

**A RESEARCH STUDY OF SUSTAINABLE PACKAGING IN PHARMACEUTICAL
MANUFACTURING UNITS**

Dissertation Submitted to



IIHMR University, Jaipur

for the partial fulfillment of the award of the degree of

Master of Business Administration (MBA) in
Pharmaceutical Management by

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DECLARATION

I hereby declare that this dissertation titled **RESEARCH STUDY OF SUSTAINABLE PACKAGING IN PHARMACEUTICAL MANUFACTURING UNITS** is the bonafide record of my original research work. I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.

Jayesh Parihariya

Date –01/07/2022

CERTIFICATE

This is to certify that the dissertation titled **Research study of Sustainable Packaging in Pharmaceutical Manufacturing Units** is a record of the research work undertaken by Jayesh Parihariya in partial fulfillment of the requirements for the award of the degree of MBA (Pharmaceutical Management) from the IIHMR University, Jaipur under my guidance and supervision and their approach to the research study has been sincere, scientific, and analytical.

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ACKNOWLEDGEMENT

It is great pleasure for me to acknowledge all those who have contributed to the conception, origin, and nurturing of this project.

This work was carried out at the **School of Pharmaceutical Management, IIHMR University, Jaipur, Rajasthan.**

It is a joy for me to express my gratitude to my esteemed preceptor and mentor, **Dr. Surya Prakash**, associate professor, for his invaluable advice, insightful recommendations, and ongoing support throughout this study. I acknowledge my obligation to his approachability and his exceptional dedication, which frequently went above and beyond the call of duty, with love and respect.

Finally, I would like to extend my heartfelt gratitude to my family and friends for their active, moral, and material assistance in lifting my spirits. My path was paved with their blessing, which gave me the confidence to tackle the difficulties. They helped me get where I am now, so thanks to them.

Jayesh Parihariya

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CHAPTER 1: ABSTRACT

The assortment of various elements that surround a pharmaceutical product from the moment it is produced until it is used is known as pharmaceutical packaging materials. As a result, the word "pharmaceutical packaging" can be used to describe the science and art of protecting against biological contamination, and technology used to finish pharmaceutical dosage forms to prevent physical damage and enclose or protect products for distribution, storage, sale, and use, including printed material, medicinal substance. From the point of manufacturing until it is used or administered, it acts as an efficient means of delivering identification, presentation, protection, information, and convenience. The purpose and type of material utilized determine the kind of pharmaceutical packaging that is employed. The evaluation of all packaging materials must be completed by testing a sample of the material and conducting stability, storage, and sterilization investigations. The preservation of pharmaceutical items' quality is greatly influenced by the packaging.

Sustainability is a subject of significant interest to both academic academics and industrial practitioners because it addresses issues that the entire world is concerned about, including climate change, the swift depletion of fossil resources, waste management, and social welfare. Sustainability takes into account social, economic, and environmental concerns to maintain the long-term wellbeing of all living species. The concept of sustainability that is used most often in literature is meeting present needs without compromising those of the future.

CHAPTER 2: INTRODUCTION

Sustainable Packaging

Packaging that satisfies all performance, cost, and fabrication requirements while being safe for people and the environment is referred to as sustainable packaging. Additionally, the product needs to be particularly created to reduce the consumption of raw materials and maximize energy use. It is important to note that the pharmaceutical packaging process has a long history and is governed by a few regulatory standards. The usage of recyclable packaging is encouraged by one of these rules. In order to promote sustainability, several manufacturers are also working to make packaging lighter by using fewer raw materials. The package's strength shouldn't be sacrificed during this process, though, therefore players are employing a number of cutting-edge design strategies to accomplish this. The pharmaceutical industry is currently growing at a steady working to tackle the concerns related to environmental degradation by implementing a shift towards sustainable/degradable packaging materials for various drugs, devices, and medical equipment.

Additionally, it is essential for creators (or packaging service providers) to select suitable, premium main packaging for each of their items; this is critical because the packing material will come into contact with the medication or treatment. However, the extensive use of primary, secondary, and tertiary pharmaceutical packaging materials has increased the environmental burden associated with waste management, making it imperative to switch to more environmentally friendly materials.

In the pharmaceutical sector, sustainable packaging is essential for maintaining the purity and quality of a drug product while also conveying information about its identity and, in some circumstances, dosing instructions. Pharmaceutical packing is often done under packaging-controlled conditions; in particular, fill/finish for parenterally administered medications is done in sterile and aseptic settings.

For secondary and tertiary packaging of healthcare products, the pharmaceutical business is moving forward and toward eco-friendly, recyclable, and reusable packaging materials like paper and cardboard. The pharmaceutical sector and package manufacturers are developing a circular economy as a result of the creation of recycling plants by a number of packaging manufacturers or their work on their development.

2.2 Raw Materials Used in Pharmaceutical Manufacturing

2.2.1 Plastic Packaging in Pharmaceuticals

One of the most extensively used materials is plastic, which is often made to endure a very long time. Thus, to stop them from deteriorating too quickly, plastics contain a complicated mixture of stabilisers. Unfortunately, many of plastics' best qualities—like their durability and inertness to chemicals, physical forces, and biological processes—also pose problems when they are released into the environment. Common plastics like polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyethylene terephthalate (PET) are incredibly persistent in the environment, where they undergo extremely slow fragmentation into small particles (projected to take centuries) through photo-, physical-, and biological degradation processes¹. A stage of the degradation process that cannot be avoided is the fragmentation of the substance into smaller and smaller particles.

Recognizing that not all bio-based polymer compounds are also biodegradable is crucial. It's equally crucial to understand that in order to achieve the most environmental advantage, characteristics like a polymer's biodegradability must be properly combined with adequate waste management. Alternative disposal options, such as waste to energy or recycling, must be found for durable products for which biodegradability is not a necessary component for criteria of performance, safety, and product life. Bio-polyurethanes based on polyols from vegetable oils for automotive and agricultural vehicles, bio fiber composites for industrial and automotive applications, and recent developments in bio-polyethylene derived from sugar cane via ethanol to ethylene are examples of such resilient bio-based polymers.

2.2.2 Glass Packaging in Pharmaceuticals

Glass is amorphous in structure, non-crystalline, and can be made from both organic and inorganic substances. Glass often exhibits a conchoidal fracture and is hard and brittle, according to ASTM. Glass can be either tinted or colourless. Although opaque or translucent, it is transparent.

Types of glass Packaging

Form 1 – Borosilicate Glass

Form 1: Super-durable borosilicate glass is the first form. This type of glass is extremely durable and chemically inert. In borosilicate glass, boron and aluminium-zinc molecules are utilized to replace alkali and earth cations, creating glass that is durable enough to manufacture heavy acids and alkali.

Form 2 – Surface Coated Soda Lime Bottle

Form 2: Soda-lime bottle surface-coated. When compared to borosilicate glass, this type of glass is more chemically inert. To prevent weathering of the manufacturing package, sulphur pretreatment is done on the soda-lime glass surface.

