Ripe Banana *(Musa acuminata x balbisiana)* Peel Pectin as a Potential Binder Excipient for Ascorbic Acid Tablet Formulation

KC C. Sta Ana[1],Ellen Mae P. Abiqui, RPh, MSPharm, CPT©[2], Kate Ciayra B. Domine[3], Jessie Mei R. Garcia[4], Mark Andrew Lonogan[5], Griselle Ann A. Marquez, RPh, CIP[6], Ivy Rose C. Orozco, RPh, CIP[7]Frenchie D. Rivera[8]

[12345678]College of Pharmacy, LORMA Colleges, City of San Fernando, La Union, Philippines
[1]kc.staana@lorma.edu, [2]ellenmae.abiqui@lorma.edu, [3]kateciayra.domine@lorma.edu,
[4]jessiemei.garcia@lorma.edu, [5]markandrew.lonogan@lorma.edu, [6]griselleann.marquez@lorma.edu,
[7]ivyrose.orozco@lorma.edu, [8]frenchie.rivera@lorma.edu

Abstract

The pharmaceutical industry in the Philippines is still dependent on imported synthetic binders. This calls for the development of sustainable alternatives that are locally sourced. This study evaluated the potential of ripe banana peel pectin as an organic binder for ascorbic acid tablets. Two hundred thirty-four (234) tablets were prepared at 7.5%, 10%, and 12.5% w/v pectin concentrations, with another 20 commercial tablets using microcrystalline cellulose as a control. The pectin was characterized by determining its degree of esterification, moisture and ash content, and angle of repose. Tablet quality was determined through friability and disintegration tests following pharmacopeial standards. One-way analysis of variance (ANOVA) with Tukey's HSD or Games-Howell post hoc analyses were used to analyze the results. The pectin was low-methoxyl, and had a 7.21% moisture content, 8.06 ash content, and flow properties better than excellent. The 10% and 12.5% formulations ($F = 284$, $p < 0.001$) passed friability and had significant differences from Brand X. All formulations disintegrated within 15 minutes, and ANOVA ($F = 529$, $p < .001$) revealed that higher pectin concentrations prolonged disintegration time. The results suggest that 10% pectin is enough to impart sufficient tablet strength without affecting friability and disintegration time. Ripe banana peel pectin can be used as a suitable, cost-effective, and locally available excipient for tablet formulation in the Philippines.

Keywords: Ripe banana peel; pectin; tablet binder; ascorbic acid

1. Introduction

The most frequently used solid dosage forms are tablets, which have an active pharmaceutical ingredient (API) and excipients that guarantee stability, manufacturability, and patient acceptability (Ahsan, 2024). Pharmaceutically inert substances known as excipients are added to APIs to improve the weight, consistency, or performance of a drug product (Wakchaure et al., 2024). They are essential components in the creation of tablets since they increase hardness, disintegration, compressibility, and drug release, which is necessary to create a stable and effective dosage form (Akin-Ajani & Okunlola, 2021). Among these excipients, binders are an essential component because they impart cohesion to the powder material, improve compressibility, and enhance the mechanical strength and stability of tablets (Khairnar et al., 2024).

Although significant, the Philippine pharmaceutical sector is largely reliant upon imported raw materials and excipients. Thus, resulting in high production costs and supply-chain vulnerability (Reyes & Tabuga, 2020). Synthetic binders in tablet formulation, such as polyvinylpyrrolidone and hydroxypropyl methylcellulose, may be incorporated to improve tablet strength but at the cost of delayed disintegration and reduced dissolution, thereby increasing manufacturing expenses (Roy et al., 2025). Moreover, the use of certain synthetic excipients can pose safety and environmental concerns (Osteberg & See, 2003). These challenges have led to the investigation of naturally derived plant polymers as pharmaceutical binders for safer and more sustainable alternatives (Obarisiagbon et al., 2021).

Pectin is a natural biopolymer that is found in plant cell walls (Hobbs et al., 2019). Pectin is of use due to its ability to form a gelling agent, a stabilizer, and a binder, which makes it pharmaceutically significant for use in tablets and creates a drug-release controlled system (Lukova, 2023). Pectin is biodegradable and biocompatible and can form hydrogels, which may aid in matrix formation and mechanical stability (Akin-Ajani & Okunlola, 2021).

Pectin can be derived from rich and underutilized sources such as banana peels. Banana peels are considered global agricultural waste and make up about 40% of its weight (Yasin et al., 2025). In the Philippines, bananas are amongst the country's top agricultural commodities, and the Saba banana *(Musa acuminata x balbisiana)* is one of the most widely cultivated types (Department of Agriculture, 2022). Banana peel pectin has been shown to have promising binding and sustained drug-release properties, making it a potential alternative to synthetic binders (Fauzi, 2025). Its environmental and socioeconomic benefit of reducing agricultural waste and converting it into a valuable material for pharmaceutical use is a plus.

Ascorbic acid, a commonly used API, possesses antioxidant activity and offers immune support and collagen synthesis benefits (Aripova, 2020). However, the API is difficult to formulate due to its poor compressibility, brittle crystalline structure, and chemical instability, which can result in poor tablet hardness and loss of potency during storage (Pawar et al., 2024). Thus, proper binder selection is crucial in enhancing the cohesiveness and stability of formulated tablets (Ozyurt & Mehrad, 2020). While pectin from various fruit sources has been studied as a natural binder, there is little published research on the use of pectin extracted from ripe Saba banana peels for ascorbic acid tablet formulation (Fauzi, 2025). Hence, this study used pectin extracted from ripe Saba banana peels *(Musa acuminata & balbisiana)* and screened its potential as a binder for ascorbic acid tablet formulations. The study specifically sought to establish if banana peel pectin could possess similar binding capabilities to that of commercial binders, in addition to safeguarding a sustainable, locally available, and relatively low-cost pharmaceutical excipient.

2. Objectives

The objective of this research was to assess the extracted ripe banana peel pectin by measuring the degree of esterification, moisture content, ash content, and angle of repose. The intention was also to prepare ascorbic acid tablets using ripe banana peel pectin at varying concentrations of 7.5% w/v, 10% w/v, and 12.5% w/v and to determine the physical quality of the prepared pectin-ascorbic acid tablets using tablet friability and disintegration tests. Lastly, the objective was to compare the prepared ascorbic acid tablets to commercially available ascorbic acid tablets that use microcrystalline cellulose as a binder by comparing the statistical difference between the friability and disintegration parameters.

3. Materials and Methods

This section lays out the materials and method in the determination of the Potential Binder properties of the Ripe Banana *(Musa acuminata x balbisiana)* peel pectin extract. This section has included the research design, duration, and locale of the study; data-gathering tools; and methodology that was employed in the study.

Research Design

The researchers used an experimental research design to test ripe banana (*Musa acuminata x balbisiana*) peel pectin as a natural pharmaceutical binder. By using an experimental research design, the researchers were able to formulate and conduct laboratory procedures, produce data, and test the hypotheses. This approach was ideal in determining the ripe banana peel pectin binding properties as an alternative binder to well-established ones (commercial brands) because it can generate quantitative evidence and the comparison of performance outcomes. In evaluating the ripe banana peel pectin binder's performance, the researchers compared the formulated tablets with commercially available ascorbic acid tablets using microcrystalline cellulose as the binder. This binder served as a reference standard and determined the effectiveness of ripe banana peel pectin as a binder in pharmaceutical formulations.

