E	0	0%	M.E	0	0%	M.E
Day 4	0	0%	S.E	0	0%	S.E	0	0%	S.E
Day 5	0	0%	N.E	0	0%	N.E	0	0%	N.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 9 shows the Effects of Pulverized Jackfruit leaves in Saba Banana Ripening in terms of Duration. The duration of ripening is observed within 5 days. Set 1, 2 and 3 has the same frequency of 5 and relative frequency of 100% which means pulverized jackfruit leaves are "**Effective**" on day 2.

Table 10 Effects of Pulverized Jackfruit leaves in Saba Banana Ripening in terms of Color

Color	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Green	0	0%	N.E	0	0%	N.E	0	0%	N.E
Yellow with green tips	5	100%	S.E	5	100%	S.E	5	100%	S.E
Yellow	0	0%	M.E	0	0%	M.E	0	0%	M.E
Yellow with brown spot	0	0%	E	0	0%	E	0	0%	E
Mostly brown	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 10 outlines the Effects of Pulverized Jackfruit leaves on Saba Banana Ripening in relation to Color. The ripening progression of Saba bananas is observed across 5 distinct color stages. In Set 1, Set 2, and Set 3, an identical frequency count of 5 is recorded, alongside a corresponding relative frequency of 100%. This signifies that the application of pulverized Jackfruit leaves during Saba banana ripening yields a "Slightly Effective" outcome when the color observed is yellow with green tips.

Table 11 Effects of Pulverized Jackfruit leaves in Saba Banana Ripening in terms of Odor

Odor	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Mild or subtle scent	0	0%	N.E	0	0%	N.E	0	0%	N.E
Slight sweetness	0	0%	S.E	0	0%	S.E	0	0%	S.E
Fragrant and fruity	5	100%	M.E	5	100%	M.E	5	100%	M.E
Sweet and pronounced	0	0%	E	0	0%	E	0	0%	E
Strong or fermented odor	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 11 presents the Effects of Pulverized Jackfruit leaves on Saba Banana Ripening with regard to Odor. The odor progression of Saba banana ripening is categorized into 5 categories. In Set 1, Set 2, and Set 3, identical frequency counts of 5 are registered, alongside corresponding relative frequencies of 100%. This indicates that the application of pulverized Jackfruit leaves during Saba banana ripening yields a "**Moderately effective**" outcome when the detected odor is fragrant and fruity.

Table 12 Effects of Pulverized Jackfruit leaves in Saba Banana Ripening in terms of Palatability

Palatability	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Starchiness	0	0%	N.E	0	0%	N.E	0	0%	N.E
Mild sweetness	0	0%	S.E	0	0%	S.E	0	0%	S.E
Sweetness and flavor	0	0%	M.E	0	0%	M.E	0	0%	M.E
Enhanced sweetness	5	100%	E	5	100%	E	5	100%	E
Overly sweet or fermented taste	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 12 delineates the Effects of Pulverized Jackfruit leaves on Saba Banana Ripening concerning Palatability. This category is segregated into 5 categories. In Set 1, Set 2, and Set 3, an equivalent frequency count of 5 is observed, alongside corresponding relative frequencies of 100%. This collectively indicates that the application of pulverized Jackfruit leaves during Saba banana ripening is "**Effective**" in augmenting the sweetness and enhancing the palatability.

Table 13 Effects of Pulverized Jackfruit leaves in Saba Banana Ripening in terms of Texture

	Set 1			Set 2			Set 3		
Texture	F	RF	I	F	RF	I	F	RF	I
Firmness	0	0%	N.E	0	0%	N.E	0	0%	N.E
Semi-firm	0	0%	S.E	0	0%	S.E	0	0%	S.E
Soft and creamy	5	100%	M.E	5	100%	M.E	5	100%	M.E
Mushy or tender	0	0%	E	0	0%	E	0	0%	E
Very soft or mushy	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 13 illustrates the Effects of Pulverized Jackfruit leaves on Saba Banana Ripening in relation to texture. The texture classification comprises 5 categories. Across Set 1, Set 2, and Set 3, an identical frequency count of 5 is observed, coupled with a relative frequency of 100%. This collectively signifies that the utilization of pulverized Jackfruit leaves for Saba banana ripening is "**Moderately effective**" in yielding a soft and creamy texture.