Form 3 – Normal Soda Lime Bottle

Form 3: Normal lime-soda container. The glass used for this form of packaging is the same as type 2 glass, but because it has not been treated, it does not have higher chemical tolerance.

Form 4 – General Purpose Soda Lime Bottle

Form 4: Functions of a soda-lime bottle in general. Typically, only packaging for products intended for oral or topical use is made from this sort of glass.

The pharmaceutical business, whose medicines must also be stored at specific temperatures to ensure that they are not contaminated and that their characteristics remain intact, places a high value on this glass quality. Glass ought to be utilized in order to maintain the maximum temperature of the goods it contains.

Glass is not chemically reactive. It is a substance that, unless the exterior surface is exposed to other materials and chemicals, would not compromise the integrity of the content. Pharmaceutical products are made up of distinct, calculated molecular combinations. For those who are receiving treatment for certain conditions, potential exposure to these substances poses a serious risk. Glass's exceptional non-reactive qualities are therefore very helpful for its usage in pharmaceutical packaging.

2.2.3 Aluminium Packaging in Pharmaceuticals

The most practical and cost-effective replacement for conventional bottle packaging, which is cumbersome to handle and does not individually protect each pill or capsule, is aluminium foil for pharmaceutical packaging. Pharmaceutical packaging uses aluminium foil because it has excellent barrier characteristics against oxygen and moisture. In order to provide an inert environment for packing hygroscopic medicinal tablets and capsules, it is hence ideally suited.

The main packaging material that immediately contacts the tablets or capsules is aluminium foil. The quality of tablets and capsules may be directly impacted by any compromises made by foil suppliers in their usage of raw ingredients. The quality of the aluminium blister foil used for pharmaceutical packaging completely determines the shelf life of the tablets and capsules.

With rigid PVC film, PVDC-coated PVC film, cold forming foil (alu-alu base foil), and other materials, the majority of types of aluminium blister foil can be sealed. Depending on the user's unique needs, some blister lidding foil with heat seal lacquer is suitable for dealing with any of the aforementioned base materials or sealing compatibility with all different types of base materials.

Keywords- Pharmaceutical packaging, Sustainability, Packaging materials, Manufacturing units, etc.

2.3 Functions of Packaging

Barrier Protection – It is designed to guard against all harmful external factors, such as moisture, light, oxygen, and temperature changes, that could change the qualities of the product. Blister packaging can be used to offer this kind of protection.

Biological Protection – It is designed to safeguard against biological impurities.

Physical Protection – Its purpose is to safeguard pharmaceutical dosage forms from physical injury.

Information Communication – In the context of pharmaceutical products, packaging should include information about dose form usage guidelines, contents, origins, adverse effects, and cautions.

Security – Certain characteristics are present on pharmaceutical packaging to deter counterfeiting. Additionally, it inhibits little children from reaching the formulas' contents.

Convenience – Packaging must be user-friendly in order to facilitate distribution, handling, selling, and using of items and increase customer access to them.

Child – Proofing – There is always a chance that children could unintentionally obtain medicinal products, no matter how high up you keep the medication.

Fortunately, pharmaceutical packaging is made particularly to prevent kids from accessing potentially dangerous or even life-threatening prescriptions. Safety is taken into consideration when designing features like bottle tops that require a specific motion to open or tear-resistant packaging.

The kind of packaging and the materials used must be chosen in such a way that:

1. Chemical reactions, packaging material leaks, or absorption have no negative effects on the pharmaceutical product's quality in the packaging itself.
2. Product does not alter the qualities of pharmaceutical packaging or affect its protective functions in a way that would be detrimental to its quality.
3. Both the product's packaging and the product itself shouldn't have any negative effects on the new surroundings.
4. Low cost, ease of production, accessibility, and regulatory approval of both the raw material and the finished product must all be considered.

Future of Pharmaceutical Packaging-

With the demands of environmental ideals, patient fulfilment, and unique cures, the pharmaceutical industry, research, and manufacturing technologies are always evolving. This has led to significant improvements in packaging and delivery systems.

The creation of large molecule biopharmaceutical drugs—some of which are still in the pipeline for research—had been made possible by increased investment in the R&D sector. This had increased demand for injectable packaging and self-administration devices. The traditional glass and elastomeric closure systems that were previously in use might not offer the reliable obstruction qualities crucial for expensive, life-saving therapies. We now have new materials and technologies thanks to packaging R&D that guarantee a longer shelf life for pharmaceutical products.

Lyophilization helped create liposomes and then pro-liposomes. Therapies that are unstable in liquid form are lyophilized or turned into dosage forms that are dry powder. For best results, lyophilized medications require special management and storage procedures. For precise dose delivery, lyophilization chambers with suitable, non-sticky stoppers are used.

The advancement of packaging technologies has always aided advances in pharmaceutical research and development. The calibre of packing ensures that drugs will remain reliable during storage, transportation, and delivery. Therefore, the advancement of packaging is proportional to the market success of NDA Pharmaceuticals. Pharmaceutical Packaging needs to encourage the use

of 3D design software to create affordable pharmaceutical packages and their evaluation with tools like Finite Element Analysis (FEA). The need for the customer to set up expensive and time-consuming production rounds at their sites for challenging at all stages of development is eliminated by this approach of virtual to real packaging, which can produce products right from cut using software to create their models and then try them with certain parameters virtually.

A rise in self-administered therapeutics requires pharmacy research to develop self-administration-focused healthcare packages rather than healthcare centered around hospital care. Currently, hospitals and clinics are frequently where healthcare begins, but home is where maintenance therapy takes place. Self-administration had caused packaging to change in such a way to enable compliance for therapy for the treatment of chronic ailments like arthritis, cancer, multiple sclerosis, Alzheimer's disease, and other diseases that require regular medicine. Protection treatments are typically administered via injection, necessitating the necessity for delivery methods that are patient friendly. The efficacy of the drug must be kept, and packaging techniques must encourage adherence to a dose plan, guaranteeing dosing precision, and be as safe, simple to use, and painless as feasible for patients. Especially for manual carers, manufacturers of packaging for self-drug administration processes must offer delivery mechanisms that will make drug modification prior to use simple. The industry needs to develop packaging technology that is quick and affordable.