All experimental procedures involving plant sample extraction were conducted within the facilities of LORMA Colleges. Preparation and extraction of ripe banana peels were conducted in the pharmacy laboratory. The laboratory provided the necessary apparatus, equipment and controlled environment for preparing substances ideal for pharmaceutical use. Formulation and compounding of ascorbic acid tablets using ripe banana peel pectin as a natural binder started in the second semester of the academic year from January to May 2026.

Collection, Authentication, and Extraction of Ripe Banana Peel Pectin

Ripe banana (*Musa acuminata x balbasiana*) were obtained from Baracbac, Tagudin, Ilocos Sur, and authenticated at Don Mariano Marcos Memorial State University-Northern Luzon Campus, Bacnotan, La Union (DMMMSU-NLUC). The ripe banana peels were washed, dried, and pulverized to prepare for the pectin extraction. Pectin was extracted from ripe banana peels using the citric acid extraction method with some modifications (Tugon et al., 2023). The pulverized ripe banana peels were mixed with 5% citric acid (1:20 ratio) and heated at 90

degrees Celsius with 40 minutes of continuous stirring, followed by filtration. The solution was precipitated with an equal volume of 95% ethanol. The precipitate was filtered, washed, and oven-dried to obtain final ripe banana peel pectin.

Confirmatory Testing

Fourier Transform Infrared (FTIR) spectroscopy and preliminary phytochemical tests were done to affirm the presence of pectin in the extracted ripe banana peel pectin. The FTIR analysis entailed blending the dried pectin sample with KBr, compressing it to form a pellet, and subsequently scanning the infrared spectrum of 4000-400 cm^{-1}.. The characteristic absorption bands of hydroxyl and C-H groups established the structural integrity of pectin with respect to commercial pectin (Szymanska-Chargot et al., 2022). The FTIR test was selected due to its accuracy in identifying the polygalacturonate pectin backbone (Guo et al., 2021).

Preliminary phytochemical tests, which included the iodine test, the alcohol precipitation test, the potassium (KOH) test, the Molisch's test, and the Fehling's test, were also utilized to further affirm the presence of pectin in the banana peel extract (Luvedika et al., 2024).

Characterization of Ripe Banana Peel Pectin

Pectin's degree of esterification (DE) of ripe banana peel pectin was determined using the titrimetric method of Nguyen and Pirak (2019). A 0.05 g sample of pectin was dissolved and titrated with 0.1 N NaOH before and after hydrolysis. The following formula was used to calculate DE, and the test was done three times. DE = [b / (a+b)] x 100. Based on the obtained DE value, pectin was classified as either high-methoxyl pectin (DE >50%) or low-methoxyl pectin (DE <50%) (Athanasopoulou et al., 2025).

The moisture content of ripe banana peel pectin was determined using a halogen moisture analyzer following USP <731> Loss on Drying. One gram of ripe banana peel pectin was heated at 100°C until a consistent weight was attained. This test determines how much water the pectin retains, which will affect its stability, compressibility, and shelf life (Mamiru & Gonfa, 2023).

The ash content of ripe banana peel pectin was determined following the method described by Mamiru and Gonfa (2023). About 1-2 g of ripe banana peel pectin was incinerated at 600°C in a muffle furnace for 3-4 h until a constant weight was attained. This test determines the amount of inorganic mineral residues in the pectin sample. It is an indicator of pectin's purity and efficacy as a binder (Das et al., 2025).

The angle of repose was determined using the funnel method (ISO 4323, 1977). The ripe banana peel pectin powder sample was allowed to freely flow through a funnel to form a cone, and the height and radius were measured. The following formula was used to calculate the angle of repose. $\theta = \text{Arctan } h/r$). This test evaluates the pectin powder's flowability, which is significant for uniform die filling and tablet manufacturing (USP <1174>).

Formulation of Ascorbic Acid Tablets with Binder Using Wet Granulation

The ascorbic acid formulations were made by a granulation approach, using ripe banana peel pectin as a natural binder at concentrations of 7.5%, 10%, 12.5% w/v. Each tablet was set to hold 250 mg ascorbic acid, 15 mg starch (disintegrant) , 25 mg of lactose (diluent), and 5 mg magnesium stearate (lubricant). The use of wet granulation improved powder flow, compressibility, and uniform drug distribution, at the same time ripe banana peel pectin helped in tablet cohesion, and made the whole manufacturability smoother.

Table 1 Formulation of the different concentrations of 1 ascorbic acid tablet using ripe banana peel pectin as a binder

Ingredient	Function	F1 (7.5% w/v)	F2 (10% w/v)	F3 (12.5% w/v)
Ascorbic Acid	Active ingredient	250 mg	250 mg	250 mg
Ripe Banana Peel Pectin	Binder	9.6 mg	12.8 mg	16 mg
Starch	Disintegrant	15 mg	15 mg	15 mg
Lactose	Diluent	25 mg	25 mg	25 mg
Magnesium Stearate	Lubricant	5 mg	5 mg	5 mg

Evaluation of Formulated Ascorbic Acid Tablets

Tablets were made with ascorbic acid 7.5%, 10%, and 12.5% w/v. The friability and disintegration tests were done using USP methods. In the friability test, tablets were cleaned of dust, weighed, and put in the friabilator at 25 ± 1 rpm for 100 times. After tumbling, the tablets were weighed, and the percentage loss of weight was determined, checking the mechanical strength and ability to hold up to breakages.

In the disintegration test, tablets were put in a basket-rack assembly having an HCl medium at a temperature of 37±2°C to copy the gastric medium, and the time for complete disintegration was checked. All findings were repeated three times, and the results were checked. These are the physical quality and durability of formulated tablets and checking on tablet performance as per the pharmacopoeia.

Data Analysis

The following statistical tools were used in analyzing and interpreting the data collected for this study:

For SOP 2, the mean of the friability and disintegration time of prepared ascorbic acid tablets containing 7.5%, 10%, and 12.5% w/v ripe banana peel pectin was calculated. Using the mean can provide a comprehensive overview of each formulation's performance. It highlights the uniformity and consistency of the test results within each group or formulation. The average value of each formulation can be compared to one another, and conclusions can be drawn about the effect of varying concentrations of ripe banana peel pectin on a tablet's durability and time to dissolve, thereby supporting the most ideal formulation.

For SOP 3, Analysis of Variance (ANOVA) was used to analyze if there is a significant difference between friability and disintegration time of the formulated and commercial ascorbic acid tablets. If there were significant differences between formulations, a Tukey post hoc test was performed to analyze the specific difference. This is to make sure that the difference between

each formulation during testing is not random. Thus, it is more proper to compare each formulation of different concentrations of ripe banana peel pectin.

