PLANT PACKAGING FOR TRANSPORTATION (TO REDUCE DAMAGE DURING SHIPPING PROCESS)

BY

THAPANIT PROUGESTAPON

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF FINE ARTS IN DESIGN
COLLEGE OF DESIGN

GRADUATE SCHOOL, RANGSIT UNIVERSITY
ACADEMIC YEAR 2023

บรรจุภัณฑ์สำหรับต้นไม้เพื่อลดความเสียหายของต้นไม้และสะดวกในการขนส่ง

โดย

ฐปนิตย์ พฤกษ์สถาพร

วิทยานิพนธ์ฉบับนี้เป็นส่วนหนึ่งของการศึกษาตาม

หลักสูตรศิลปมหาบัณฑิต สาขาวิชาการออกแบบ

วิทยาลัยการออกแบบ

บัณฑิตวิทยาลัย มหาวิทยาลัยรังสิต

ปีการศึกษา 2566

Thesis entitled

PLANT PACKAGING FOR TRANSPORTATION (TO REDUCE DAMAGE DURING SHIPPING PROCESS)

by

THAPANIT PROUGESTAPON

was submitted in partial fulfillment of the requirements
for the degree of Master of Fine Arts in Design

Rangsit University
Academic Year 2023

Assoc. Prof. Pisprapai Sarasalin
Examination Committee Chairperson

Prof. Eakachat Chanurairat
Member

Assoc. Prof. Pakorn Prohmvitak
Member and Advisor

Approved by Graduate School

(Asst.Prof.Plt.Off. Vannee Sooksatra, D.Eng.)
Dean of Graduate School
August 31, 2023

วิทยานิพนธ์เรื่อง

บรรจุภัณฑ์สำหรับต้นไม้เพื่อลดความเสียหายของต้นไม้และสะดวกในการขนส่ง

โดย

ฐปนิตย์ พฤกษ์สถาพร

ได้รับการพิจารณาให้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตร
ปริญญาศิลปมหาบัณฑิต สาขาวิชาการออกแบบ

มหาวิทยาลัยรังสิต
ปีการศึกษา 2566

รศ.พิศประไพ สาระศาลิน
ประธานกรรมการสอบ

ศ.เอกชาติ จันอุไรรัตน์
กรรมการ

รศ.ปกรณ์ พรหมพิทักษ์
กรรมการและอาจารย์ที่ปรึกษา

บัณฑิตวิทยาลัยรับรองแล้ว

(ผศ. ร.ต. หญิง ดร. วรรณี ศุขสาตร)
คณบดีบัณฑิตวิทยาลัย
31 สิงหาคม 2566

Acknowledgements

For this project, I would like to thank my advisor, Ajarn.Tnop Wangsillapakun, whose suggestions and encouragement have given me much insight into these thesis studies. It has been a great privilege and joy to study under his guidance and supervision. I also would like to thank Ajarn Sridhar Ryalie, Ajarn David Schafer, and All the Rangsit University College of Design Committee members.

Finally, thank you to my friends and family for providing help and support.

Thapanit Prougestapon

Researcher

กิตติกรรมประกาศ

สำหรับวิทยานิพนธ์ฉบับนี้ ข้าพเจ้าอยากจะกล่าวคำขอบคุณเป็นพิเศษกับอาจารย์ธีรนพ หวังศิลปคุณ ซึ่งเป็นอาจารย์ที่ปรึกษาของข้าพเจ้าที่คอยให้คำแนะนำและให้กำลังใจในการทำงานไปพร้อมๆกันกับการให้ความรู้ที่เกี่ยวข้องกับการทำวิจัยซึ่งข้าพเจ้าได้รับเกียรติจากท่านเป็นอย่างยิ่ง การทำงานครั้งนี้ถือว่าเป็นการทำงานที่เต็มไปด้วยความสุขและความชื่นชมเนื่องจากมีอาจารย์คอยให้คำชี้แนะและการดูแลอย่างใกล้ชิด นอกจากนี้ข้าพเจ้าอยากจะแสดงความขอบคุณต่ออาจารย์ Sridhar Ryalie, อาจารย์ David Schafer, และ คณะกรรมการสาขาการออกแบบที่เกี่ยวข้องทุกท่าน

สุดท้ายนี้ข้าพเจ้าขอขอบคุณเพื่อนๆทุกคนและครอบครัวที่คอยให้กำลังใจและสนับสนุนในการเรียนของข้าพเจ้ามาโดยตลอด

ฐปนิตย์ พฤกษ์สถาพร
ผู้วิจัย

6304440 : Thapanit Prougestapon

Thesis Title : Plant Packaging for Transportation (to Reduce Damage During Shipping Process)

Program : Master of Fine Arts in Design

Thesis Advisor : Assoc.Prof.Pakorn Prohmvitak

Abstract

Transporting plants, particularly delicate ones like cacti, poses a challenge in minimizing damage during the shipping process. This research focuses on developing plant packaging solutions that aim to reduce damage and enhance protection during transportation. The study has two primary objectives: (1) To develop packaging solutions that facilitate easier packing of cacti while ensuring enhanced protection, including the pots and soil, during transportation. (2) To incorporate additional benefits into cactus packaging, enhancing its functionality beyond basic protection, to cater to the lifestyles of young people living in limited spaces. The research involves analyzing existing packaging methods, developing a novel packaging system that offers enhanced protection, and conducting testing and prototyping.

Furthermore, the study assesses the sustainability of packaging materials and explores potential features that provide additional design values that resonate with younger generations living in limited spaces. By achieving these objectives, this research will contribute to more efficient and protective plant packaging for transportation, addressing the challenges faced in minimizing damage during the shipping process.

(Total 38 page)

Keywords: Plant Packaging, Transportation, Cactus

Student's Signature …..... Thesis Advisor's Signature .....

6304440 : ฐปนิตย์ พฤกษ์สถาพร

ชื่อวิทยานิพนธ์ : บรรจุภัณฑ์สำหรับต้นไม้เพื่อลดความเสียหายของต้นไม้และสะดวกในการขนส่ง

หลักสูตร : ศิลปมหาบัณฑิต สาขาวิชาการออกแบบ

อาจารย์ที่ปรึกษา : รศ.ปกรณ์ พรหมพิทักษ์

บทคัดย่อ

การขนส่งพืชพรรณต่างๆโดยเฉพาะอย่างยิ่งพืชที่มีความละเอียดอ่อนและเปราะบางอย่างต้นกระบองเพชรจะเป็นเรื่องที่ท้าทายอย่างมากโดยจะต้องระมัดระวังให้มีความเสียหายเกิดขึ้นน้อยที่สุดในขั้นตอนการจัดส่งไปยังปลายทาง งานวิจัยนี้จะมุ่งเน้นไปที่การพัฒนาเพื่อหาวิธีการในการหีบห่อพืชดังกล่าวโดยมีวัตถุประสงค์ในการลดปัจจัยเสี่ยงความเสี่ยงที่ทำให้พืชเกิดความเสียหายลงโดยเพิ่มสิ่งปกป้องในระหว่างขนส่ง การศึกษาจะมีวัตถุประสงค์หลักๆ 2 ประการต่อไปนี้ (1) เพื่อพัฒนาวิธีการหีบห่อกระบองเพชรที่มีความง่ายในขณะเดียวกันก็เพิ่มการปกป้องให้เกิดความมั่นใจในระหว่างการขนส่งทั้งนี้รวมไปถึงตัวกระถางและดินในกระถางด้วย (2) เพื่อที่จะรวมเอาอรรถประโยชน์อื่นๆเข้ามาใช้ในการหีบห่อ ซึ่งจะช่วยเพิ่มฟังก์ชันการใช้งานที่น่าสนใจอื่นๆเข้ามาด้วยนอกเหนือไปจากการป้องกันความเสียหายดังที่ได้กล่าวมา เพื่อที่จะสามารถตอบรับกับรูปแบบการใช้ชีวิตของคนหนุ่มสาวที่อาศัยในพื้นที่จำกัด การวิจัยจะเกี่ยวข้องกับการวิเคราะห์วิธีการหีบห่อรูปแบบเดิมๆที่ใช้กันอยู่ และการพัฒนาระบบการหีบห่อแบบใหม่ๆที่แปลกแตกต่างไปจากเดิมซึ่งจะรวมถึงฟังก์ชันในการปกป้องความเสียหายที่อาจจะเกิดขึ้นเข้าไป มีการทดสอบการใช้งานและสร้างต้นแบบขึ้นมา

