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Study and Exploration of Industrial Packaging for Date Syrup Products

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General Introduction

The product quality is a crucial requirement, starting from the designing process up to that of manufacturing, and ending with the product's delivery.

In a world of never-ending brand competitiveness to produce environmentally-friendly products, that would both appeal to their consumers, and minimize wastes and thus global pollution, businesses, and specifically the food industry, finds itself in a constant journey of product improvement and quality enhancement.

As part of this PPP report, we offer you this dissertation which is organized into 3 chapters.

The first will present general information on food products' packaging, the second will deal with the four products we were in charge of designing and the third will study the possible future advanced packaging processes.

Chapter 1: Project Context

I. Definition of Packaging:

Packaging is defined as "enclosing a product, item or package in a bag, box, cup or other container". It performs the following functions:

- Containment
- Protection or preservation
- Communication
- Utility or performance

A device or container is considered a wrapper/package if it performs one or more of these functions.
Therefore, packaging is a multifunctional service.

Packaging functions range from technical ones to marketing oriented ones as shown in the following table:

Technical Functions		Marketing Functions	
contain	measure	communicate	promote
protect	dispense	display	sell
preserve	store	inform	motivate

Figure 1: Packaging Functions

I. Packaging Levels

Packaging may be looked at as several different types. For example, a transport package or distribution package is the package form used to ship, store, and handle the product or inner packages. Some identify a consumer package as one which is directed toward a consumer or household. It is sometimes convenient to categorize packages by layer or function: "primary", secondary", etc…

1. Primary Packaging

It is the material that first envelops the product and holds it. This usually is the smallest unit of distribution or use and is the package which is in direct contact with the contents.

2. Secondary Packaging

It is outside the primary packaging, used to group primary packages together.

3. Tertiary Packaging

It is used for bulk handling, warehouse storage and transport shipping. The most common form is a palletized unit load that packs tightly into containers.

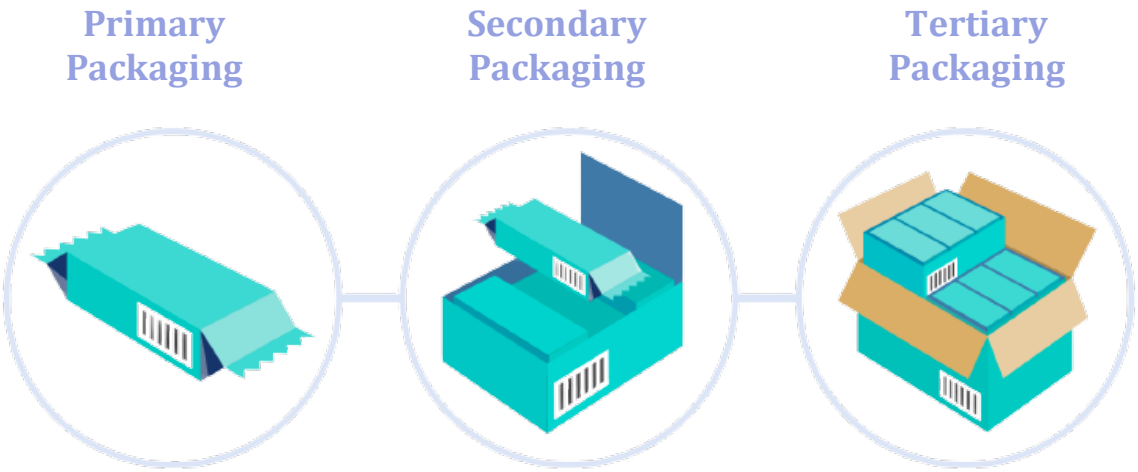


Figure 2: Packaging Levels

II. Introduction and history of package development:

Packaging is not a recent phenomenon, but rather an activity closely associated with the evolution of society, and can be traced back to human beginnings.

The nature, degree, and amount of packaging at any stage of a society 's growth reflects the needs, cultural patterns, material availability and technology of that society.

A study of changing roles of packaging and forms over the centuries is a study of the growth of civilization.

Social changes are inevitably reflected in the way we package, deliver and consume goods.

I. Functions of packaging:

The functions of a package are:

- To preserve the quality and freshness of food,
- To add appeal to the food to attract consumers,
- To facilitate its storage and distribution.

The basic functions required of a package can be grouped under four major categories:

1. Product Containment:

The primary function of any package is to contain the food and facilitate handling, storage, and distribution all the way from the manufacturer to the ultimate user or even the time the rest

portion is utilized by the consumer. However, there are usually various levels of packaging. A primary package is one that comes into direct contact with the contained product, e.g., metal cans, glass jars, and plastic pouches.

By law, a primary package must not yield any substance that may be injurious to the health of the consumer. Further development to facilitate handling is to bundle a series of primary packages together, and this leads to the concept of secondary packages. Examples of secondary package is corrugated box in which tins of apple juice are packed.

As methods of handling and transportation have become more sophisticated, these secondary packages are often palletized and secured by strapping with metal or, more commonly, by shrink- or stretch-wrapped film to give yet another level of packaging, i.e., tertiary packaging. In turn, these pallet loads may be packed into large metal containers, i.e., quaternary packaging for transportation over long distances by air, land, or sea. The secondary, tertiary and quaternary packaging are also known as packing. The following characteristics are considered:

1. Adequate size and shape.

2. Proper constructional features. No leakage, spillage, diffusion…

3. Package: Must contain the commodity in natural form (biscuits packed in Pillow pack, prevent damage)

4. No subsequent damage after packaging during handling transportation and storage, thus a package must be strong enough to contain the commodity as it is.

5. Optimum compatibility (nontoxic, non-soluble with product… No physical, chemical or biochemical changes/alteration…)

6. Containment or agglomeration (small objects are typically grouped together in one package for reasons of efficiency).

2. Product Protection:

One of the most important functions of any container is to protect the product contained against any form of loss, damage, deterioration, spoilage, or contamination that might be encountered throughout the distribution chain.

Packaging can prevent physical damage, e.g., bruising caused by vibrational shocks during transportation or stacking in a warehouse. Proper packaging will also prevent material loss, e.g., potatoes from a weak sack or juice from a leaky can.

Packaging can also protect products against moisture loss or gain, dust, and light, especially UV light, which causes deterioration of some light-sensitive products. It can also protect the package contents against temperature fluctuations in the transit of chilled and frozen foods.

Packaging can also be used to control the availability of oxygen to fruits and vegetables and to protect against loss of flavor or fragrance and help products retain their nutritional value. Proper packaging may also protect the product against microbial spoilage by bacteria, yeasts, and molds. It can also protect against microbiological spoilage of stored products due to rodents and insects.

Packaging protects the product against damages which may be due to different hazards: Mechanical, Environmental, Microbial, Biochemical and Social Hazards.

3. Packaging as a Medium of Communication:

An important function of any food package is to:

- Identify the product and its origin,
- Inform the consumer how to use the contents,
- Provide any other information needed or required,
- Attract the user and encourage purchase of the product.

The information a package can convey to the consumer may include the following:

- Product manufacturing and best buy dates
- Proper storage conditions
- Nutritional information per serving
- Manufacturer ‘s name and address
- Cost
- Suggested recipes
- Country of origin
- Information transmission - Packages and labels communicate how to use, transport, recycle, or dispose of the package or product

4. Packaging as a Salesman:

The packaging and labels can be used by marketers to encourage potential buyers to purchase the product. Packaging is often referred to as the —silent salesman. Robertson (1992) concisely summarized the multifunctions of packaging when he stated that —” a package must protect what it sells and sell what it protects”. Packages can have features which add convenience in distribution, handling, display, sale, opening, reclosing, use, and reuse. According to Jelen (1985), primary packages should have the following characteristics to facilitate the sale of products**:**

1. Sanitary

2. Non toxic

3. Transparent

4. Lightweight

5. Tamper evident

6. Easy to pick up and handle

7. Easy to fit into cupboards, shelves, refrigerators, etc.

8. Easy to open and dispense from

9. Easy to reclose

10.Returnable, recyclable, or reusable

11.Safe and presents no hazards in the way of broken glass or sharp jagged metal edges

12.Display the product

13.Glamorize: Create an illusion of something very precious, by decoration, embossing techniques and exotic closures, but it should not deceive the people.

No.	Functional Property	Specific Factors
1	Gas permeability	§ O_2, CO_2, N_2, H_2O vapor
2	Protection against environmental factors	§ Light, odor, microorganisms, moisture
3	Mechanical properties	§ Weight, elasticity, heat-sealability, mechanical sealability, strength (tensile, tear, impact, bursting)
4	Reactivity with food	§ Grease, acid, water, color
5	Marketing-related properties	§ Attractiveness, printability, cost
6	Convenience	§ Disposability, repeated use, resealability, secondary use
7	Aroma	§ Aroma compound barrier property

Figure 3: Functional Requirements of Packaging Materials

Source: Jelen, P. 1985. Food packaging technology. In Introduction to Food Processing, Reston Publishing, Reston, VA, pp. 249–266.

V. Requirements for producing a successful package:

Four sets of facts are necessary to be known for producing a successful package:

1. The product:

The nature of the product, the material from which it is made and the manner in which it can deteriorate.

Its size and shape.

Its weight and density: eg. Powder – Bulk Density … size of tins

Its weakness-which parts will break, move about, become bent or scratch or abrase the box easily.

