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Establishing a Production Facility for the Extraction and Processing of Jackfruit-Based Latex *Artocarpus Heterophyllus* as an Integration into Aviation Sealants

Sweetzel Jane S. Geron, Shaira Mae I. Alcazar, Rynell Iver G. Amil, Mitzi Marie M. Cueto, Von Allen G. De Pedro, Marc Jhonas F. Dela Cruz, Krizza Mae S. Lucila, Audreian James M. Naadat and Khriz Patrick R. Rubiz

BSAero Students /PATTS College of Aeronautics, Parañaque City, Philippines

geron.jane@yahoo.com

sweetzeljane.geron@patts.edu.ph

ORCID: 0009-0008-1511-0612

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Abstract

This feasibility study aimed to create a manufacturing facility for producing the Skyjack sealant with jackfruit-based latex as its main component. It is used to cover gaps to prevent fluids from entering and also serves as protection by using it as a coating. The paper's primary goal is to develop an affordable sealant that will meet the criteria of the needs of the aviation industry for aircraft manufacturing and maintenance. This project would increase the supply of affordable and high-quality sealants nationally and internationally, maximize local resources, and create employment. Along with a few other chemical elements, jackfruit latex contains both cis-1,4 polyisoprene and trans-1,4 polyisoprene. However, since *Artocarpus Heterophyllus'* polymer chains are substantially shorter than

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Hevea Brasiliensis's, it cannot substitute natural rubber, the most widely used rubber. As a result, jackfruit latex cannot be utilized to replace natural rubber (NR). However, it can be used as a low molecular weight natural resin to enhance tires' wet skid resistance (WSR) and better disperse carbon black in rubber compositions.

***Keywords*:** Artocarpus heterophyllus, aviation, sealant, natural rubber

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Introduction

Jackfruit, or the Artocarpus Heterophyllus, is a tropical fruit tree in Asia, Africa, and South America. The everyday use of the jackfruit tree is for consuming its fruit and using its tree for medical purposes. It yields resin; latex yields 71.8% resin, consisting of 63.3% Doraville (yellow) and 8.5% Albanese (white). This latex is often used as an adhesive for mending broken chinaware or earthenware, caulking boats, mending holes in buckets, and trapping birds, and as a substitute for rubber. Its main component is made from the waste of pili trees called “spent resin” used on aircraft fuel tanks.

In the aviation industry, many large companies use sealant for aircraft, especially in faying surfaces in which two (2) components or faces are contacting each other in similar or dissimilar materials and tightly placed to create a linkage. The sealant is not only used for structure but also in the interior of the aircraft, which those interior are needed to be snug fit and also comfortable for the passengers flight long haul flights with seven (7) to eighteen (18) hours of long flight which those interior needed to compact under the cabin pressure throughout the flight with that aviation safety under the regulation of the European Aviation Safety Agency (EASA), they certify and publish or issue airworthiness directive under the safety publication of tools. A sealant is a barrier that protects two (2) surfaces that are connected, which prevent dust, dirt, moisture, and chemical reaction on a particular surface which can lead to corrosion and could cause hazard not only to a specific part but also to the whole structure of an aircraft. The aircraft's aesthetics frequently reflect the owner's ideals and thoroughness in many aspects of their professional lives. Exterior aesthetics are rarely left to chance, and their ongoing upkeep and capacity to function are provided for by committed professionals and artisans who fully grasp their worth and relevance.

Sealant is widely utilized in chemical, aviation, construction, automotive, agricultural,

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maritime, and transport sectors. The availability of alternative sealants is the primary focus of the sector for manufacturers seeking sustainable, accessible, and less expensive goods. The agencies or airline companies are responsible for developing specialist adhesive formulas and sealing materials that fulfill demanding criteria. Aviation adhesives and sealants are in high demand in general, commercial, and military end-use applications due to significant growth in aircraft manufacturing operations to meet increased demand for air travel. Given that we only import aviation sealants from other countries, it opens the possibility of developing and formulating sealants that are more cost-effective and less expensive.

"Regardless of how frequently private jet customers fly, their time aboard the aircraft should always be a truly memorable experience," says RAS Business Development Manager Roger Patron. The impact should be visually outstanding from the time their automobile dumps them at the aircraft's steps, and it should be reinforced even more by the class and quality of the aircraft's exquisite interior. Every owner has preferences regarding taste, style, sector, and traveling companions. Therefore, every private aircraft's interior design and atmosphere should resonate with and fit the owner's expectations, time after time.