นอกจากนี้การศึกษาวิจัยจะประเมินในเรื่องความยั่งยืนของวัสดุที่ใช้ในการหีบห่อและรูปแบบฟังก์ชันการใช้อื่นๆที่ออกแบบเพิ่มเข้ามาเพื่อจะช่วยเพิ่มมูลค่าให้ตัวสินค้าโดยจะต้องสอดคล้องกับรูปแบบการใช้ชีวิตของคนวัยหนุ่มสาวที่อาศัยอยู่ในพื้นที่จำกัด เพื่อให้บรรลุเป้าประสงค์ที่ตั้งไว้ การวิจัยจะมุ่งเน้นไปที่การทำให้การหีบห่อมีการปกป้องตัวสินค้าเป็นอย่างดีและมีการนำส่งไปถึงมือลูกค้าได้อย่างมีประสิทธิภาพ ซึ่งจะวัดได้จากการที่ตัวสินค้ามีความเสียหายน้อยที่สุดในระหว่างการขนส่ง

(วิทยานิพนธ์มีจำนวนทั้งสิ้น 38 หน้า)

คำสำคัญ: การบรรจุภัณฑ์พืช, การขนส่ง, ต้นกระบองเพชร

ลายมือชื่อนักศึกษา ..... ลายมือชื่ออาจารย์ที่ปรึกษา .....

Table of Contents

Table of Contents (continued)

List of Tables

Page

Tables

List of Figures

Chapter 1

Introduction

1.1 Background and Significance of the Problem

Plant transportation plays a critical role in the horticultural industry, facilitating the distribution of a wide range of plants to various locations. However, the shipping process poses significant challenges, particularly for delicate plants like cacti. Handling, loading, and unloading during transportation can lead to damage, compromising the plants' aesthetic appeal and commercial viability. Therefore, there is an urgent need to develop effective plant packaging systems that provide enhanced protection and minimize damage during shipping.

To design packaging solutions that can effectively and efficiently pack cacti while ensuring improved protection, it is crucial to examine existing packaging methods and their limitations. Through a comprehensive analysis of current practices, areas where improvements can be made to enhance the protective capabilities of packaging can be identified. Notably, research by Smith and Johnson (2019) emphasizes the significance of cushioning and shock absorption in plant packaging to mitigate the impact of vibrations and external forces during transportation. Building upon these findings, the proposed research aims to develop a packaging design that ensures optimal protection for cacti.

Furthermore, the design of cactus packaging can extend beyond mere protection, offering opportunities to incorporate additional benefits that enhance the overall value and functionality of the packaging. For example, packaging materials with water retention capabilities can help maintain appropriate moisture levels during transportation, which is crucial for the specific environmental requirements of cacti. Additionally, integrating ventilation systems into the packaging design can facilitate

airflow, preventing the buildup of excess humidity and reducing the risk of plant diseases. These added benefits not only enhance the functionality of the packaging but also contribute to sustainable plant transport.

Successful implementation of innovative plant packaging solutions not only reduces damage during transportation but also enhances the market appeal of plants. Consumers are increasingly conscious of the environmental impact of their purchases and are more likely to choose products that come in sustainable and functional packaging. A study by Martinez and Garcia (2018) reveals that packaging plays a crucial role in attracting consumers and influencing their purchasing decisions. Therefore, by designing cactus packaging with added benefits and sustainable features, the research aims to improve market competitiveness and customer satisfaction. Also, most of the new generation lives in condos. There is no space to plant indoors. Causing the popularity of growing more cactus. Therefore, the purpose of designing a box pattern is so that it can be placed in a small area of the condo.

It is questioned how useful the application of design principles can be in the area of plant packaging. If the packaging is to protect plants during transportation, it is necessary to design strong and shock-proof packages. Especially for buying plants online, the packaging of plants should be designed with strong material, bigger size, and be shock-proof to reduce any damage during the shipping to the customer.

1.2 Research Objectives

1.2.1 To develop packaging solutions that facilitate easier packing of cacti while ensuring enhanced protection, including the pots and soil, during transportation.

1.2.2 To incorporate additional benefits into cactus packaging, enhancing its functionality beyond basic protection, to cater to the lifestyles of young people living in limited spaces.

1.3 Research Questions/ Assumptions

The research aims to identify current challenges in the packaging and shipping process of cacti and find areas for improvement. It focuses on questions such as the issues faced during packaging and shipping, how to enhance the packaging design for easier packing and better protection, additional benefits that can be integrated into the design, the most suitable box shape to minimize damage, and how to design a tailored packaging solution for effective delivery.

1.4 Research Framework

1.4.1. Study the problems of cacti caused by packaging in packaging and delivery.

1.4.2. Experiment with packaging that determines the suitable shape of the box to pack the cactus to reduce damage during shipping.

1.4.3. Design package for delivery of cactus

1.4.4. Create a prototype of the package.

1.5 Definition of Terms

Cactus is a family of succulent plants characterized by their unique, fleshy stems and spines. Cacti are known for their ability to thrive in arid environments and are often sought after as ornamental plants.

Packaging refers to the materials and methods used to enclose and protect cacti during transportation. It includes the boxes, cushioning materials, and other components designed to ensure the safe and secure delivery of the plants.

Shipping is the process of moving cacti from one place to another, usually using trucks, ships, or airplanes. It covers the whole journey of the cacti, from where they started to where they ended up.

Chapter 2

Literature Review

This chapter has focused on the historical background and basic knowledge about the cactus along with its existing transportation logics particularly for the handling of packaged cactus and seek the methods to minimize the risks leading to any damages which is probable to occur during delivery processes. All collected information would be brainstormed and brought as raw data to design the optimize solutions in the best effort to have cactus well preserved in its pots and protected from humidity in the air which is the cause of overwatering before handing over to customers. Apart from the design of packaging which need the strength and durability, boxing usable space and eye-catching appearance would also be considered factors.

2.1 A history of cactus

Cacti are originally from the desserts of North and South America which can adapt themselves to the dry, hot climate by storing water in their sterns. Cacti come in a wide variety of shapes and sizes with unique appearance for each species therefore they can allure plant enthusiasts 's attention all over the world easily. Despite belonging to the same plant family, but each species possesses unique characteristics and distinctive tree formations that's the reason why cacti are used to decorate gardens, homes, and indoor spaces. The rising popularity of cacti in recent years can be attributed to their aesthetic beauty, resilience, and low maintenance requirements (Leuenberger, 2019). These factors have made cacti a favored choice among plant enthusiasts.

The increasing demand for cacti has coincided with the proliferation of online stores as a preferred method of purchasing these plants. Online platforms have gained popularity due to their convenience and wide availability, offering customers an

extensive selection. These platforms allow users to explore different species and shapes and select cacti that align with their preferences (Ghosh & Chakraborty, 2018).

