



**ALTERNATIVE DESIGN FOR CUSHION PACKAGING BY
APPLYING ALGINATE MATERIAL**

BY

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**AN INDEPENDENT STUDY SUBMITTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
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**SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY
THAMMASAT UNIVERSITY**

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INDEPENDENT STUDY

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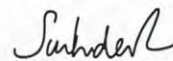
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ALTERNATIVE DESIGN FOR CUSHION PACKAGING BY APPLYING ALGINATE
MATERIAL

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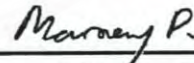
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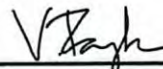
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ABSTRACT

Protective packaging, in general, does not perform well in terms of performance and sustainability. Either the packaging makes too many concessions to unsustainable materials in the name of protection, or its sustainability credentials are strong but its protective components are not. With the rise of e-commerce, the use of protective packaging is increasing, exacerbating these issues. End users are seeing more protective packaging than ever before and are constantly inconvenienced when goods are broken or when packaging content must be disposed of. It is essential to develop novel protective packaging strategies that work optimally over a wide variety of factors. These have to let to my research, the study will be proposing to apply alginate to be material for new design of protective packaging. The research will be conducted into options to design sustainable cushioning packaging by design usefulness equation for compare alginate with existing material and review article is to render a presentation on the advances of alginate which can be apply to design protective packaging in the future. To address this shortcoming, I propose to apply alginate to be material for new design of protective packaging. First, I study from existing product and cushioning material. Next, I study about properties of Alginate. Then, design usefulness equation for

(2)

compare alginate with existing material. Lastly, review article is to render a presentation on the advances of alginate which can be apply to design protective packaging in the future.

Keywords: Packaging design, Protective packaging, Sustainable packaging design, Cushioning package design, Alginate



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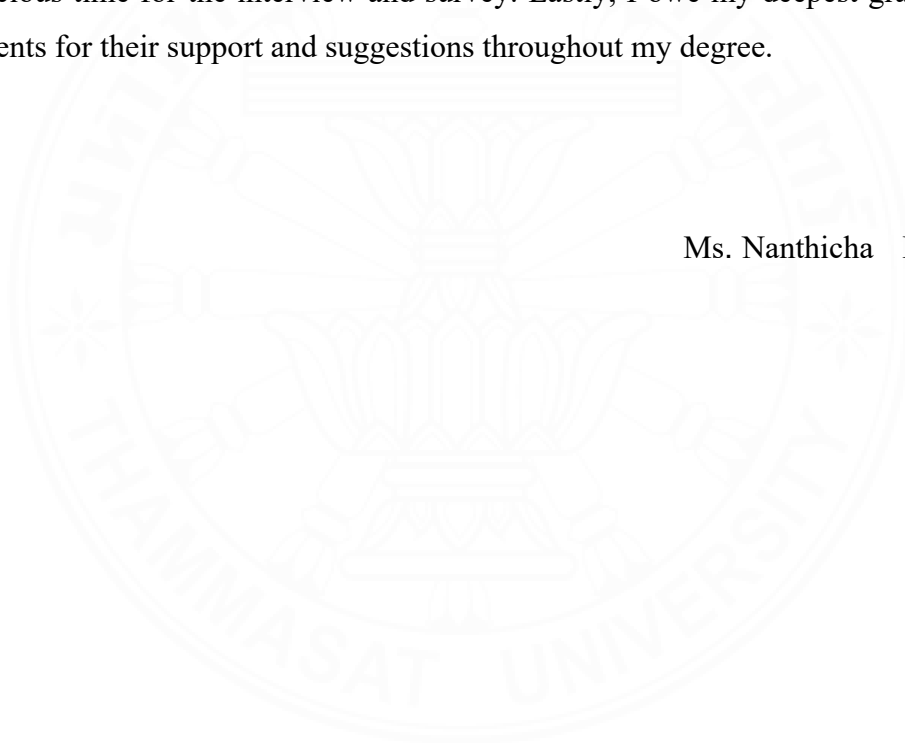


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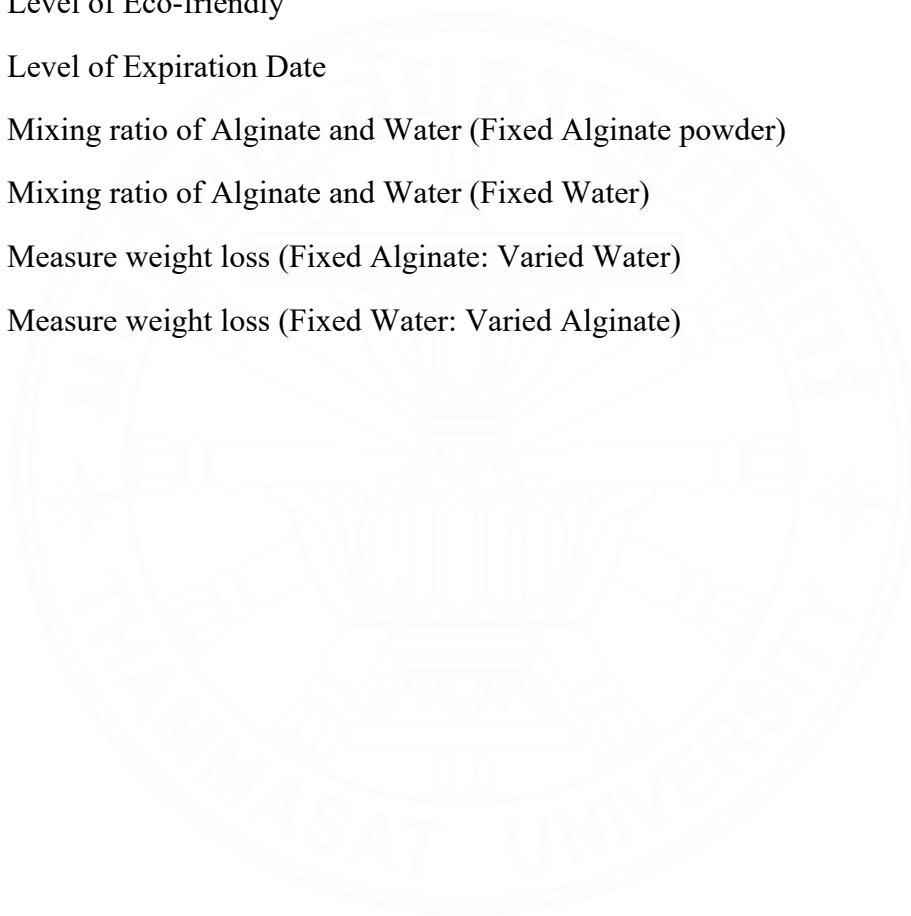
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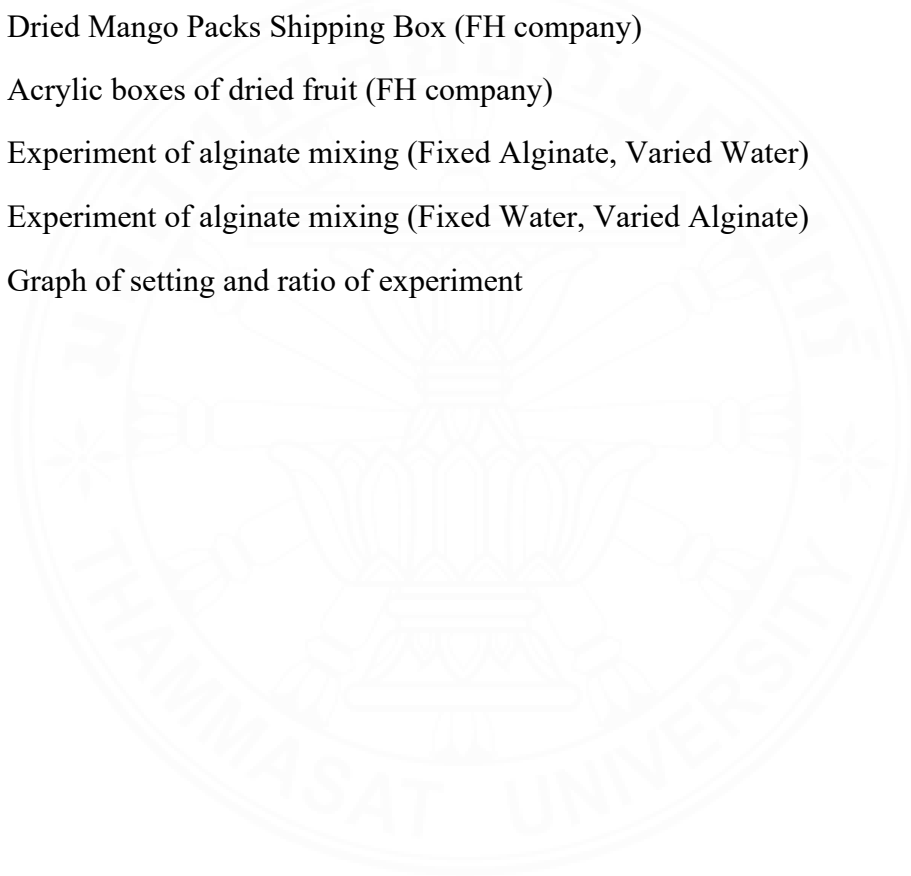
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CHAPTER 1

INTRODUCTION

Presented in this chapter is the introduction of alginate in terms of material packaging to ensure that products are environmental and economic efficiency. Protective packaging should protect the product during transportation while still meeting a variety of other sustainability criteria; however, this type of packaging often fails to meet both performance and broader sustainability criteria.