4. Results

Table 2 Summary of the Characterization of Ripe Banana Peel Pectin

Parameter	Result	Interpretation
Degree of Esterification	48.49%	Classified as low-methoxyl pectin
Moisture Content	7.21%	Within acceptable limit (<10%)
Ash Content	8.06%	Within acceptable pharmaceutically acceptable range (5–10%)
Angle of Repose	24°	More than excellent flowability

Table 3 Summary of Friability Test Results

Formulation	Mean Friability Range	USP Standard	Interpretation
7.5% w/v	1.487%–1.650%	<1.0%	Failed
10% w/v	0.828%–0.917%	<1.0%	Passed
12.5% w/v	0.577%–0.653%	<1.0%	Passed
Brand X	0.412%–0.434%	<1.0%	Passed

Table 4 Statistical Analysis of Friability Test

Test	Comparison	Mean Difference	F-value	p-value	Significant
ANOVA	All groups	—	284	< .001	Significant
Tukey	7.5% vs 10%	0.693	—	< .001	Significant
Tukey	7.5% vs 12.5%	0.960	—	< .001	Significant
Tukey	7.5% vs Brand X	1.140	—	< .001	Significant
Tukey	10% vs 12.5%	0.267	—	< .001	Significant
Tukey	10% vs Brand X	0.447	—	< .001	Significant
Tukey	12.5% vs Brand X	0.181	—	0.011	Significant

Table 5 Summary of Disintegration Test Results

Formulation	Overall Mean Disintegration Time	USP Standard	Interpretation
7.5% w/v	9 min 14 sec	≤15 minutes	Passed
10% w/v	11 min 45 sec	≤15 minutes	Passed
12.5% w/v	13 min 26 sec	≤15 minutes	Passed
Brand X	8 min 48 sec	≤15 minutes	Passed

Table 6 Statistical Analysis of Disintegration Test

Test	Comparison	Mean Difference	F-value	p-value	Significant
ANOVA	All groups	—	529	< .001	Significant
Tukey	7.5% vs 10%	-137	—	< .001	Significant
Tukey	7.5% vs 12.5%	-234.9	—	< .001	Significant
Tukey	7.5% vs Brand X	43.6	—	0.232	Not Significant
Tukey	10% vs 12.5%	-97.6	—	< .001	Significant
Tukey	10% vs Brand X	181.0	—	< .001	Significant
Tukey	12.5% vs Brand X	278.5	—	< .001	Significant

5. Discussion

Table 2 shows the results of the test. The pectin from ripe banana peel has the right amount to be a binder in medicine tablets. The amount of esterification (48.49%) means it is a low-methoxyl pectin. It has many free carboxyl groups that can link together. This helps the tablets stay together better when pressed. According to Li et al. (2024) and Wan et al. (2019), low-methoxyl pectin acts well during the pressing process, and makes the tablets stronger.

Table 2 displays a moisture content of 7.21% for the extracted pectin. This value is lower than the pharmaceutical maximum limit of 10%. This value suggests stability during storage as well as low susceptibility to microbial contamination and hydrolytic degradation. The importance of a controlled moisture content in tablet formulation lies in the fact that excessive moisture may hasten degradation, while extremely low levels may negatively impact compressibility and cohesion. The moisture content has previously been reported as being beneficial for improved hydrogen bonding and tablet integrity during tablet compression (Lad et al., 2023; Veronica et al., 2024).

As stated in Table 2, the percentage of ash content was 8.06%. This is within the pharmaceutically acceptable range of 5-10%, indicating a pharmaceutically acceptable purity and the presence of mineral ions capable of ionic cross-linking and binding functionality. According to Das et al. (2025), calcium, magnesium, potassium, and other minerals present in the sample promote stronger polysaccharide interactions that foster increased cohesion of the tablet and hence improve their mechanical stability. Acceptable ash values also represent purity and reproducibility of the excipients of plant origin (Akin-Ajani and Okunlola 2021; Owusu et al. 2021).

The measured angle of repose in Table 2 is 24°, showing exceptional flowability, even higher than excellent, and indicating low interparticulate friction and powder cohesiveness. In tablet manufacturing, good powder flow is needed as it facilitates uniform die filling and consistent tablet weight. Positive particle size distribution and surface characteristics show less friction and better powder flow during compression (Shah et al., 2023).

Friability test results in Table 3 indicated that, as ripe banana peel pectin concentration increased, so did the mechanical strength of the tablets. The 7.5% w/v formulation failed the USP specification of less than 1.0% weight loss. This meant insufficient binder concentration to maintain adequate interparticle bonding. The 10% and 12.5% formulations passed the USP specifications, while the 12.5% gave the lowest friability values of the formulations containing

ripe banana peel pectin. The results show a concentration-dependent strengthening of the tablet structure by ripe banana peel pectin.

Table 4's statistical analysis further corroborated the effect of binder concentration on friability. The one-way ANOVA confirmed a highly significant difference among all of the groups ($F = 284$, $p < .001$), indicating that the observed variations were not due to chance and that binder concentration does indeed affect friability. The Tukey post hoc analysis further revealed that all pairwise comparisons were statistically significant, reaffirming that even a modest increase in binder concentration produced quantifiable improvements in the mechanical strength of the tablets. Similar findings were reported by Zahir et al. (2022), who found that increasing the binder concentration of natural binders produces stronger solid bridges during compression; Ofoefule et al. (2020), who stated that the binder concentration needs to be enough to coat the granules and withstand mechanical stress; and Obarisiagbon et al. (2021), who discovered that increasing the concentration of ripe banana peel pectin significantly reduced the friability of the tablet by improving the cohesion and compactness.

Table 5 indicates that all formulations of the prepared tablets passed the USP disintegration test which states that uncoated tablets should disintegrate within 15 min. However, increasing the tablet binder concentration increased the disintegration time. The 7.5% formulation tablet had the fastest disintegration time, while the 12.5% formulation had the slowest. This was due to stronger cohesion in the tablet and decreased porosity, which delayed liquid penetration into the interior of the tablet.

Table 6's statistical analysis results show a significant difference between products for the dependent variable disintegration time ($F = 529$, $p < .001$). Post hoc Tukey analysis indicated a statistically significant difference between all formulations, except for the 7.5% formulation and Brand X, which showed no statistical difference ($p = 0.232$). This data demonstrates that the 7.5% formulation can match the disintegration of a commercial product, while higher concentrations greatly impeded tablet breakdown.

The increase in time it takes for the tablets to break apart, shown in Tables 5 and 6, matches earlier findings. Obarisiagbon et al. (2021) found that adding more natural binder makes tablets harder and likely to crumble but can slow their breakdown and how quickly the drug is released. Lawal et al. (2015) also noted that better binder efficiency tends to make the tablets stronger but causes them to break apart more slowly.

Commercial tablets in Tables 3 and 5 showed less friability and dissolved faster than the experimental tablets. This might be because of better industrial manufacturing and artificial ingredients like croscarmellose sodium, a disintegrant that helps the tablets break down quickly. According to Desai et al. (2021), artificial disintegrants make tablets dissolve faster by swelling and through capillary action. However, Mustapha et al. (2023) say that natural binder materials can make the tablets gummy, which does not let the tablets dissolve quickly even though it keeps them strong.

Overall, the results from Tables 2-6 showed that ripe banana peel pectin has the right physicochemical and functional characteristics to serve as a natural tablet binder. Using higher concentrations of the binder led to stronger tablets with less friability, but it did increase disintegration time. From the data tables, 10% and 12.5% ripe banana peel pectin concentrations had satisfactory pharmaceutical properties and passed all pharmaceutical requirements, making ripe banana peel pectin a potentially suitable natural tablet binder.

6. Conclusion

The results showed that pectin derived from ripe banana peel is a promising sustainable natural binder excipient for ascorbic acid tablet formulation. Characterization revealed that the right substance of pectin was obtained with the purity confirmed through chemical analysis as well as the moisture and ash contents, which were within acceptable ranges. The flow properties were more than excellent. The low-methoxyl pectin was extracted, which is known to be a stronger binder gel-forming agent. It was also found that binder concentration had a significant influence on friability and disintegration. Increasing the concentration was shown to reduce friability and hence improve tablet strength. However, increasing concentrations delay disintegration due to the formation of stronger, resilient gels. The 7.5% formulation showed rapid disintegration but poor mechanical strength, while the 12.5% formulation showed improved robustness but excessively retarded disintegration. The 10% formulation, therefore, presented a balanced profile with both improved friability and acceptable disintegration performance. In conclusion, ripe banana peel pectin is a viable, sustainable pharmaceutical excipient. Nonetheless, further work is required for its full optimization.