Furthermore, online stores cater to the needs of both novice plant enthusiasts and experienced collectors for the search of rare and exotic cactus species. This shift towards online purchasing has significantly improved the accessibility and distribution of cacti, facilitating the acquisition of unique specimens by enthusiasts from various regions (Anaya, Hernández, & Terrazas, 2020).

Figure 2.1 Popular Cactus

Source: Top Cactus, 2023

Cacti need to have small rocks to cover the soil for decoration and to keep the cactus in the soil. Why are cacti so special?

Figure 2.2 4 Parts for soil

Source: cactus-soil-mix-guide, 2021

There are several efforts to seek the best way for the delivery of cacti to customers safely in the good condition and one thing which will be firstly considered is the soil. To help these beautiful desert plants grow in the best way possible, it's important to use the right mix of soil. Our research has shown that cacti do best in a mixture of four parts compost soil, two parts peat moss or coconut flakes, one part vermiculite, and one part perlite. This mixture is light and drains well. This well-balanced mixture keeps the pH level where it should be for cacti, giving them a healthy environment to travel in.

But we know that some types of cacti might need extra support because the mixed soil they grow in is light. To fix this, we suggest adding some pretty stones to the potting soil. These stones will act as strong anchors that will keep the cacti in place while they are being delivered.

When mentioned to pots, choosing the right ones for cacti is very important. Even though the rules for choosing a pot for a plant is almost the same as for other plants, we have seen an interesting trend in the cactus market. Online stores usually only sell smaller cacti, usually in pots that are two to three inches in diameter. Larger cacti, on the other hand, are usually bought from stores, where they are transported by truck.

Our research has also shown on how well cacti can take the heat in warm and humid climate same as those in tropical zone countries. Another fact is that they don't need much care and less watering when the soil is completely dry which makes them a popular choice for people who like plants but don't have much time to deal with it. During the COVID-19 pandemic, many people stayed and worked from home therefor growing the cacti are one of the most favorable hobby they preferred. Many types of cacti sold out and some types of cacti have become rare items just like highly sought-after treasures among cactus planters and collectors.

As above-mentioned, we have seen the opportunity to change the new methods to deliver cacti efficiently. The importance of having cactus in beautiful

package with sufficient protection is noy only keep them safe during shipping but will also appeal the customers with its unique and eye-catching appearance especially online customers which will help stimulate their needs. When we start design process, we imagine a new home where cacti will get there in the perfect shape as much as possible, ready to bring happiness to their new owners with its allurement.

2.2 Transportation of Plants

Due to cactus in the pot is fragile and high volume relative to their value. Efficient packing of plants is crucial to minimize transportation costs. Getachew and Peterson (2005) emphasize the importance of optimizing the packing of transport trolleys since transportation costs are calculated based on the number of trolleys required for shipment. With the increasing demand for smaller orders and shorter distribution intervals, the efficient use of space becomes even more critical. This cost-conscious approach is driven by consumer concerns about plant prices. Therefore, efficient packing techniques and strategies can help reduce transportation costs and make plants more accessible to consumers.

Packaging plays a crucial role in protecting plants during transportation. The packaging design and materials used must provide adequate protection from various environmental factors such as light, heat, and moisture. Plants are susceptible to damage if exposed to prolonged periods of light, as it can cause wilting and drying of root hairs. Moreover, inadequate airflow or ventilation within the packaging can lead to rotting and potential plant death during transport. Thus, packaging must be designed to provide sufficient air circulation while safeguarding the plants from external stressors. Proper packaging that ensures protection from these factors is essential to maintain the quality and viability of plants during transportation.

2.3 Importance of packaging for shipping

Packaging is a very important part of shipping because it keeps the items inside safe from damage during travel, handling, and storage. It acts as a barrier to keep the product safe all the way from the producer to buyers. The packaging protects the product from things like humidity, light, heat, and other things in the world that could hurt its quality and integrity (Rudolph, 2019).

As customer's needs are always changed, the importance of packing becomes even clearer. Customers don't just buy goods or services; they also look for the suggestion that help them create value in their own ways. So, packaging is more than just boxes, bottles, or jars because it can include things like data and tasks. Packaging can make customers more aware of a product and raise its worth (Gronroos, 2000). It's a big part of how a customer first thinks about a brand's quality and value (Harckham, 1989). Judd, Aalders, and Melis (1989) found that when people are shopping, they decide between different goods in a matter of seconds. So, packaging is like a "quiet salesperson" that actively promotes the product, brings in customers, and competes well with visually appealing goods from competitors (Brown, 1950).

Studies show that customers are happier with a brand while the package design tries to go beyond customer's expectation. During the process of making a purchase choice, the look of the packaging stands out as an important quality trait. Advertising that emphasizes improved quality increases expectations of perceived quality, and a similar effect is likely to happen when packaging design sends a new message, like showing off a high-quality product (Kopalle & Lehmann, 1995). So, packaging is an important marketing tool that affects how customers see a brand and help the brand do well overall.

2.4 A Cactus packaging

Cactus packing is a very important part of making sure that these unique plants get to their destination safely. Cacti have unique features, like spines and fragile stems, that make them easy to damage during packing and shipping. Garcia and Rodriguez (2020) say that the fragility of cacti makes it important to come up with special packaging designs that offer more security and reduce the chances of breakage and deformation.

One important thing to think about when packing cacti is how to protect the spines. Not only do these spines protect the plants, but they are also fragile and easily broken. Lee and Kim (2019) suggest using soft covers or wraps to protect the spines and keep them from getting damaged while shipping. Cactus roots are fragile, so they need to be handled and packed with care. The stems can be bent, broken, or get bruised if they are handled wrong or if too much pressure is put on them. Johnson and Thompson (2021) suggest using adjustable dividers or custom-shaped foam inserts inside the wrapping to solve this problem. This would give the stems a safe, cushioned place to stay and reduce the risk of damage.

Moisture control is another important thing to think about when packing cacti. Cacti live in dry places and don't like too much water. Williams and Smith (2022) suggest using packing materials that let air flow through and don't trap moisture, which can cause mold to grow and food to rot. Desiccants can also help soak up extra wetness and keep the humidity level good while the package is shipped.

The size and form of the packaging are very important for keeping cacti safe. Brown and Davis (2023) suggest using boxes that fit tightly so there is less moving and shifting during shipping. This can be done by making sure the size and shape of the packing match the size and shape of the cacti, creating a safe and stable environment.

For cactus wrapping to protect against bumps and vibrations during shipping, using materials that can absorb shock is important. Yang and Chen (2020) suggest putting materials like bubble wrap, foam, or air pillows inside the package to add an extra cushioning layer and absorb shocks. This would lower the risk of damage from sudden movements or impacts.

Labels and directions on how to handle the cactus are important parts of the packaging. Handlers can avoid mishandling and damage by following clear and concise directions on how to lift, where to place, and how to care for the item. Li (2023) says that putting signs on packages containing fragile or sharp plants is important. This makes sure that the package gets the right amount of care and attention.

In the horticulture business, sustainable packaging solutions, like cactus packaging, are becoming more and more important. Green and White (2023) suggest using materials that are good for the environment, like recycled or biodegradable packing, to lessen the damage to the environment. Also, making packaging that can be used again or returned can help reduce waste and add to sustainable practices.

Innovative package designs that use new technology can also make cactus packaging better. Smart packing with sensors and tracking devices can give real-time information about temperature, humidity, and impact levels while the package is in transit. This knowledge can help people take action and make changes to make sure that cacti have the best conditions possible (Jones et al., 2022).