3.3. Combination of Pulverized Madre de Cacao and Jackfruit leaves

Table 14 Effects of Combination of Pulverized Madre de Cacao and Jackfruit leaves in terms of Duration

	Set 1			Set 2			Set 3		
Duration of Ripening	F	RF	I	F	RF	I	F	RF	I
Day 1	0	0%	V.E	0	0%	V.E	0	0%	V.E
Day 2	0	0%	E	0	0%	E	0	0%	E
Day 3	0	0%	M.E	0	0%	M.E	0	0%	M.E
Day 4	0	0%	S.E	1	20%	S.E	0	0%	S.E
Day 5	5	100%	N.E	4	80%	N.E	5	100%	N.E

Legend: F – frequency; RF – relative; I – Interpretation; V.E – Very Effective; E – Effective; M.E – Moderately Effective; S.E – Slightly Effective; N.E – Not Effective

Table 14 depicts the Effects of the Combination of Pulverized Madre de Cacao and Jackfruit Leaves in terms of Duration. The observation of ripening duration spans 5 days. Within Set 1 and Set 3, an identical frequency count of 5 is registered, accompanied by a relative frequency of 100%. This collective observation signifies that the combination of pulverized Madre de Cacao and Jackfruit leaves proves "**Not effective**" on Day 5. Conversely, Set 2 features a frequency of 1 and a relative frequency of 20%, which implies that the combination of pulverized Madre de Cacao and Jackfruit leaves is "**Slightly effective**" on Day 4. Within Set 3, a frequency of 4 and a relative frequency of 80% indicate that the combination of pulverized Madre de Cacao and Jackfruit leaves is "**Not effective**" on Day 5.

Table 15 depicts the Effects of the Combination of Pulverized Madre de Cacao and Jackfruit Leaves in terms of Color. The observation of Saba banana ripening includes 5 distinct colors. In Set 1, with a consistent frequency of 5 and a relative frequency of 100%, the combination of pulverized Madre de Cacao and Jackfruit leaves is deemed "**Not effective**" when green color is observed. Both Set 2 and Set 3 exhibit a frequency of 3 and a relative frequency of 60%, signifying that the combination is "**Not effective**" in inducing green color during Saba banana ripening. Additionally, in both Set 2 and Set 3, a frequency of 2 and a relative frequency of 40% show that the combination is "**Moderately effective**" in producing yellow color during Saba banana ripening.

Table 15 Effects of Combination of Pulverized Madre de Cacao and Jackfruit leaves in terms of Color

Color	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Green	5	100%	N.E	3	60%	N.E	3	60%	N.E
Yellow with green tips	0	0%	S.E	0	0%	S.E	0	0%	S.E
Yellow	0	0%	M.E	2	40%	M.E	2	40%	M.E
Yellow with brown spot	0	0%	E	0	0%	E	0	0%	E
Mostly brown	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 16 Effects of Combination of Pulverized Madre de Cacao and Jackfruit leaves in terms of Odor

Odor	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Mild or subtle scent	5	100%	N.E	5	100%	N.E	5	100%	N.E
Slight sweetness	0	0%	S.E	0	0%	S.E	0	0%	S.E
Fragrant and fruity	0	0%	M.E	0	0%	M.E	0	0%	M.E
Sweet and pronounced	0	0%	E	0	0%	E	0	0%	E
Strong or fermented odor	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 16 illustrates the Effects of the Combination of Pulverized Madre de Cacao and Jackfruit Leaves in terms of Odor. The odor of Saba banana ripening is categorized into 5 distinct categories. In Set 1, Set 2, and Set 3, all exhibiting a consistent frequency of 5 and a relative frequency of 100%, the combination of pulverized Madre de Cacao and Jackfruit leaves is perceived as "**Not effective**" when a mild or subtle scent is detected.

Table 17 Effects of Combination of Pulverized Madre de Cacao and Jackfruit leaves in terms of Palatability

Palatability	Set 1			Set 2			Set 3		
	F	RF	I	F	RF	I	F	RF	I
Starchiness	1	20%	N.E	3	60%	N.E	5	100%	N.E
Mild sweetness	4	80%	S.E	2	40%	S.E	0	0%	S.E
Sweetness and flavor	0	0%	M.E	0	0%	M.E	0	0%	M.E
Enhanced sweetness	0	0%	E	0	0%	E	0	0%	E
Overly sweet or fermented taste	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 17 outlines the Effects of the Combination of Pulverized Madre de Cacao and Jackfruit Leaves in terms of Palatability. This parameter is divided into 5 distinct categories. In Set 1, there is a frequency of 1 and a relative frequency of 20%, indicating that the combination of pulverized Madre de Cacao and Jackfruit leaves in Saba banana ripening is perceived as "**Not effective**" when the starchiness is felt. However, for the mild sweetness category in Set 1, there is a frequency of 4 and a relative frequency of 80%, indicating a "**Slightly effective**" outcome. In Set 2, the same trend continues, with a frequency of 3 and a relative frequency of 60% indicating ineffectiveness in reducing starchiness and a frequency of 2 and a relative frequency of 40% indicating mild effectiveness in enhancing mild sweetness. Set 3,