, which can be categorized in six portions which are 1) Introduction, 2) Problem Statement, 3) Research Objectives, 4) Addressed Issues, 5) Research scope and Limitations.

1.1 Introduction

In 2020, 84 percent of customers will continuously buy online, according to a Shopify worldwide assessment of eleven markets. Given the state of retail over the last year, this is not a shocking finding. The breakdown of that proportion, on the other hand, is fascinating. We are now living in a time when all demographics are accustomed to purchasing online. It is very improbable that dependence on online shopping would be reversed at a time when customer demand for speed and convenience is stronger than ever, with 70% of buyers stating speed and convenience to be their top priorities.

With the increase in the quantity of delivered items, more shipments are passing via cross-border logistics networks. As they pass through, the number of touchpoints grows, as does the danger of harming items and packaging. However, the e-commerce process might add an infinite number of stops along the purchaser's trip. The 'final mile' of the route can then be handled in a variety of ways by delivery firms, who can pass goods and packaging from one delivery person and location to the next. Brands who do not have a strong protective packaging solution are risking the potential presented by e-commerce.

Protective packaging, in general, does not perform well in terms of performance and sustainability. Either the packaging makes too many concessions to unsustainable materials in the name of protection, or its sustainability credentials are strong but its

protective components are not. Furthermore, according to DHL, more than 24% of e-commerce packaging is empty space. Because of consumer knowledge of plastic pollution and excessive waste, the existing packaging paradigm is neither ecologically nor financially viable.

Plastics are now utilized in excess of 300 million tonnes per year across the world, with an alarming yearly growth rate. As a result, plastic packaging is dumped into the environment, and the trash problem grows year after year. The usage of bio-based polymer packaging materials is a viable option. The findings support the use of natural materials based on biopolymers and, implicitly, sodium alginate, with or without additional natural additives, to replace plastic packaging. Natural materials have risen to prominence as the packaging of the future.

1.2 Problem Statement

Nowadays, concerns about the influence of industrial sectors on the environment have prompted a quest for sustainable solutions for both material production and processing. Plastic waste contamination is one of the most serious issues, as these materials are both biocompatible and extremely resistant to deterioration. Bio-based polymers are utilized to replace non-renewable plastics with readily available, sustainable, and locally sourced alternatives (Wool & Sun, 2005).

In 2019, Amazon's e-commerce platform produced 465 million pounds of plastic packaging trash. Every 70 minutes, the equivalent of a delivery van's worth of plastic is thrown into major rivers, lakes, and seas. It claimed that the quantity of air pillows alone could circle the globe 500 times. Every year, around 3 billion trees are pulped to make paper-based packaging. Each year, less than 14 percent of all plastic packaging manufactured in the world gets recycled. The great majority gets disposed of in landfills, incinerators, or is allowed to contaminate streams and harm wildlife. It has the ability to survive in the environment for hundreds of years.

Protective packaging is needed to ensure the safe and reliable transportation of products. However, there are trade-offs in terms of environmental and economic efficiency. Protective packaging can preserve the product while simultaneously satisfying a number of other environmental criteria; however, this style of packaging

does not necessarily work well in terms of both durability and overall sustainability. Reflecting the predominant necessity to secure the product, protective packaging often depends on an unnecessary quantity of plastic or the use of bulky material, the use of material that is not readily recyclable, or the use of material derived from unsustainable materials, both of which have negative environmental implications. With the rise of e-commerce, the use of protective packaging is increasing, exacerbating these issues. End users are seeing more protective packaging than ever before and are constantly inconvenienced when goods are broken or when packaging content must be disposed of. It is essential to develop novel protective packaging strategies that work optimally over a wide variety of factors. These have to let to my research, the study will be proposing to apply alginate to be material for new design of protective packaging. The research will be conducted into options to design sustainable cushioning packaging by design usefulness equation for compare alginate with existing material and review article is to render a presentation on the advances of alginate which can be apply to design protective packaging in the future.

1.3 Objective

Objectives of this project are listed below:

- To introduce alginate as alternative material for cushion packaging .
- To apply usefulness concept to cushion packaging.

1.4 Addressed Issues

In this research, there are many factors to achieve the objective of the project that leads to review article is to give a presentation on the properties of alginate and apply it to new materials for cushioning packaging. It is important to consider of pollution and unnecessary waste; the existing packaging paradigm is neither ecologically nor financially viable.

However, litter is a big source of concern for many people. Food and beverage containers, which are thrown away, are the third most common type of litter. Packaging

is the source of the most trash, trailing only cigarettes and food. Packaging that is excessive and wasteful can contribute to air pollution in a variety of ways. Another source of air pollution from packaging is landfills. Birdlife Worryingly, plastic kills approximately one million seabirds each year. Unfortunately, the abundance of plastic in the environment is having a serious and negative influence on avian life. Because of the amount of plastic trash in the oceans, plastic waste is now discovered in over 90% of seabirds. In terms of landfill space, the UK generated 9.3 million tonnes of packaging trash in 2017. Water pollution, packaging manufacture may consume a lot of water while also polluting it. Not just water bottles consume a lot of water; various package production processes use a lot of water as well, squandering valuable water resources. Plastic pellets used in packaging might potentially have an impact on water quality. Toxic chemicals are released by the pellets and can seep into the water. Species extinction and landfills are the outcome of excessive wasteful packing and may be extremely hazardous to the environment. Landfills not only emit enormous amounts of methane and other harmful compounds, which contribute to global warming, but they also cause species extinction.

For the exiting cushioning packaging consist with bubble, air pillows, cellular sheeting, loose-fill materials, various paper forms, foam plastic cushions, and plastic films. It performs poorly in terms of performance and sustainability. Either the packaging makes too many concessions to unsustainable materials in the name of protection, or its sustainability credentials are strong but its protective components are not.

1.5 Research Scopes and Limitations

In this research, there are several scopes and limitations have been concerned to complete the research objective in order to review article is to make a presentation on the advances in alginate that can be applied to designing protective packaging in the future and use usefulness equation to compare alginate with the existing material. The. Therefore, the scopes of this study are described as follow:

1. Compare data of existing product in area of environmentally safe.

2. Design usefulness equation and table to find better material to solve the problem.



CHAPTER 2

REVIEW OF LITERATURE

2.1 Literature review

Expanded paper cushioning material and plastic cushioning material are the 2 most popular cushioning materials used for durable packaging. Since methods and cushion curves for studying the frequency response function (FRF) are highly advanced, methods for designing vibration damping packaging and shock-absorbing for expanded plastic are widely used (Q Zhang et al., 2017). Experiment to Compare Cushion Performance, for example. It was recommended that the conventional cushion curve for corner foam be moved toward higher static loading by approximately 23–35 percent in order to equal the cushion curves of corner foam and flat foam (with shear force). (Changfeng Ge & Haoqi Huang, 2015). To investigate how velocity configurations and various peak acceleration affect repetitive shock induced product damage due to cumulative fatigue. (Hiroaki Kitazawa et al., 2014). A damping design that integrates shock absorption with vibration damping packaging was developed and a multibody dynamic simulation was used to study the vibration reaction of the packaging. (Zhang Q, Saito K & Nagaoka K., 2016).