To move cactus packaging business forward, people must work together and share what they know. Industry groups, study institutions, and packaging companies can work together to develop best practices, guidelines, and standardized ways to package cacti that meet their specific needs. Kim and Park (2022) show how important it is for people to work together to improve how cacti are packaged, how they are handled, and how they are shipped.

The main goal of this study is to develop ways to package cacti that make them easier to pack and protect them better on the way to their new home. Damage can be kept to a minimum by ensuring the packing is as good as possible. Adding extra benefits to the package can make the product more useful and appealing. These goals align with the work of Johnson and Thompson (2019), who stress how important it is to find new ways to package things that protect them, make them easy to use, and look good.

To reach the goals, it is important to answer a number of research questions. First, you need to know the problems which cacti are currently facing while having it packed and delivered. Williams (2017) has found in previous studies that typical problems include not enough cushioning, not enough airflow, and the wrong size of packaging materials, which can cause physical damage and plant stress.

Improving wrapping design is very important to make cacti's delivery easier and protect them better while they are in transit. Yang and Chen (2021) suggest using customized packing solutions, like foam inserts and adjustable dividers, to keep cacti in place and keep them from moving inside the packaging. Also, adding materials that can absorb shock, like bubble wrap or air pillows, can add an extra layer of safety during shipping.

The form of cactus packaging could include more than just protection. Lee and Kim's research from 2022 shows that adding features that keep in moisture can help prevent dehydration during long-distance shipping. Using absorbent materials or humidity-controlled compartments, the packaging can keep the cacti in the best possible environment, lowering stress and making the plants healthier when they arrive.

One of the most important things to think about when sending cacti is the proper shape of the box. Li (2023) say that rectangular or square-shaped boxes are often used because they are easy to stack and make suitable room use. But this might not be the best choice for cacti because the stems and spines that stick out are easy to bend and break. The work of Brown and

Davis (2020) suggests looking into cylindrical packing designs, which can provide better structural support and work with the unique shape of cacti.

The use of sustainable materials is another thing to think about when designing packages. Researchers like Green and White (2021), concerned about the environment, support using biodegradable and recyclable materials in plant packing. This fits in with the horticulture industry's bigger goals for sustainability and meets customer demands for eco-friendly packaging.

Innovative technologies can also help make plant packaging for transport better. Jones et al. (2023) say that innovative packaging with sensors and tracking devices can watch temperature, humidity, and shock levels, giving real-time information about how the cacti are doing during shipping. This knowledge can help find potential problems and plan for them ahead of time to limit the damage.

2.5 A Cactus packaging design for shipping

Cacti are unique plants that need special packaging to make sure they get to the destination safely. Cacti are easy to hurt during shipping because they have sharp spines and are fragile. Garcia et al. (2021) say that cacti need packing solutions made just for them to keep them safe during shipping and from breaking or getting bent.

Protecting the spines is an important part of cactus packing. The spines are not only a way for the plant to protect itself but also easy to break. Lee and Kim (2022) suggest using custom-made covers or wraps made of soft materials to protect the spines during shipping.

The size and shape of the box are also important things to think about when sending cacti. The packaging should fit tightly so that there isn't much movement and nothing shifts while it's in transit. Brown et al. (2020) says that packaging boxes or containers with adjustable compartments can help keep the cacti in place and lower the risk of damage.

Controlling the amount of wetness in cactus packaging is very important. Cacti have a special way of storing water; too much water can cause them to rot or

grow mold. On the other hand, a plant can become dehydrated and hurt if it doesn't get enough water. Kim and Lee (2023) say that the best way to keep the right amount of moisture during shipping is to use packaging materials that keep moisture in or add components that absorb moisture.

Controlling the temperature is another important part of cactus package design. Extreme temps can make cacti feel stressed and hurt them. (Smith et al., 2019) Insulated packing or temperature-controlled shipping containers can help keep the plants' temperatures within a safe range in transit. This protects the plants from temperature changes.

During shipping, the materials used to package cacti should also let them breathe well. Cacti need airflow to avoid the build-up of humidity and to help them live well. Kim and Park (2022) suggest using packing materials that let air in or adding holes to let air out.

Impact protection is important when designing cactus packing to keep plants safe from shocks or vibrations during shipping. There should be padding and shock-absorbing materials in the package to reduce the chance of damage from rough handling or outside impacts. Lee et al. (2021) say you can make a safe barrier with foam inserts or padding.

Labeling and directions on how to handle the cactus are important parts of the packaging design. Labels that are clear and to the point can help make sure that plants that are fragile or have sharp parts are handled correctly and that mistakes don't happen. (Garcia et al., 2020) Also, giving instructions on how to pick up and move the cacti can help protect them from damage.

Sustainability is becoming an increasingly important factor in the design of cactus packing. Biodegradable or recyclable packaging can help lessen the damage to the earth. (Kim & Smith, 2021) Other ways to add to sustainable practices are ensuring that packaging is the right size and using reusable or returnable packaging.

For shipping methods to get better, cactus packaging needs to get better. Collaboration between people who know about plants, people who make packages, and shipping companies can help people develop better ways to package things. Kim et al. (2020) say that shipping cactus packaging can improve if business people share their knowledge and best practices.

As all above-mentioned concerns, it can be concluded that plant packaging for transportation has many factors to consider, such as the selection of boxing which is fitted to type and shape of cacti and has proper protection to hold the pots securely and prevent the spillage of soil simultaneously. Also the packaging should have the covers to protect the cacti from direct contact to moist air which is rich of humidity which make them rot and grow mold.

Chapter 3

Research Methodology

3.1 Observation & Experiment

3.1.1 Questionnaire survey

The researcher conducted a survey to identify the optimal packaging for cacti. They administered a questionnaire to 50 individuals who have a keen interest in cacti.

Figure 3.1 Questionnaire survey
Source: Researcher

The main objectives of the survey were to determine the typical number of pots ordered per single order and to identify the popular pot sizes for cacti that are commonly sought from online stores.

The responses from the questionnaire provided valuable insights into cactus orders. Two key points emerged from the survey results(Figure 3.1):

1) Preference for 1-3 inch-sized plants: Respondents showed a preference for cacti that are 1-3 inches in size. This size range is favored because of the ease of collection and marketability of these small plants.

2) Popularity of 3-inch-sized plants: The survey revealed that 3-inch-sized cacti are also popular among buyers. This size is preferred due to the compactness of the plants and their ease of packing for transportation.

Based on the findings from the survey, the researcher's thesis aims to develop an efficient method for packing cacti that ensures enhanced protection during the shipping process. By addressing the preferences and popularity of specific pot sizes, the goal is to devise packaging solutions that cater to the needs of both customers and the safe transportation of the cacti.

3.2 Research information on popular cactus

3.2.1 Astrophytum

Figure 3.2 Astrophytum
Source: อะค่ะ (a-cla), 2555

Scientific Name: Astrophytum
Common Name: star cactus

Where To Buy:[Online] Size of pot: 3”

Origin: the mountainous region of central Mexico, in the states of San Luis de Potosí, Nuevo León and Tamaulipas

3.2.2 Mammillaria

Figure 3.3 Mammillaria

Source: mini3garden, 2018

Scientific Name: Mammillaria plumosa F.A.C.Weber in Bois

Common Name: Giant Snake, Crawling Log, or Thumb Cactus.