CHAPTER 3: LITERATURE REVIEW

- Anupama Singh, Independent Researcher and Pramod Sharma, Indian Institute of Technology, Roorkee, November 2011. To learn about the countless potential applications for eco-friendly pharmaceutical packaging. The single eco-friendly packaging material that combines the qualities of glass, paper, plastic, metal, and rubber was the subject of this study.
- Valentina Siracusa, the University of Catania and Marco Dalla Rosa, University of Bologna 2018 this study results in stability of the packaging materials to the intended storage and use conditions, much more investigation is mandatory.
- Raju, Geo, Prabir Sarkar, Ekta Singla, Harpreet Singh, and Rachit Kumar Sharma. "Comparison of environmental sustainability of pharmaceutical packaging." *Perspectives in Science* 8 (2016): 683-685. According to the study, it is necessary to include multiple environmental effect categories when assessing sustainability.
- Ashok, A., C. Rajesh, and R. Ranjith. "Biodegradable polymers for sustainable packaging applications: a review." *IJBB* 1, no. 11 (2016). This study was conducted to suggest the need for alternative packaging materials derived from renewable resources. It focused on showcasing comparable properties of these materials to those of conventional plastics.
- Qasim, Umair, Ahmed I. Osman, Ala'A. H. Al-Muhtaseb, Charlie Farrell, Mohammed Al-Abri, Muzaffar Ali, Dai-Viet N. Vo, Farrukh Jamil, and David W. Rooney. "Renewable cellulosic nanocomposites for food packaging to avoid fossil fuel plastic pollution: a review." *Environmental Chemistry Letters* 19, no. 1 (2021): 613-641. The study indicates the utilization of nanocomposites comprised of abundant and biodegradable fillers and polymers has opened new avenues for both academia and industry to make sustainable products that could replace conventional synthetic materials causing environmental pollution.
- Shah, Ananya, and Manan Shah. "Characterisation and bioremediation of wastewater: a review exploring bioremediation as a sustainable technique for

pharmaceutical wastewater." *Groundwater for Sustainable Development* 11 (2020): 100383. The objective of this review was to characterize the PIWW and to compare the various methods of treatment with a focus on the Bioremediation techniques-its emergence and the current trends.

- Morashti, J.A.; An, Y.; Jang, H. A Systematic Literature Review of Sustainable Packaging in Supply Chain Management. *Sustainability* 2022, 14, 4921. <https://doi.org/10.3390/su14094921>The systematic literature review was conducted by utilizing data mining tools to systematically grasp research trends for future research agenda in sustainable packaging in supply chain management.
- Monkhouse C, Bowyer C, Farmer A. PACKAGING FOR SUSTAINABILITY: Packaging in the context of the product, supply chain, and consumer needs. IEEP Report for INCPEN. 2004 Sep 27. This study has demonstrated the fact that different solutions will apply to different situations. One type of packaging cannot be advocated as being the best environmental option in all scenarios. A case-by-case approach needs to be taken to ensure that in each instance the environmental impacts of packaging use are minimized.
- Owusu-Bio, Matilda Kokui, Abdul Sameed Muntaka, and Frank Osei Bonsu. "An investigation into sustainable product packaging practices and performance in the pharmaceutical industry in Ghana." *International Journal of Development and Sustainability* 5, no. 9 (2016): 433-445. The purpose of this study was to examine the performance of the Ghanaian pharmaceutical industry's sustainable product packaging methods. Investigating the degree to which stakeholders in the pharmaceutical sector are aware of and follow environmental sustainability criteria was the study's first explicit goal. The study's conclusions showed that companies at the manufacturing level have policies governing their operations and how they package their products so as to not have significant adverse effects on the environment.
- Patil, M.S.S. and Nitave, S.A., 2020. RECENT TRENDS AND FUTURE OF PHARMACEUTICAL PACKAGING TECHNOLOGY. Although very few pharmaceutical companies are currently spending time and money on packaging

research and development, the study has revealed a comprehensive approach to packaging that extends beyond the practical component of packaging. Since the packaging of pharmaceutical items affects their durability, acceptance by patients, transportation, etc.

- Mittal, S., Wadhwani, B. and Lakhani, M., 2021. Innovations in Pharma Packaging Technologies. *Journal of Young Pharmacists*, 13(3) This study demonstrates how closely related the packaging business is to the production of pharmaceuticals, demonstrating the need for it to implement moral and rational practices in its production. This is only possible if the needs of the product, as well as its price, security, and user-friendliness, are taken into account when creating a brand identity.
- Sabee, M.M.S.M., Uyen, N.T.T., Ahmad, N., and Hamid, Z.A.A., 2021. *Plastics Packaging for Pharmaceutical Products*. This study shows that plastic is still the choice of many pharmaceutical manufacturing organizations. Its strength, durability, flexibility, biocompatibility, and toughness are essential for a wide range of pharmaceutical products.

CHAPTER 4: OBJECTIVES

- To study the integrative view of packaging in pharmaceutical industries to corroborate the true sustainability of pharmaceutical packaging.
- To study the new solutions for sustainable packaging.

CHAPTER 5: RESEARCH QUESTION

Evaluate the pharmaceutical manufacturing units to study the importance of sustainable packaging and its existence in the pharmaceutical companies.

CHAPTER 6: METHODOLOGY

Sample Design: The respondents to the study were from the pharmaceutical manufacturing units, particularly from the packaging department, and it used a quantitative research methodology. Data was gathered from pharmaceutical production facilities across all India.

Data collection method: A standard questionnaire that was distributed to packaging personnel and those employed by manufacturing facilities was used to gather the quantitative data. I have reached out to folks who work in the packaging and pharmaceutical production departments. Some of them I have met through referrals, and I have done so through LinkedIn. I've conducted in-person interviews with two people who work in the pharmaceutical manufacturing unit in addition to those I've already met. I've started distributing google forms for the second survey procedure, and the questions were created as multiple-choice and Likert scale questions.

Sample size: In order to find out about issues and get an explanation on the issue, I gathered data from 33 manufacturing units across most of India.

Analysis: Analysis was done by using Microsoft Excel.

Data collection tool: Questionnaire.

Exclusion and Inclusion criteria: All the respondents were from the pharmaceutical manufacturing industry.