Its strengths: which part will withstand loads or pressures and which might be suitable for loading the product in the pack.

The effect of moisture and temperature changes on the product and whether it will absorb moisture or corrode.

Compatibility: whether the product is likely to be affected by any of the possible packaging materials, which items can be packed together, with protection if necessary and which items must not be packed together under any circumstances.

How far stripping down may be carried out to reduce the package size to a minimum such that the customer can handle them. (Generally, for merchandize foods like kitchen machine, blender etc.)

2. Transport hazards:

The type of transport-road, rail, sea or air.

The degree of control over the transport. Is it private or public transport?

The form of transport- bulk, freight container, Unitized load, postal, passenger train, etc.

The mechanical conditions and duration of storage (manufacturer State Distributor District Distributor … Taluka / CityRetailer. The longer the journey or handling more strength is required in packaging & packing materials leading to higher cost).

The nature and intensity of mechanical and climatic hazards in transport, storage, retailing and use. Packaging / packing material has to withstand wide range of temperatures and relative humidity

Whether handling aids are available for loading and off-loading at all points between maker and user. (Viz. Lifts, Trolleys, Slip conveyers etc.)

The importance of minimum volume in relation to transport costs. Over packaging must be prevented.

3. Contamination:

- By materials of adjacent packs

- By leaking contents of adjacent packs

- Radioactivity.

VI. Material Comparison

1. Industrial Food Packaging Materials: 4 Main Types

i. Metal

Made from tinplated steel or aluminum and is the result of mined bauxite that is smelted into alumina.

- **Advantages**

- Protection: Total protection of contents when sealed with a double-seam.
- Tamperproof: Designed to resist access to the product contained within the package
- Versatility: Can be made in a wide range of shapes and sizes.

- **Drawbacks**

- High Costs: High manufacturing costs make metal packages expensive compared to other containers.
- Heavy: They are heavier than plastic containers and therefore have higher transport costs.
- Unavailability: Lack of can-making factories in developing countries and small-scale food processors.

ii. Plastic

Polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate and polyethylene, all of which are derived from fossil fuels and are used in food packaging.

- **Advantages**

- Light & Durable: Durable plastics consume less energy during the production process than metals, too, in part due to how light they are.
- Lightweight: The lightness of plastic is closely tied to its superior sustainability. Its comparatively low weight contributes to its lower energy consumption and greenhouse gas emissions over other materials.
- Versatile: You can mold plastic into essentially limitless shapes. Think of the vast variety of plastics packaging you see all the time.

- **Drawbacks**

- Degradation: Plastics are non-degradable materials. The decay of this material is not easy. It might take centuries and cause pollution in the environment.
- Harmful: The plastic material that is used in means of human consumption purposes, such as food packaging bags contains harmful components.
- Low Melting Point: Plastic packaging doesn't withstand in an area where the temperature is a little high.

iii. Glass

Made of three natural ingredients: silica sand, soda ash and limestone.

- **Advantages**

- Total Protection: Impervious to micro-organisms, pests, moisture, oxygen and odors
- Heat Processable: Subjecting the annealed glass to a thermal process to increase its resistance, and to make it safer in case of breakage.

- Recyclable: 100% recyclable and can be recycled endlessly without loss in quality or purity.
- Re-usable: Glass bottles can be reused for an extremely long time. They are one of the most sustainable drinking containers that you can use because their lifespan is so long.

- **Drawbacks**

- Higher weight: Higher weight than most other types of packaging, which incurs higher transport costs.
- Fragility: Containers are easily broken, especially when transported over rough roads.
- Hazards: There are potentially serious hazards from glass splinters or fragments that can contaminate foods.

iv. Paper

Uses plant fibers like cotton, linen and hemp, as well as grasses like straw, wheat and kenaf

- **Advantages**

- More Biodegradable Than Other Materials: Paper has higher biodegradation rates when compared to other kinds of packaging – especially plastic. This means that paper packaging breaks down in natural environments quickly when exposed to bacteria, yeast, and other organisms.
- Easy to Recycle: Paper is one of the most recyclable materials in the world. In fact, paper and paperboard made up nearly 67% of the total municipal solid waste (MSW) recycled in the U.S. in 2018 – the highest of any other kind of material. Plus, according to the American Forest & Paper Association, the U.S. paper recycling rate has met or exceeded 63% since 2009.
- Bio-based: Paper is primarily composed of forestry materials found in nature (i.e., fiber). This is beneficial because when the material decomposes, it reverts back to natural materials from our environment. Since paper is based on wood, it's one of the world's few truly sustainable products.
- Better for the Environment: At 1% of the world's greenhouse gas emissions, the pulp, paper and print value chain is one of the lowest industrial emitters in the world.

And when managed sustainably, younger forests can actually help reduce carbon dioxide emissions through carbon sequestration, defined as "the process of capturing and storing atmospheric carbon dioxide." Since carbon dioxide is the most frequently produced kind of greenhouse gas, this can be significant. Here's how:

Though older forests store more carbon than younger ones, younger forests sequester more carbon dioxide than older forests.

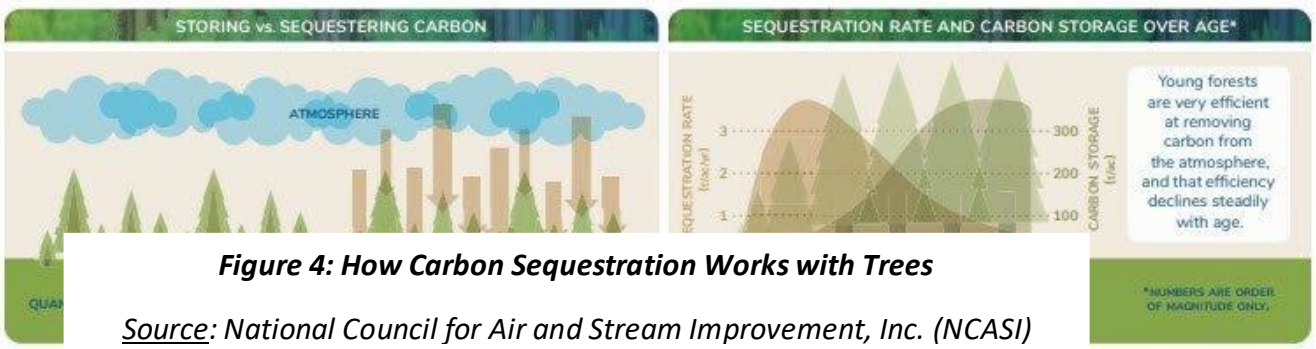


Figure 4: How Carbon Sequestration Works with Trees

Source: National Council for Air and Stream Improvement, Inc. (NCASI)

As trees get older, their ability to sequester carbon lowers. That's because of their growth rate. "Biological growth in trees is very rapid at young ages, and this growth rate declines as the trees age," Steve Prisley, a principal research scientist with NCASI, explains. Since younger trees (and forests) grow faster than their older counterparts, they can remove more carbon dioxide than older forests that have the same area coverage.

Consequently, sourcing fiber from forests for paper products can be better for the environment when managed in a sustainable way. And what is a sustainably managed forest?

"The bottom line [of a sustainably managed forest] is that we're not removing more trees than can be regrown, or we're not harvesting faster than the forest is growing. The goal is to balance the growth and harvest with the removals from the forest and ensure our harvesting rate is sustainable relative to growth."
- Steve Prisley, Principal Research Scientist, NCASI

- Reusable: Paper isn't just more recyclable than other materials – it's also easier to reuse with little environmental impact. That's because it can re-pulped without the use of chemicals. The life cycle of paper is long, too – recycled paper fibers can be reused up to 5 to 7 times to make new products.
- You Can Print Directly on Paper: Paper is advantageous for brand visibility because you can easily print your logo or other designs right on the material.
- Versatile: You can easily combine paper with other materials to achieve unique aesthetics, which can influence purchasing decisions. Per a national study conducted by the Paper and Packaging Board and IPSOS, 7 in 10 consumers – 72% – reported that packaging design can influence whether or not they purchase a product, and 83% of consumers said that paper and cardboard design can be innovative. In addition, 63% of consumers said that paper and cardboard packaging makes a product seem premium or high quality.
- Positive Public Perception: According to a recent study conducted by GlobeScan for the Forest Research Council (FSC) of 12,000 participants from 15 countries, climate change was the #2 most concerning global issue.

Not surprisingly, stainability is on consumers' minds as they make purchasing decisions. In another study of conducted by McKinsey, 55% of U.S. consumers surveyed said they were either extremely or very concerned about how product packaging impacts the environment. Since paper is bio-based, biodegradable, reusable, and recyclable, it's a popular option for packaging materials.

- **Drawbacks**

- Poor Barrier Properties: Paper offers less of a barrier to oxygen, light, and microbes than other packaging materials such as plastic. As a result, the items it stores – food products especially – have shorter shelf lives when stored in mainly paper packaging. (For paper to have better barrier properties, plastic usually needs to be added in plastic layers of laminates.)