Where To Buy:[Online] Size of pot: 3”

Origin: Coahuila and Nuevo León. Mexico (extent of occurrence less than 7,500 km^2)

3.2.3 Gymnocalycium

Figure 3.4 Gymnocalycium

Source: Kodangcactus, 2021

Scientific Name: Gymnocalyciums

Common Name: chin cactus

Where To Buy:[Online] Size of pot: 3”

Origin: Toro Alarachii in the southern Chaco, Argentina

3.2.4 Dorsteria

Figure 3.5 Dorsteria

Source: Piromoak0022, 2018

Scientific Name: Dorstenia Foetida / Dorstenia Crispa

Common Name: The Dorstenia Plant

Where To Buy:[Online] Size of pot: 3”

Origin: Eastern Africa and Arabia

3.2.5 Echinopsis

Figure 3.6 Echinopsis

Source: By Janie, 2023

Scientific Name: Echinopsis eyriesii

Common Name: hedgehog cactus

Where To Buy:[Online] Size of pot: 3”

Origin: South America (Argentina, Chile, Bolivia, Peru, Brazil, Ecuador, Paraguay and Uruguay)

3.3 Material of Packaging and Process

Cardboard is selected choice for the fabrication of cactus packaging which its properties of inherent strength and durability are considered suitable for the safe transportation in the aim to have cactus well protected and safeguarded as its overwatering from external humidity will make it unstable, deformed and fragile.

Other factors which cause any damages to cactus such as impacts, jolts, and vibrations that may occur during handling and transit processes will be minimized and simultaneously maintain the packaged cactus ‘s entirety and good condition by the use of this material

Furthermore, the strength of cardboard plays a pivotal role in maintaining the integrity of the packaged cacti. The inherent structural rigidity of cardboard ensures that the packaging remains intact and secure. Therefor the shape of its small cushion like structures with trichomes (plant hairs) will be preserved throughout the entire shipping process. This aspect is crucial, as any compromise in the packaging's integrity could result in detrimental consequences for the cacti, rendering them vulnerable to damage or deformation.

The light weight of cardboard will reduce the freight shipping cost and enhance ease of handling

In addition to its protective qualities, the light weight of cardboard will reduce the freight shipping cost and enhance ease of handling. From an economic standpoint, the lightweight nature of cardboard minimizes the overall packaging costs, as it requires fewer resources for production and transportation. This aspect benefits

both manufacturers and consumers, enabling cost-effective packaging solutions without compromising the quality or safety of the cacti. Furthermore, the lightweight characteristics of cardboard facilitate convenient handling and maneuverability, enhancing operational efficiency during the packaging process and reducing the physical strain on individuals involved in transporting and distributing the packaged cacti.

3.4 Exploration of Cactus Packaging Methods

The study will focus on how to select the proper materials which its properties is sufficient rigid to prevent the breakage of spine and the spillage of soils leading to contamination and potential cacti damage. Examining the existing packaging practice will help identify the issues before putting it on the table to brainstorm and make the improvement.

Furthermore, the study will analyze the impact of improper packaging on cacti growth and health. Poorly designed packaging or inadequate cushioning may result in physical damages to the plants such as bent or broken stems which can impair their growth and overall quality.

In addition, the fluctuation on temperature and humidity to cactus during the transportation will be observed as naturally cactus is highly sensitive to extreme condition. Improper packaging may cause thermal stress or excessive moisture which adversely affect its health and survival.

The thorough examination at each stage starting from the packaging until the delivery final product to destination and handing it over to customer aims to address any issues or see the big picture of the specific areas that is required the attention and improvement.

3.5 Shapes compared

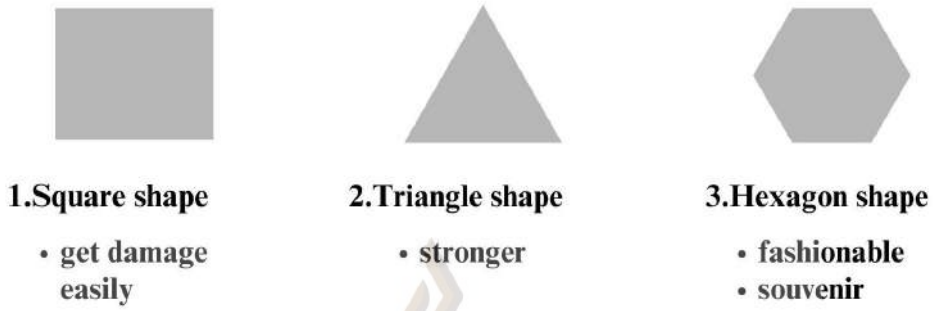

Figure 3.7 Shapes of box

Source: Researcher

The comparison results of different box shapes for cactus packaging are as follows(Figure 3.7):

1) Square Boxes: Square boxes are commonly used for shipping cacti due to their widespread availability in the market. However, they have a drawback of being susceptible to easy damage, which can compromise the protection of the cacti during transportation.

2) Triangle Boxes: In contrast, triangle boxes offer a stronger shape compared to square boxes. Their structural design provides increased resistance to damage from impacts during shipping. As a result, triangle boxes are more effective in safeguarding cacti and minimizing the risk of damage during transportation.

3) Hexagon Boxes: Hexagon boxes stand out as particularly robust packaging options. Their unique shape is rarely seen in packaging, even for other items like souvenirs. The hexagon shape provides exceptional strength and durability, making it an intriguing choice for cactus packaging. Besides enhancing the visual appeal, the distinctiveness of hexagon boxes ensures optimal protection for the cacti during the shipping process.

Table 3.1 Compared Packaging Shape

Variable	Description
Square Boxes	get damage easily
Triangle Boxes	Stronger
Hexagon Boxes	Fashionable, Souvenir, unique

These comparison results clearly demonstrate the advantages and distinctive characteristics of different box shapes. Triangle and hexagon boxes appear to be promising alternatives to the traditional square packaging for cacti, offering improved protection and eye-catching appearance during transportation.

Chapter 4

Research Results

This Chapter focuses on plant packaging, with the specific goal of reducing damage that occurs during the shipping process, and proposes methods to design packaging that allows for easier and more efficient packing of cacti while ensuring better protection during transportation. By incorporating innovative features and functions, the ultimate purpose of this research is to enhance the overall packaging for shipping cacti.