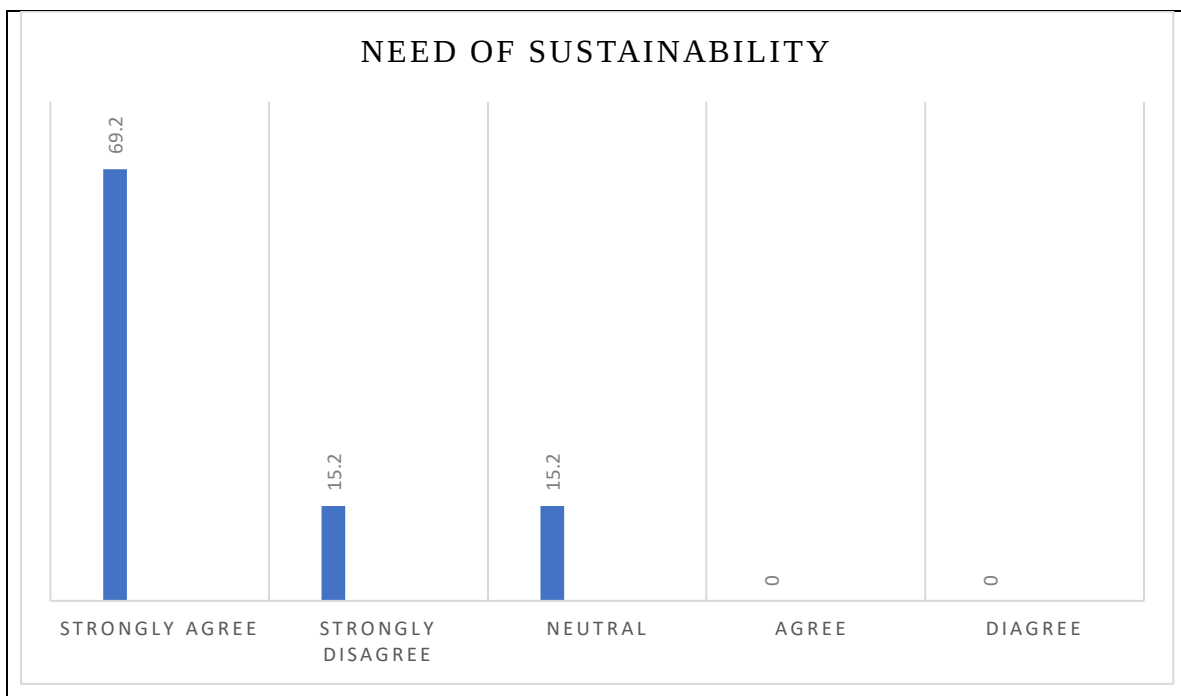
Study area: Pan India

CHAPTER 7: RESULT AND DISCUSSION

1. Needs of sustainable packaging

According to the secondary data, I found that among the responses 69.7 % of manufacturing units agreed that sustainable packaging in the pharmaceutical manufacturing industry is required. And 15.2% disagreed with sustainable packaging and 15.2% were neutral toward sustainable packaging.

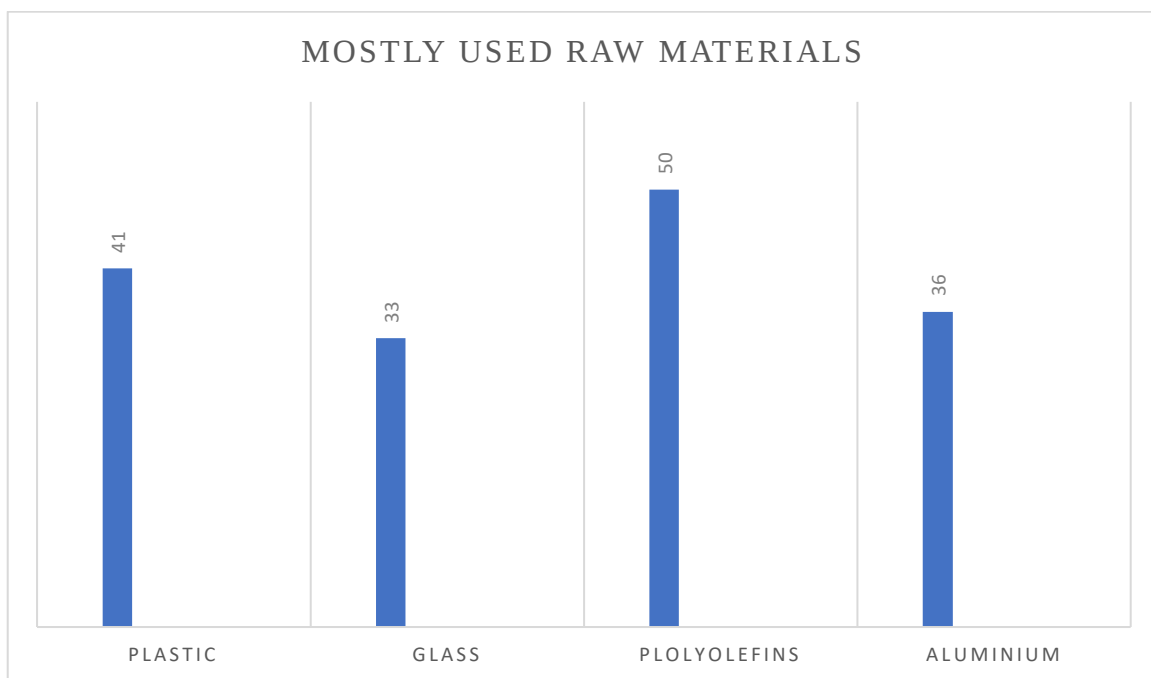
Figure 1: Shows the data on the need for sustainability in manufacturing units



2. Raw Materials used for the packaging

According to the secondary data from the manufacturing units, it was found that 80% of the packaging of medicines is made use of plastics (PET, PVC, PP, etc.). About 41% of manufacturers relied entirely on plastics for packaging and almost 42% used them occasionally. Glass was used by 33% of the manufacturers. It is seen that glass is used less frequently as compared to plastics for packaging. Polyolefins are used up to 50% of the time, and Aluminium finds applications roughly 36% of the time

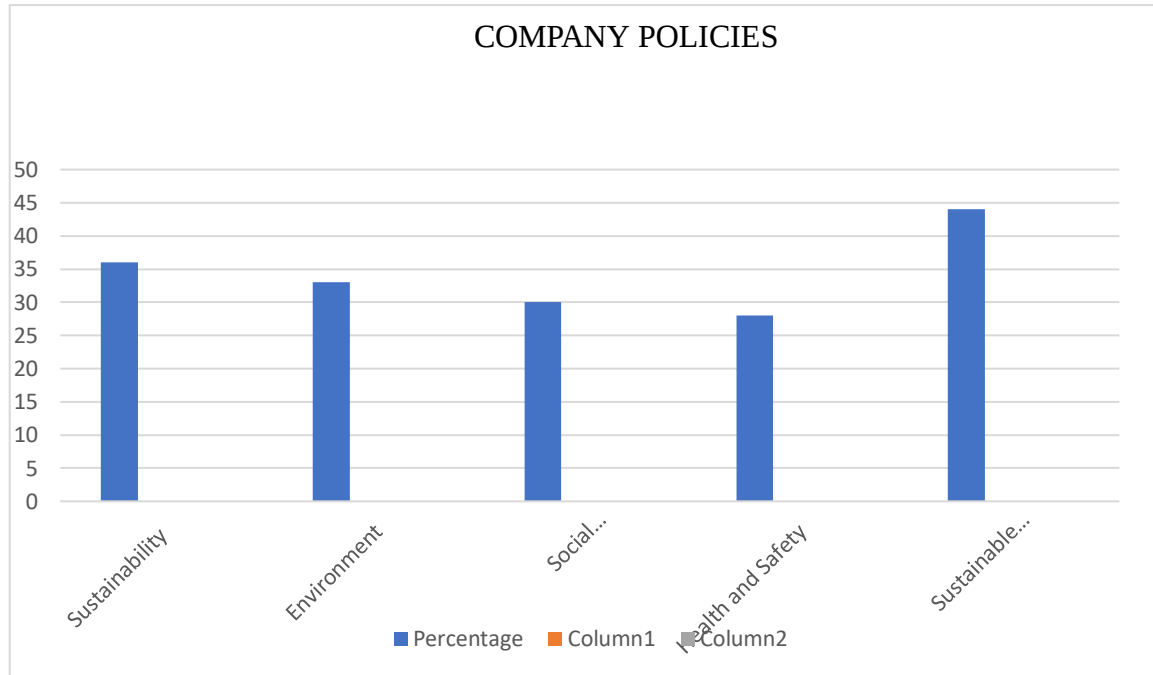
Figure 2: Shows the data of mostly used raw materials in manufacturing units



3. Company Policies

As per the secondary data, it was noted that 36% of pharmaceutical manufacturing units focused on sustainable policies. About 33% of these units cared for the environment, and 28% prioritized health and safety.