- Often Ends Up in Landfills: Even though paper is very recyclable and reusable, it still fills up landfills. In 2018, paper and paperboard (that is, cardboard) materials made up the largest component of U.S. MSW at 11.8%, or 17.2 million tons.
  While paper does have a high biodegradation rate, this happens in aerobic environments, which are environments where paper materials are broken down by the action of oxygen-breathing microorganisms. Conversely, paper has a slow anaerobic (oxygen-absent) biodegradation rate in environments without oxygen, like landfills, because it's resistant to degeneration when compacted.
  Within less than a year of being brought to a landfill, anaerobic conditions get created, no matter what type of MSW has been deposited – including paper. Bacteria then decompose MSW in landfills and produce methane, a potent greenhouse gas.
- Takes Up More Space in Landfills: Paper takes up more space than the same weight of plastic in landfills because it's less dense than other types of waste. For example, 1 lb. of paper will occupy more space in a landfill than 1 lb. of food waste, glass, or even some plastics.
- Weight: Higher weight than most other types of packaging, which incurs higher

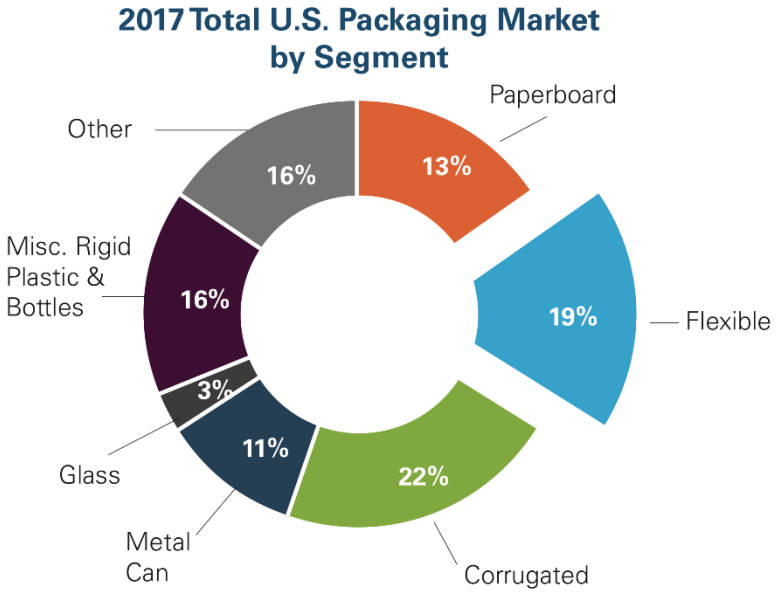


Figure 5: U.S. Packaging Materials

Source: Annual Survey of Manufacturers

U.S. Census Bureau 2013-2017

2. Breakdown Comparison Between Food Packaging Materials

The food processor has a variety of packaging materials to choose from for food packaging, specifically, paper, glass, metal, and plastics. The choice of the proper packaging material will be made by the food processor based on the requirements:

1. Composition of the food (solid or liquid)

2. Physical, chemical, and microbiological and deteriorative reactions that might occur

3. Storage conditions and time of storage

4. Socioeconomic situation of the anticipated customer or market

5. Desired package attractiveness

6. Cost of the packaging material

7. Packaging technology selected

8. Specific functional properties of the packaging material

There are several reasons for selecting or rejecting a particular packaging material over another, as summarized in the following Table:

Paperboard	Glass	Steel	Plastics
Selection			
Easily machined and folded	Product visibility	Strong, stiff	Fabricability
Easy to bond	Impervious, inert	Malleable	Variety of forms
Composites well	Image of high quality	Retortable	Tough, lightweight
Printability	Ovenable, Reusablity	Permanence, Reusablity	Wide range of properties
Rejection			
Chances of water absorption	Shatters, Scratability	Corrodes	Thermal limit
Penetrable	High weight-to-strength ratio	Limits shapes	Permeable
Image	Limited shapes	Appearance	Absorbs flavors
Tears, punctures	Large sizes	Flavor distortion	Distortion and creep

Figure 6: Comparison Between Packaging Materials

3. Comparison Between Plastic Food Packaging

Film	Coating	Barrier to		Strength	Clarity	Thickness (µm)
		Moisture	Air/odours			
Cellulose	PvDC	*	***	*	***	21-40
	Aluminium	***	***	*	***	19-42
	Nitro-cellulose	***	***	*	-	21-42
LDPE	-	**	*	**	*	25-200
HDPE	-	***	**	***	*	350-1000
Polypropylene	-	***	***	***	***	20-40
	PvDC	***	***	***	***	18-34
	Aluminium	***	***	***	-	20-30
Polyester	-	**	**	***	**	12-23

Coextruded film	Typical food applications
High impact polystyrene-PET	Margarine, butter tubs
Polystyrene- polystyrene-PvDC- polystyrene	Juice and milk bottles
Polystyrene- polystyrene-PvDC-polyethylene	Tubs for butter, cheese, margarine, bottles for coffee, mayonnaise, sauces.

Figure 7: Comparison of properties of Plastic packaging materials

VII. Characteristics of an ideal package:

1. Compatible with product.

2. Protection from Mechanical hazards especially transportation. climatic hazards, microorganisms: Packaging do not harbor bacteria, restrict their growth…. Flavor gain/loss/salts/difference in temperature.

3. Fit into a production line.

4. Advertising potential.

5. Attractive appearance.

6. Easy to handle during…Production, storage and Distribution

7. Moisture proof/resistance.

8. Sufficient mechanical strength to withstand drop, vibration, compression etc.

9. Acid, alkali resistance.

10. Grease & oil resistance.

11. Resistance to photo-chemical changes in product.

12. Resistance to insects and rodents.

13. Fire proof resistant to smoke, fume and water.

14. Pilfer proof (malpractice).

15. Inert: No effect on flavor/aroma.

16. Not injurious to health.

17. Economic.

18. Easy availability.

19. Protect against climatic hazards.

20. Protect against microorganisms. It should not harbor microbes rather restrict their growth by controlling growth factor like.

Chapter 2: Presentation of the Products

A. Marshmallow:

1. Choice of the packaging material:

According to researchers, consumers normally purchase marshmallows in simple polypropylene (PP) pouch packaging. So, what is PP?

i. Polypropylene (PP)

A polypropylene bag is high clarity and crystal clear in order to enhance the image of whatever product is inside. This PP bag offers a highly protective barrier against both moisture and vapors. These poly bags delay evaporation and dehydration to preserve the freshness and taste of packaged foods. Generally, PP plastics are stronger, clearer, and more expensive than their PE plastic counterparts. Polypropylene bags are great for the following industries — food, electronics and electronics manufacturing, hospitals, agriculture, and more.

ii. Advantages of PP:

-More resistant to chemicals, high temperatures, and scratches

-Crystal clear for great product presentation

-Stiff and hard plastic

-Rough surface has the potential to produce scratches

-Outstanding vapor and moisture barrier

-Meets FDA and USDA specifications

-Difficult to break, but not very flexible

iii. Recycling PP:

While PP is easily among the most popular plastic packaging materials in the world, only around 1-3% is recycled in the US, which means most PP is headed for the landfill. Here it degrades slowly and takes around 20-30 years to completely decompose.

Again, you may ask: "if it's recyclable, why do we throw so much of it away?" And the answer, again, is that unfortunately, it doesn't always make sense financially to reuse this material. Polypropylene recycling is difficult and expensive and, in many cases, it's hard to get rid of the smell of the product this plastic contained in its first life.

For this reason, PP is usually included in plastic lumbers, park benches, auto parts, speed bumps, and it's used for other industrial applications.

2. Packaging & Design:

After brainstorming for the marshmallow packaging, we came out with these packaging Must-Haves that would make the product both presentable and alluring:

i. Technical requirements:

-Re-sealability: and that is to ensure that the marshmallows remain spongy and soft.

-Transparency: the content inside will be clearly visible and more inviting to the buyer.

ii. Marketing requirements:

-Fun gentle colors.

-Fun diverse games on the packaging's back: Riddles, labyrinths, crosswords, spot the differences games, etc.…

-Packaging that makes a crisp cracking sound: Children find products inviting and more exciting if they have such sounds.

Example: Chips' packages.

iii. Boxes VS Bags:

A bag is the best choice. Why?

-Better visibility of the product

-A zipped bag is better for the preservation of the product after it's been opened.

-Better audible features (cracking...)

iv. Product's name:

Marshmallow + Dates = Mallow-Date

v. 3D Design & Labeling:

Figure 8: Marshmallow Package: Front view.

Figure 9: Marshmallow Package: Back view.

Figure 10: Marshmallow Package Label

3. Industrial Manufacturing of the packaging:

i. How Are Reclosable Bags Made?

The plastic is melted down to a point in which it is pliable. It is then poured into a very thin mold that is in the shape and size of the bag being made. The closures on the bags are formed in separate molds out of stronger, thicker plastic. The closure tracks are then transfixed to the lips of the baggies. The most common brand bags are made a little differently. The common brand bags offer a zipper closure bag as well; these zipper bags have a plastic slider zipper used to push the lips of the bag closed and to fasten them shut.