7. Acknowledgements

We extended our heartfelt appreciation and gratitude to all those who contributed to completing this research endeavor. Special thanks to our esteemed Dean, Ma'am Ellen Mae P. Abiqui, RPh, MSPharm, CPT, for her unwavering guidance and dedication to nurturing the best in her students. We are deeply grateful to our research instructor, Ma'am Ivy Rose C. Orozco, RPh, CIP, and our faculty research adviser, Ma'am Griselle Ann A. Marquez, RPh, CIP, for their invaluable supervision, support, and words of encouragement that propelled us forward. Our sincere appreciation also goes to our esteemed panel members, whose guidance, feedback, suggestions, and expertise greatly enriched our study. Thank you to Ma'am Eloisa C. Espadilla, our statistician, for her invaluable assistance in statistical analysis and interpreting the results. Lastly, we express our profound gratitude to each research team member for their unwavering dedication, tireless effort, and outstanding contributions, which were instrumental in the successful completion of this study. No words can adequately express our gratitude.

To God be the glory.

The Researchers,
Sta. Ana, KC C.
Domine, Kate Ciayra
Garcia, Jessie Mei
Lonogan, Mark Andrew
Rivera, Frenchie

8. References

Ahsan, M., Ashraf, H., Iahtisham-Ul-Haq, Liaquat, A., Nayik, G. A., Ramniwas, S., Alfarraj, S., Ansari, M. J., & Gere, A. (2024). Exploring from ripe and unripe banana peel: A novel functional fat replacer in muffins. Food Chemistry: X, 23, 101539. https://doi.org/10.1016/j.fochx.2024.101539

Akin-Ajani, O. D., & Okunlola, A. (2021, September 16). Pharmaceutical applications of . s—The New-old polysacharides. IntechOpen. https://doi.org/10.5772/intechopen.100152

Aripova, S. F. (2020). Ascorbic acid: Properties and applications in pharmaceuticals and cosmetics. Chemistry and Chemical Technology, 1(4), 1-8. https://science.lpnu.ua/jcct

Athanasopoulou, E., Charpa, P., Sarafidou, M., Koutinas, A., & Tsironi, T. (2025). Extraction of pectin from banana peels and utilization in a bioactive coating for postharvest banana preservation. Discover Food, 5(1). https://doi.org/10.1007/s44187-025-00606-0

Das, D. et al (2025). Isolation and Characterization of Pectin from Fruit and Vegetable Processing Wastes. DOI:10.1007/978-1-0716-4763-9_12

Department of Agriculture. (2022). Philippine banana industry roadmap 2021–2025. Department of Agriculture – Bureau of Agricultural Research; UPLB Foundation, Inc.; Philippine Council for Agriculture and Fisheries

Desai, P. M., Liew, C. V., & Heng, P. W. S. (2021). Review of disintegrants and the mechanisms of tablet disintegration. Drug Development and Industrial Pharmacy, 47(8), 1181–1195. https://doi.org/10.1080/03639045.2021.1994112

Fauzi, M. F. (2025). Banana-derived excipients: drug release, performance, and stability. Pharmacy Reports, 5(1), 99. https://doi.org/10.51511/pr.99

Guo, J. F., Liu, C. M., Ma, C. H., Yang, H. N., & Wang, Y. (2021). Methods for determination of degree of methylesterification and acetylation of . Separations, 8(5), 68. https://www.mdpi.com/2076-3417/11/10/4461

Hobbs JK, Hettle AG, Vickers C, Boraston AB. (2019). Biochemical Reconstruction of a Metabolic Pathway from a Marine Bacterium Reveals Its Mechanism of Depolymerization. Appl Environ Microbiol 85:e02114-18. https://doi.org/10.1128/AEM.02114-18

Khairnar, R. G., Darade, A. R., & Tasgaonkar, R. R. (2024). A review on tablet binders as a pharmaceutical excipient. World Journal of Biology Pharmacy and Health Sciences, 17(3), 295–302. https://doi.org/10.30574/wjbphs.2024.17.3.0142

Lad, E. M., Finger, R. P., & Guymer, R. (2023). Biomarkers for the Progression of Intermediate Age-Related Macular Degeneration. Ophthalmology and Therapy, 12(6), 2917–2941. https://doi.org/10.1007/s40123-023-00807-9

Lawal, M. V., Odeniyi, M. A., & Itiola, O. A. (2015). Effect of thermal and chemical modifications on the mechanical and release properties of paracetamol tablet formulations containing corn, cassava and sweet potato starches as filler-binders. Asian Pacific Journal of Tropical Biomedicine, 5(7), 585–590. https://doi.org/10.1016/j.apjtb.2015.05.003

Li, R., Fan, H., Li, B., Ge, J., Zhang, Y., Xu, X., Pan, S., & Liu, F. (2024). Comparison on emulsifying and emulgelling properties of low methoxyl with varied degree of methoxylation from different de-esterification methods. International Journal of Biological Macromolecules, 130432–130432. https://doi.org/10.1016/j.ijbiomac.2024.130432

Lukova, P. (2023). Utilization of as a polysaccharide microcarrier for drug delivery. World Journal of Biology Pharmacy and Health Sciences. https://doi.org/10.30574/wjbphs.2023.15.2.0364

Luvedika Maheshwaran, Ladhurshika Nadarajah, S. P. N. N. Senadeera, C. B. Ranaweera, A. K. Chandana, and R. N. Pathirana. (2024). "Phytochemical Testing Methodologies and Principles for Preliminary Screening/Qualitative Testing." Asian Plant Research Journal 12 (5): 11–38. https://doi.org/10.9734/aprj/2024/v12i5267.

Mamiru, D., & Gonfa, G. (2023). Extraction and characterization of from watermelon rind using acetic acid. Heliyon, 9(2), e13525. https://doi.org/10.1016/j.heliyon.2023.e13525

Mustapha, A., Ahmed, T., & Yusuf, K. (2023). Comparative evaluation of natural gums and synthetic binders in immediate-release tablet formulations. Journal of Pharmaceutical Sciences and Research, 15(1), 45–53. https://doi.org/10.5530/jpsr.2023.1.6

Nguyen, B. M. N., & Pirak, T. (2019). Physicochemical properties and antioxidant activities of white dragon fruit peel pectin extracted with conventional and ultrasound-assisted extraction. Cogent Food & Agriculture, 5(1). https://doi.org/10.1080/23311932.2019.1633076

Obarisiagbon, Aiwaguore Johnbull, Airemwen, Collins Ovenseri, and Obianuju, Jennifer Chude (2021); Evaluation of Musa Paradisiaca (Banana Peel) as A Pharmaceutical Excipient in Ciprofloxacin Tablet Formulation; International Journal of Scientific and Research Publications (IJSRP) 11(5) (ISSN: 2250-3153), DOI: http://dx.doi.org/10.29322/IJSRP.11.05.2021.p11380

Ofoefule, S. I., Onwualu, P., & Anyakora, C. (2020). Evaluation of the binding properties of banana peel in tablet formulations. Journal of Pharmaceutical Research and Development, 5(2), 45–52. https://doi.org/10.1234/jprd.2020.0045

Osterberg, R. E., & See, N. A. (2003). Toxicity of excipients—A Food and Drug Administration perspective. International Journal of Toxicology, 22(5), 377–380. https://doi.org/10.1177/109158180302200507