The majority of plastic eCommerce packaging, such as envelopes, protective covers, and bubble wrap, is composed of polyethylene, the world's most prevalent plastic. Before reaching its ultimate form, oil or gas is subjected to a variety of industrial heating, cooling, chemical treatments, and moulding processes. And, while the production of plastic appears to be an expensive and difficult process, the scale of production results in massive amounts of low-cost material. In the EU, about 90% of plastic is generated from virgin fossil fuels, with just 9% made from recycled resources.

Trees are chopped down and converted into wood chips, which are then cooked in water or combined with chemicals to generate pulp. This pulp is then spread out and pressed on enormous flat screens, which removes the water and yields paper. To make cardboard, two flat layers of paper are bonded on either side of a corrugated sheet to give strength. A fully mature tree may produce enough paper to fill around 150 big

cardboard boxes. Globally, around 55% of all cardboard is still produced by chopping down trees, although the bulk of logging is now done in a regulated, renewable manner.

2.2 Cardboard packaging

The extraction and manufacturing of paper and board goods requires a large amount of energy. However, because manufacturers employ renewable energy sources such as biomass, biogas, and hydropower, the industry's global carbon impact is low, at approximately 1%. In many situations, waste materials from the paper and cardboard industries are used as fuel. According to the French Cardboard Association, 1 tonne of cardboard emits 538 kg of CO₂ over its whole life cycle, which includes purchase, transit, production, and disposal.

The majority of cardboard is recyclable. Corrugated cardboard and paperboard are the two most common forms of cardboard. According to the American Forest & Paper Association, Old Corrugated Cardboard/Containers (OCC) a recycling industry name referring to old corrugated cardboard achieved a staggering 96.4 percent recovery rate in 2018, the highest recycling percentage among paper goods. It should be noted that not all cardboard can be recycled. While old pizza boxes with oil stains or food leftovers are recyclable in theory, they should not be recycled. When cardboard arrives to a recycling plant, it goes through a procedure that permits it to be recycled into new cardboard and other paper goods. First, separate the cardboard from the other paper goods. After being separated, the cardboard is baled and sent to a mill where it is shredded into minute pieces. Some of the brown paper may be stacked and reused to produce thicker cardboard, while the rest is recycled into various paper goods. Waste paper deinking agent and other waste paper recycling chemicals, such as dissociation accelerator, fluorescence quencher, bacteria sludge control agent and resin control agent, etc

2.3 Plastic packaging

Plastic production contributes for 3.8 percent of worldwide greenhouse gas emissions, about twice that of the whole aviation sector. If the plastics industry were a country, it would be the fifth greatest producer of greenhouse gases in the world. Plastic is produced in a more efficient method that uses approximately 40% less energy than cardboard while also creating less trash. On the surface, plastic packaging looks to have a smaller carbon footprint than cardboard packaging but also consider what happens before and after the plastic is manufactured. Plastic is largely derived from crude oil, which has a substantial carbon footprint due to the extraction, refining, and shipping requirements. Furthermore, the most majority of plastic is not recycled and instead ends up in landfills, rivers, or, in many cases, industrial incinerators.

Recycling is required since virtually all plastic is non-biodegradable and so accumulates in the environment, causing harm. Almost all recycling is now done by remelting and reforming wasted plastic into new goods, a process known as mechanical recycling. In a different technique known as feedstock recycling, discarded plastic is turned back into its starting ingredients, which may then be recycled into new plastic. This provides the prospect of more recycling but comes at a higher energy and capital expense. As part of energy recovery, waste plastic may also be burned in place of fossil fuels. It is the primary mode of plastic waste disposal in several nations, particularly if landfill diversion regulations are in place.

2.4 The disposal of plastic vs cardboard waste

While solid waste recycling rates have steadily grown, many of the goods we use and discard on a daily basis end up in places we wouldn't anticipate, such as an incinerator. In the EU, for example, below are the breakdowns for the disposal of plastic vs. cardboard trash: Plastic is recycled 40% of the time, disposed of in a landfill 30% of the time, and burnt 30% of the time. Cardboard is recycled 86% of the time, disposed of in a landfill 10% of the time, and burnt 7% of the time. Under the right conditions, cardboard decomposes faster than plastic and may completely disintegrate in about two months. Plastic, on the other hand, is expected to last between 400 and 1000 years.

Because widespread use of plastic began in the 1960s, this is merely an estimate. Despite the fact that cardboard decomposes quickly, it produces methane, one of the most major greenhouse gases, into the sky. Plastic degrades at such a slow rate that it emits almost no greenhouse gases.

2.5 Container and packaging products waste

Containers and packaging are defined by the EPA as goods that are anticipated to be discarded the same year the products they contain are acquired. Containers and packaging account for a significant percentage of municipal solid waste (MSW), accounting for 82.2 million tons generated in 2018. (28.1 percent of total generation). Packaging is a product that is used to wrap or protect commodities such as food, drinks, medicines, and cosmetics. Containers and packing are used in product shipment, storage, and protection.

Container and packaging materials, particularly corrugated boxes, are commonly recycled. The recycling percentage of produced packaging and containers was 53.9 percent in 2018. Furthermore, container and package combustion were 7.4 million tons (21.5 percent of total combustion with energy recovery) in 2018, while landfills received 30.5 million tons (20.9 percent of total landfilling).

MSW packaging and containers goods are manufactured from a variety of materials, including paperboard and paper, steel, glass, aluminum, wood, plastics, and trace amounts of other materials.

2.5.1 The environmental impact of excessive packaging.

Consider how a basic single-use plastic bottle is made to learn how bad packaging harms the environment. Polyethylene Terephthalate (PET) bottles are made from crude oil, a fossil fuel. The crude oil is distilled and mixed with other chemicals until it has a sticky consistency. It is then heated and forced into a mould with the help of air, a process known as injection moulding. Once cooling, the bottle keeps its form and is ready to absorb our water after a label and cap are applied. To begin, the primary ingredient required to manufacture our PET container is crude oil, a fossil fuel that, as we all know, is unsustainable and unethical given how heavily we rely on it. Second,

the number of operations that our bottle must go through necessitates a substantial quantity of energy - both electrical and human. The method described here is applicable to nearly all forms of plastic, not only the ordinary plastic bottle. And because our PET bottle isn't biodegradable, it'll wind up in a landfill or, worse, floating in the ocean for the next 10,000 years.

2.6 Alginate

Alginate, also known as Alginic acid, is a chemical present in brown algae cell walls. Since it is more naturally removed from cells as a polysaccharide, it is considered extremely stable. Alginate is often mixed with water to make a viscous gum paste that is ideal for making dental impressions, hands, feet, and other small-scale products. Alginate is a naturally gelling material and it has the potential to carry up to 200-300 times its own weight of water. The thickness of the alginate can be adjusted to fit the casting or use, making it a versatile tool for casting, thickening, and medicinal applications.

Since alginate molding compounds have extreme precision in a versatile, fast-setting medium, they were initially developed for creating dental impressions. The benefits of these molding substances for casting the face and other parts of the human body were easily noticed by makeup artists. Casting hands, noses, ears, and eye areas with alginate is easy.



Figure 2.1 Alginate mold

Alginate is a hydrocolloid impression medium that is elastic and permanent. Indirect restorations are inextricably linked to irreversible hydrocolloid impressions.

Alginate is a common dental material, and alginate impressions are a clear, cost-effective, and necessary part of dental practice. Alginate hydrogel mechanical properties. Stress measurements under three consecutive 50 percent compressive strains were used to determine the Young's modulus of G-type (black bars) and M-type (white bars) alginate hydrogels (1, 2, and 3). * $p \leq 0.05$, ** $p \leq 0.01$ based on ANOVA analysis; error bars reflect standard deviation.

2.6.1 Alginate: properties and application

Alginate has received much attention due to its biocompatible, nontoxic, and cost-effective characteristics; alginate has been widely researched for uses in the energy and environmental sectors. Moreover, Brown seaweeds contain alginate in their cell walls. The seaweed belongs to the phylum Phaeophyceae and is gathered all over the world to be processed into the raw ingredient sodium alginate. This is the material that is utilized to make the Alginate product. Alginate is a naturally occurring substance found in brown seaweed that is both culinary and dermatologically safe. Because of its capacity to absorb water, alginate is a helpful substance in the medical industry. It is now used in slimming aids (weight loss supplements), thickening ingredients for soups, jellies, ice cream, cosmetics, beverages, and medicinal preparations.

Application in Packaging- As an edible susceptor, high salinity alginate gelatin was employed. White ginseng extruded was used to produce anti-bacterial films and healthful meals. Antiradical capabilities were found in a polycaprolactone/alginate-calcium film based on oregano.