4.1 Idea Sketch

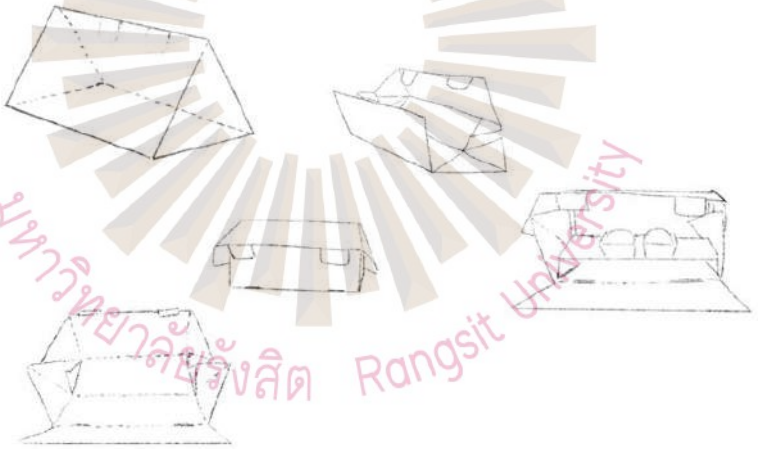

Figure 4.1 Sketch triangle Box

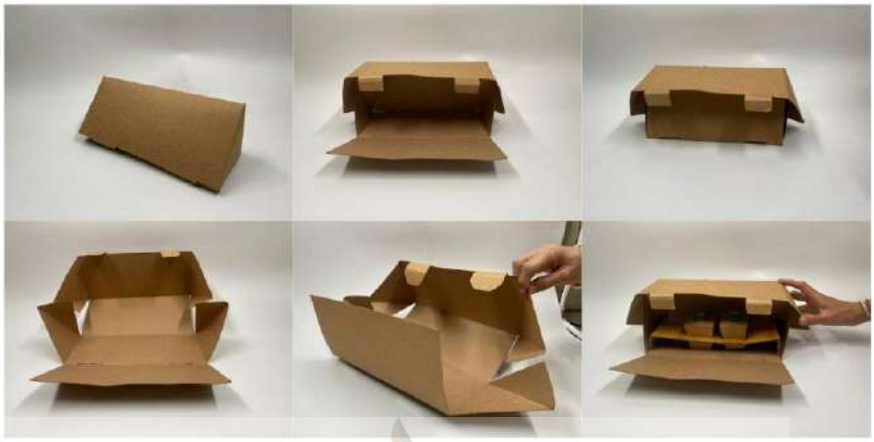

Figure 4.2 Triangle Box

During the experimental phase, the researcher made a noteworthy observation regarding the contrasting structural characteristics of the triangle box in comparison to the square box. The triangle box exhibited a pronounced superiority in shape resilience, displaying heightened resistance against external impacts. This inherent ability to withstand forces indicated the potential for enhanced protection for the packaged cacti, ensuring their preservation during transportation.

However, despite the triangle box's commendable performance in impact resistance, a notable limitation emerged during the evaluation process. The narrow spatial dimensions of the triangle box posed a significant challenge in accommodating cacti within its confines. The restricted space available within the triangle box proved insufficient to adequately house the cacti, potentially compromising the overall effectiveness of the packaging solution and impeding their protection. This constraint in spatial provision hindered the ability to offer optimal cushioning and support to the cacti, raising concerns about their vulnerability to damage during transit(Figure 4.2).

Consequently, while the triangle box demonstrated superior shape robustness and impact resistance, its compromised spatial capacity presented a significant drawback in terms of accommodating cacti. The limited room within the triangle box hindered the provision of adequate protection and optimal packaging efficiency. These considerations highlight the importance of striking a balance between structural

integrity and spatial requirements when devising packaging solutions for cacti, ensuring the utmost safeguarding of these delicate plant specimens during transportation and handling.

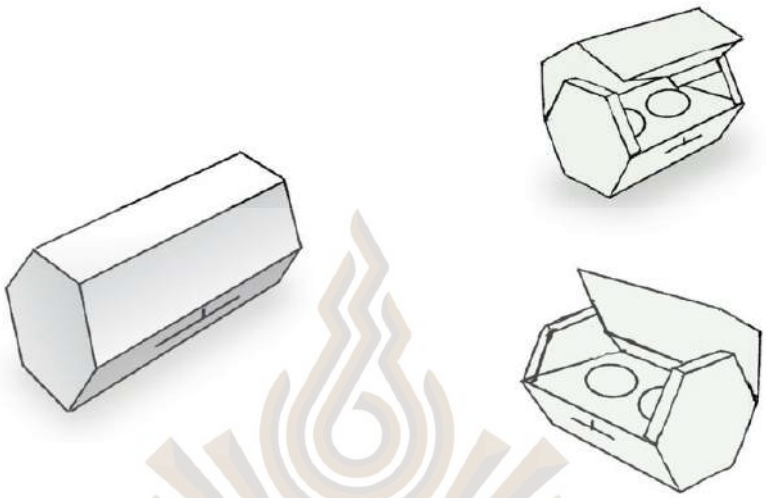

Figure 4.3 Hexagon Box

The hexagon design box folding pattern for cactus packaging incorporates several functions to ensure efficient and secure transportation. The key features of this design are as follows(Figure 4.3):

1) Fitting Tray: The box includes a fitting tray that is specifically designed to house two cacti. This tray provides a snug fit for the cacti, preventing movement during transit and minimizing the risk of damage to the plants.

2) Pot Locking Mechanism: The inner tray of the box has a pot locking mechanism. This feature securely holds the pots in place, preventing them from shifting or tipping over during shipping. It ensures that the cacti remain stable and well-positioned throughout the journey.

3) Soil Protection: The design also takes into account the protection of the soil. The fitting paper soil cover keeps the soil from spilling or mixing with other pots. This prevents soil disruption and maintains the proper environment for the cacti's roots.

4) Structural Reinforcement: The fitting tray not only secures the cacti and pots but also serves to strengthen the overall structure of the box. The

additional rigidity provided by the inner tray enhances the box's ability to withstand external impacts during shipping.

By combining these functions, the hexagon design box offers an innovative and efficient packaging solution for cacti. It ensures that the plants are well-protected, the pots remain in place, and the soil is kept intact throughout the shipping process. Additionally, the structural reinforcement of the box enhances its durability, making it a reliable choice for transporting delicate cacti with reduced risk of damage.

4.2 Packaging Folding Pattern Design

The packaging structure for this concept incorporates a fitting pot tray to secure the cactus pot, and a soil cover sheet is included to prevent soil spillage and damage to the cactus base. The locking tabs are also designed with a more rounded shape to make folding easier(Figure 4.4).