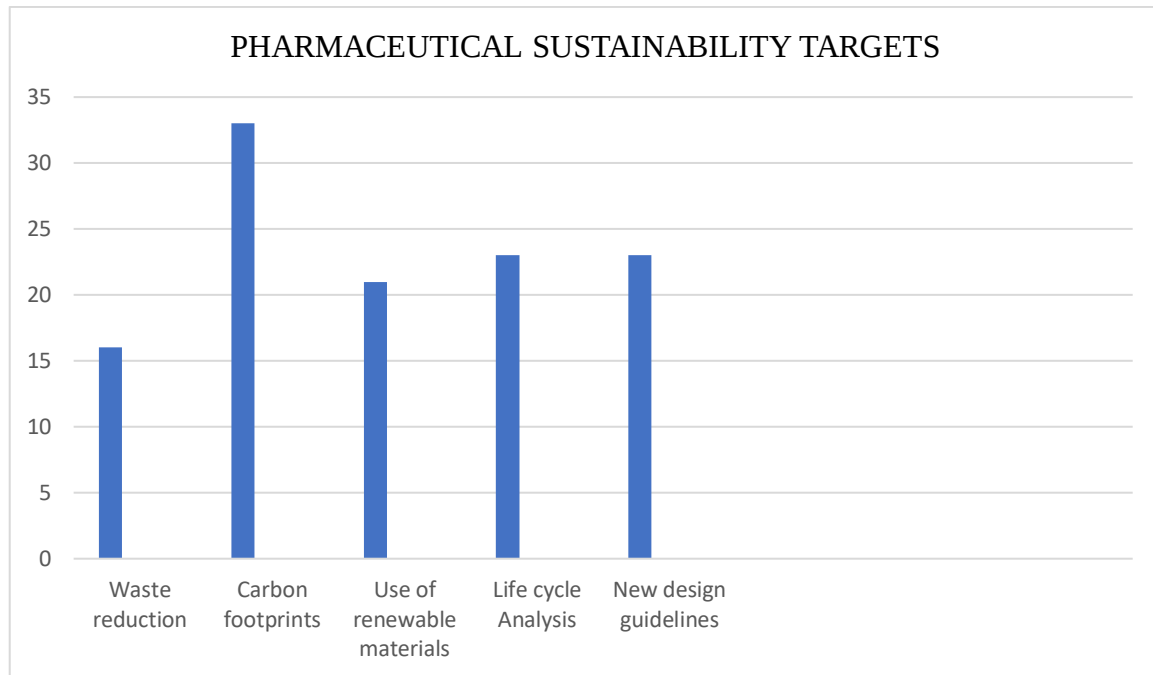
Figure 3: Shows the data of company policies in the companies



4. Pharmaceuticals sustainability targets

From secondary data, it was observed that 16% of manufacturing units focused on waste reduction. Approximately 33% of these units worked towards reduced carbon footprints. There was a sizable share of 21% who focused on the use of recyclable materials. Up to 23% of the units focused on new design guidelines for packaging and life cycle analysis each.

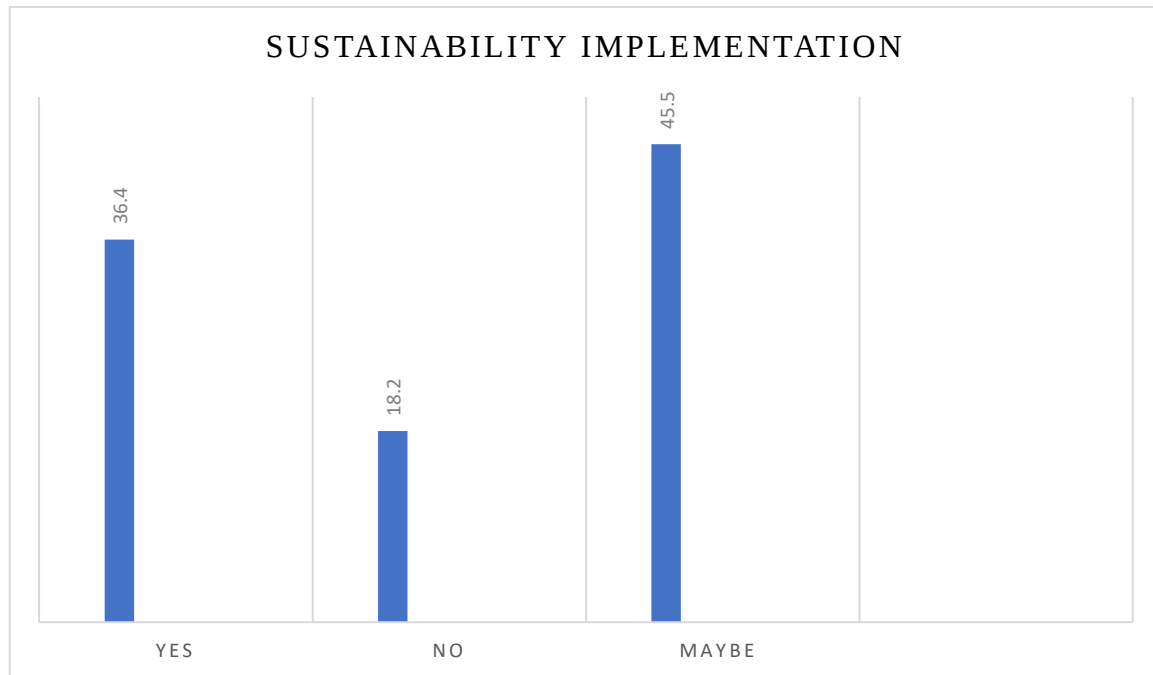
Figure 4: Shows the data of sustainability targets in the companies



5. Implementation of sustainability in manufacturing and supply chain

Through the data, about 36.4% were found to be unsure about the applications of sustainable packaging in their field. There are 45.5% of units working towards sustainability whereas about 18.2% have denied its implementation.