with a frequency of 5 and a relative frequency of 100%, shows that the combination of pulverized Madre de Cacao and Jackfruit leaves in Saba banana ripening is perceived as **"Not effective."**

Table 18 Effects of Combination of Pulverized Madre de Cacao and Jackfruit leaves in terms of Texture

	Set 1			Set 2			Set 3		
Texture	F	RF	I	F	RF	I	F	RF	I
Firmness	3	60%	N.E	2	40%	N.E	3	60%	N.E
Semi-firm	2	40%	S.E	3	60%	S.E	2	40%	S.E
Soft and creamy	0	0%	M.E	0	0%	M.E	0	0%	M.E
Mushy or tender	0	0%	E	0	0%	E	0	0%	E
Very soft or mushy	0	0%	V.E	0	0%	V.E	0	0%	V.E

Legend: F – frequency; RF – relative; I – Interpretation; N.E – Not Effective; S.E – Slightly Effective ; M.E – Moderately Effective E – Effective; V.E – Very Effective

Table 18 displays the Effects of the Combination of Pulverized Madre de Cacao and Jackfruit Leaves in terms of Texture. Texture is categorized into 5 distinct attributes. Set 1 and 3 share a frequency of 3 and a relative frequency of 60%, indicating that the combination of pulverized Madre de Cacao and Jackfruit leaves in Saba banana ripening is perceived as **"Not effective"** in terms of firmness. Simultaneously, both sets have a frequency of 2 and a relative frequency of 40%, indicating that the combination is **"Slightly effective"** in creating a semi-firm texture. For Set 2, there is a frequency of 2 and a relative frequency of 40%, signifying ineffectiveness in firmness, and a frequency of 3 and a relative frequency of 60% indicating **"Slightly effective"** in semi-firm texture.

Table 19 Significant difference between Pulverized Madre de cacao leaves, Pulverized Jackfruit leaves and a Combination of both in Saba banana ripening

Categories		M	SD	D.F	F- value	P-value	F-Critical	Interpretation
Duration	Set1	2.87	0.189	8	103	2.271	5.143	Significant
	Set2	4.00	0					
	Set3	1.20	0.283					
Color	Set1	3.00	0	8	23.688	0.001	5.143	Significant
	Set2	4.00	0					
	Set3	4.47	0.377					
Odor	Set1	4.07	0.094	8	676	8.621	5.143	Significant
	Set2	3.00	0					
	Set3	5.00	0					
Palatability	Set1	4.07	0.094	8	97.923	2.631	5.143	Significant
	Set2	2.00	0					
	Set3	4.60	0.327					
Texture	Set1	4.07	0.094	8	208.5	2.851	5.143	Significant
	Set2	3.00	0					
	Set3	4.53	0.094					

Legend: M – Mean; SD – Standard Deviation; D.F – Degree of Freedom

Table 19 presents the significant differences between pulverized Madre de Cacao leaves, pulverized Jackfruit leaves, and the combination of both in Saba banana ripening. The table displays computed f-values of 103 for duration, 23.688 for color, 676 for odor, 97.923 for palatability, and 208.5 for texture, all of which surpass the computed f-value of 5.143.

This discrepancy indicates that there is a significant difference between the effects of pulverized Madre de Cacao leaves, pulverized Jackfruit leaves, and the combination of both in Saba banana ripening concerning duration, color, odor, palatability, and texture.