The study determined how to establish a production facility for Jackfruit-based Latex as integration into aviation sealants. Specifically, it sought to answer questions related to the following aspect of the study:

Marketing Aspect:

1. What service can the business offer Skyjack mainly to Airbus Philippines?
2. What marketing approach will the company use to incorporate jackfruit-based latex?
3. What places can be accessible to the target market of the company Skyjack?

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4. Who comprises the target market of the company?

Technical Aspect:

1. What facilities and materials are required to integrate Jackfruit-Based Latex?
2. What quality measures should be observed to maintain the quality of the company's services?

Management Aspect

1. What are the requirements and responsibilities of each job in the organization?
2. How will the company set up the schedule for all of its activities?

Financial Aspect:

1. How much would the initial capital be?
2. What amount would be allocated for the construction and the land?

Socio-Economic Aspect:

1. What could the business do to support our citizens in Philippine society?
2. How can the company safeguard the interests and well-being of its target market?

According to Chen et al. (2018), when enterprises select new projects involving ambient intelligence products, they should consider the performance of these products. Novel ambient intelligence products may generate some external economy or diseconomy to an enterprise's existing ambient intelligence products and competitors.

Gurbuz (2017) stated that a product, whether a physical item or a service, should be practical and appealing to the senses to meet the consumer's needs, provide value, and be provided in the manner they requested. Additionally, it must incorporate other particular components, such as offering client services. In terms of Marketing, Technical, Management, Financial, and Socio-

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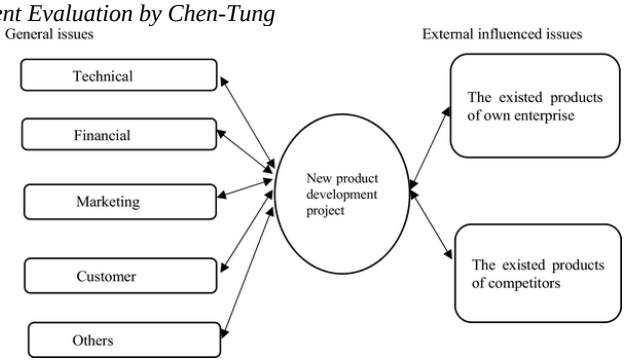
Economic Aspects, it was shown how it is associated with the product and the business to be proposed. The jackfruit-based latex is commonly used as an adhesive. The rubber from Jackfruit latex was low molecular weight with narrow unimodal molecular weight distribution (MWD), whereas that obtained from E. Heterophylla showed very broad MWD, a feasible sealant for aircraft structures and interior design.

Figure 1- *New Product Development Evaluation by Chen-Tung*



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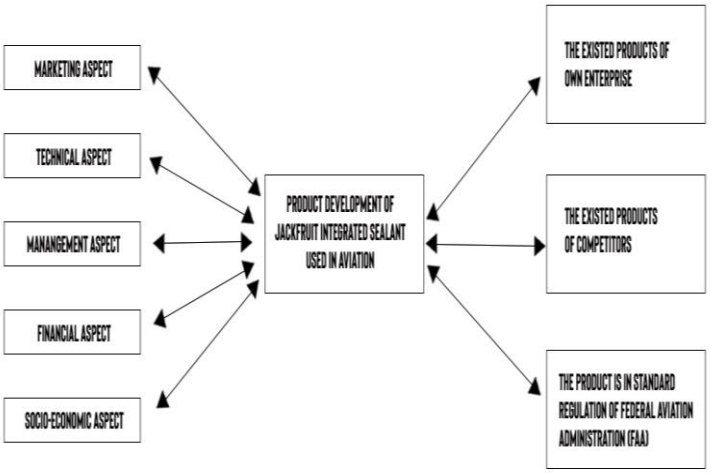
Product Development

Figure 2- *New Product Development Evaluation*



The researchers aim to assess the feasibility of developing an integrated jackfruit sealant by

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evaluating its marketing, technical, management, financial, and socio-economic aspects. They also want to determine if the proposed product can help businesses increase their market share by meeting customer demand. The researchers believe that an integrated jackfruit sealant has the potential to be a viable business venture. However, they must conduct further research to assess its feasibility and develop a sound business plan.

Literature Review

Extraction and Analysis of Natural Rubber from the Latex of Ficus carica, Artocarpus heterophyllus, and Polymer Analysis of Durio zibethinus Wagner I. and Lackner M. (2021) stated that tropical fruits, including durian (Durio zibethinus) and jackfruit (Artocarpus heterophyllus), just one-third of the fruit is edible. Trying to find more ways for industrial applications to use the other fruit elements can reduce the amount of waste set ablaze or dumped in landfills. Another fruit tree of importance that can also thrive in Vienna is the fig tree (Ficus carica). Currently, the plant's principal product is its fruits, but there are also ingredients in the tree's latex that are of interest. It is known that latex contains natural rubber, which might be used in industrial settings.