Application in paper industry- To achieve high water retention of paper coating, alginate partly complexed with calcium was combined with starch. This benefit is critical for size press coating formulation in order to enhance coating rheology, ensure consistent coat weight, and limit migration.

Application in textiles and medical textiles- Alginate calcium fibers are naturally flame resistant and retain antibacterial activity after 30 washing cycles (non-leaching antimicrobial agent). Fibers are easily manufactured and can be used to immobilize enzymes or as a support for bioactive compounds. Wet-spinning is the most common

method for producing fibers that may be used to make highly absorbent wound dressing materials.

Application in wound dressing and hemostatic material- Calcium alginate fibers have a unique gel-forming capacity in that the fiber progressively converts into a fibrous gel as a result of ion exchange between sodium and calcium ions in the fiber. To increase processability, alginates nanofibers were produced using an electrospinning technique in the presence of various synthetic polymers and/or surfactants.

Application in new industry- Alginates outperform other comparable compounds/products in terms of coating runnability, particularly in hot, on-machine surface coatings. Since the European Union banned synthetic plastics, alginate has grown in popularity as a packaging material. Alginates are utilized as thickeners for the dye paste in textile printing.

2.6.2 Bio-fabricating Materials from Alginate

Alginate polymers are also frequently used for molding and casting in the dental technology industry. It is also used to produce waterproof and fireproof fabrics. Miriam Ribul and her 2014 essay on Material Activism are responsible for open-source documentation of how to make bioplastics using simple equipment and locally available materials. She demonstrated 20 well-known ways for material synthesis using only four fundamental formulas, enabling collaborative production of petroleum-based plastic substitutes. Juliette Pépin's (also 2014) visual study book on bioplastics digs extensively into the sensory and visual components of basic recipes with several variations. Although bioplastics production is undeniably a craft that has been spread throughout many nations and times, leaving remains of many similar recipes behind, this type of recording and sharing effort is certainly attributed to these two ancestors.

Product design makes use of the material properties of alginate bioplastic. Exploration of its potential use as a bioplastic by mixing it with water, rigidity-enhancing agents such as chitosan, and flexibility-enhancing chemicals such as glycerin. Table 1 shows the results. The following alginate recipe is provided below:

Cecilia Raspanti (TextileLab, Waag), Flexible Bio-plastic Alginate Recipe, Fabricademy Class "Biofabricating Materials", 20

Table 2.1 Flexible Bio-plastic Alginate Recipe

Description	Quantity
Alginate Mixture	
Water	400ml
Alginate (food grade)	25g
Vegetable Glycerin	60g
Cure Solution	
Water	200ml
Calcium Chloride	15g

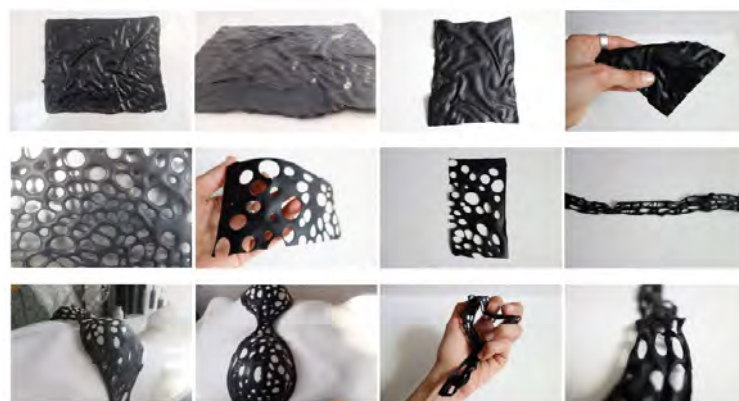


Figure 2.2 Prototypes with Alginate as Textile (Catherine Euale)

2.6.3 Brown seaweeds

Seaweed aquaculture contributes to climate change adaptation by reducing wave energy and protecting shorelines, as well as improving pH and supplying oxygen to the seas. When added in cow feed, it can also help reduce agricultural emissions by improving soil quality, substituting synthetic fertilizer, and lowering methane emissions from cattle. Seaweed farming practices may be modified to optimize climatic benefits, which, if economically compensated, can enhance income for seaweed farmers. The availability of acceptable areas and competition for good locations with other objectives, engineering systems capable of coping with severe circumstances offshore, and growing market dematrimony all limit the potential of expanding seaweed aquaculture.

2.6.4 Decomposition Time of Alginate

As we all know, Silicones are derived from petroleum materials. It is used to create "archival" molds, which means they will remain precisely the same for years and years. The same thing happens in a landfill, with particles of silicone enduring hundreds of years without deterioration.

Alginate is a one-time mold. Usually, only one casting may be poured from it before it shrinks. This is, in many respects, a feature rather than a bug. When alginate dries, it shrinks to roughly half its original size and hardens to the consistency of a rock. It is still very porous and can absorb water up to its weight. This water brings with it a slew of bacteria capable of chewing up the organic and inorganic components contained in alginate. Nothing toxic leaches from the dried alginate that may endanger these little creatures. Alginate can biodegrade in as little as a year, depending on how deeply it is buried and how moist it becomes.

2.6.5 Recyclability level of Alginate

Alginate impression materials are highly popular in regular dental procedures. Therefore, there are many studies studying alginate recycling. There has been some study done on the impact of dental alginate impression waste as supplementary fertilizer

on plant yields by calculating the weight of cauliflower crop, and on soil quality by determining the soil pH (Ultisol® Jatinangor). The study discovered that alginate waste had no substantial impact on soil quality. On the other hand, the use of dental alginate waste considerably raised the cauliflower weight by 1,92 and 1,80 times, respectively, as compared to the control. Furthermore, alginate impression materials could well be recycled into diatomite, and researchers are looking into its use as an abrading agent for denture base resins. By heating hardened alginate impression materials, a lump-like solid was powdered using a mortar and a pestle then blended with wax.

There has also been some research on a method for comprehensive functional recycling of alginate-based composite materials created by ionotropic gelation. The original material, an alginate/fiberglass foam with thermal insulation properties, was created using a proprietary method in which fiberglass waste is incorporated into a polyanionic gel matrix and then freeze-dried. The functional recycling is accomplished by disassembling the ionic matrix, which is initially formed by the interaction of a cation (e.g., calcium) and the negatively charged alginate backbone, using a chelator (Ethylenediaminetetraacetic acid disodium salt) with a high affinity for the cations, resulting in a homogeneous solution. After the chelating activity is deactivated under moderate acid conditions, an ionotropic gel can be reformed. They were able to preserve or improve the original material's thermal, mechanical, and acoustic properties, and they successfully evaluated the potential of numerous recycling cycles.

2.6.6 Eco-Friendly level of Alginate

Alginate (in the form of alginic acid) found in brown algae served as a functional component of conventional fertilizers, facilitating water retention in soils. As a result, alginate's primary role in agricultural areas was as a soil conditioner. Alginate has the advantage of being a superabsorbent (SAP) or water-retaining substance. In agriculture, these alginates are commonly referred to as nonionic or ionic moisture-holding hydrogels for improving soil water retention, which is a fundamental soil characteristic. The use of alginate can improve water retention and increase nutritional

availability. High-capacity absorbents can undoubtedly improve the water-retention capacity of such soils.

In agricultural regions, superabsorbents have been researched and developed to enhance the abiotic characteristics of soil. These include boosting their water-retention capacity, establishing a more efficient water-use system, and improving soil permeability and infiltration rates. They also help to reduce the frequency of watering and avoid erosion and water drainage.

The pathogens are directly suppressed by seaweed alginate. Furthermore, alginate pellets successfully implemented as a carrier material for biocontrol agents have been shown to minimize the multiplication of *Rhizoctonia* (fungi) disease in potatoes, while incorporating *Ascophyllum nodosum* extract into the planting medium caused a delay and decreased incidence of *Verticillium* (fungi) wilt in pepper plants. As a result, it has been established that alginates play a role in host defensive systems. Those that trigger defensive responses, actually results in protection against diseases or insect damage, are of special importance in agricultural systems.

2.7 Usefulness of product

The existing were unable to identify a direct measure of utility through a survey of design literature. The patent office uses skilled engineering designers to determine the originality and utility of an invention in order to assess its patentability. To contend that approaches for evaluating designs and products are the most similar to what may be used to assess product usefulness. The “weighted objective approach” as a representative assessment method. Although an item might be seen to be beneficial, this perception can only be verified when it is backed by outcomes from its real usage; it is the item's actual use that clearly proves its usefulness. Developing this concept beyond families to societies, they construct a wide concept of product usage with which to evaluate the degree of usefulness of an item. As a result, they suggest that perhaps the usefulness of an item be determined by its actual consumption, which is an example of the notion of ‘social utility’.