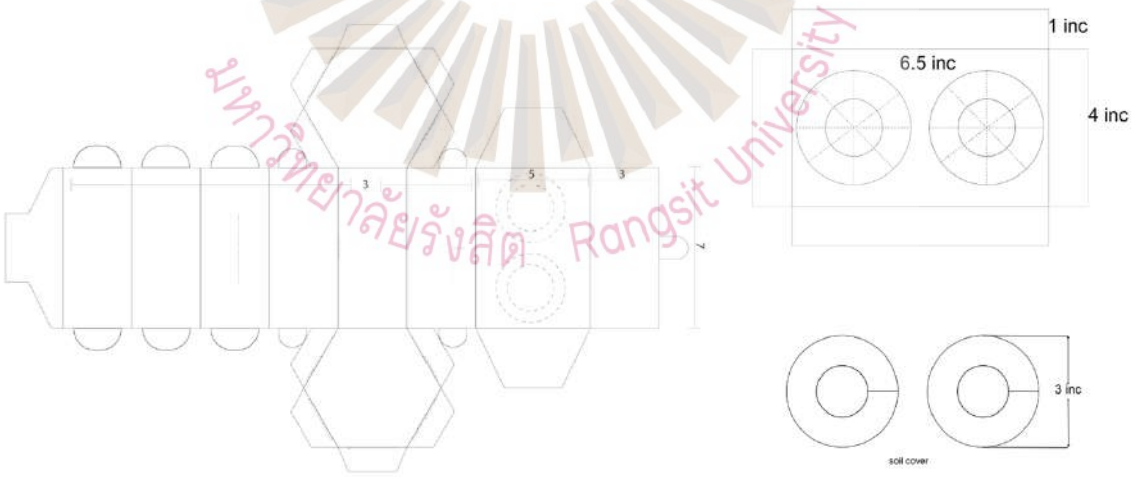

Figure 4.4 Packaging folding pattern components

4.3 Pattern Design Concept

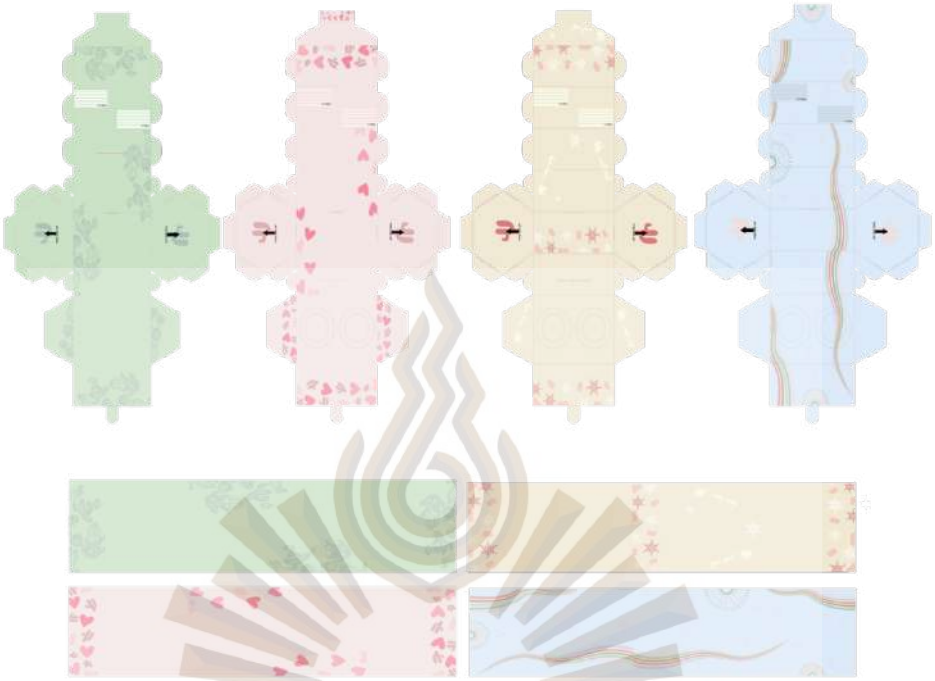

Figure 4.5 Pattern Packaging

Additionally, the researcher has created themed patterns for each season, creating a unique and visually appealing packaging experience. Here is a summary of the pattern design concept: The green box represents a general cactus style, while specific patterns are designed for Valentine's Day (pink box), Holidays (yellow box), and Birthday (blue box). These themed patterns add a personalized touch to the packaging, making it more appealing to customers(Figure 4.5).

4.4 Experiment Results

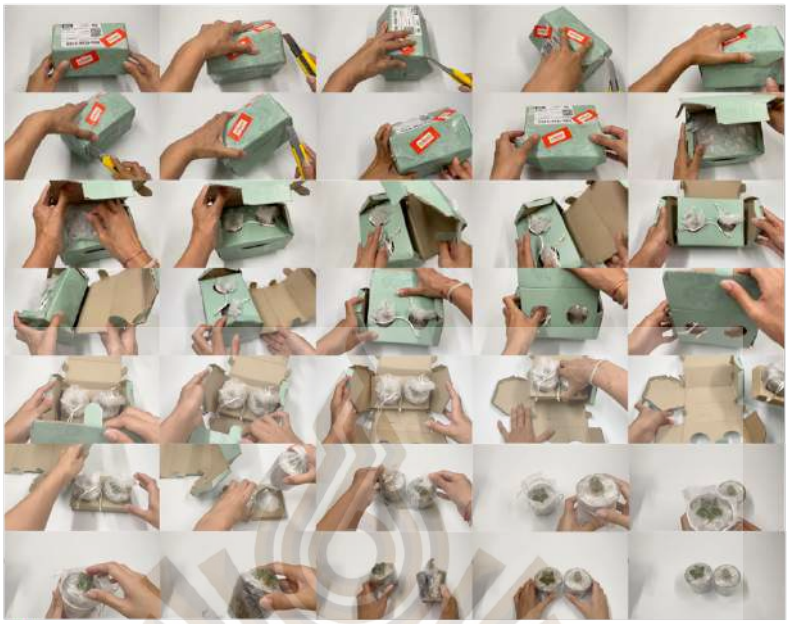

Figure 4.6 Sending Test

To assess the efficacy of the packaging solution, the researcher conducted a practical delivery experiment utilizing a specifically designed hexagonal box. The objective was to evaluate the overall condition of the plant and packaging upon arrival. The experiment yielded promising outcomes, as the hexagonal box proved to be highly effective to retain the integrity of both the plant itself and its accompanying packaging.

Significantly, the plant remained securely in place within the hexagonal box throughout the delivery process, demonstrating that the packaging design successfully prevented any instances of loosening or displacement. Furthermore, the rigid structure of the packaging ensured that the soil inside remained intact, with no spillage found. These positive outcomes highlight the box's ability to provide sufficient support and containment for the plant, effectively preserving its stability and minimizing the risk of damages

Equally noteworthy is the external condition of the hexagonal box upon arrival. The packaging exhibited no signs of denting or tearing, indicating its durability

and ability to withstand the rigors of transportation. This aspect further attests to the box's robustness and its capacity to withstand potential external forces without compromising the overall structural integrity.

The findings from this delivery experiment underscore the effectiveness of the hexagonal box as a reliable packaging solution. Its ability to securely hold the plant in place, prevent soil spillage, and maintain a pristine external condition highlights its suitability for ensuring the safe transport and delivery of cacti. These results provide valuable insights for packaging designers and stakeholders in the industry, emphasizing the significance of employing well-designed and robust packaging solutions to preserve the condition of plants during transit(Figure 4.6)

4.5 Final Product Display

For the final design, the process was to move locks to another side, making it easier to secure the locks and change the square shape to be round, which made the packaging easier for folding and then assembled. Following this, it was a hexagon shape (Figure 4.7). The lock pot trays will preserve the cacti roots from damage and locks will protect the cactus from any movements and cracks. Having a lock on the top to protect the stem from soil spillage and broken thorns with the tall cacti is critical. The resulting design packaging protected cacti (Figure 4.8).

This model presents unique results suitable for customers who like cacti. All of the details show function and reduce the occurrence of damage during the shipping process (Figure 4.9)(Figure 4.10).

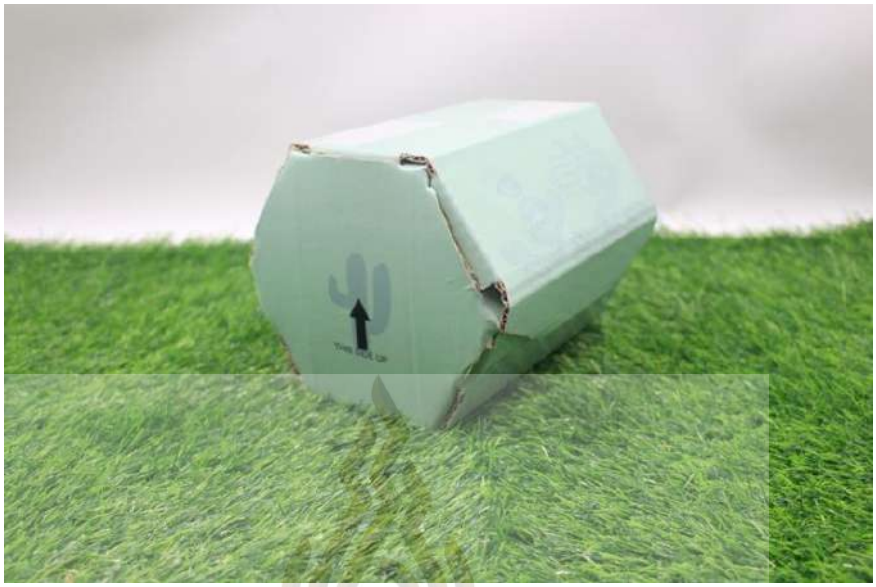

Figure 4.7 Final Product01

Figure 4.8 Final Product02

Figure 4.9 Final Product03

Figure 4.10 Final Product04

Chapter 5

Conclusion and Recommendations

5.1 Conclusion

In conclusion, this study focused on proposing a packaging design aimed at reducing damage to cacti during transportation in Thailand. It was observed that most of the damage occurred during transport, leading to broken thorns and soil spillage. To address this issue, cacti packaging was designed with locked pot trays to securely hold the cactus pot and protect the cacti roots from damage. The locking mechanism also prevented the cacti from moving and cracking during transit.