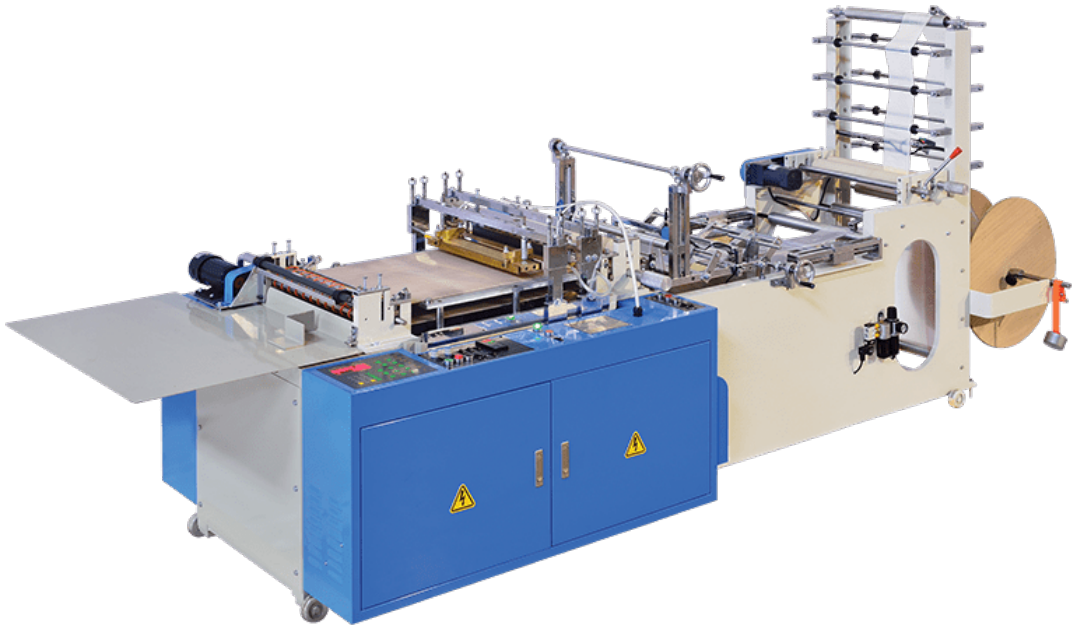


Figure 11: Zipper Bag Manufacturing Machine

After the zipper bag is made, these 8 stages will terminate the packaging of the product:

1.	Pouch-picking Station (Required)
2.	Date-printing Station (Required)
3.	Pouch-opening Station (Required)
4.	Material-filling Station-1 (Required)
5.	Material-filling Station-2 (Optional)
6.	Air-exhausting Station (Optional)
7.	Matrial-detecting Station (Optional)

B. Milk Drink:

1. Sequence of layers of the bottle:

- 2 layers of HDPE

- Aluminum layer

- EVA « ethylene-vinyl acetate »

- Paperboard

i. Paperboard:

Paperboard is eco-friendly as it is based on wood.

ii. Polymers:

In order to preserve the product and to enhance the storage life, we have used 2 layers of HDPE. Our paperboard is laminated externally and internally with these 2 layers.

Factors that are behind the polymer selection:

- Moisture in the atmosphere.
- Oxygen.
- Preservation and safety of the product.
- Barrier properties.
- Cost.

We have chosen HDPE layers over the PP (polypropylene), the two most used plastics for milk drinks, because :

- HDPE's Chemical resistance is superior as well as resistance to oil and grease.

- HDPE has 90% crystallinity which increases its stiffness.

- The HDPE film offers excellent moisture protection and significantly decreases

gas permeability.

iii. EVA « ethylene-vinyl acetate »:

It has excellent sticking or gluing properties; it is used between the aluminum and the inner layer for better tightening. EVA is a copolymer. EVA film is tough and tacky so we have used it with HDPE as a tie-layer

iv. ALUMINIUM:

Aluminum foil acts as a complete barrier to light and oxygen (which cause fats to oxidize or become rancid), odors, flavors, moisture, and bacteria. Aluminum foils are a good choice for dairy products; they also help in preservation of dairy products for some time without refrigeration.

v. Remarks:

- The packaging materials proposed for this product aims to minimize losses and wastages of the product caused by its transportation or because of the environmental hazards
- This product is not a recyclable product because of the complexity of the recycling of multilayer packaging compared to monolayer packaging

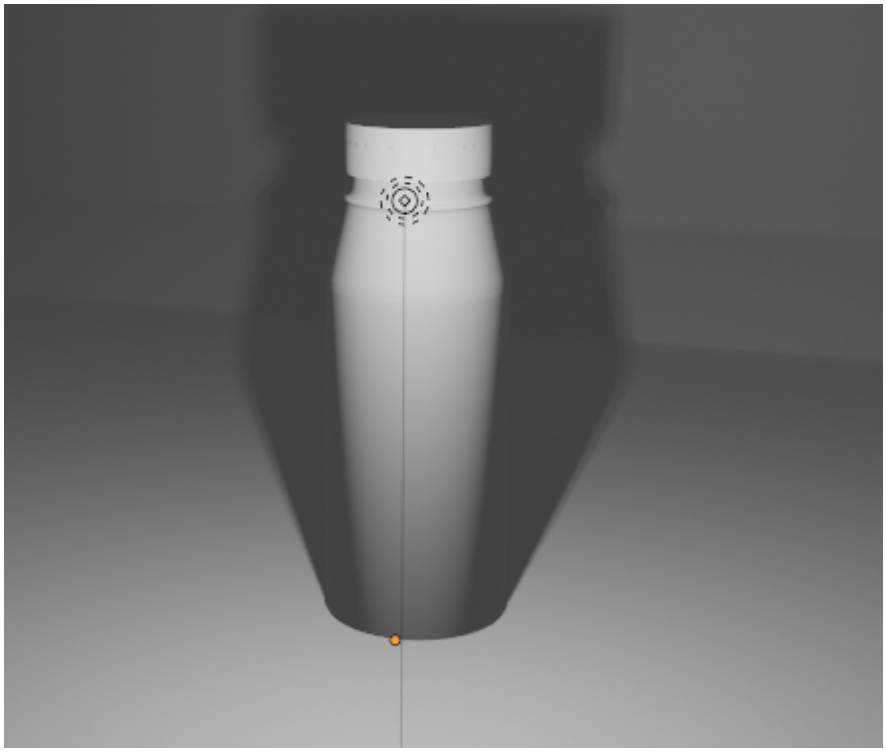
2. The Bottle Cap:

We have chosen high density polyethylene (HDPE) because of its strength and its excellent properties.

3. Packaging Design:

i. Packaging Label:

ii. Packaging 3D Design:



4. Lamination technique used in the manufacture of the packaging:

i. What is lamination:

Laminating is the process through which two or more flexible packaging webs are joined together using a bonding agent. The substrates making up the webs may consist of films, papers or aluminum foils.

ii. Advantages of lamination technique in this product:

Lamination of paperboard with polymers serves following purposes:

- Provide protection to the food and to the paperboard against hazardous environmental effects like sunshine, moisture, air, dust, oxygen.
- These layers give extra strength and stiffness to the packaging.

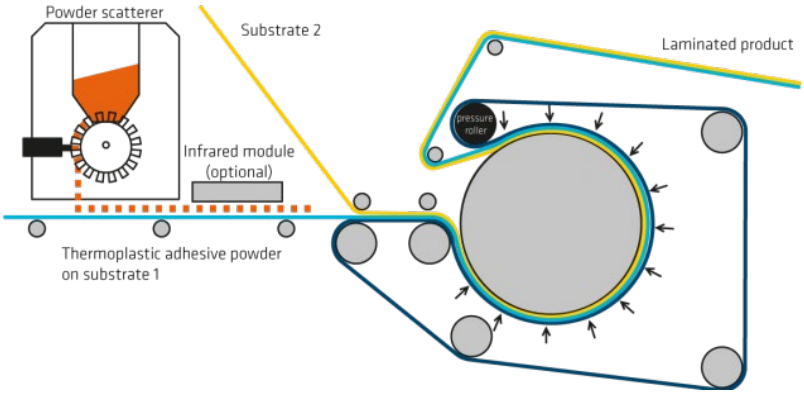


Figure 12: Typical lay-out for laminating with thermoadhesive powder on a LFC calender and the use of a Powder Scattering Devise

C. NOUGAT:

1. Description of the Product:

The product will be Nougat based on dates and covered with Chocolate for extra sweetness and more attractiveness to kids who are most likely to be chocolate lovers

2. Material choice:

Most chocolate products use Aluminum foil, we will use that as well or laminate and we're going to add Sulphite paper for the external wrapping as well as plastic foil to protect the label.

i. Why use aluminum foil? (advantages)

Many chocolate goods are kept for lengthy periods of time, but when they are exposed to moisture and light, they deteriorate and the surface loses its appealing brightness. Aluminum foil or laminate offers the best protection, providing a total barrier to light, moisture, and any penetration of aroma and flavor.