Thermal Behavior of Chitosan/Natural Rubber Latex Blends TG and DSC Analysis

Thermogravimetry (TG) and scanning calorimetry have been used to investigate the thermal behavior of blends of chitosan (CS) and synthetic rubber latex (NRL) (DSC). The addition of NRL alters the CS's decomposition behavior. The influence of blend makeup on the quantity of solid residue at different temperatures has been researched. Kinetic parameters of deterioration have been determined by calculating using the Horowitz-Metzger equation. From the kinetic energy value systems, it is found that out of the series of blend configurations, CS15NRL85 exhibits improved heat stability. The CS/NRL mixtures are thermodynamically incompatible, according to DSC studies. Two glass transitions correspond to the blend's CS and NRL phases,

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according to Rao, V. and Johns, J. (2008)

Possibility of Artocarpus Heterophyllus Latex as an Alternative Source for Natural Rubber

In addition, Bhadra S. et al. (2017) stated that natural rubber (NR) is widely used in manufacturing rubber goods and cannot be substituted by synthetic rubber. Hevea rubber tree is the only affordable and commercially feasible source of NR at this time. Finding alternative sources of NR was the goal of the current research. The primary component of NR is cis-1,4 polyisoprene. In order to determine whether jackfruit latex (Artocarpus heterophyllus) can be used as a substitute source of NR, it was collected and examined. According to research using FTIR, 1H NMR, and GC-MS, jackfruit latex contains both cis-1,4 polyisoprene and trans- 1,4 polyisoprene in addition to a small number of other chemical components. However, jackfruit latex has a substantially lower molecular weight than NR. Jackfruit latex does not significantly alter the mechanical properties of vulcanized rubber compounds due to the low molecular weight polymer and the inclusion of numerous other chemical constituents as impurities. However, it helps increase wet skid resistance (WSR) and helps carbon black blend more evenly. Jackfruit latex can, therefore, not be used to replace NR. However, it can be utilized as a low molecular weight natural resin, mainly to increase the dispersion of carbon black in rubber compounds and to improve WSR for tires.

Physical Characterization of Latex from Artocarpus Heterophyllus Lam. (Jackfruit) and Four Related Artocarpus spp.

The physical characteristics of Artocarpus J.R. Forster & G. Forster latex from five species, specifically: Fosberg, A. Altilis (Parkinson). Blancoi A. Merr A. Blanco, camansi hybridus Lam., and A. as potential natural adhesives, Ovatus Blanco. According to surface morphology, all five Artocarpus spp. have no particular forms but are viscoelastic and flexible otherwise.

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Measurements of contact angles revealed that all Artocarpus spp. were hydrophilic and had low contact angle values due to the latex's natural source. All Artocarpus latex samples were matched to polyvinyl acetate using FTIR analysis. The area with the highest resin content was A. Ovatus, with all species possessing natural resin. The highest Young's modulus of elasticity values belonged to Ovatus, and the highest percentage of elongation values belonged to A. heterophyllus. The highest adhesive shear strengths at maximal forces were found in A. Ovatus. Out of the eight examined variables, A. was found by cluster analysis. Due to heterophyllous latex gum-like characteristics, it was designated as the outgroup. As mentioned earlier, all the experiments revealed that the latex of all five Artocarpus spp. possessed qualities resembling polymer adhesive, including A. mangoes and A. Ovatus in adhesive strength tests.

An Improved Method for Fractionation of Small Quantities of Lettuce Latex

Swanson, C.L., Buchanan, R.A. and Otey, F.H. (1979) stated that smaller samples, on the order of 0.3 to 0.5 g, need to be treated on a microscale since they cannot be handled by typical extraction methods like Soxhlet extraction or accelerated solvent extraction (ASE). In microcentrifuge tubes, the proponents extracted latex from lettuce plants, dried it under a vacuum, and then resuspended the dried sample in acetone by placing it inside an ultrasonic cleaner. The refined suspension was quickly separated into fractions representing the latex's resin and rubber content using acetone and toluene. Using this method, the proponents contrasted the latex from blooming lettuce stems with bolting lettuce stems. The amount of rubber in the bolting stems was higher than in the floral stems, even though both had a similar amount of resin.