Ozyurt, H. C. , & Mehrad, R. (2020). Development of effervescent tablet formulation which contain ferrous salt and ascorbic acid combination. EMU Journal of Pharmaceutical Sciences, https://dergipark.org.tr/en/pub/emujpharmsci/issue/53889/687217

Pawar, T. S., Gawade, A., Gawade, B., & Tayade, R. P. (2024). A comprehensive study of stress degradation pathways of ascorbic acid to standardize flavonoids-related impurities derived from ascorbic acid. International Journal of Pharmaceutical Sciences and Drug Research, 16(1), 110–118. https://ijpsdronline.com/index.php/journal/article/view/8493/1092

Reyes, C. M. & Tabuga, A. D. (2020). A Profile of the Philippine Pharmaceutical Industry.chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.phcc.gov.ph/storage/pdf-resources/1678085936_PCC-Issues-Paper-2020-02-A-Profile-of-the-Philippine-Pharmaceutical-Industry.pdf

Roy, P. S., Biswas, A., Pratihar, S., & Ghosh, A. K. (2025). Effect of different binders on tablet hardness and disintegration time. International Journal of Pharmaceutical Research and Applications, 10(2), 1612–1620. https://doi.org/10.35629/4494-100216121620

Shah, D. S., Moravkar, K. K., Jha, D. K., Vijay Lonkar, Amin, P. D., & Chalikwar, S. S. (2023). A Concise Summary of Powder Processing Methodologies for Flow Enhancement. Heliyon, 9(6), e16498–e16498. https://doi.org/10.1016/j.heliyon.2023.e16498

Szymańska-Chargot, M., Pękala, P., Siemińska-Kuczer, A., & Zdunek, A. (2022). Isolation, structural characterization, and physicochemical properties of pectic polysaccharides from selected cereal by-products. Polymers, 14(4), 546. https://www.mdpi.com/2079-6412/12/4/546

Tugon, T., Larasati, R., Adnan, S., Sucimilawati, E., Agustiani, F., & Jaswir, I. (2023). Characterization of banana peel (Musa acuminata Colla) as a potential halal pharmaceutical excipient. Indonesian Journal of Halal Research, 5(1), 41–52. https://doi.org/10.15575/ijhar.v5i1.21285

Veronica, N., Heng, P. W. S., & Liew, C. V. (2024). Understanding the Roles of Excipients in Moisture Management in Solid Dosage Forms. Molecular Pharmaceutics, 21(5), 2484–2500. https://doi.org/10.1021/acs.molpharmaceut.4c00031

Wakchaure, S., Kale, S., Shelke, S., Kanase, S., & Thombare, H. (2024). A detailed review on the use of excipients in drug formulation. International Journal of Pharmaceutical Sciences, 2(7), 1919–1926. https://doi.org/10.5281/zenodo.12923017

Wan, L., Chen Qianqian, Huang, M., Liu, F., & Pan, S. (2019). Physiochemical, rheological and emulsifying properties of low methoxyl prepared by high hydrostatic pressure-assisted enzymatic, conventional enzymatic, and alkaline de-esterification: A comparison study. 93, 146–155. https://doi.org/10.1016/j.foodhyd.2019.02.022

Yasin, M., Gangan, S., & Panchal, S. K. (2025). Banana peels: A genuine waste or a wonderful opportunity? Applied Sciences, 15(6), 3195l. https://doi.org/10.3390/app15063195

Zahir, A. M., Ibrahim, M., & Rahman, S. (2022). Natural polymers as binders in pharmaceutical dosage forms: A review of mechanical and disintegration properties. International Journal of Applied Pharmaceutics, 14(3), 12–21. https://doi.org/10.22159/ijap.2022.v14i3.44102

9. Appendices

APPENDIX A
Certificate of Plant Authentication

DON MARIANO MARCOS MEMORIAL STATE UNIVERSITY
NORTH LA UNION CAMPUS, Bacnotan, La Union, Philippines
COLLEGE OF AGROFORESTRY AND FORESTRY
www.dmmmsu.edu.ph | +63-938-032-6976 | caff.nlu@dmmmsu.edu.ph

DMMMSU-NLUC
CAFF
RELEASED
Rev

IDENTIFICATION CERTIFICATE OF PLANT MATERIAL

This is to certify that **MARK ANDREW A. LONOGAN, KATE CIAYRA B. DOMINE, JESSIE MEI R. GARCIA, KC C. STA. ANA,** and **FRENCHIE D. RIVERA,** students of the College of Pharmacy, Lorma Colleges, City of San Fernando, La Union, have submitted plant specimen for proper identification. After a thorough and closer examination on the morphological and botanical characteristics of the specimen, it was identified and described as follows.

Common Name - 'Saba' Banana
Scientific Name - *Musa acuminata x balbisiana*
Family Name - Musaceae

This certification is issued to **Mark Andrew A. Lonogan, Kate Ciayra B. Domine, Jessie Mei R. Garcia, KC C. Sta. Ana,** and **Frenchie D. Rivera,** for all legal intentions and purposes.

Issued this 10th day of September 2025, College of Agroforestry and Forestry, Don Mariano Marcos Memorial State University, North La Union Campus, Bacnotan, La Union.

Prepared and examined by:

FOR. RUBY ANNE G. OLBINADO
Dendrologist/Faculty, CAFF
PRC License Number: 0012952

Noted:

FOR. JAY MARK G. CORTADO
Dean, CAFF

APPENDIX B
Certificate of Exemption from Review

LORMA COLLEGES

LC-REC Form #039
CERTIFICATE OF EXEMPTION FROM REVIEW

CERTIFICATION OF EXEMPTION FROM REVIEW

REC Reference #: 2026-071

To: Mark Andrew Lonogan, Kate Ciayra B. Domine, Jessie Mei R. Garcia, Frenchie D. Rivera, KC C. Sta. Ana