Another benefit is that foils are simple to fold, allowing customers to keep what's left of a chocolate bar for later use. The bright color of the wrapper gives a feeling that it's very clean and well preserved. The bright color of the wrapper gives a feeling that it's very clean and well preserved. The wrapper's tightness provides more protection, prevents bacterial spread, and makes the chocolate bar safer to eat. The light weight of the foil makes no discernible difference to the original product; hence the price and sales calculations are unaffected.

ii. Disadvantages of aluminum foil:

A negative aspect of tin foil is that the assembly process of aluminum may be a very high energy consuming process. However, the recycling, smelting and recasting of aluminum consumes less energy and is a relatively simple process. On the contrary to other aluminum products, tin foil seems to be difficult to recycle due to its thin thickness which can make it burn within the

smelting process. Due to the thickness and production process of foil the mechanical characteristics vary from bulk aluminum.

iii. Statistics about aluminum foil:

Retail packaging accounts for between 1% (eutrophication) to 9% of total packaging (CED non-renewable). The consumption of aluminum accounts for about two-thirds of the burden, while wrapping paper accounts for one-third. It's important to remember that the aluminum and paper components of the package serve various purposes while nevertheless contributing to a single packaging solution. The impact of chocolate distribution and sales is second only

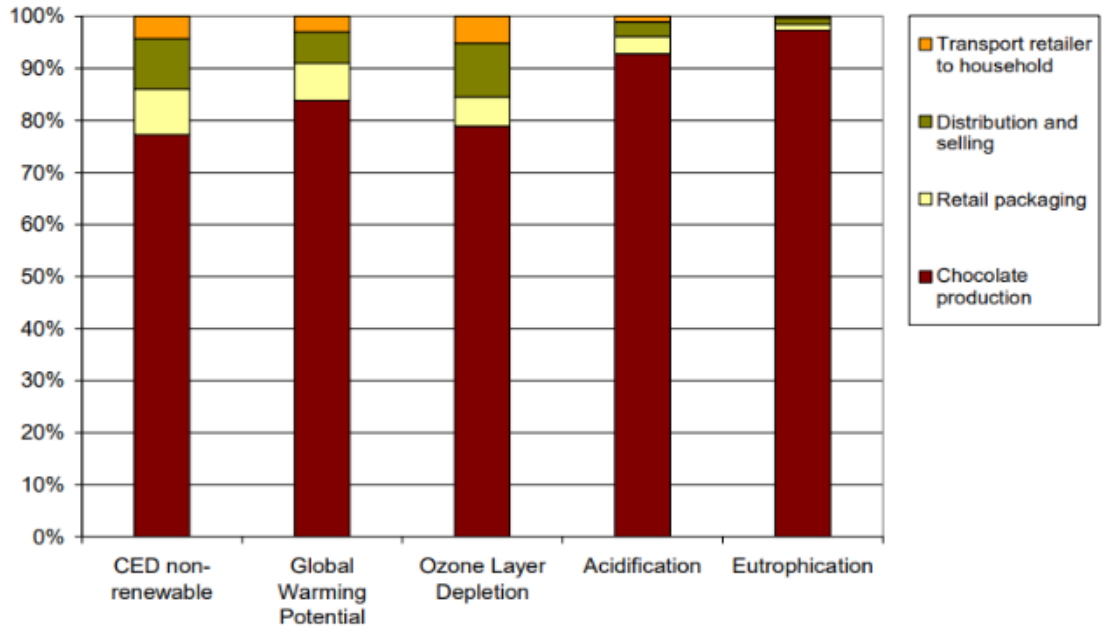


Figure 13: **Results of the standard case for 1kg milk chocolate packed in 100g bars made from aluminum foil and wrapped with paper**

to nonrenewable cumulative energy demand and ozone layer depletion in the indicator nonrenewable cumulative energy demand and ozone layer depletion.

Although the aluminum foil paper is not intended for use with chocolate, the metal's heat conductivity is excellent. It's evident that if it's a mold, the plastic is plastic. So, what's the point of using aluminum foil? Cocoa cake formed from cocoa beans and cocoa butter, sugar, milk, and other ingredients are used to make chocolate. When chocolate is exposed to direct light, the cocoa butter reacts with the moisture and oxygen in the air to produce the chocolate scent. And the flavor will be lost; there will be no chocolate aroma when peeling the chocolate paper, and it

will be tasty when eaten; aluminum foil paper was used to keep the chocolate delectable, as well as serve as an insect and bacteria barrier.

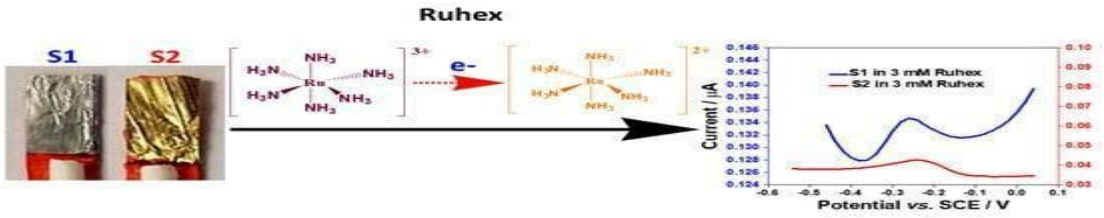


Figure 14: **Chemical reaction of aluminum foil**

3. MECHANICAL STUDY USING TENSILE TEST:

i. What is tensile test:

Tensile test is used to determine the basic mechanical characteristics and properties of a material. A tensile test can be either uni-axial, applied force along one axis, or bi-axial, applied force along two axes simultaneously.

ii. The process of the test:

In order to thoroughly study the mechanical material behavior of aluminum foil a tensile test was carried out on aluminum foil samples cut out in different directions. Eleven directions were examined which are illustrated in this picture:

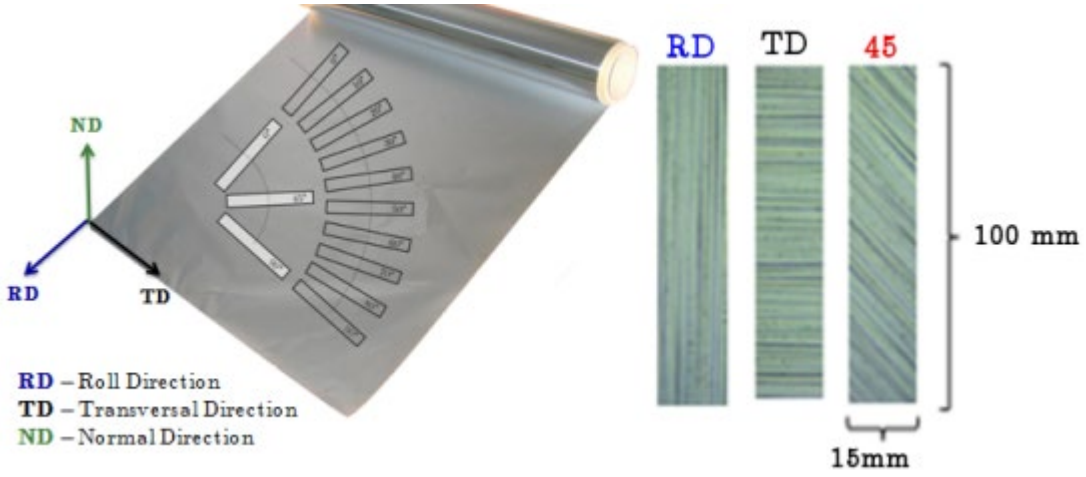


Figure 15: **The samples were cut out from the foil sheet in different directions, as illustrated. 0° is defined as RD and 90 ◦ is defined as TD**

First rectangular samples (200x25 mm) were cut out from an aluminum foil sheet. A preparation of 15 samples in every direction were made. The samples were 27 thereafter cut again with a more precise and sharper double cutter into the size (200x15 mm) and red tape was applied on the edges with a distance of 100 mm apart. The gauge length is equal to the distance between the tape, the sample is mounted into the tensile tester so that the tape is not visible. After finishing the preparation of all samples, the five best samples (no visible cracks or holes) were chosen and the tensile tests were executed. The tensile test was performed with an Instron tensile tester with 50 mm wide and smooth rubber grips and a 100 N load cell.

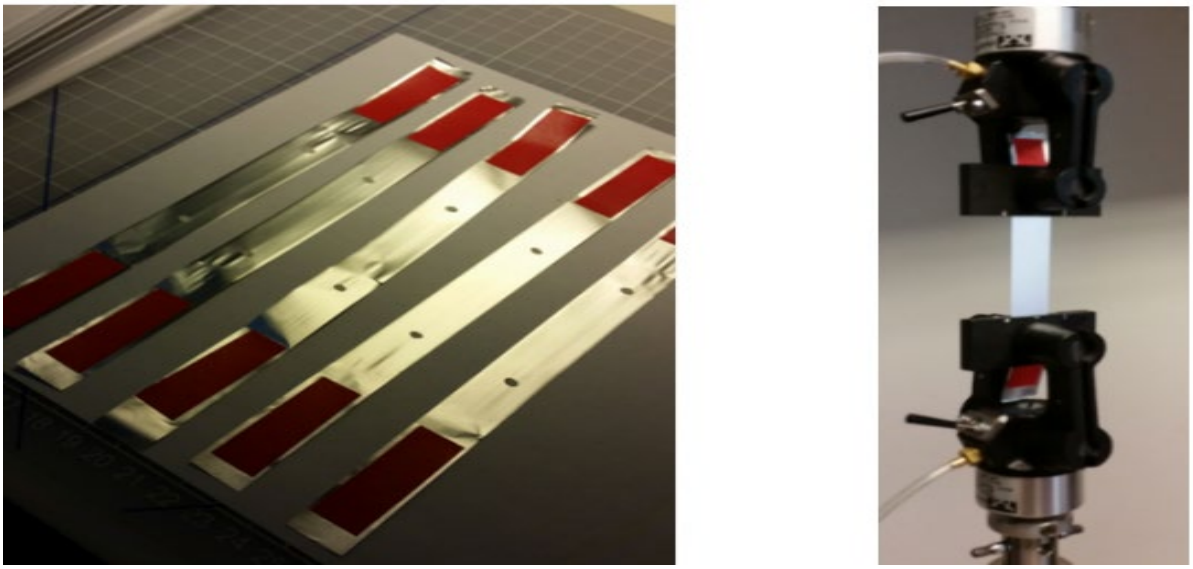


Figure 16: **Prepared samples, cut in the Double cutter and taped**

iii. Results:

The tests were carried out with a strain rate of 9 mm/min and a preload of 0.2 N. From every tensile test force and displacement data was acquired. From the tensile test data some material characteristics could be determined. E is the slope on the dotted line shown in the Figure below. The ultimate tensile stress σ_{uts} and the ultimate tensile strain uts is the maximum strain and stress before break. The yield stress, σ_y, is the stress-value where the material starts to yield. Tensile absorption energy, W_t is the shaded area and the failure energy, W_f , is area under the failure part of the curve

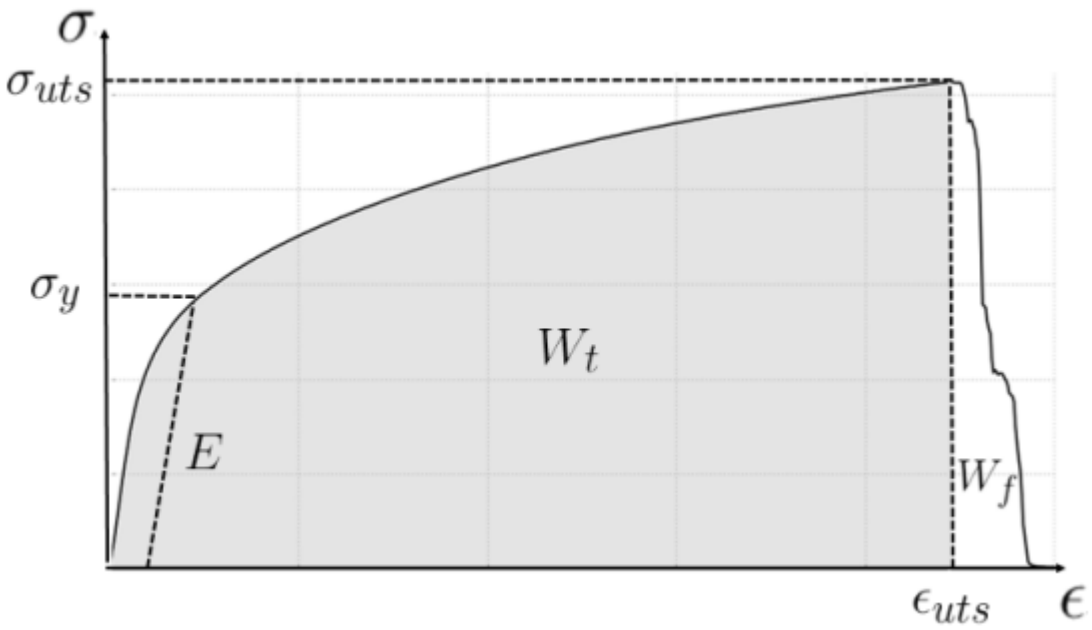


Figure 17: **Identification of key values**

4. PACKAGING & DESIGN:

i. Logo:

Figure 18: **Identification of key values**

ii. Packaging Label:

Figure 19-1: **Package labeling Version 1**

Figure 19-2: **Package labeling Version 2**

iii. Packaging 3D Design:

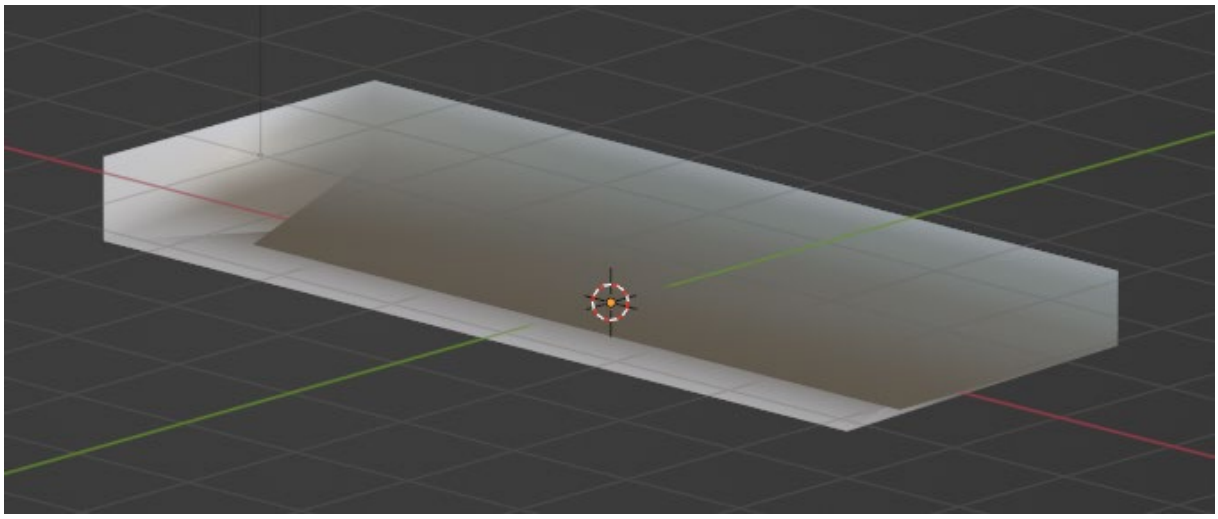


Figure 19-3: **Package 3d Design Version 1**

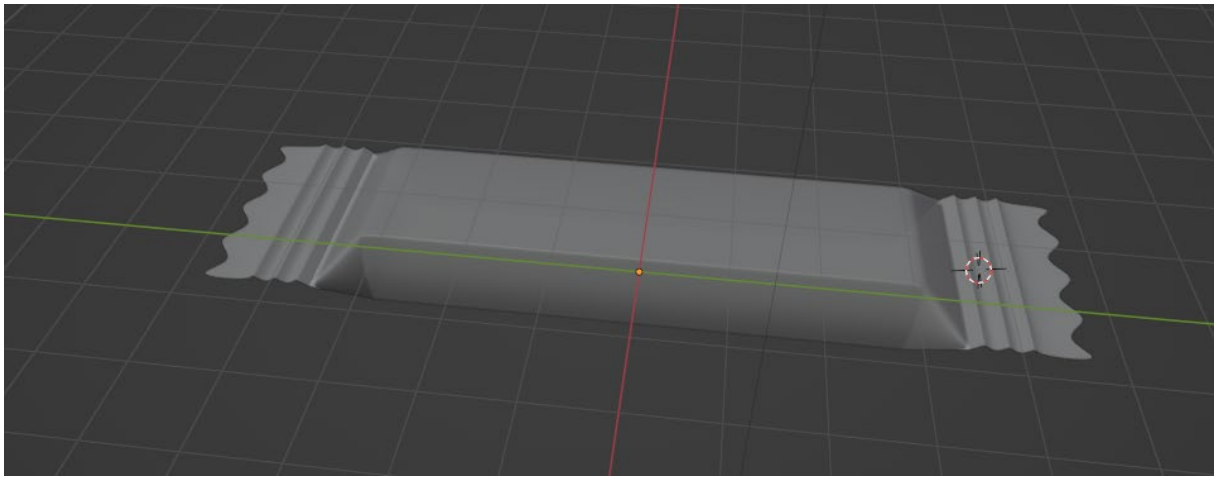


Figure 19-4: **Package 3d Design Version 2**

5. INDUSTRIAL STUDY:

i. GENERAL STUDY

- **THE MANUFACTURING PROCESS**

The fabrication of the packaging is the initial step in the packaging process. When it comes to packaging design, the production process must be taken into account. The following are some of the aspects that will have an impact on the manufacturing process:

-The packaging's material or substrate

-The cost of these items

-Where will the packaging be manufactured?

-How long will it take to manufacture the packaging?

-Whether automation or hand assembly will be utilized

- **THE FILLING & ASSEMBLING PROCESS**

After the manufacturing process is completed, the packaging needs to be filled and assembled. This can take many forms depending on the nature of the product. Some of the examples include:

- Is the package a simple box inside of which the product will sit?

- Does the packaging require a separate tray or insert to encompass the product?

- Is assembly and filling automated or manual?

These are only a few of the many points that need to be considered during the filling and assembly process. Both the product and packaging have to be protected while expediting the process.

- **THE TRANSPORTATION OF THE PRODUCT:**

Once the packaging has been fulfilled, the product will be transported to wherever it is being sold. It is imperative for the product to be protected during this important step. Whether it is being moved by land, sea, or air, steps need to be taken to protect the integrity of the product. This needs to be incorporated into the design of the packaging. Consider the transportation of the product and take steps to protect it. In addition to protecting the packaging and final product, it's important to note that packaging efficiency is also important when it comes to logistics. Well thought-out packaging means more efficiency in transportation which can reduce costs. In our case chocolate needs to be preserved at a lower temperature to stay in the same shape and avoid being spoiled.

- **THE SHELF LIFE:**

Shelf life is yet another area to consider when designing a packaging design. While we're mostly familiar with shelf life in terms of perishable items, shelf life also represents how well the product

will appear on the shelf and how it can attract the buyer. From tamper protection to fragility, these have to be considered well in advance. A design that is too intricate and fragile might easily damage a store shelf or on display, making it unattractive to consumers.