Fluorosiloxane Sealants for Aviation Industry

Donskoi A.A. and Bartiko N.V. stated that some considerations are the characteristics of sealants based on fluoro siloxane oligomers. Applying polysiloxanes containing the -trifluoro

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propyl radical as the foundation for sealants in real-world situations is demonstrated. It is known that the siloxane chain's flexibility gives materials their high freeze resistance. In contrast, high values of the polar-Si-O-energy bond enable the proponents to produce materials with excellent thermal stability. Fluorosiloxane sealants' mechanical and technological characteristics are reported, and their advantages over materials based on organofluorine rubbers are demonstrated. It demonstrated that sealants based on fluorosilicate oligomers exhibit appropriate stability to the sustained action of various fuels and are frequently employed in aircraft construction.

Properties and application of rubber-based sealants

Syao, O. and Malysheva, G.V. (2014) stated that the characteristics of the chemical nature, physical state, mechanism of hardening, application technology, qualities, and primary practical domains of application of sealing and tightening materials based on polysulfide and siloxane rubbers. The most widely used polysulfide and silicon-organic sealant brands in engineering and construction are considered. The proponents cover several technological sealant application techniques in manufacturing and maintaining various machinery and equipment.

Importance of Sealants for Interior Noise Control of Automobiles

In modern automobiles, sealant materials are used for a variety of purposes, including the sealing of body seams, the sealing of access holes, and the filling of hollow cavities. These applications are primarily used to stop corrosion, stop water ingress, and lower noise levels in the passenger area. However, until recently, nothing was known about how well sealant materials could reduce noise. This essay covers the prerequisites for a noise control material and how a sealant material can meet them. In addition to having sound absorption qualities with a suitable formulation, well-engineered sealant materials can also provide vibration-dampening properties throughout an important frequency and temperature range.

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Methodology

Dried latex remained on the stalk when removed from the tree; the latex was gathered for study. The jackfruit was then split open with a knife. Instantly, sticky latex threads were attached to the knife and collected as a sample. The jackfruit comprises the seeds, wrapped by fibers and enclosed in edible pulp, and the core: the center, and the fiber strands surrounding the pulp, which is secreted mainly by the latex. The fruit was disassembled into its constituent parts, and samples were obtained from the pulp, fibers, and core. Two trees were sampled for their branches, fruits, and leaves. The little tree had green branches and leaves since it was an inside pot plant, whereas the enormous tree was hibernating outdoors and was much older. When the branches were severed, creamy white latex oozed out and dried. Because of the season, the fruits had already fallen unripe and somewhat dried from the tree. For additional examination, four plant components were cut into pieces: old branches, new branches, unripe fruits, and leaves.

Polymer analysis Materials

Rotary evaporator Tetrahydrofuran (THF) by Honeywell, 99.9% purity, for HPLC Columns: 3 Phenomenex Phenogel columns: 10000, 500, 50 RI-Detector: PerkinElmer Series

200 Refractive Index Detector Pump: Jasco PU-980 Intelligent HPLC Pump Standard: Polystyrene, molecular weights: 162 g/mol, 945 g/mol, 3,090 g/mol.

Gel Permeation Chromatography

The extraction solvent cyclohexane had to be evaporated before the extracts could be analyzed with GPC. A rotating evaporator was employed for this. Cyclohexane evaporated at a pressure of 200 mbar and a temperature of 40°C. The extract was then dissolved in THF at around 10mg/mL. Insoluble components were removed using a syringe filter before the samples were analyzed using the previously indicated GPC apparatus. The following was the experimental

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procedure: the autosampler fed 100 µL of a 0.35 mL/min flow rate into the column. Each sample's analysis required 47 minutes at 43 °C. With the help of the polystyrene standards, a standard curve could be created to determine the unknown samples' molecular weights based on their retention volumes. A baseline correction had to be applied before the data could be analyzed. The molecular mass was then determined for each value of the retention volume. The following formula (1) was used to determine the areas A of the measured segments:

A_i=((H_i+H_(i+1))*0.5)/(|V_i-V_(i+1) |) (1) At point i, Hi is the highest point. The numerator represents the mean value of two picked peak heights. The retention volume at the point I is described by vi. The denominator describes the volume difference between the two chosen points of interest. The peak regions between all of the measured sites were determined for this analysis. The values of Mw (weight average molecular weight), Mn (number average molecular weight), and Polydispersity d (Mw/Mn) can then be used to determine the molecular weight distribution. The following formulas (2) and (3) for Mn and Mw, respectively, can be used to calculate these values using the peak areas and corresponding molecular weights obtained from the standard curve. (M_n) =(∑▒A_i)/(∑▒A_i /M_i) (2) (M_w) =(∑▒A_i *M_i)/(∑▒A_i) (3)

Determination of Natural Rubber Content in Jackfruit Latex

The latex can be extracted in order to get the natural rubber component. Weighing the latex before extraction and comparing it to the weight of the extracted rubber allowed us to investigate this using latex from different regions of the jackfruit. However, the jackfruit latex's natural rubber component has yet to be identified. Verifying the findings and examining the rubber content in various jackfruit portions would be interesting.