From: LORMA Colleges - Research Ethics Committee

Date: January 20, 2026

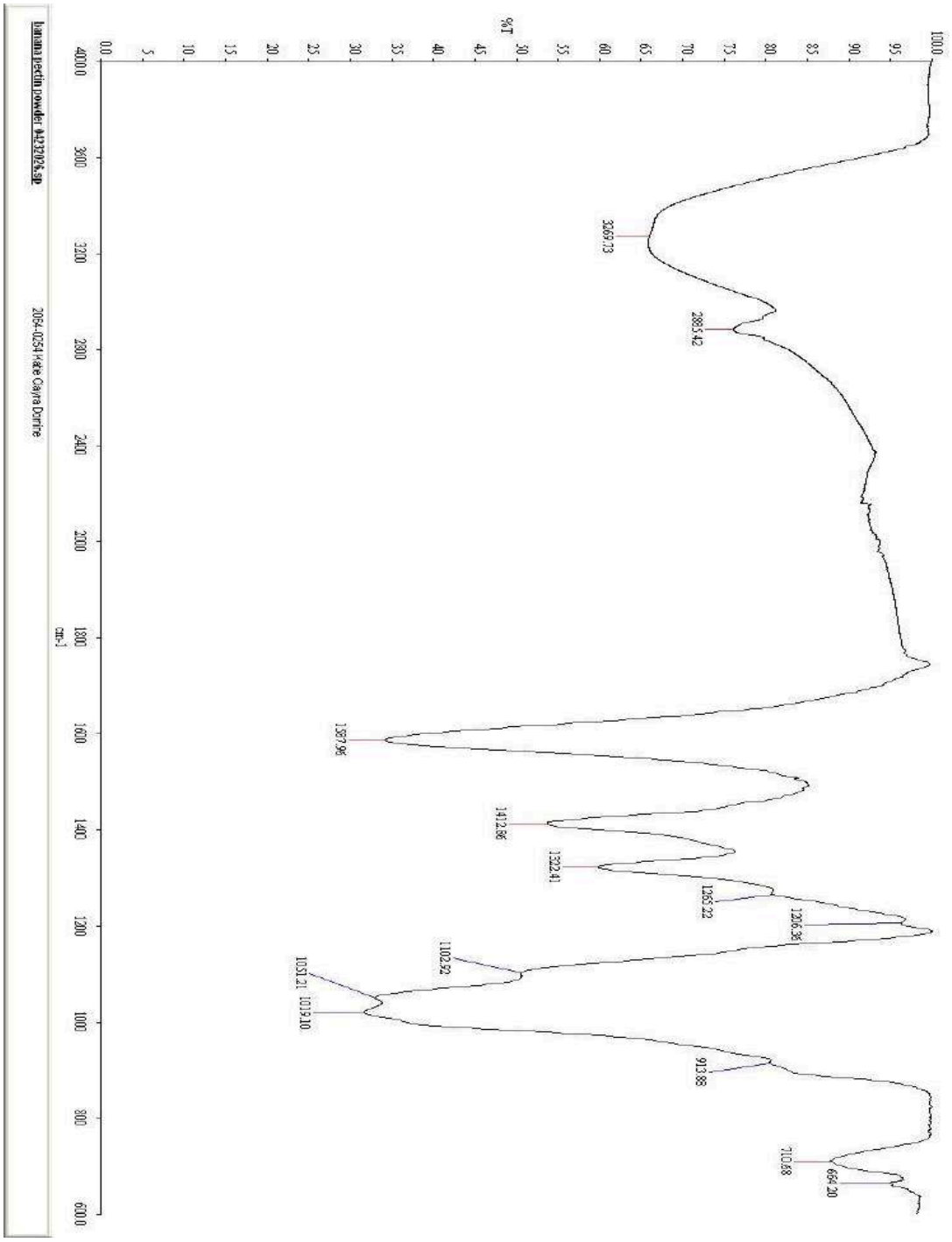
This is to certify that the Research Proposal entitled, "RIPE BANANA *(MUSA ACUMINATA X BALBISIANA)* PEEL PECTIN AS A BINDER EXCIPIENT FOR ASCORBIC ACID TABLET FORMULATION" submitted by Mark Andrew Lonogan, Kate Ciayra B. Domine, Jessie Mei R. Garcia, Frenchie D. Rivera and KC C. Sta. Ana of College of Pharmacy has been reviewed by the Research Ethics Committee of LORMA Colleges and found that all ethical considerations are in place to conduct the research in the stated locale of the study. Hence, this research proposal is exempted from review.

JEROME P. VERA, LPT
Chairman, LC-REC

APPENDIX C
Timetable

Parts	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
INTRODUCTION Background of the Study											
Conceptual Framework											
Operational Paradigm											
Statement of the Problem, Statement of Hypothesis											
Scope and Limitation											
METHODOLOGY Research Design and Method, Population and Locale of the study											
Data Gathering Tools, Data Gathering Procedures, Ethical Considerations, Treatment of Data											
Filing of BAI Permit to Handle Test Animals											
Filing of LC-REC Approval Letter											
Perform Data Gathering											
RESULTS AND DISCUSSION											
CONCLUSIONS AND RECOMMENDATIONS											
Thesis Approval											
Bound Manuscript											
Copyright/Patent Filing											

APPENDIX D
Result of FTIR Test



APPENDIX E
Formulation of Ascorbic acid tablets

Formulation of 7.5% concentration:

Ascorbic acid……...19.5 g

Starch……..……..1.17 g

Lactose……..……1.95g

Magnesium Stearate…….……...0.39 g

Ripe Banana Peel Pectin.....……...0.75 g

Purified water……..…….10 ml

To make……..…....78 tablets

Formulation of 10% concentration:

Ascorbic

acid……..19.5 g

Starch……...…1.17 g

Lactose……..……..……..1.95g

Magnesium Stearate……..……...…....0.39 g

Ripe Banana Peel Pectin.....……..…….....1.0 g

Purified water……10 ml

To make…….....78 tablets

Formulation of 12.5% concentration:

Ascorbic acid…….……...19.5 g

Starch……...…1.17 g

Lactose……..……..……..1.95g

Magnesium Stearate……....0.39 g

Ripe Banana Peel Pectin.....……...1.25 g

Purified water……..…….10 ml

To make…….....78 tablets

Preparation:

1. Weigh the ascorbic acid, starch, and lactose, then transfer into a mortar or mixer and blend thoroughly until a uniform powder mixture is obtained.
2. Weigh the ripe banana peel pectin and measure the distilled water, then gradually add the water to the while stirring continuously until a smooth and lump-free binder solution is formed.
3. Slowly add the binder solution to the powder mixture while mixing continuously until a cohesive, damp mass with a sand-like consistency is formed.
4. Pass the wet mass through an appropriate sieve to produce moist granules.
5. Spread the granules evenly on a tray and dry in an oven at 50°C for one hour.
6. Pass the dried granules through a finer sieve to obtain uniform particle size.
7. Weigh the required amount of magnesium stearate, add it to the granules, and mix gently for a short duration to ensure uniform distribution.
8. Compress the final blend into tablets using the tableting machine.

APPENDIX F
Raw Data of the Tablet Friability Test

Formulated Tablets						
Binder Concentration	**No. of Trial**	**Initial Weight (g)**	**Final Weight (g)**	**% Weight loss**	**USP Standard**	**Interpretation**
7.5 %	1	5.714	5.625	1.556%	< 1.0% weight loss No cracking, cleavage, or breaking.	FAILED
	2	5.821	5.725	1.650%		FAILED
	3	5.779	5.693	1.487%		FAILED
10 %	1	5.796	5.748	0.828%		PASSED
	2	5.777	5.724	0.917%		PASSED
	3	5.753	5.703	0.869%		PASSED
12.5 %	1	5.664	5.627	0.653%		PASSED
	2	5.717	5.684	0.577%		PASSED
	3	5.817	5.783	0.584%		PASSED
Commercially Available Tablet						
Commercial	1	6.241	6.215	0.412%		PASSED
	2	6.342	6.314	0.434%		PASSED
	3	6.478	6.451	0.426%		PASSED

APPENDIX G
Raw Data of the Tablet Disintegration Test

Formulated Tablets				
Binder Concentration	**No. of Trial**	**No. of Tablet**	**Results (minutes:seconds)**	**Interpretation**
7.5 %	1	1	8:54	PASSED
		2	9:31	PASSED
		3	7:15	PASSED
		4	10:29	PASSED
		5	9:11	PASSED
		6	10:36	PASSED
	2	1	10:43	PASSED
		2	9:07	PASSED
		3	8:10	PASSED
		4	9:24	PASSED
		5	8:56	PASSED
		6	10:12	PASSED
	3	1	9:09	PASSED
		2	7:11	PASSED
		3	9:25	PASSED
		4	9:58	PASSED
		5	8:41	PASSED
		6	9:32	PASSED
	1	1	10:54	PASSED
		2	12:05	PASSED
		3	12:25	PASSED
		4	11:40	PASSED

