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

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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.

Keywords: Plant Packaging, Transportation, Cactus

1. Introduction

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.

The implementation of innovative plant packaging solutions successfully reduces damage during transportation and 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) revealed 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. Additionally, the popularity of growing more cactus is on the rise, especially among the new generation living in condos with limited space for indoor planting. Hence, the purpose of designing a box pattern is to create a packaging solution that can be placed in a small area of the condo, making it convenient for plant enthusiasts to keep cacti.

The application of design principles, in-plant packaging is essential 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 utilize robust materials, larger size, and be shock-proof to reduce any damage during shipping to customers. By incorporating these design elements, the packaging can effectively safeguard the plants during transit, ensuring they arrive in pristine condition to the customers.

1.1 Transportation of plants

Transportation of plants involves significant considerations due to their fragile nature 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.

1.2 History of cactus

Cacti, with their diverse array of types and shapes, have captured the attention of plant enthusiasts. Despite belonging to the same plant family, each cactus species possesses unique characteristics and distinctive tree formations, adding to their allure and appeal in 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 to browse through. These platforms allow users to explore different species and shapes, enabling them to select cacti that align with their preferences (Ghosh and Chakraborty, 2018).

Furthermore, online stores cater to the needs of both novice plant enthusiasts and experienced collectors in 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 et al., 2020).

Figure 1: Popular Cactus

Cacti need to have small rocks to cover the soil for decoration and to make the cactus stay in the soil.

Why are cacti so special?

Figure 2: 4 Parts for soil

One of the primary considerations when cultivating cacti is the soil composition. The ideal soil mixture for cacti is lightweight and well-draining, consisting of four parts compost soil, two parts peat moss or coconut flakes, one part vermiculite, and one part perlite. This balanced blend helps maintain the appropriate pH level for cacti, ensuring optimal growth conditions. In cases where the soil is too lightweight to provide sufficient support for the plants, decorative stones can be incorporated into the potting mix to anchor the cacti securely.

When it comes to selecting pots for cacti, they generally follow the same principles as pots for other plants. However, it is worth noting that online stores often specialize in selling smaller cacti. Larger cacti, on the other hand, are typically purchased from physical shops, where they are transported by truck. The most commonly available sizes of cacti sold online are in two to three-inch pots, catering to the preferences and convenience of online customers.

Cacti are well-suited to hot climates and can thrive in warm and arid conditions commonly found in tropical countries. These plants exhibit exceptional adaptability and require minimal attention or care, making them a preferred choice for many individuals. Their ability to withstand extended periods of drought and their low water requirements contribute to their resilience. Consequently, the cactus business has experienced a surge in popularity, particularly during the COVID-19 pandemic, as people sought out low-maintenance and visually appealing plants for their homes. Additionally, certain cactus species have gained status as rare and sought-after trees, attracting interest from both the market and collectors.

1.3 Importance of packaging for shipping

Packaging plays a crucial role in shipping by protecting the contents from potential damage during transportation, handling, and storage. It serves as a barrier, safeguarding the product throughout the entire logistics chain, from the manufacturer to the end user. Packaging serves as a shield against external factors such as humidity,

light, heat, and other environmental elements that could compromise the integrity and quality of the product (Rudolph, 2019).

The significance of packaging becomes even more pronounced as customer demands increase. Customers do not merely purchase goods or services; they seek solutions that fulfill their unique value-creation processes. Packaging, therefore, goes beyond traditional notions of boxes, bottles, or jars, as it can provide dimensions such as data and functions. Packaging serves as a means to enhance customer awareness and elevate product value (Grönroos, 2000). It plays a vital role in shaping a customer's initial impression of a brand, its quality, and its value (Harckham, 1989). Research indicates that customers make decisions between different products within seconds while shopping (Judd et al., 1989). Thus, packaging serves as a "quiet salesperson," actively marketing the product, attracting customers, and competing effectively with visually compelling competitor products (Brown, 1950).

Studies suggest that brands attempting to exceed customer expectations through packaging design are rewarded with increased customer satisfaction. During the purchase decision-making process, the appearance of the packaging emerges as an influential quality attribute. Advertising that emphasizes improved quality raises expectations of perceived quality, and a similar effect can be presumed to exist when packaging design communicates a new message, such as showcasing a high-quality product (Kopalle & Lehmann, 1995). Packaging, therefore, serves as a vital marketing tool that influences customer perceptions and contributes to overall brand success.