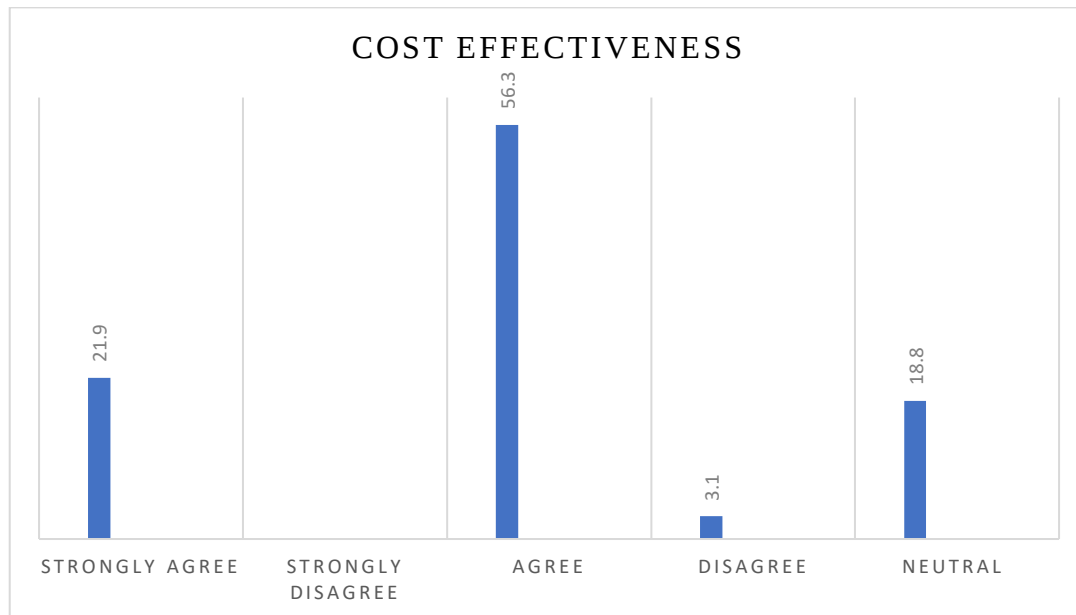
Figure 5: Shows the data of sustainability implementation in the manufacturing units



6. Sustainable packaging cost-effective

As per the data, 56.3% of respondents have agreed that it must be cost-effective, but its applications and implementation are still under the R&D phase. Cost-effectiveness was a major concern for about 21.9% of manufacturing units who strongly agreed about the same, while 18.8% were still unsure and 3.1% disagreed with the idea. They believed that sustainable packaging would be expensive as compared to conventional packaging.

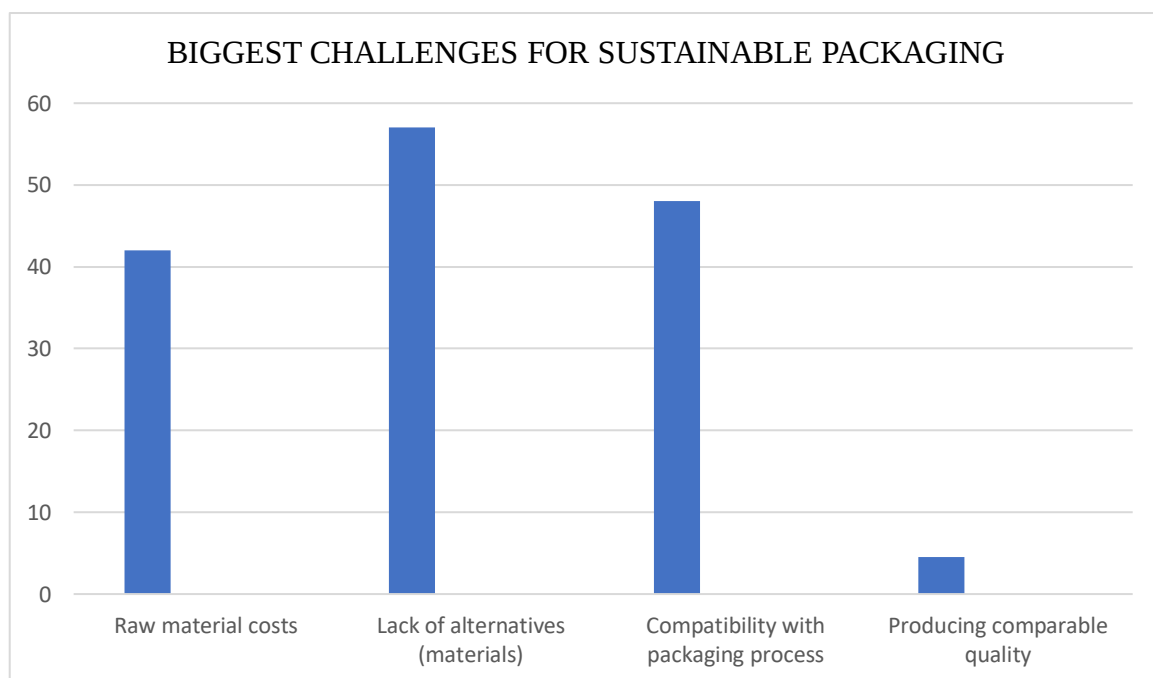
Figure 6: Shows the data of sustainable packaging cost effectiveness



7. Biggest challenges for Sustainable Packaging

As per the data, 57% of pharmaceutical face the problem of a lack of alternatives materials for the packaging and 42% of units face the challenge of costs of raw materials and 48% of challenging the compatibility with the packaging process, and 36% of units not able to produce comparable quality products.

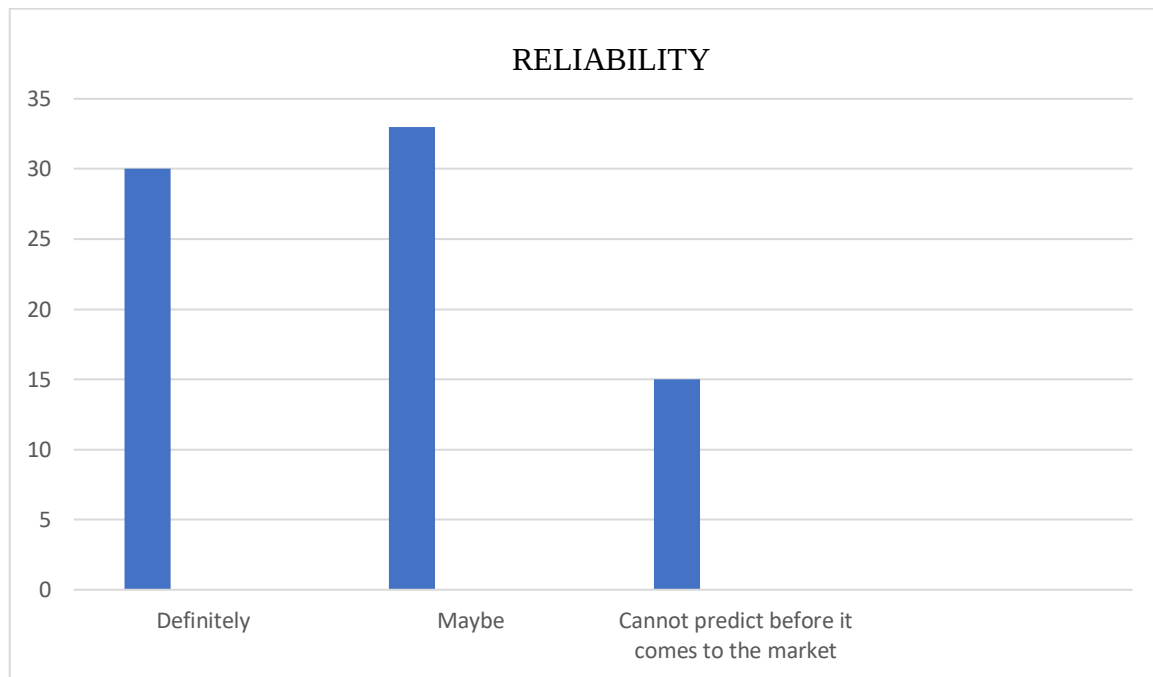
Figure 7: Shows the data of challenges for sustainable packaging