CHAPTER 3

RESEARCH CONCEPT

3.1 Research Concept

The analysis definition is split into five phase. The problem is identified in the first step. The second stage is a study of the literature. The third step involves selecting materials from the obtained idea/requirement. The final stage is design prototype, and testing.

3.1.1 Identify problem

Phase 1: 3.1.1.1 Choose topic

 3.1.1.2 Set objective and purpose

3.1.2 Literature review

Phase 2: 3.1.2.1 Collect data

 3.1.2.2 Gather the related research articles

 3.1.2.2 Identification of existing research

 3.1.2.3 Identify properties of material

3.1.3 Pre-liminary study

Phase 3: 3.1.3.1 Design usefulness equation and table

 3.1.3.2 Assessing product/material usefulness

3.1.4 Application

Phase 4: 3.1.4.1 Usefulness calculation

 3.1.4.2 Experiment test

 3.1.4.3 Write a manuscript for report

3.1.5 Independent Study

Phase 5: 3.1.5.1 Write the full manuscript of the independent study

3.1.5.2 Review and revise the manuscript

3.1.5.3 Finalize the independent study

3.2 Usefulness concept

Use the usefulness idea to identify a utility measure that is relevant to this research, which is concerned with environmental effect during utility. Several variables must be addressed when designing a material or product that has an environmental impact. There was a requirement to identify the utility of cushioning packing material in this investigation. To begin, the decomposition time level is defined as the length of time that elapses between the deterioration of a product or material. Second, using normal waste recycling procedures, the recyclability level may be determined from high to poor. Third, the eco-friendly level of the product/material during the process may be determined, ranging from high to poor. Expiration Date is the period of time a product may be used or stored before deteriorating. Finally, usage frequency refers to how frequently the product has been used. The parameters considered in the method are described further below.

3.2.1 Level of decomposition Time

Understanding how long different forms of waste take to degrade is critical for sustainability. We should concentrate our efforts, in particular, on minimizing the use of items that produce waste materials that take a long time to decompose.

The "Decomposition time level" is the amount of time that passes between the degradation of a product or substance. The longer the duration required to decompose, the higher the value of the decomposition time level, and hence the lower the usefulness. Seven level of decomposition time have been identified (Table 3.1).

Table 3.1 Level of decomposition Time

Code	Points in a scale of 7	Level of Decomposition Time	Range of decomposition times (in year)	Example
A	7 (>6.0 - 7.0)	Extremely high	< 1	<ul style="list-style-type: none"> • Newspaper • Paper towel • Apple core
B	6 (>5.0 - 6.0)	Very high	> 1 - 10	<ul style="list-style-type: none"> • Canvas Product • Plywood • Milk Cartons
C	5 (>4.0 - 5.0)	High	> 10 - 50	<ul style="list-style-type: none"> • Lumber • Cigarette Butts
D	4 (>3.0 - 4.0)	Medium	> 50 – 100	<ul style="list-style-type: none"> • Nylon Fabric • Foamed Plastic Cups
E	3 (>2.0 - 3.0)	Low	> 100 - 500	<ul style="list-style-type: none"> • Plastic Beverage Bottles • Aluminum cans
F	2 (>1.0 – 2.0)	Very low	> 500 – 1,000	<ul style="list-style-type: none"> • Monofilament Fishing Line • Sanitary Pads
G	1 (0.0 - 1.0)	Extremely low	> 1,000, and not decompose	<ul style="list-style-type: none"> • Glass Bottle

3.2.2 Level of Recyclability

The waste management strategy is a nationally and internationally system for prioritizing waste treatment procedures in order to get the greatest environmental results. "It defines the recommended order of waste management techniques, from most desirable to least wanted."

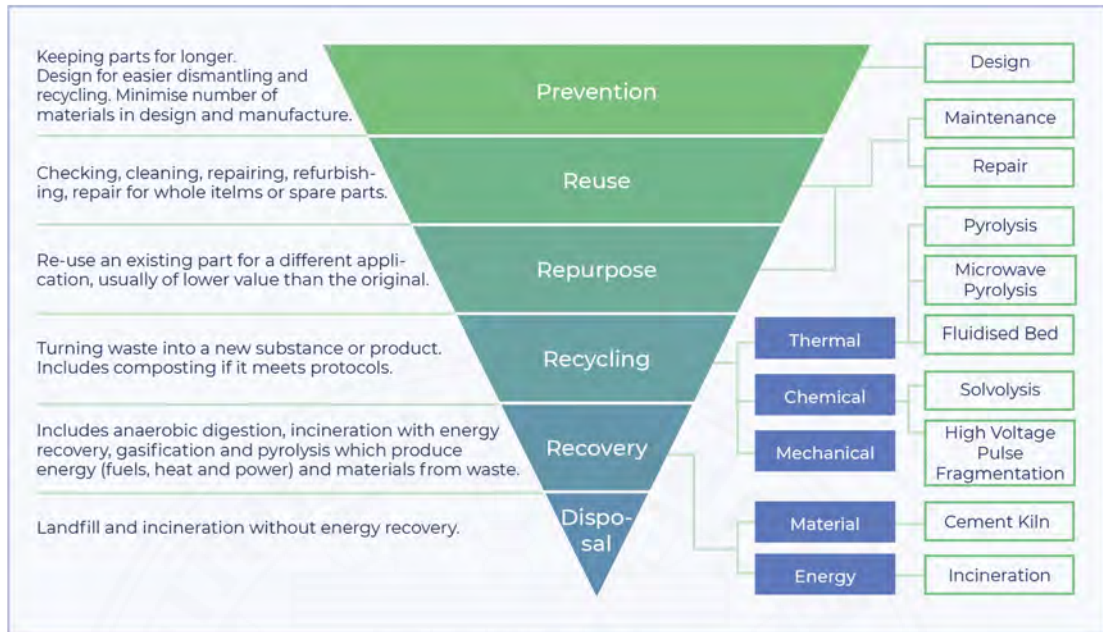


Figure 3.1 Waste management hierarchy (Bax&Company)

The goal of the waste hierarchy is to produce the least amount of waste while getting the most value out of things. The waste hierarchy, when used correctly, can provide several benefits. From figure 8 it shows six waste management practices, from most to least desired, which start with prevention and end with disposal. This research would focus on recycling methods.

Any recovery operation in which waste materials are reprocessed into commodities, materials, or substances for original or new purposes is referred to as waste recycling. It includes organic material reprocessing but does not include energy recovery or reprocessing into materials for use as fuels or in backfilling operations.

The "Recyclability level" can be described as a method for recycling waste. The waste has to be sent to the establishment or recycling centre for thermal, chemical, and mechanical methods. That means there is a specific place and tool needed, as well as high energy and chemical processing, so it should have higher values of usefulness. The level of recyclability of waste depends on how easily or various ways of recycling waste. Some waste might be recycled at home without special tools or technology, but some is not. Five level of recyclability have been identified (Table 3.2).

Table 3.2 Level of recyclability

Code	Points in a scale of 5	Level of Recyclability	Description
H	5 (>4.0 - 5.0)	Extreme	<ul style="list-style-type: none"> can be recycled without specific tools and a specific place.
I	4 (>3.0 - 4.0)	High	<ul style="list-style-type: none"> have to recycle with a specific tool but not in a specific place.
J	3 (>2.0 - 3.0)	Medium	<ul style="list-style-type: none"> Various recycling methods include necessary and unnecessary special tools and special places.
K	2 (>1.0 - 2.0)	Low	<ul style="list-style-type: none"> have to recycle with a specific tool and in a specific place, such as a local recycling centre.
L	1 (0.0 - 1.0)	Very Low	<ul style="list-style-type: none"> have to recycle with a specific machine or technology and in a specific place.

3.2.3 Level of Eco-Friendly

Eco-friendly simply means "friendly to the environment" or "not harmful to the environment." This phrase most usually refers to green living activities or goods that help preserve resources such as energy and water. Eco-friendly items also help to reduce pollution in the water, land, and air.

Starting from raw materials and during the production process, understanding how eco-friendly products and materials are. We should concentrate our efforts, in particular, on increasing the use of items that eco-friendly produce or materials.