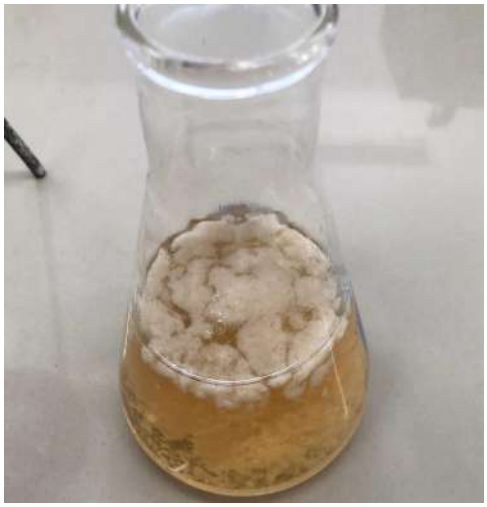
10 %		5	12:49	PASSED
		6	12:22	PASSED
	2	1	10:20	PASSED
		2	11:29	PASSED
		3	12:53	PASSED
		4	11:49	PASSED
		5	12:40	PASSED
		6	12:42	PASSED
	3	1	11:56	PASSED
		2	10:42	PASSED
		3	10:38	PASSED
		4	11:12	PASSED
		5	11: 05	PASSED
		6	12:06	PASSED
12.5 %	1	1	13:04	PASSED
		2	14:11	PASSED
		3	13:03	PASSED
		4	12:17	PASSED
		5	14:36	PASSED
		6	13:31	PASSED
	2	1	12:15	PASSED
		2	13:36	PASSED
		3	12:43	PASSED
		4	14:52	PASSED
		5	13:13	PASSED
		6	14:34	PASSED
	3	1	14:06	PASSED

		2	13:11	PASSED
		3	12:35	PASSED
		4	13:02	PASSED
		5	13:54	PASSED
		6	13:11	PASSED
Commercially Available Ascorbic Acid Tablet				
Commercial	1	1	8:04	PASSED
		2	8:15	PASSED
		3	9:05	PASSED
		4	8:40	PASSED
		5	9:42	PASSED
		6	9:30	PASSED
	2	1	8:10	PASSED
		2	8:47	PASSED
		3	8:30	PASSED
		4	8:55	PASSED
		5	8:19	PASSED
		6	9:41	PASSED
	3	1	9:03	PASSED
		2	8:19	PASSED
		3	8:26	PASSED
		4	9:43	PASSED
		5	8:01	PASSED
		6	9:22	PASSED

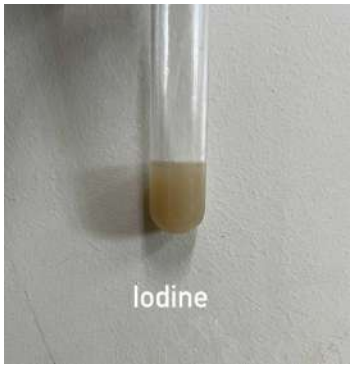
APPENDIX H
Photo documentation of Procedures

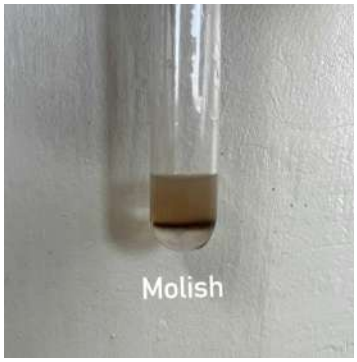
Collection and Drying of Banana Peels	
	
	

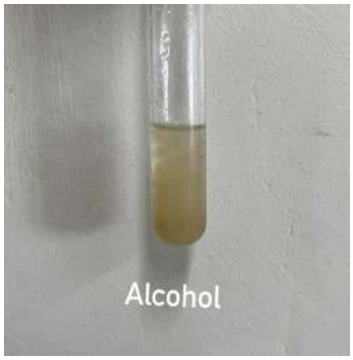
Extraction of Pectin from Banana Peel

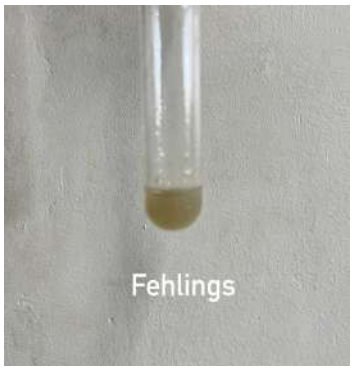


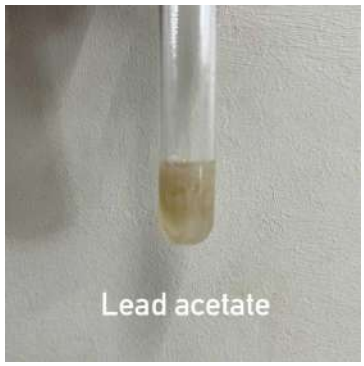
Phytochemical Analysis

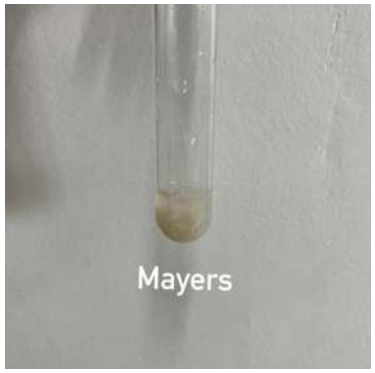








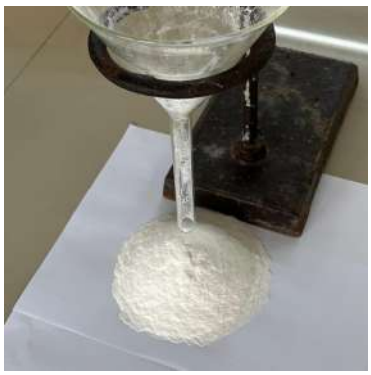


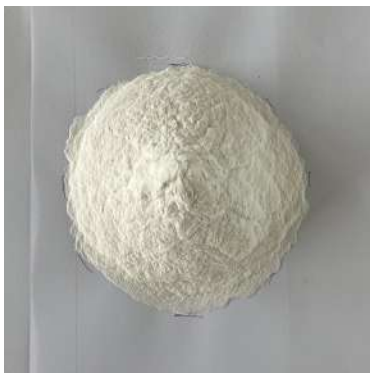


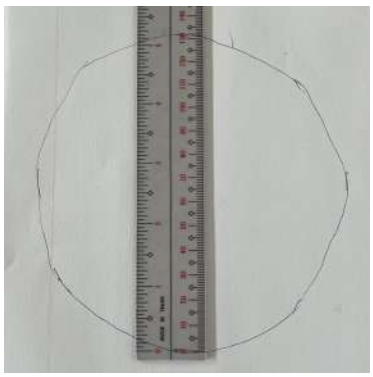
Evaluation of Banana Peel Pectin Powder:

Degree of Esterification (Trial 1-2-3)