2. Objectives of the study

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.

3. Materials and methods

This study focuses on investigating the issues related to cacti packaging and delivery, aiming to identify potential challenges and develop effective solutions. The research employs a combination of experimental and design approaches to address the objectives outlined below.

Firstly, the study examines the problems encountered in cacti packaging during the shipping process. By conducting a comprehensive analysis of existing practices, potential shortcomings and areas for improvement will be identified.

Secondly, experimental investigations will be conducted to explore packaging options that can mitigate damage to cacti during shipping. Specifically, the research will determine the optimal shape and design of the packaging box, aiming to minimize the risk of damage caused by external impacts and handling.

Next, based on the findings from the experimental phase, a tailored packaging design will be developed specifically for the delivery of cacti. This design will encompass features that provide secure and protective packaging while considering factors such as space efficiency, ease of handling, and aesthetic appeal.

Finally, a prototype of the designed packaging will be created. This prototype will serve as a tangible representation of the proposed packaging solution, allowing for testing, evaluation, and potential modifications to ensure its effectiveness and practicality.

The combination of qualitative and quantitative methods employed in this study will enable a comprehensive examination of the challenges faced in cacti packaging and the subsequent design and development of an innovative packaging solution to reduce damage during shipping.

4. Results & Discussion

The aim of this paper is to present research focused on plant packaging, with the specific goal of reducing damage that occurs during the shipping process. The paper also 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 Shapes compared

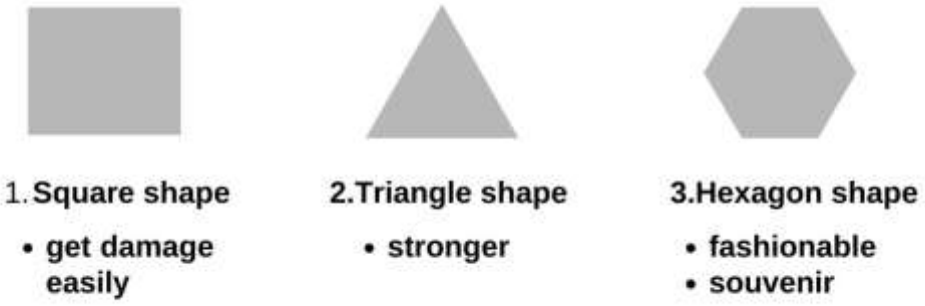

Figure 3: Shapes of box

The comparison results of different box shapes for cactus packaging are as follows:

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.

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 visual appeal during transportation.

4.2 Questionnaire survey

Figure 4: 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. 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:

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.

4.3 Material

Cardboard has emerged as the primary material of choice in the production of cactus packaging, primarily due to its advantageous properties that cater to the specific requirements of this application. The utilization of cardboard as a packaging material offers several notable benefits, making it an ideal option for ensuring the safe transportation and protection of cacti.

One significant advantage of cardboard is its exceptional ability to provide robust protection to the packaged cacti. This material possesses inherent strength and durability, which effectively safeguards the delicate and susceptible nature of cacti during the rigors of transportation. By acting as a resilient barrier, cardboard shields the cacti from potential damage caused by impacts, jolts, and vibrations that may occur during the handling and transit processes. As a result, the risk of physical harm, such as breakage or deformation of the cacti, is substantially minimized. 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, thereby preserving the shape and form of the cacti throughout the entire shipping journey. 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.

In addition to its protective qualities, the lightweight nature of cardboard contributes significantly to its appeal as a preferred packaging material for cacti. The relatively low weight of cardboard offers various advantages, particularly in terms of cost reduction and 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 proves beneficial for both manufacturers and consumers, as it enables 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.