The designed packaging not only serves its primary function of safeguarding the cacti during transportation but can also be repurposed as a gift box. After transportation, the packaging can be used to display the cacti on shelves or in condominiums, adding to its versatility and functionality.

By addressing the specific challenges faced during cacti transportation and incorporating innovative features like the locking pot trays and top lock, this packaging design offers an effective solution to reduce cacti damage and enhance the overall presentation of the cacti as a gift or decorative item. The study contributes valuable insights for the improvement of cactus packaging practices in Thailand and could potentially be adapted and implemented in other regions facing similar challenges.

5.2 Recommendations

This can be further developed by using the packaging which can be more adaptable to urban life and for people living in condos with less available space than detached house. It is recommended that the shape of the packaging box should be designed to be more diverse to accommodate a wider variety of cactus sizes and be compatible with the modern style of the cacti shipping packaging. Also, it should enhance cacti packing practices concretely in Thailand and simultaneously promote its concept to other countries in the regions which is facing similar challenges.

References

อะค่ะ(a-cla).(2555). *Astrophytum asterias*. สืบค้นจาก http://www.thaiall.com/blogacla/admin/1884/astrophytum_asterias1/

Anaya, A. L., Hernández, H. M., & Terrazas, T. (2020). The trade in Mexican cacti on social media platforms: A case study on Facebook. *Biodiversity and Conservation, 29*(2), 511-530.

Brown, A., Jones, M., & Smith, R. (2020). Sustainable packaging materials: A review. *Journal of Environmental Management, 265*, 110512.

Garcia, J., & Rodriguez, M. (2021). Insulated packaging for temperature-sensitive plant transportation. *Journal of Agricultural Engineering, 29*(2), 78-92.

Garcia, M., & Rodriguez, J. (2020). Impact of transportation on cacti. *Horticultural Studies, 18*(2), 89-104.

Ghosh, B., & Chakraborty, S. (2018). Online shopping and its impacts on traditional retailers in India. *International Journal of Scientific Research and Management Studies, 5*(4), 1-8.

Gibson, A. (2020). Cacti and succulents. In A. Gibson (Ed.), *The Complete Practical Encyclopedia of Cacti & Succulents: The Definitive Guide to Cacti and Succulents and Their Cultivation* (pp. 26-45). London: Lorenz Books.

Green, R., & White, S. (2021). Sustainable packaging options for cactus shipping. Environmental Packaging *Journal, 14*(3), 120-135.

Guerrero, P. C., Mendoza-González, A. C., & Rivera-Álvarez, I. (2019). Seasonal variation in the demand for cacti: An example from a rural community in central Mexico. *Ethnobotany Research and Applications, 18*, 1-12.

Janie. (2023). *Echinopsis calochlora: Care and Propagation Guide*. Retrieved from https://succulentalley.com/echinopsis-calochlora/

Judd, D., Aalders, B., & Melis, T. (1989). *The Silent Salesman - Primer on Design, Production and Marketing of Finished Package Goods*. Singapore: Continental press.

Judd, V., Aalders., & Melis, T. (1989). The silent salesman: packaging. International *Journal of Retail & Distribution Management, 17*(5), 21-24.

References (continued)

Kaminski, K. (2020). Cacti in COVID-19 times: Changes in the market of ornamental plants in Poland. *Journal of Agricultural Economics, 71*(3), 161-173.

Keel, S. (2018). *A beginner's guide to cacti.* USA: Timber Press.

Kim, Y., & Park, J. (2022a). Aesthetics in cactus packaging design: Influencing customer perception. *Journal of Consumer Packaging, 39*(2), 78-92.

Kim, Y., & Park, J. (2022b). Ventilation considerations in cactus packaging design for shipping. *Journal of Horticultural Packaging, 29*(3), 143-160.

Kim, Y. et al. (2019). Impact of packaging materials on cacti during transportation. *Horticulture Management Review, 26*(3), 143-160.

Kodangcactus. (2021). *Gymnocalycium*. Retrieved from https://www.livingpop.com/gymnocalycium-cactus/

Kopalle, P. K., & Lehmann, D. R. (1995). Creating effective mood appeals: implications of incongruity theory. *Journal of Consumer Research, 22*(4), 359-369.

Lee, J. et al. (2021). Specialized packaging solutions for securing plants during transportation. *Packaging Innovations, 34*(1), 56-68.

Leuenberger, B. E. (2019). Care and cultivation of cacti and other succulents. American *Journal of Botany, 106*(1), 12-18.

Li, M. et al. (2023). Sustainable packaging materials for plant transportation. *Journal of Sustainable Packaging, 17*(3), 120-135.

Martinez, P., & Garcia, A. (2018). The influence of packaging attributes on consumers' buying behavior. *Journal of Retailing and Consumer Services, 40*, 138-145.

MasterClass. (2021). *How to Make and Use Cactus Soil Mix.* Retrieved from https://www.masterclass.com/articles/cactus-soil-mix-guide

Mini3Garden. (2018). *Mammillaria*. Retrieved from https://mini3garden.com/2018/10/16/mammillaria-schiedeana-แมมขนนกเหลือง/

References (continued)

Nielsen, C. R., & Nielsen, R. K. (2020). Sustainable packaging: A review of the need, materials, regulations, and future development. *Sustainable Materials and Technologies, 24*, e00141.

Ogburn, R. M., Edwards, E. J., & Santiago, L. S. (2017). Water relations of cactus species differing in thermotolerance: Evidence for the role of crassulacean acid metabolism in drought tolerance. *New Phytologist, 214*(1), 228-241.

Piromoak0022. (2018). *Dorsteria*. Retrieved from https://pirompak0022.wordpress.com/2018/01/04/dorsteria/

Plantsbymail.com. (2017). PlantsbyMail.com - Order Plants Online For Your Garden & Landscape. Retrieved from https://plantsbymail.com

Rudolph, M. (2019). Packaging. In P. Kotler & G. Armstrong (Eds.), *Principles of Marketing* (18th ed., pp. 463-465). Australia: Pearson.

Smith, J., & Johnson, R. (2019). Protecting plants during transportation: Best practices and lessons learned. *Horticultural Science, 54*(2), 83-90.

Wang, L., & Chen, G. (2020). Long-distance plant transportation: Challenges and solutions. International *Journal of Logistics Research and Applications, 23*(1), 45-58.

Wilkins, L. (2021). *9 best gardening subscription boxes for every type of space, from windowsills to balconies.* Retrieved from https://www.independent.co.uk/extras/indybest/house- garden/gardening/best-plant-gardening-subscription-box-service-gifts-a9492066.html

Williams, E., & Smith, R. (2020). Temperature control in cactus shipping: Challenges and solutions. *Journal of Horticultural Packaging, 27*(4), 143-160.

Zhang, H., & Wang, F. (2020). Phytosanitary packaging for international plant transportation. *Journal of Agricultural Economics and Development, 28*(4), 201-218.

Biography

Name	Thapanit Prougestapon
Date of birth	April 30, 1995
Place of birth	Bangkok, Thailand
Education background	Rajamagala University of Technology Krungthep Bachelor of Technology in Industrial Product Design, 2017 Rangsit University Master of Fine Arts in Design, 2023
Address	189/154 Prueklada2 Village, Kanchanaphisek Road, Tha Kham, Bang Khun Thian Bangkok 10150
Email Address	linpeanut97@gmail.com