- **THE USER EXPERIENCE:**

The user's experience is the final phase in the packaging process. Leading brands understand this and place a high importance on this aspect of the packaging process. They recognize that packaging serves as a medium for communicating with customers. Packaging should provide the consumer with an experience in addition to safeguarding the product. It should convey a tale and earn the trust of the customer. This alone gives the brand a good return on its marketing effort.

ii. MANUFACTURING PROCESS OF THE PACKAGING:

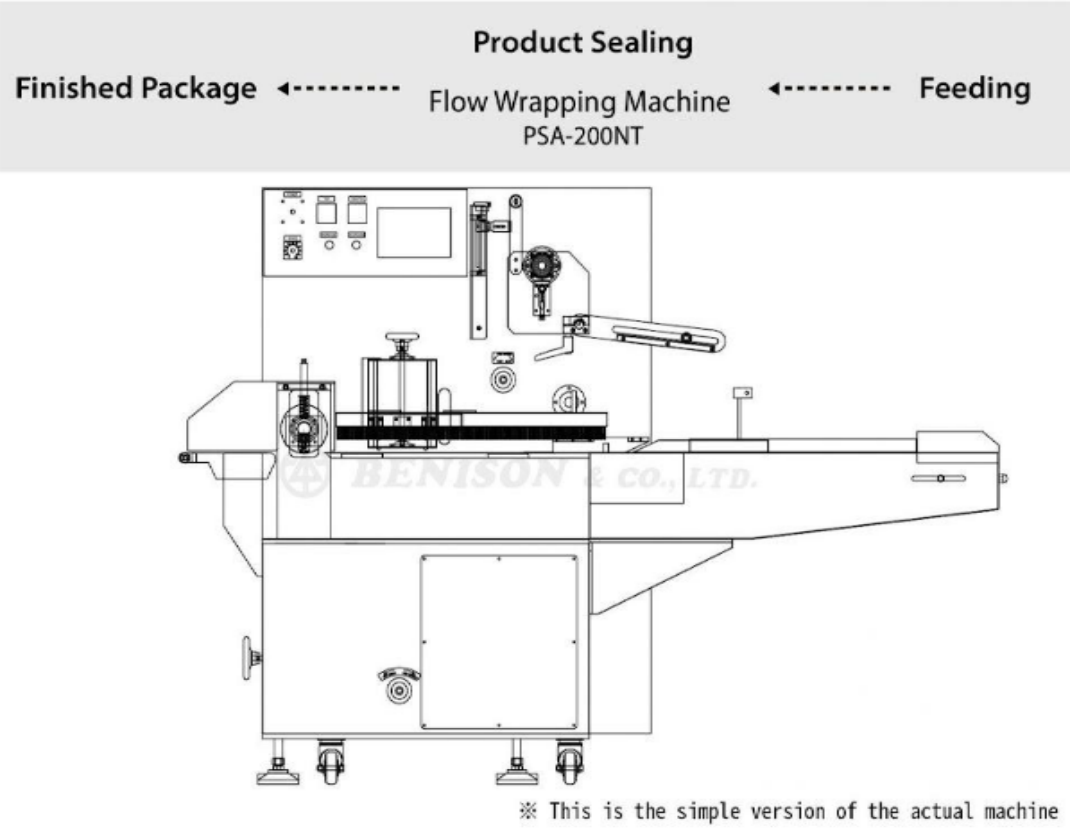


Figure 20: **Flow wrapping machine simple design**

We need a flow wrapping machine with high speed to support our production line. After consideration, we chose Flow Wrapping Machine PSA-200 NT. With PSA-200 NT nougat and chocolate products can be wrapped in a more efficient way.

- **Material**

In this case, we're going to use aluminum foil for the wrapping of the nougat chocolate bar, plastic foil to wrap the external part of the paper designed for label protection

- **Machine Specifications**

- Flow Wrapper Machine PSA-200 NT
- Packaging Capacity: 125packs/minute (depends on product size)

- **Features**

- Easy to operate.
- Printing sensor can be installed to make sure printed packs be in the right position
- Two-side knife sealer can double the machine speed comparing to standard model
- Enable to pack different size of products, with easy adjustment
- Suitable for food and non-food industries
- All machinery and equipment comply with food safety production regulations
- The equipment, material, and quantity can be adjusted based on actual production needs
- Benison can provide consultation about plant layout planning, production line optimization, and labor allocation.

D. Juice Drink:

1. Choice of the packaging material:

A tetra pack comes under the category of aseptic packages. For a material to be aseptic, it should have the following features:

- The packaging material must be compatible with the product intended to be packed.
- The physical integrity of the package is necessary to assume containment of the product and maintenance of sterility.
- The packaging material must be able to withstand sterilization and be compatible with the methods of sterilization.
- The package must protect the product from oxygen; also, the package must retain the product's aroma.

i. What is Tetra pack?

Tetra pack is the most common name for aseptic cartons used for liquid food items which have to be stored for up to one year without refrigeration. Aseptic here means "free from pathogenic micro-organisms", so this packaging process eliminates the food and packages from harmful elements. This type of packaging also blocks light completely to preserve vitamins A, B2, B6, B12, C and K, which are all photosensitive and would become damaged in the presence of light.

Functional Layer: Aluminum

Heat Seal: LDPE

Basic Level: BOPP

ii. Laminate Structure of a Tetra pack:

A tetra pack is made of six layers i.e.

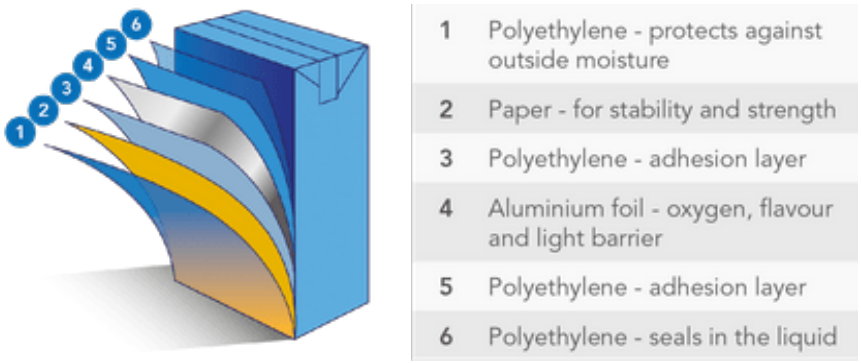


Figure 21: **Tetra pack layers**

1. **PE**: Contributes 15% of the total packaging; it's water proof, anti-corrosive, and protects the printing from outside moisture.
   Bonding layer: Reinforcing the lamination of PE and paper.
2. **Paper**: Substrate for printing and a support layer that contributes 80% of the total packaging providing strength, stability, smoothness, tenacity and stiffness.
3. **PE**: Acts as an adhesive bonding paper layer. It's water proof, and moisture proof.
   Bonding layer: Reinforce the lamination of PE and aluminum foil.
4. **Aluminum foil**: Contributes 5% of the total packaging. It forms a barrier against light, flavor, and oxygen, eliminating the need for refrigeration and preventing spoilage without using preservatives.
   Bonding layer: Reinforce the lamination of PE and aluminum foil.
5. **PE**: – Acts as an adhesion layer. Increases strength of laminate and thickness.
6. **Modified PE**: Modifying heat sealing performance, increase sealing quality.

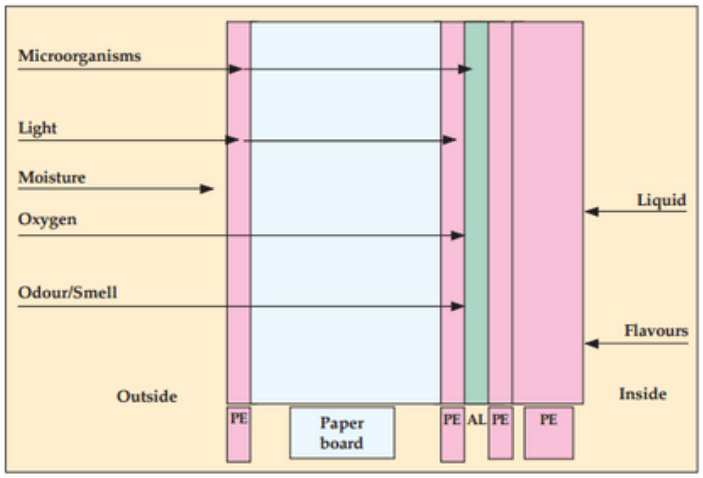


Figure 22: **Diagrammatic Representation of Tetra pack acting as a Barrier.**

iii. Types Of Tetra packs:

These packages come in various sizes and shape configurations. These packages also have a variety of openings and closures appropriate to product and consumer needs. Depending on the two points mentioned, following diagrams shows the types of tetra packs available.