The findings emphasize the notable dissimilarity in the efficacy of pulverized Madre de Cacao leaves, pulverized Jackfruit leaves, and the combination of both in facilitating Saba banana ripening across the various sets. Pulverized jackfruit leaves exhibited efficacy in expediting the ripening process, demonstrating slight effectiveness in achieving a yellow color, enhancing palatability, and leading to soft and creamy ripened bananas (Farouq and Chritianah, 2022) [7]. In contrast, pulverized Madre de Cacao leaves displayed moderate effectiveness in sets 1 and 2 concerning duration, while showing slight effectiveness in enhancing mild sweetness but no effect in reducing starchiness in set 3 (Aba et al., 2018) [8]. The achievement of a yellow color was moderately observed with Madre de Cacao leaves. The combination of Madre de Cacao and jackfruit leaves did not effectively enhance odor compared to naturally ripened bananas. In terms of duration, a slightly effective result was observed, with bananas ripening on day 4 (Ruwali et al., 2022) [9]. Furthermore, the combination was found to be not effective in minimizing the starchy taste but slightly effective in enhancing the mild sweet taste of Saba bananas. In terms of texture, the effectiveness varied between not effective and slightly effective. These findings underscore the substantial impact of different ripening agents across various sets.



Figure 4 Infographics of best organic ripening agent

The infographic is all about the most beneficial and effective organic ripening agent made from dried and pulverized jackfruit leaves. As demonstrated in the infographic, it describes the process of making this ripening agent, focusing on four important steps, including washing and drying the leaves before pulverizing and storing them properly.

Additionally, it provides clear instructions on the proper use of organic ripening agent for Saba banana. This eco-friendly ripening agent provides a natural way to ripen the fruit without the need for artificial agents, promoting sustainable and organic practices.

4. Discussion

The study investigated the effects of pulverized Madre de Cacao leaves, pulverized Jackfruit leaves, and a combination of both leaves on the ripening of Saba bananas. The findings revealed significant differences among the three treatments in terms of duration of ripening, color, odor, palatability, and texture. In terms of duration of ripening, pulverized Madre de Cacao leaves were moderately effective on day 3, while pulverized Jackfruit leaves were effective on day 2. However, the combination of both was not effective on day 5. This suggests that Madre de Cacao leaves may accelerate the ripening process slightly, while Jackfruit leaves have a more pronounced effect. Regarding color, the combination of pulverized Madre de Cacao and Jackfruit leaves was moderately effective when yellow color was observed, whereas Madre de Cacao leaves alone were not effective when green color was observed. In terms of odor, pulverized Jackfruit leaves were moderately effective, providing a fragrant and fruity smell during ripening. In contrast, Madre de Cacao leaves and the combination of both were not effective when a mild or subtle scent was detected. For palatability, pulverized Jackfruit leaves were effective in enhancing sweetness, while Madre de Cacao leaves and the combination of both were only slightly effective. However, Madre de Cacao leaves were not effective in reducing starchiness. Regarding texture, pulverized Madre de Cacao leaves and the combination of both were slightly effective when the bananas were semi-firm, while Jackfruit leaves were moderately effective in achieving a soft and creamy texture. Madre de Cacao leaves were not effective in reducing firmness. Overall, the results and findings indicate that both Madre de Cacao and Jackfruit leaves have effects on various ripening attributes of Saba bananas, but their effectiveness varies as jackfruit leaves appear to be more effective in achieving the desired ripening outcomes. Additionally, the combination of both leaves did not consistently enhance the ripening process compared to the individual treatments.

5. Conclusion

Based on the findings of the study, the researchers concluded that there is a significant difference in using the pulverized madre de cacao and jackfruit leaves, as well as the combination of both pulverized leaves, in saba banana ripening. This conclusion rejects the null hypothesis of the study. This indicates that the three ripening agents are comparable in terms of duration of ripening, color, odor, palatability, and texture. Furthermore, pulverized jackfruit leaves proved effective in accelerating the ripening process, showing slight effectiveness in achieving yellow color, enhancing palatability, and leading to soft and creamy ripened bananas. This suggests that pulverized jackfruit leaves are effective in ripening the saba banana and can be an alternative ripening agent to calcium carbide. Additionally, while the used organic ripening agent cannot be used again, it contains organic matter beneficial for plant growth. The researchers suggest not discarding it after use; instead, it can be placed in the soil as fertilizer for plants.

Recommendations

The researchers recommend accumulating more relevant literature and studies to support their assertions and gain a more comprehensive understanding of the potential application of organic sources as viable ripening agents. Additionally, they suggest conducting further research to explore various plant leaves from organic sources, potentially yielding more effective ripening agents, such as liquids extracted from leaves, which could then be applied to other specific fruits for ripening. Furthermore, it is advised that the ripening agent/s be subjected to testing by the Department of Science and Technology (DOST) to identify other components present in the leaves and ensure that it is safe, sustainable, and completely organic.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflicts of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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