The "Eco-friendly level" is defined as the use of raw materials and manufacturing techniques that assist conserve resources such as energy and water. The raw materials of products and the production process, which aid in the conservation of resources such as energy and water, should have greater usefulness values. The level of eco-friendly of a product is determined by how much raw material and the manufacturing process have an environmental impact. Some products are beneficial to promoting production because raw materials are preserved resources through processing, which are harmless or have less impact on the environment, but some

products are non-renewable and also harmful to the environment during chase the raw material and production processes.

Table 3.3 Level of Eco-friendly

Code	Points in a scale of 5	Level of Eco-friendly	Description
M	5 (>4.0 - 5.0)	Extreme	<ul style="list-style-type: none"> The raw materials of products and the production process help preserve resources such as energy and water.
N	4 (>3.0 - 4.0)	High	<ul style="list-style-type: none"> The raw materials of products and the production process help preserve resources such as energy and water, but use some mild chemicals in the production process.
O	3 (>2.0 - 3.0)	Medium	<ul style="list-style-type: none"> The raw materials of products and the production process consume large amounts of natural resources such as water and wood.
P	2 (>1.0 – 2.0)	Low	<ul style="list-style-type: none"> The raw materials of products and the production process harm the environment.
Q	1 (0.0 - 1.0)	Very Low	<ul style="list-style-type: none"> The raw materials of products and the production process are extremely harmful to the environment and contain dangerous chemicals in the production process.

3.2.4 Expiration Date

The expiration date specifies how long the product will be available. A product that has been used or stored for a long period of time will deteriorate. This includes the characteristics of the product and its storage location. The expiration date is one factor that has an effect on product usefulness.

The " Expiration Date " can be described as time the product will be available. The longer period of time before deteriorate, the higher the value of the expiration date, and hence the higher the usefulness. Five level of expiration date have been identified (Table 3.4).

Table 3.4 Level of Expiration Date

Code	Points in a scale of 5	Level of Eco-friendly	Available time (month)
R	5 (>4.0 - 5.0)	Extreme	> 60
S	4 (>3.0 - 4.0)	High	> 36-60
T	3 (>2.0 - 3.0)	Medium	> 12-36
U	2 (>1.0 – 2.0)	Low	> 0-12
V	1 (0.0 - 1.0)	Very Low	> 0-6

3.2.5 Usage frequency

The frequency of usage indicates how frequently the product has been utilized. A product that has been used frequently should be deemed more useful than those that have been used seldom. It is defined as the rate of usage over a set period of time.

3.2.6 Assessing product/material usefulness

The usefulness of an object may be characterized as effective, which characterizes an object as aiding another in completing a certain purpose. It also has an impact on appropriateness and social worth (Sarkar and Chakrabarti, 2011) There are five parameters: Decomposition time level, Recyclability level, Eco-friendly level, Expiration date and Usage frequency. For determining the utility of a product or material, we suggest the following equation, as illustrated below.

$$\text{Usefulness } (U) = \text{Decomposition time level } (D) \times \text{Recyclability level } (R) \times \text{Eco-friendly level } (E) \times \text{Expiration date} (Ed) \times \text{Usage frequency } (F) \quad (\text{Eq.1})$$

From Tables 3.1, 3.2, 3.3, and 3.4 which contain three of the components in the equation, followed by the decomposition time level (D), recyclability level (R), eco-friendly level (E), and expiration date (Ed), the factors in the equation can be obtained

by considering the properties and characteristics of the product or material and comparing them with the table above. For usage frequency (F) in the equation, such as hour, day, month, or year, the unit should be the same.

3.3 Research activity (Gantt chart)

No.	Activities	Year	2020												2021							
		Academic year	2/2019						1/2020						2/2020							
		Month	01	02	03	04	05	06	07	08	09	10	11	12	01	02	03	04	05	06	07	08
1.	Research on the related work		■	■																		
2.	Meet advisor			■																		
3.	Rough ideas/designs on the topic				■																	
4.	Identify problem: Phase 1																					
	Choose topic					■																
	Set objective and purpose						■															
5.	Literature review: Phase 2																					
	Collect data							■	■	■												
	Gather the related research articles										■											
	Identification of existing research											■	■									
	Identify existing product gaps based on the literature review.													■	■	■						
6.	Research concept: Phase 3																					
	Research concept																	■				
	Design usefulness equation and table																		■			
	Assessing product/material usefulness																			■		
7.	Application: Phase 4																					
	Usefulness calculation																				■	
	Experiment test																				■	
	Write a manuscript for report																				■	
8.	Independent Study: Phase 5																					
	Write the full manuscript of the independent study																					■
	Review and revise the manuscript																					■
	Finalize the independent study																					■

CHAPTER 4 APPLICATIONS

4.1 Applying the Usefulness concept

According to the concept of “usefulness” mentioned earlier in Section 3.2, in this study,

$$\text{Usefulness (U)} = \text{Decomposition time level (D)} \times \text{Recyclability level (R)} \times \text{Eco-friendly (E)} \times \text{Expiration date(Ed)} \times \text{Usage frequency (F)} \quad (\text{Eq.1})$$

Applying the concept of usefulness in this study, packaging cushioning is necessary to safeguard objects during transportation. From the Fruit House company, a seller of fresh and processed fruits, delivering items in the context of COVID-19, the online shopping market is growing in popularity, and a growing number of customers are opting for online purchasing. As a result of this circumstance, the FH business is responsible for product packing and delivery to customers directly. For shipping orders of 200 or more each week, packing is required. Fresh fruit, such as Phulae Pineapple, dried fruit tell of pack packing, and dried fruit inform of gift set are the three main types of FH goods. There are many forms of cushioning packing for the various types of products that are required, depending on the size and packaging of the product.

4.1.1 Calculating “usefulness (U)”

According to the FruitHouse company, a seller of fresh and processed fruits, there are 200 orders per week that have to be shipped to customers. Each type of product can be categorized into 3 groups, which are: fresh fruit shipped with cardboard dividers as protective packaging; plastic packs of dried fruit shipped with paper wrap as protective packaging; and acrylic boxes of dried fruit shipped with bubble wrap as protective packaging.

The subsections that follow provide in examples of how to calculate "usefulness."

4.1.2 Usefulness calculation for “Group A: Fresh fruit”

According to the previous mention in section 3.2.1, the fresh fruit uses cardboard dividers as protective packaging during shipping. The usage frequency is 50 orders per week from a total of 200 orders. For cardboard divider, there is no standard that defines or requires corrugated cardboard boxes to have an expiration date. However, via studies and observations, it was possible to establish a consensus that they can live up to two years under optimum conditions (controlled humidity and temperature).



Figure 4.1 Phulae Pineapple Shipping Box(FH company)

Cardboard paper

1. *Decomposition time level (D)*: Cardboard paper takes approximately **2 months** can be obtained from Table 3.1.

= Extremely high (Code A): 7/7 (7 scale from the maximum – 7 scale)

**notice: different sources provide different estimates of how long different waste products take to degrade in landfills. However, the results do not differ significantly.*

2. *Recyclability level (R)*: From section 3.2 can be obtained from Table 3.2

= Low (Code K): 2/5 (2 scale from the maximum – 5 scale)

3. *Eco-friendly (E)*: From section 3.2 can be obtained from Table 3.3

= Medium (Code O): 3/5(3 scale from the maximum – 5 scale)

4. *Expiration date (Ed)*: Cardboard paper can live up to 2 years can be obtained from Table 3.4

= Medium (Code T): 3/5 (3 scale from the maximum – 5 scale)

5. *Usage frequency (F)*: From section 4.1.1, 50 orders per week
 = $(50/168) \times 8$ (ratio of number of orders/total number of hours shipment in one time
 × work shift)

Therefore, applying Eq. 1 can determine *Usefulness (U) of Cardboard paper*:
Usefulness (U) = Decomposition time level (D) x Recyclability level (R) x Eco-friendly (E) x Expiration date(Ed) x Usage frequency (F)

-Eq.1

$$= (7/7) \times (2/5) \times (3/5) \times (3/5) \times ((50/168) \times 8)$$

$$= \mathbf{0.342}$$

4.1.3 Usefulness calculation for “Group B: Plastic packs of dried fruit”

According to the previous mention in section 4.1.1, the plastic packs of dried fruit uses paper wrap as protective packaging during shipping. The usage frequency is 100 orders per week from a total of 200 orders. For mulberry paper, there is no standard that defines or requires corrugated mulberry paper to have an expiration date. However, via studies and observations, papers last well without any major loss in quality and should keep for at least 5 years.