Figure 5: Cardboard

4.4 Idea Sketch

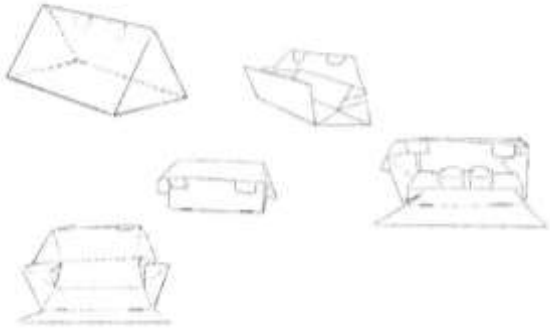

Figure 6: Sketch triangle Box

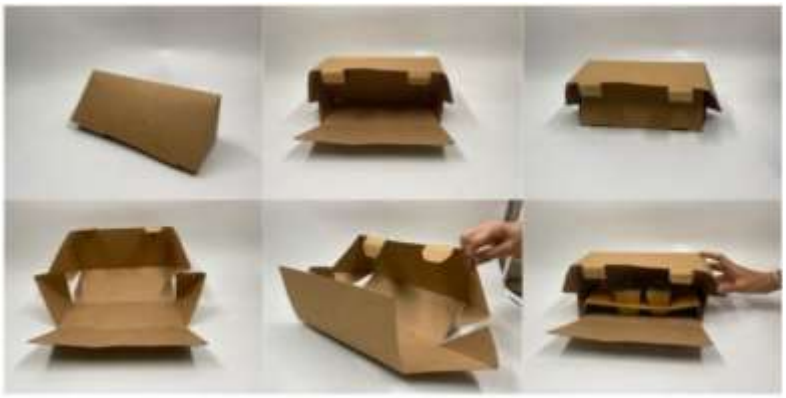

Figure 7: Triangle Box

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.

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.

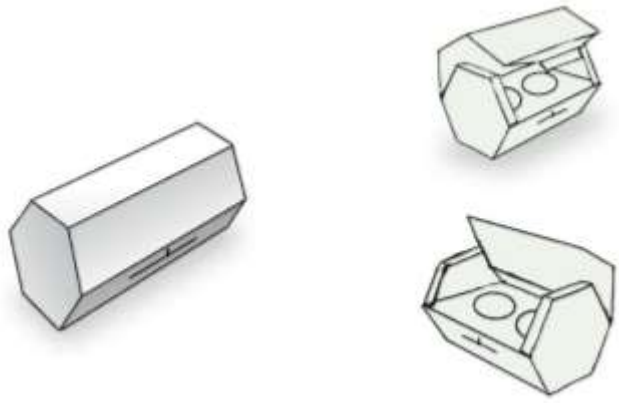

Figure 8: Hexagon Box

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:

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.

4.5 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.