8. Sustainable packaging is reliable as compared to Conventional packaging

About 30% of units believe that sustainable packaging will be reliable. However, 33% are unsure whereas 15% can't predict until and unless it is confirmed, and the related studies give better results regarding sustainable packaging.

Figure 8: Shows the data comparison between sustainable packaging and conventional packaging



CHAPTER 8: CONCLUSION

Sustainability in packaging is crucial for all businesses. The significance of sustainability for pharmaceutical production facilities is the main topic of this study. One of the biggest and currently the most significant industries in the world is pharmaceuticals. If sustainability is accomplished in this area, it might have significant environmental implications.

According to secondary statistics, the pharmaceutical business cannot currently function sustainably on its own. It would require a step-by-step process to accomplish. The best course of action would be to find suitable alternatives and strike a balance between several factors like cost, compatibility, simplicity of refusal, etc. The information we have gathered leads us to the conclusion that industrial facilities depend on traditional packaging materials because of their dependability and compatibility. Sustainable packaging may one day be dependable, according to numerous industrial businesses. In contrast to this 30%, 48% of people say they can't forecast unless sufficient research has been done that is tailored to their particular products.

Even though all of these goods belong under the category of "Pharmaceuticals," each one has a unique composition that will be taken into consideration when deciding on the best alternative packaging material. Because of this, further research is required to create sustainable packaging materials. Once that is accomplished, plastics can be gradually phased out in order to transition to sustainability in the long run. The conventional packaging industry is predicted to reach USD 178.1 billion by 2026 at a CAGR of 10.4% until then.

REFERENCES

- Ding, B. (2018). Pharma Industry 4.0: Research opportunities in sustainable pharmaceutical supply chains. *Process Safety and Environmental Protection*, 119, 115-130.
- Saha, T., Hoque, M. E., & Mahbub, T. (2020). Biopolymers for sustainable packaging in food, cosmetics, and pharmaceuticals. In *Advanced Processing, Properties, and Applications of Starch and Other Bio-Based Polymers* (pp. 197-214). Elsevier.
- Khalil, H. A., Davoudpour, Y., Saurabh, C. K., Hossain, M. S., Adnan, A. S., Dungani, R., ... & Haafiz, M. K. M. (2016). A review on nano cellulosic fibres as new material for sustainable packaging: Process and applications. *Renewable and Sustainable Energy Reviews*, 64, 823-836.
- Raju, G., Sarkar, P., Singla, E., Singh, H., & Sharma, R. K. (2016). Comparison of environmental sustainability of pharmaceutical packaging. *Perspectives in Science*, 8, 683-685.
- Mahalik, N. P., & Nambiar, A. N. (2010). Trends in food packaging and manufacturing systems and technology. *Trends in food science & technology*, 21(3), 117-128.
- Singh, A., Sharma, P. K., & Malviya, R. (2011). Eco-friendly pharmaceutical packaging material. *World Applied Sciences Journal*, 14(11), 1703-1716.
- Pareek, V. I. K. A. S., & Khunteta, A. (2014). Pharmaceutical packaging: current trends and future. *Int J Pharm Sci*, 6(6), 480-485.
- Lorenzini, G. C., Mostaghel, R., & Hellström, D. (2018). Drivers of pharmaceutical packaging innovation: A customer-supplier relationship case study. *Journal of Business Research*, 88, 363-370.
- Salmenperä, H., Kauppi, S., Dahlbo, H., & Fjäder, P. (2022). Increasing the Circularity of Packaging along Pharmaceuticals Value Chain. *Sustainability*, 14(8), 4715.
- Sharma, R. K., Sarkar, P., & Singh, H. (2020). Assessing the sustainability of a manufacturing process using life cycle assessment technique—a case of an Indian pharmaceutical company. *Clean Technologies and Environmental Policy*, 22(6), 1269-1284.
- Meherishi, L., Narayana, S. A., & Ranjani, K. S. (2019). Sustainable packaging for supply chain management in the circular economy: A review. *Journal of cleaner production*, 237, 117582.
- Milanesi, M., Runfola, A., & Guercini, S. (2020). Pharmaceutical industry riding the wave of sustainability: Review and opportunities for future research. *Journal of cleaner production*, 261, 121204.

- Kumar, S., & Gupta, S. K. (2012). Applications of biodegradable pharmaceutical packaging materials: a review. *Middle East Journal of Scientific Research*, 12(5), 699-706.
- de Oliveira, D. P., Costa, J. S. R., & Oliveira-Nascimento, L. (2021). Sustainability of blisters for medicines in tablet form. *Sustainable Chemistry and Pharmacy*, 21, 100423.
- Srivastava, V., Singh, S., & Das, D. (2021, September). Biodegradable Fibre-Based Composites as Alternative Materials for Sustainable Packaging Design. In *Proceedings of the International Conference on Sustainable Design and Manufacturing* (pp. 87-98). Springer, Singapore.
- Smale, E. M., Egberts, T. C., Heerdink, E. R., van den Bemt, B. J., & Bekke, C. L. (2021). Waste-minimizing measures to achieve sustainable supply and use of medication. *Sustainable Chemistry and Pharmacy*, 20, 100400.
- Mondal, S. (2020). Nanocellulose reinforced polymer nanocomposites for sustainable packaging of foods, cosmetics, and pharmaceuticals. In *Sustainable nanocellulose and nanohydrogels from natural sources* (pp. 237-253). Elsevier.
- Rajesh, P., & Subhashini, V. (2021). Sustainable packaging from waste material: A review on innovative solutions for a cleaner environment. *Bioremediation and Green Technologies*, 259-270.
- García González, A. (2020). Exploring The Effects of Plastic-Free Packaging in The Pharmaceutical Industry.
- Ashok, A., Rejeesh, C., & Renjith, R. (2016). Biodegradable polymers for sustainable packaging applications: a review. *IJBB*, 1(11).
- Mittal, S., Wadhvani, B., & Lakhani, M. (2021). Innovations in Pharma Packaging Technologies. *Journal of Young Pharmacists*, 13(3), 197.
- Negash, Y. T., Sarmiento, L. S. C., Tseng, M. L., Jantarakolica, K., & Tan, K. (2021). Sustainable product-service system hierarchical framework under uncertainties: The pharmaceutical industry in Ecuador. *Journal of Cleaner Production*, 294, 126188.