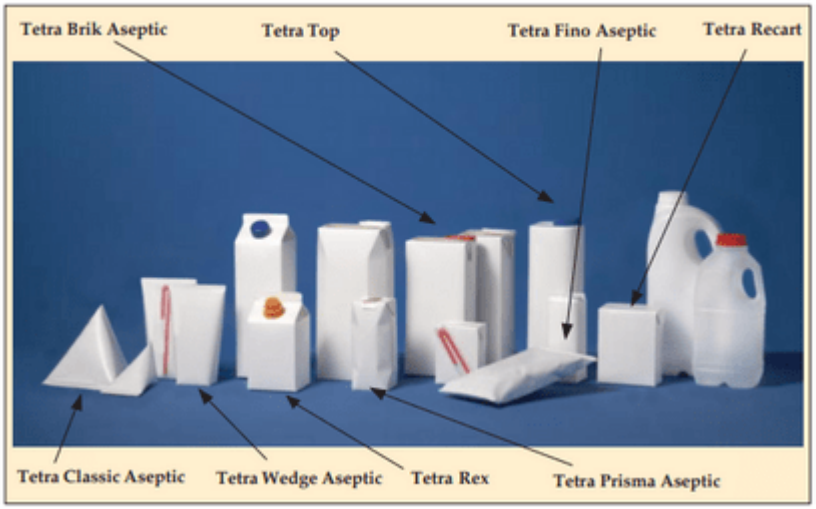


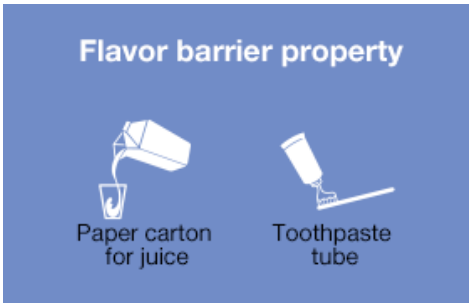
Figure 23: **Types of Tetra Packs**

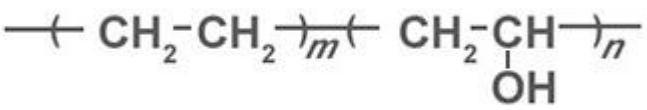
iv. Co-extrusion coating with Soarnol

Soarnol is an ethylene-vinyl alcohol copolymer developed by Mitsubishi Chemical's own technology.

It has high gas barrier properties, oil resistance and high transparency derived from vinyl alcohol structure as well as moisture resistance and extrudability comes from ethylene unit.

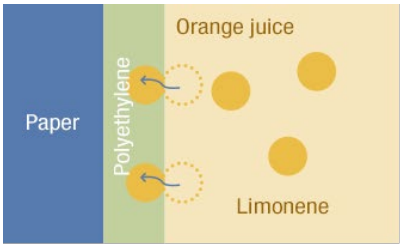
Additionally, Soarnol is consist of carbon, oxygen and hydrogen so no harmful gases is generated when incineration and its combustion heat is a half of polyethylene.

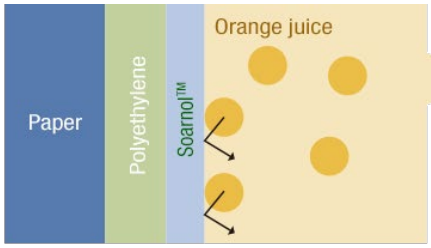




Soarnol can be coated onto base film and paper. Not only a pellet type for extrusion coating application, but also Soarnol solution type is available.

One example for co-extrusion coating of Soarnol is a paper carton for orange juice. Conventional paper carton has polyethylene as innermost layer but it absorbs limonene which is a main substrate of orange flavor so that it loses original taste. On the other hands, Soarnol has abilities to protect such absorption and migration so by coating Soarnol, it's possible to reduce a deterioration of a taste. Additionally, Soarnol prevent an oxidation of vitamin C and this keeps original taste of orange juice longer.

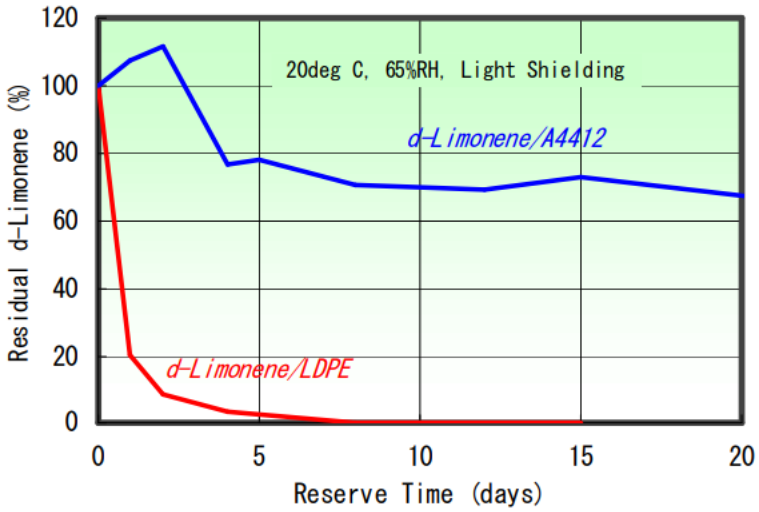




Orange juice, fruit juice seasoning

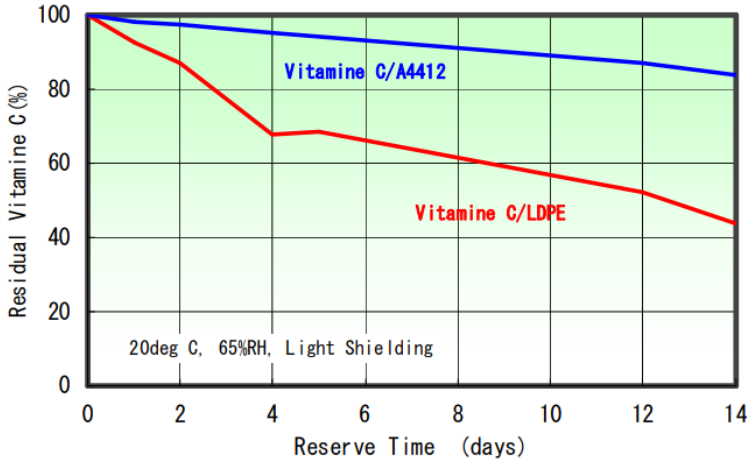
Effect of the Innermost Layer Soarnol

Layer Construction : Web/A4412/LDPE/A4412/Orange Juice



Effect of the Outermost Layer "SoarnoL

Layer Construction : Web/A4412/LDPE/A4412/Orange Juice



v. Recyclability & Sustainability:

The Tetra pack carton is the future packaging – being primarily made using paperboard (a renewable forest-based resource) and fully recyclable. Not only this it offers consumers convenience, easy opening, optimal shelf life.

Tetra packs are recycled, but the recycled part is not used for manufacturing of tetra packs, hence they are said as non-sustainable. It is unclear whether this is because their paperboard needs to come from virgin sources to avoid contamination, or whether the quality of the recycled paperboard isn't high enough to make new cartons, or there is some other reason. Whatever the reason, it is turned into office paper.

vi. Material of the Cap: HDPE

HDPE is a high-density plastic with a semi- to non-porous surface that is very stiff, has a good temperature resistance and water vapor barrier. It makes for excellent push fit caps and plugs, offering smooth and simple assembly, and can protect package contents from damage. As one of the most versatile plastic materials around, HDPE is used in many different applications, including plastic bottles, milk jugs, shampoo bottles, bleach bottles, cutting boards, and piping. Known for its outstanding tensile strength and large strength-to-density ratio, this plastic has a high-impact resistance.

2. Packaging Design:

i. Packaging Label:

ii. Packaging 3D Design:

Chapter 3: Future of Food Packaging Materials

Innovations and advancements in material science have given food packaging a positive future in terms of efficiency and environmental impacts.

Smart packaging (or Intelligent packaging) has been gaining publicity lately, with an expected market of $26.7 billion by 2024. Smart packaging represents packaging systems carrying sensors that help prolong the shelf life of foods, reveal information on freshness and quality, and enhance the safety of the product and consumer.
Another technology in packaging systems is *active packaging*, which is the integration of additives with the packages to improve food shelf-life and quality
Nanotechnology, as well, has been able to penetrate the food packaging industry. It helps augment the thermal and mechanical properties of food packages. Nano sensors embedded within the packaging systems can also help monitor, identify, and warn about the safety and quality of the foods. Although the effect of nanoparticles on human health is yet to be well understood, nanotechnology displays a promising future. When it comes to waste management, packaging waste has occupied a large portion of municipal solid waste (MSW), resulting in a rise in environmental concerns. *Biodegradable polymers* have arisen as alternatives to traditional plastics in food packaging. These polymers decompose into CO2, water, inorganic compounds, and biomass.

Conclusion

We have tried throughout this project to design 4 labeled packages for different products, ensuring their protection as well as their attractiveness in the eyes of our target audience which is children, ranging from toddlers to teenagers.

In an attempt to ensure eco-friendliness and the organic aspect of our packages, our choice of the packaging materials was quite selective.

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Annexes

Figure 1: Packaging Functions

Figure 2: Packaging Levels

Figure 3: Functional Requirements of Packaging Materials

Figure 4: How Carbon Sequestration Works with Trees

Figure 5: U.S. Packaging Materials

Figure 6: Comparison Between Packaging Materials

Figure 7: Comparison of properties of Plastic packaging materials

Figure 8: Marshmallow Package: Front view.

Figure 9: Marshmallow Package: Back view.

Figure 10: Marshmallow Package Label

Figure 11: Zipper Bag Manufacturing Machine

Figure 12: Typical lay-out for laminating with thermoadhesive powder on a LFC calender and the use of a Powder Scattering Devise

Figure 13: Results of the standard case for 1kg milk chocolate packed in 100g bars made from aluminum foil and wrapped with paper

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