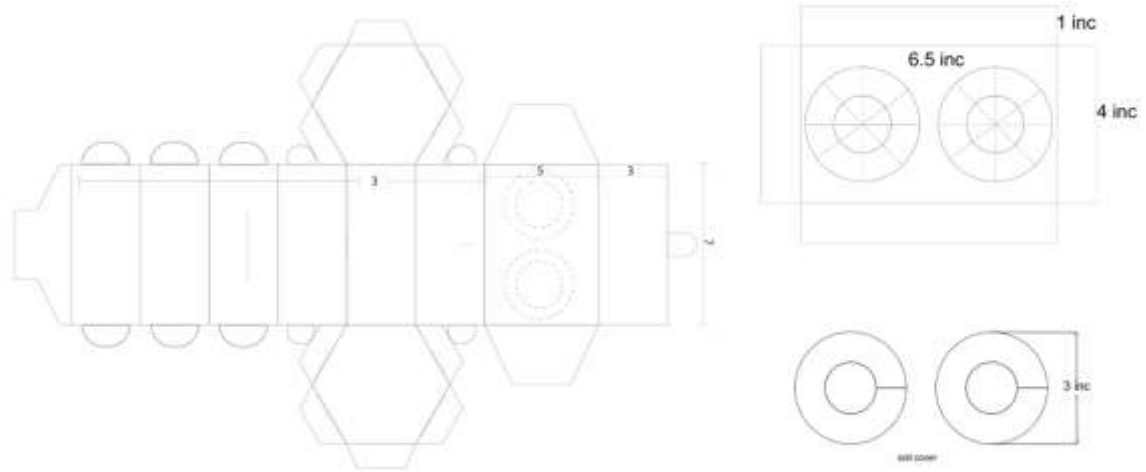

Figure 9: Packaging folding pattern components

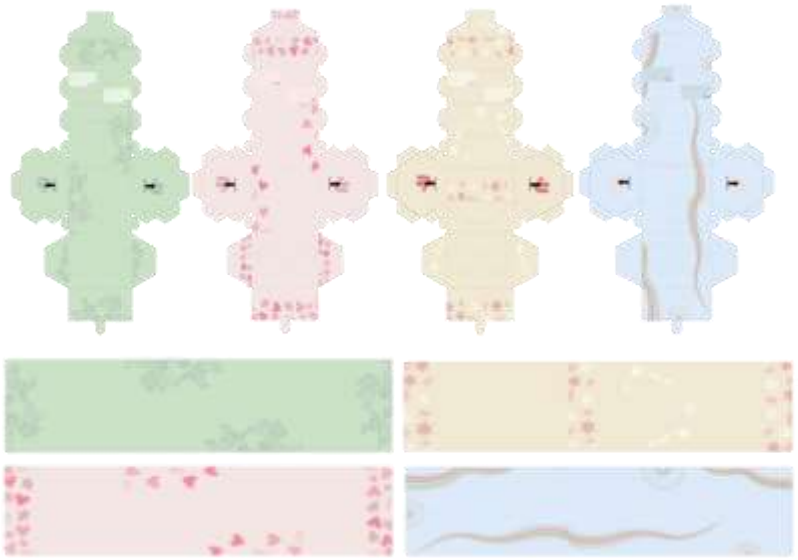

Figure10: Pattern Packaging

4.6 Pattern Design Concept

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.

4.7 Experiment

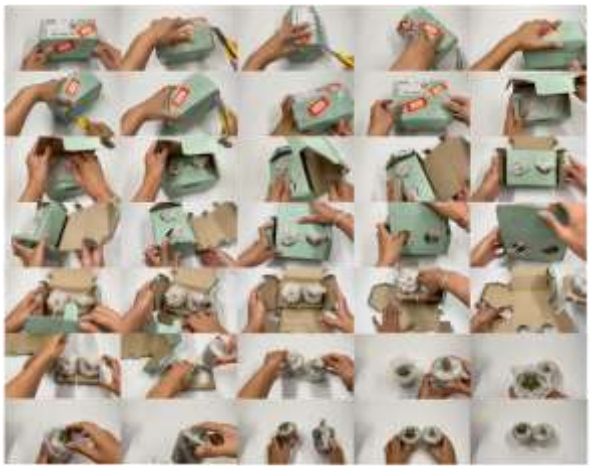

Figure 11: Sending Test

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 in maintaining the integrity of both the plant 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 careful construction of the packaging ensured that the soil within remained intact, with no spillage observed. 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 damage.

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 actual 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.

4.8 Final product

In the final design, a series of modifications were implemented to optimize the functionality and protection of the packaging. One significant adjustment involved relocating the locks to an alternate side, facilitating easier and more secure fastening. Additionally, the square shape of lock the packaging was transformed into a round configuration, rendering the folding and assembly process more streamlined. As a subsequent improvement, the packaging was ultimately transformed into a hexagon shape. This comprehensive redesign process aimed to enhance the overall efficiency and convenience of the packaging assembly. The primary objective of these design modifications was to ensure the preservation and safeguarding of the cacti throughout the shipping and handling processes. The integration of lock pot trays played a pivotal role in protecting the delicate roots of the cacti, shielding them from potential damage. Furthermore, the incorporation of locks within the packaging served to immobilize the cacti, minimizing the risk of movement and subsequent cracking during transit. The inclusion of a top lock was specifically crucial for taller cacti, as it prevented soil spillage and mitigated the likelihood of thorns being broken, thereby providing critical protection for the cactus stem.

The resulting design packaging successfully achieved the desired objectives of preserving and protecting the cacti. The culmination of these design modifications yielded a unique and functional packaging solution tailored specifically for customers with a penchant for cacti. By prioritizing both functionality and protection, the details of this model exemplify a purposeful approach that effectively reduces the occurrence of damage during the shipping process.

Figure 12: Final Product 01

Figure 13: Final Product 02

Figure 14: Final Product 03

Figure 15: Final Product 04

5. 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.

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