Differential Scanning Calorimetry

The extracted sample, weighing 2-4 mg, was heated and chilled at 10°C/min.

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First, from -30°C to 100°C, then from 100°C to -30°C, there were two heating/cooling cycles. 50mL/min of nitrogen was flowing.

Results and Discussion

After comprehensive evaluations and studies have been conducted to determine this project's feasibility study, the advocates have listed the following conclusions:

Marketing Aspect

1. The company produces a sealant with jackfruit-based latex as its main component for the leading airline manufacturer in the Philippines, Airbus Philippines, to supply its aircraft.
2. Along with recommending the product to the aviation industry, the company utilizes advertisements and promotions.
3. The enterprise is located in Laguna Technopark, Biñan, Laguna.
4. The company's target market is the leading airline in the Philippines contracts with Airbus Philippines to supply its wide-body and narrow-body aircraft.

Technical Aspect

1. The needed facilities and materials for integrating Jackfruit-Based Latex include machinery and equipment and a plant site for manufacturing and production of the latex.
2. The company produces jackfruit-based latex to the highest quality standards. There are several tests performed in the plant to ensure and control quality.

Management Aspect

1. Each job in the organization requires standardized qualifications to guarantee the caliber of the work and output.
2. The company set up the project schedule for all its activities and a long-term timetable to create a feasible, strategic timeline.

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Financial Aspect

1. The enterprise has an initial capital of Php 12,500,000.00. This includes every financial affair of the company.

2. The amount allocated for the construction and the land to be utilized is Php 5,893,200.80.

Socio-Economic Aspect

1. To support our citizens in Philippine society, the company offers possible job opportunities in the community.

2. The enterprise aligns its goal and vision with the preferences and values of its target market.

Conclusions

Based on the summary of findings, it has been concluded that the sealant with jackfruit-based latex, with the scientific name Artocarpus heterophyllus, with the primary objective of the study to determine the profitability of the project with regards to the establishment of a production facility for the extraction and processing of the jackfruit-based latex, is profitable with a payback period of 1.168032391 years or 426 days. With the projected values, the company has been able to attain an internal rate of return percentage of 85%, signifying a good IRR for the company, clearly exceeding the cost of capital towards more net cash for the company, with the cost of capital amounting to Php 12,500,000.00, and a net present value of Php 63,627,762.19.

Recommendations

The following recommendations for future studies are based on the findings of the study herein:

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For Future Studies

Research to explore the influence of various aspects of location consideration and its selection and other dynamically dependent factors that could include comparing relationships across different locations and the quality, including the cost of living and overall standard regarding business sustainability.

With the limited allocation and variable access to time and resources, considering utilizing a more comprehensive range of data, there is a significant barrier to the effectiveness of fulfilling and attaining the objectives, as stated in the former part of this study. Therefore, the researchers recommend that for future studies, one must identify effective means of data gathering and access a more significant population for attaining additional data regarding public perspective beneficial for the execution of research with a similar context.

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This study is a product of the collective efforts of many individuals. Because of this, the researchers express their gratitude to PATTS College of Aeronautics for allowing them to share their humble expertise with the Filipino youth and everyone in between. Likewise, they thank various individuals, entities, and organizations who facilitated such operations in this inquiry process.

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Bionote

Sweetzel Jane S. Geron is a graduate of Aeronautical Engineering at PATTS College of Aeronautics. She has demonstrated a solid commitment to her academic growth by completing various training programs and workshops. Noteworthy among her accomplishments is the HEATCON Composite System Training undertaken in 2022, followed by the Maintenance Repair Overhaul Training in 2021. Furthermore, Ms. Geron's scholarly contributions extend beyond her studies. She is a Co-Author of a research paper presented at the Philippine Aviation Research Conference (PARC) in September 2021. Additionally, she holds the position of an affiliated member within the Aeronautical Engineer Research Organization, a distinction she has upheld since 2019 to the present day.