Dissertation Project: Sustainable Packaging in Pharmaceutical Production Units

Sustainable Packaging in Pharmaceutical Production Units:

Sustainable packaging materials are those used to wrap pharmaceutical products in any dose form while still being safe for the environment. They may come from naturally occurring substances like carbohydrates, proteins, etc. that cause little to no harm to the ecosystem and the animals that rely on it. This research emphasizes environmentally friendly materials, their categorization, applications, and benefits before summarizing the extent and anticipated future requirements for pharmaceutical packaging. Based on their functions, chemical makeup, and the type of raw material utilized in their production, various classifications have been made. This review discusses all of the aforementioned factors as well as the pharmaceutical industry's role in the creation of such sustainable packaging.

Therefore, the survey's goal is to learn how pharmaceutical production facilities are using sustainable packaging in their facilities and how they are putting new alternative solutions into practice.

* Required

Email *

1. What is the name of your organization?

2. Do you agree that environmental sustainability is important in a packaging?

Mark only one oval.

☐ Strongly

☐ disagree

☐ Neutral

☐ Strongly

agree

3. For Packaging which raw material is mostly used in your production unit (1=
* Never Use,2= Almost Never,3= Occasionally/Sometimes,4= Almost every
time,5=Frequently use

Mark only one oval per row.

	1	2	3	4	5
Plastic					
Glass					
Polyolefins	☐	☐	☐	☐	☐
Aluminum	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐

4. Do you have an alternative raw material for the packaging purpose that has no * harmful
effect on the environment?

Mark only one oval per row.

	Never	Once	Twice	Always
Starch				
Xylan				
Cellulose	☐	☐	☐	☐
	☐	☐	☐	☐
Chitin/Chitosan	☐	☐	☐	☐

5. Which type of biodegradable plastic is used for packaging in your
*production?

Mark only one oval per row.

	☒ rarely used	☒ Frequently used	☒ Mostly used
Oxo-- Biodegradable	☐	☐	☐
Hydro-- Biodegradable			

6. Does your company have policies? (1=Not important at all ,2= Of little * importance,3 = Of average importance, 4= very important ,5= Essential)

Mark only one oval per row.

	1	2	3	4	5
Sustainability	☐	☐	☐	☐	☐
Environment					
Social responsibility					
Health and Safety	☐	☐	☐	☐	☐
Sustainable procurement /Purchasing	☐	☐	☐	☐	☐

- 7.If a company has specific sustainability targets, what is its focus? *

(0 - Not important ,1- Important, 2- Very Important, 3- Extremely Important

Mark only one oval per row.

	0	1	2	3
Waste reduction	☐	☐	☐	☐

Carbon footprints

Use of recyclable
materials

Life cycle Analysis
New design guidelines

8. What criteria does your company use to evaluate sustainable packaging?

Mark only one oval per row.

Column 1

☐

Recycled Content

☐

Energy Consumption

☐

Toxic or harmful ~~Conts~~

Social Implications Water
Consumption

Greenhouse gas
emissions

☐☐

9. Which factors have the most influence on your company's sustainability activities in the packaging industry?

Mark only one oval per row.

Column 1

☐

-- Consumer/Market
demands

- Pricing Pressure ☐

- Retailer/Brand owner requirement ☐

- Regulatory requirements ☐
- Competitive pressure ☐

- Investor pressure ☐

- Increased media attention

10. What are the benefits of sustainable packaging according to you?

Mark only one oval per row.

Column 1

Reduced carbon footprint

☐

More storage and more space with

☐

green packaging

Packaging is free off allergens and toxins

☐☐

Reduced wastage

☐

Increased sales

☐

Saved money with ecofriendly packaging

11. Regulation in pharma and manufacturing act as barrier for implementing new sustainability measure.

Mark only one oval.

☐ Strongly

☐ disagreeDisagree

☐ Neutra

☐☐

IAgree

Strongly agree

12. Have you started implementing changes across your manufacturing line or supply chain to improve sustainability?

Mark only one oval.

☐ Yes

☐ No

☐ May be

13. The consumers want environmentally friendly packaging in addition to eco-friendly products. Do you agree with the statement?

Mark only one oval.

- ☐ Strongly
☐ disagreeDisagree
☐ Neutra
☐ lAgree
☐ Strongly agree

14. Which type of plastic packaging that can be easy to start

***degrade/decompose**

Mark only one oval per row.

	2-4 months	5-6 months	8-10 months	10-12 months
Oxo Biodegradable	☐	☐	☐	☐
Hydro Biodegradable	☐	☐	☐	☐

15. Which non-Plastic environmentally friendly packaging material is on
***demand?**

Mark only one oval per row.

	lowdemand	highdemand	extremely low	extremely high
Glass	☐	☐	☐	☐

Metals				
Aluminum	☐	☐	☐	☐
Polyesters	☐	☐	☐	☐
	☐	☐	☐	☐

16. Do you agree? the sustainable packaging is not only the cost effective for the consumers and manufacturers, but it also helps to ensure a cleaner environment for the future generations!

Mark only one oval.

- ☐ Strongly
☐ disagreeDisagree
☐ Neutra
☐ lAgree
☐ Strongly agree

17. What do you think are the biggest challenges to making your current packaging process more sustainable?

Mark only one oval per row.

Column 1

☐

– Raw materials costs

☐

– Lack off alternatives
((materials))

– Compatibility with

☐

packaging process

☐

– Producing comparable
quality

18. What are the different ways does your organization to implement sustainable practices in pharmaceutical packaging?

Mark only one oval per row.

Column 1

Sustainability plan	☐
Use ecofriendly materials	☐
Invest in clean technologies	☐

19. What are the basic needs for the development of ecofriendly pharmaceutical packaging material?

Mark only one oval per row.

Column 1

Reduction off the quantity off packaging material	☐
Recycling off pharmaceutical	☐

packaging material

Elimination off

contaminating

packaging

20.What new innovations mostly does pharmaceutical implementing for the sustainable packaging or towards sustainable packaging? (1= Not,2= Definitely,3= Possibly, 4= Probably not,5= Very Probably)

Mark only one oval per row.

	1	2	3	4	5
Build waste reduction into product development	☐	☐	☐	☐	☐
Invest in energy and utility saving solutions	☐	☐	☐	☐	☐
Alternative packaging materials to reduce plastic pollution	☐	☐	☐	☐	☐
Consumer behavior and demand for packaging sustainability	☐	☐	☐	☐	☐

21. Do you think sustainable packaging will be reliable as current conventional packaging?

Mark only one oval per row.

Column 1

Definitely

☐

May be

☐

Cannot predict before it
comes to the market

22. Would you like to give any suggestions regarding sustainable packaging? *

[illegible]

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