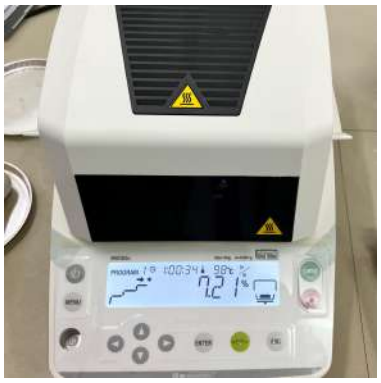
Angle of Repose





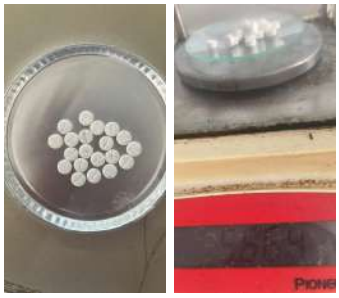


Ash Content

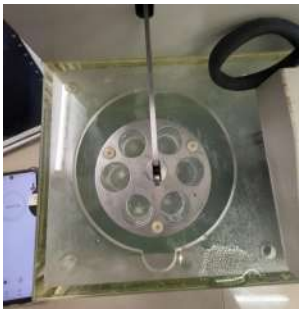
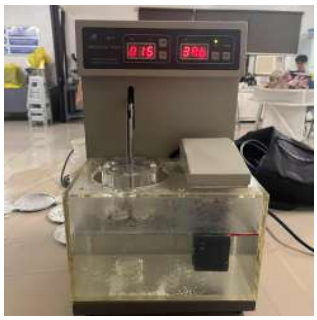
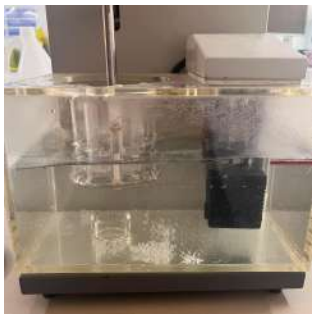
Moisture Content
 

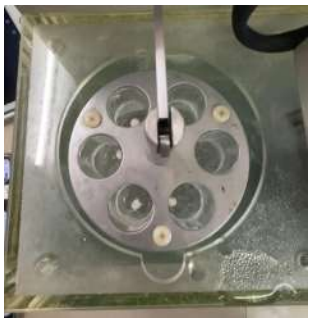
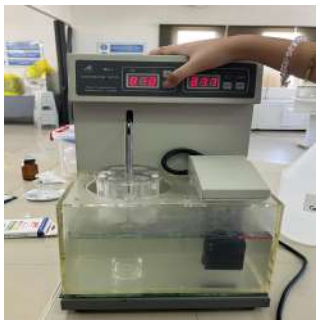
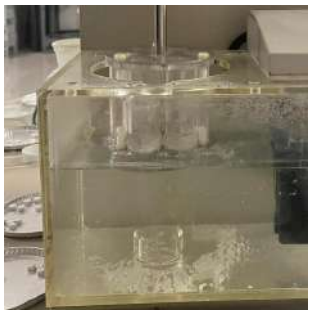
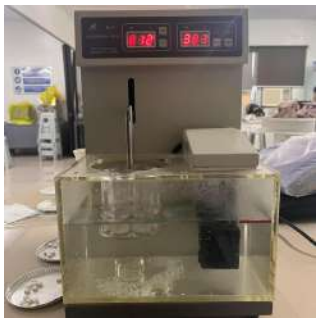
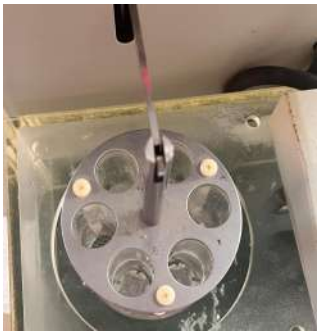
Friability Test	
Formulation Concentration: 7.5%	
Result	Photo documentation
Trial 1	Before:   After:   
Trial 2	Before:    After:

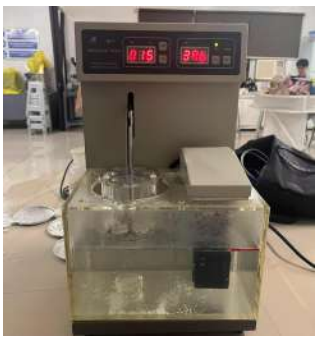
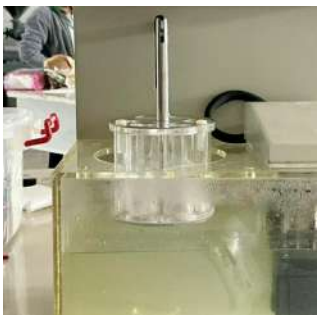
	
Trial 3	Before:  After: 
Formulation Concentration: 10%	
Trial 1	Before:  After: 
Trial 2	Before: 

	After: 
Trial 3	Before:  After: 
Formulation Concentration: 12.5%	
Trial 1	Before:  After: 

Trial 2	Before:  After: 
Trial 3	Before:  After: 
	

Disintegration Test			
Formulation Concentration: 7.5%			
Trial 1			
Trial 2			
Trial 3			
Formulation Concentration: 10%			
Trial 1			

Trial 2			
Trial 3			
Formulation Concentration: 12.5 %			
Trial 1			
Trial 2			

Trial 3			
Commercial Ascorbic acid			
Trial 1			
Trial 2			
Trial 3			

10. Author(s)

KC C. Sta Ana is a Pharmacy student at Lorma Colleges whose dedication and sense of responsibility are evident through her leadership and organizational involvement. She serves as the Auditor of the Pharmacy Student Body Organization for the academic year 2025-2026, showcasing her commitment to service and teamwork. Her experience and active participation continue to strengthen her skills for future professional endeavors.

Ellen Mae P. Abuqui, RPh, MSPharm, CPT, is the Dean of the College of Pharmacy at LORMA Colleges and also the Higher Education Academic Director. She pursued her Master of Science in Pharmacy and achieved her CPT-Certification at Saint Louis University. These accomplishments demonstrate her academic competence and her perseverance and strong commitment to her profession. Through her leadership and dedication, she continues to contribute significantly to the advancement of healthcare education.

Kate Ciayra B. Domine is a Pharmacy student at Lorma Colleges who demonstrates dedication, perseverance, and responsibility in both her academic and personal pursuits. Despite the challenges of balancing work and studies, she remains committed to achieving her goals and continuously improving her knowledge and skills in the field of pharmacy. Her determination, strong work ethic, and ability to manage multiple responsibilities reflect her passion for professional growth and future success in healthcare.

Jessie Mei R. Garcia is a Pharmacy student at Lorma Colleges. She is driven by continuous learning and self-improvement in her academic journey. She consistently strives for excellence and remains committed to developing her knowledge and skills for her future goals.

Mark Andrew A. Lonogan is a Pharmacy student at Lorma Colleges. He is driven by a strong commitment to academic growth and a passion for continuous learning within the field of healthcare. Through his active participation in various school activities, and laboratory exercises.

Griselle Ann A. Marquez, RPh, CIP, is a full-time faculty member of the College of Pharmacy at LORMA Colleges. A proud Lormanian pharmacist, she earned her Bachelor of Science in Pharmacy from the institution in 2014 and is currently pursuing her Master's in pharmacy at University of the Philippines. Her dedication and commitment to academic excellence and student development is reflected in her research and ethics training as well as her service as a student body organization adviser.

Ivy Rose C. Orozco, RPh, CIP, is the Research Coordinator of the College of Pharmacy at LORMA Colleges. She completed her Bachelor's degree at University of Santo Tomas and later pursued her Certified Immunization Pharmacist (CIP) credential through the Philippine Pharmacists Association. Her achievements reflect her dedication to professional development in the field of Pharmacy.

Frenchie D. Rivera is a Pharmacy student at Lorma Colleges who is committed to academic growth and professional development. Her experiences in the pharmacy course continue to strengthen her understanding of pharmaceutical sciences and patient care. Through attending school activities and seminars, she continues to grow.