Figure 4.2 Dried Mango Packs Shipping Box (FH company)

Paper wrap

1. *Decomposition time level (D)*: paper takes approximately **2-6 week** can be obtained from Table 3.1

= Extremely high (Code A): 7/7 (7 scale from the maximum – 7 scale)

***notice: different sources provide different estimates of how long different waste products take to degrade in landfills. However, the results do not differ significantly.**

2. *Recyclability level (R)*: From Section 3.2 can be obtained from Table 3.2
= Low (Code K): 2/5 (2 scale from the maximum – 5 scale)
3. *Eco-friendly (E)*: From Section 3.2 can be obtained from Table 3.3
= Medium (Code O): 3/5(3 scale from the maximum – 5 scale)
4. *Expiration date (Ed)*: paper can live up to 5 years can be obtained from Table 3.4
= High (Code S): 4/5 (4 scale from the maximum – 5 scale)
5. *Usage frequency (F)*: From Section 4.1.1, 100 orders per week
= $(100/168) \times 8$ (ratio of number of orders/total number of hours shipment in one time
×work shift)

Therefore, applying Eq. 1 can determine *Usefulness (U) of paper*:
 $Usefulness (U) = Decomposition\ time\ level (D) \times Recyclability\ level (R) \times Eco\text{-}friendly (E) \times Expiration\ date(Ed) \times Usage\ frequency (F)$

-Eq.1

$$= (7/7) \times (2/5) \times (3/5) \times (4/5) \times ((100/168) \times 8)$$

$$= 0.91$$

4.1.4 Usefulness calculation for “Group C: Acrylic boxes of dried fruit”

According to the previous mention in section 4.1.1, acrylic boxes of dried fruit shipped with bubble wrap as protective packaging. The usage frequency is 50 orders per week from a total of 200 orders. For bubble wrap, there is no standard that defines or requires corrugated bubble wrap es to have an expiration date because unless it has sustained severe damage, bubble wrap used to convey products may almost always be reused. However, via studies and observations, bubble wrap should last between 5 and 7 years without being used.



Figure 4.3 Acrylic boxes of dried fruit (FH company)

Bubble wrap (Low-density polyethylene):

1. *Decomposition time level (D):* LDPE will decompose in 2 years to 20 years can be obtained from Table 3.1

= High (Code B): 6/7 (6 scale from the maximum – 7 scale)

*notice: different sources provide different estimates of how long different waste products take to degrade in landfills. However, the results do not differ significantly.

2. *Recyclability level (R)*: From Section 3.2 can be obtained from Table 3.2
= Very Low (Code L): 1/5 (1 scale from the maximum – 5 scale)
3. *Eco-friendly (E)*: From Section 3.2 can be obtained from Table 3.3
= Very Low (Code Q): 1/5 (1 scale from the maximum – 5 scale)
4. *Expiration date (Ed)*: Bubble wrap should last estimate around 6 year can be obtained from Table 3.4
= Extreme (Code R): 5/5 (5 scale from the maximum – 5 scale)
5. *Usage frequency (F)*: From Section 4.1.1, 50 orders per week
= $(150/168) \times 8$ (ratio of number of orders/total number of hours shipment in one time \times work shift)

Therefore, applying Eq. 1 can determine Usefulness (U) of Bubble wrap:
Usefulness (U) = Decomposition time level (D) \times Recyclability level (R) \times Eco-friendly (E) \times Expiration date (Ed) \times Usage frequency (F)

-Eq.1

$$= (6/7) \times (1/5) \times (1/5) \times (5/5) \times ((50/168) \times 8)$$

$$= \mathbf{0.016}$$

4.1.5 Usefulness calculation for “Alginate Material”

As a consequence, an example calculation demonstrated the usefulness of cardboard paper, paper wrap, and bubble wrap. Because alginate is an alternative protective packaging material, it can be used to replace protective packaging in Groups B and C. As a result, in this part, we may attempt to substitute alginate material in the cases of groups B and C. Considering alginate is a relatively new material for cushioning packaging, we use bioplastic information in our computation.

4.1.5.1 Usefulness calculation for “Alginate Material in Group B”

1. *Decomposition time level (D)*: alginate takes approximately 1 year can be obtained from Table 3.1
= Extremely high (Code A): 7/7 (7 scale from the maximum – 7 scale)

*notice: different sources provide different estimates of how long different waste products take to degrade in landfills. However, the results do not differ significantly.

2. *Recyclability level (R)*: From Section 2.6.4 can be obtained from Table 3.2
= Medium (Code J): 3/5 (3 scale from the maximum – 5 scale)
3. *Eco-friendly (E)*: From Section 2.6.5 can be obtained from Table 3.3
= High (Code N): 4/5 (4 scale from the maximum – 5 scale)
4. *Expiration date (Ed)*: bioplastic can live up to 1 years can be obtained from Table 3.4
= Low (Code U): 2/5 (2 scale from the maximum – 5 scale)
5. *Usage frequency (F)*: From Section 4.1.1, 100 orders per week
= $(100/168) \times 8$ (ratio of number of orders/total number of hours shipment in one time
 \times work shift)

Therefore, applying Eq. 1 can determine Usefulness (U) of paper:
Usefulness (U) = Decomposition time level (D) x Recyclability level (R) x Eco-friendly (E) x Expiration date(Ed) x Usage frequency (F)

-Eq.1

$$= (7/7) \times (3/5) \times (4/5) \times (2/5) \times ((100/168) \times 8)$$

$$= \mathbf{0.91}$$

4.1.5.2 Usefulness calculation for “Alginate Material in Group C”

1. *Decomposition time level (D)*: alginate takes approximately 1 year can be obtained from Table 3.1
= Extremely high (Code A): 7/7 (7 scale from the maximum – 7 scale)

*notice: different sources provide different estimates of how long different waste products take to degrade in landfills. However, the results do not differ significantly.

2. *Recyclability level (R)*: From Section 2.6.4 can be obtained from Table 3.2
= Medium (Code J): 3/5 (3 scale from the maximum – 5 scale)
3. *Eco-friendly (E)*: From Section 2.6.5 can be obtained from Table 3.3
= High (Code N): 4/5 (4 scale from the maximum – 5 scale)
4. *Expiration date (Ed)*: bioplastic can live up to 1 years can be obtained from Table 3.4
= Low (Code U): 2/5 (2 scale from the maximum – 5 scale)
5. *Usage frequency (F)*: From Section 4.1.1, 50 orders per week

$$= (100/168) \times 8 \text{ (ratio of number of orders/total number of hours shipment in one time} \\ \times \text{work shift)}$$

Therefore, applying Eq. 1 can determine Usefulness (U) of paper:
Usefulness (U) = Decomposition time level (D) x Recyclability level (R) x Eco-friendly (E) x Expiration date(Ed) x Usage frequency (F)

-Eq.1

$$= (7/7) \times (3/5) \times (4/5) \times (2/5) \times ((50/168) \times 8) \\ = \mathbf{0.46}$$

4.2 Experiment test

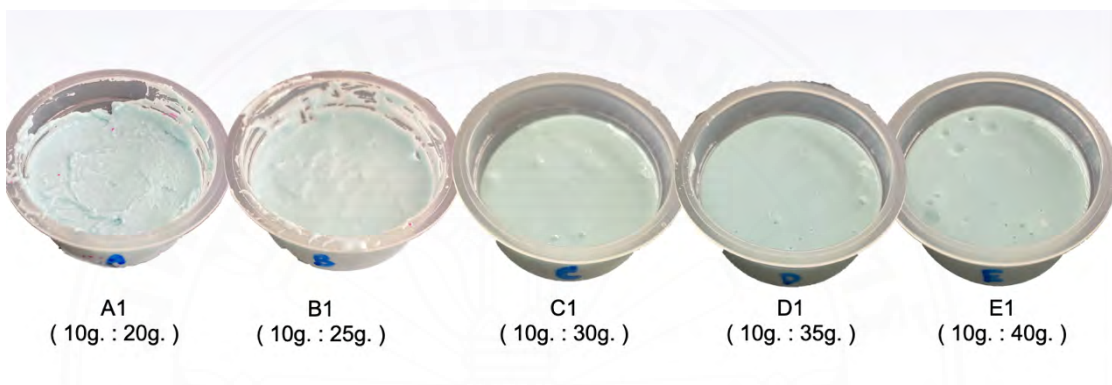
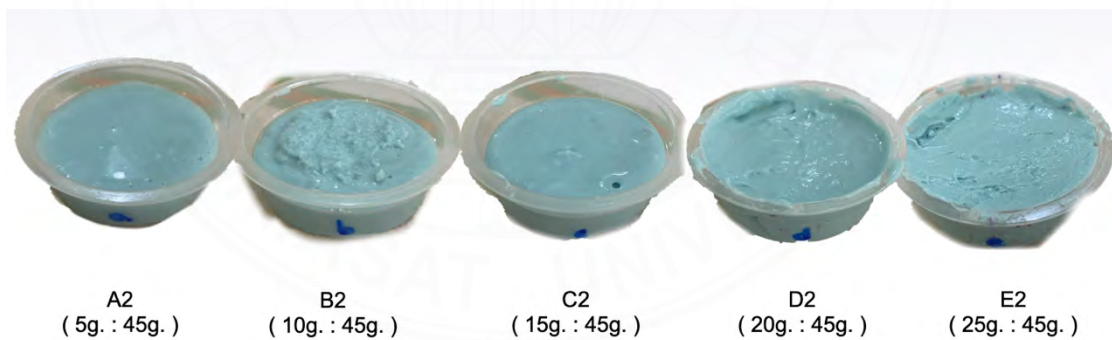
In this experiment examine how the mixture ratio of water and alginate powder affects the setting time and whether it provides any benefits. A consistent temperature is used to bake the workpiece. Examine the workpiece for lost weight and surface after it has lost water due to baking. There are 10 experiment examples, separated into two groups, which are 5 examples with fixed powder and 5 examples with fixed water. And the ratio of mixing shown below.

Table 4.1 Mixing ratio of Alginate and Water (Fixed Alginate powder)

	Alginate powder	Water	Ratio	Setting time
A1	10 g.	20 g.	2	1.26 min
B1	10 g.	25 g.	2.5	2.02 min
C1	10 g.	30 g.	3	2.08 min
D1	10 g.	35 g.	3.5	2.22 min
E1	10 g.	40 g.	4	2.38 min

Table 4.2 Mixing ratio of Alginate and Water (Fixed Water)

	Alginate powder	Water	Ratio	Setting time
A2	5 g.	45 g.	9	6.20 min
B2	10 g.	45 g.	4.5	2.40 min
C2	15 g.	45 g.	3	2.36 min
D2	20 g.	45 g.	2.25	2.16 min
E2	25 g.	45 g.	1.8	1.03 min

**Figure 4.4** Experiment of alginate mixing (Fixed Alginate, Varied Water)**Figure 4.5** Experiment of alginate mixing (Fixed Water, Varied Alginate)

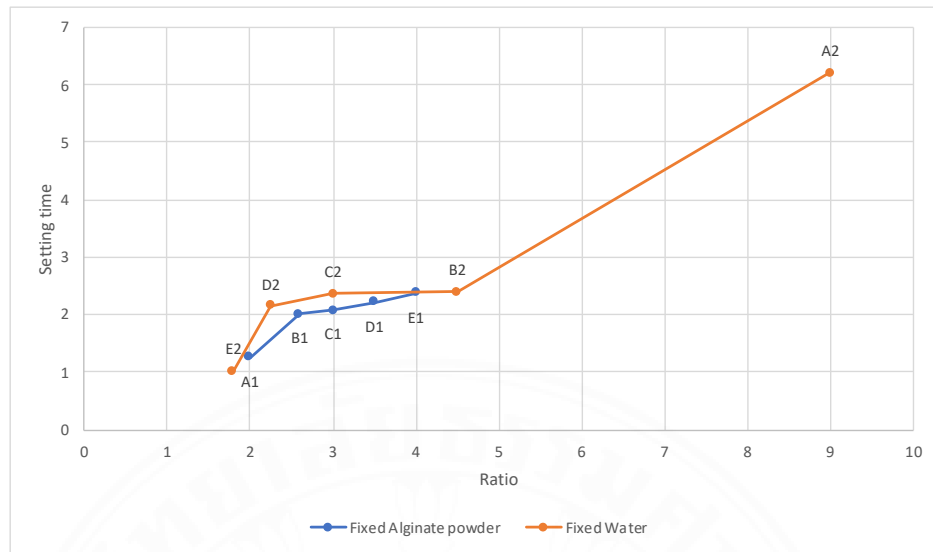


Figure 4.6 Graph of setting and ratio of experiment

A consistent temperature is used to bake the workpiece. Examine the workpiece for lost weight and surface after it has lost water due to baking. With temperature at 50 C° to bake 10 examples for 60 min. And the results of lost weight shown below.

Table 4.3 Measure weight loss (Fixed Alginate: Varied Water)

Weight	Before	After	Percentage of weight loss
A1	30 g.	12 g.	60%
B1	35 g.	14 g.	60%
C1	40 g.	18 g.	55%
D1	45 g.	25 g.	44%
E1	50 g.	30 g.	40%

Table.4.4 Measure weight loss (Fixed Water: Varied Alginate)

Weight	Before	After	Percentage of weight loss
A2	50 g.	28 g.	44%
B2	55 g.	34 g.	38%
C2	60 g.	36 g.	40%
D2	65 g.	40 g.	38%
E2	70 g.	52 g.	26%

4.3 Contribution

This study aims to introduce the properties and applications of alginate in current use, as well as provide alternative materials for protective packaging from an alginate perspective. Alginate offers several advantages, whether in the environmental, biomedical, or food industries, and more comprehensive research of alginate is required, leading to points of innovation. Usefulness, which was utilized in this study, could be used to identify utilities that are connected to the environmental effect of protective packaging materials and products that must be considered in terms of environmental impact and usefulness. The experiment test represented a variable setting time derived from the alginate power and water interaction, along with weight loss from the baking process.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Alginates are popular for technical knowledge as a medicinal or biomedical component or as a compound for innovative biotechnology, and these previous studies are turning to a more detailed study of alginate's structure and properties, supposed to lead to points of scientific advancement that, when combined with scientific observation, will benefit traditional alginate exploitation techniques.

Usefulness, Group A: Fresh fruit: Cardboard paper got usefulness(U) is 0.342, Group B: Plastic packs of dried fruit: Paper wrap got usefulness(U) is 0.91, Group C: Acrylic boxes of dried fruit: Bubble wrap got usefulness(U) is 0.016. From the results, the paper wrap got the highest score of usefulness, which is 0.91. This result can be explained as the paper wrap's highest utilization in this case study. There is only one example of a usefulness calculation. For example, the product A got very high in D, R, E, and Ed but very low in F compared with the product B, which got medium in D, R, E, and Ed but very high in F. Product B might be more useful in that case. On the other hand, the product C got very high D, R, E, and Ed but very low F compared with the product D, which got very low D, R, E, and Ed but high F, which might have got close usefulness value. The material usefulness (U) of replacing alginate is 0.91 in group B and 0.46 in group C. The usefulness of group B, which substitutes protective packaging with alginate material from paper wrap, is unaffected. The utility value of group C, which substitutes protective packaging with alginate material derived from bubble wrap, is rapidly growing.

From the experiment result, the suitable mixing ratio is 1:3, which is C1 and C2 because of the texture and surface are smooth and good for forming. (The outcome may be affected by the room temperature as well as the temperature of the water. The result of baking processing is the average weight loss of fixed alginate powder, which ranges from 20ml. to 40ml., around 52% of loss weight, and the average weight loss of fixed

water, which is 45ml., around 47% of loss weight. C1 and C2 are also the best models because the final products do not lose shape and do not become too moist.

5.2 Limitation

During the COVID-19 period, designing and testing prototypes in the real situation was impossible. For that reason, this research can only review and apply the usefulness concept of alginate. For the experiment, there needs to be studied in more depth to understand the properties of alginate impression, but with the situation, we have to end this experiment at this point.

Time for development in this project is limited and there is no experimental equipment to test. The time for development in this research is quite short for design and test performance of prototypes. With this limitation of time, the usefulness equation needs to add more conditions for more efficiency, such as the expiration date. There can be more conditions for the expiration date in the ratio of stored with unpacked. It might be affected by the range of time of deterioration.

5.3 Future work

This research will study more in detail the use of alginate as a composition of bioplastics in further experiments. Following the experiment, bioplastic by using alginate, the literature review will continue with 3F, which are fit, form, and function, for the design of protective packaging that applies to alginate material. In the form of protective packaging that uses alginate, it is planned in the form of a mail chain by 3D printing. Research studies have shown that the mail chain has a very strong and flexible structure. Then, test the performance of the prototype and compare it with the existing product that could be found in the market, and also use the usefulness equation that in this research is designed to be a comparing value.

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