

PHARMACEUTICAL PACKAGING

Abstract

Packaging serves to separate a product from its environment by enclosing it. The object is protected, important information is communicated, and it is protected against physical damage, content loss, ingredient deterioration, and the entry of unwelcome environmental components including moisture, oxygen, and light. Pharmaceutical packaging is crucial in converting formulas into alluring products that are ready for the market. Packaging is closely related to a variety of pharmaceutical product characteristics, including stability, sales, and patient adherence. This present study explores the variety of advancements in packing techniques, material choice, equipment, and labeling in light of these factors. This research carefully analyses the different packaging materials and packaging strategies used in the pharmaceutical industry.

Keywords: Pharmaceutical packaging, Stability, Patient adherence, Packing techniques, Packaging strategies

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I. INTRODUCTION

The primary objective of this chapter is on highlighting the crucial importance of packaging and highlighting its incorporation into any drug discovery and development programme. While specific packaging requirements, such as material, style, and so on, may vary depending on product characteristics, production, distribution, sales, and usage/administration, there are some common factors that apply to all product classifications, whether ethical, over-the-counter (OTC), veterinary, or others.

A Pharmaceutical Bundle carrier is a thing or equipment that holds the Pharmaceutical Item and may or may not have direct contact with the item. The holder for pharmaceutical uses must be strong and solid ^[1]. Pharmaceutical items require superior packaging than most other products in order to satisfy their primary requirements, which include being effective, safe, consistent, trustworthy, pure with few contaminants, and having few adverse effects. The packaging should also guarantee that the product remains stable on the shelf for an extended period of time. This high level of packaging is required to support and satisfy the critical demands of pharmaceutical goods. When done effectively, it is transparent to the end user; when done poorly, it is subject to criticism from all sides ^[2,3]. For the different pharmaceuticals and medical gadgets accessible today, a range of sophisticated packaging methods are used. However, the quantities involved are often lesser when compared to food goods. Despite this, pharmaceutical packaging security and integrity are critical and are strictly regulated by licencing agreements ^[4].

II. IDEAL CHARACTERISTICS OF PHARMACEUTICAL PACKAGING^[5,6]

1. It should be mechanically strong enough to survive handling, filling, closing, and transportation.
2. It should not react to the chemical stored in it.
3. It should be of such a form that it can be rich and the material can be extracted properly from it.
4. It should not filter soluble base from the contents.
5. Microbial growth should not be permitted in the container.
6. When sterilising, the container must withstand the heat.
7. The container's contents should not be absorbed by it.
8. The container's construction material should be neutral or inert.
9. Any component of the container or closure should not interact with one another.
10. The closure should be non-toxic and chemically stable with the container contents.

III. PHARMACEUTICAL PACKAGING FUNCTIONS^[7,8,9]

We may evaluate a package or packaging system at any moment depending on how well it executes its tasks. The performance might be categorized as either favorable, bad, or neutral. Each function is frequently evaluated separately of the other. This technique, however, overlooks the whole package system notion and can result in the failure of a package design that appeared to be appropriate for one purpose. The finest package developers employ strategies that take into account all three purposes at the same time. These are the functions listed below:

1. **Protective Function:** This includes shielding the product from the environment or shielding the environment from the product. Protection from stress and vibration, crushing, dampness, heat, corrosion, and other factors are examples. Poisoning prevention for children is also mentioned.
 - **Protection against Temperature:** When the temperature rises, the reaction rate accelerates, reducing the shelf life of medicinal items. Effective packaging is critical in protecting the goods from such environments.
 - **Protection against Moisture and Humidity:** When exposed to excessive humidity, pharmaceutical powders may experience caking, which occurs when the powder clumps together. Moisture levels both inside and outside the product container impact clumping. The selection of packing material and closures is critical to avoiding such moisture-related issues. For moisture-sensitive items, incorporating sachets of silica gel desiccant in the package might be beneficial.
 - **Protection against Light:** When exposed to excessive humidity, pharmaceutical powders may experience caking, which occurs when the powder clumps together. Moisture levels both inside and outside the product container impact clumping. The selection of packing material and closures is critical to avoiding such moisture-related issues. For moisture-sensitive items, incorporating sachets of silica gel desiccant in the package might be beneficial.
2. **Physical/mechanical Protection -** The basic function of pharmaceutical packaging is to keep the substance enclosed and secure. To build outstanding packaging, consider the product's specifications as well as the production and delivery processes. This implies that the packaging should not leak or allow the medication to soak through, that it should be strong enough to resist routine handling, and that it should not be impacted by the final dosage form's components.
 - **Secondary Packaging Aids in Product Protection Against Compression:** Secondary packaging aids in product protection against compression. Secondary packets are made from the cardboard.
 - **Impact Resistance:** Impact resistance is achieved by dropping the product. Impact damage can be avoided or minimized by cushioning the primary pack and placing it in a secondary pack.
 - **Protection against Vibration:** Vibration causes emulsion cracking during shipping. As a result, proper packing is required.
 - **Biological Hazards Protection:** Packaging protects the product against microbial contamination.
3. **Presentation and information:** Packaging is an important source of information about pharmaceutical items. Labels and packaging inserts for patients convey this information.
4. **Convenience:** Convenience is connected with product usage or administration, for example, a unit dosage eye drop that eliminates the need for preservative while also reducing hazards related with cross infection by providing only a single dose.

IV. TYPES OF PACKAGES^[6,8,10]

Various forms of packaging are used in the pharmaceutical sector to guarantee the safe and effective confinement, delivery, and use of medical medicines.

- 1. Primary Packaging:** The primary packaging system is the material that immediately surrounds and protects the goods. Package components and subcomponents that come into direct touch with the product or have a substantial influence on its shelf life are included. Ampoules, vials, prefilled syringes, IV containers, and other items are examples. Non-reactive materials such as aluminum and PVC are the most commonly utilized for primary packaging. Similarly, instead of glass, high-quality plastic is utilized for liquid dosing. This prevents the items from spilling or becoming damaged during transit from the manufacturing to the pharmacy. Polyethylene, polyvinyl chloride, nylon, polycarbonate, and polyethylene terephthalate are the most popular polymers used for tablets and pills.
- 2. Secondary Packaging:** The package that is not part of the primary package is referred to as the secondary package. This packaging provides additional protection during storage as well as information on the drug product, such as leaflets. Secondary packaging is used to bundle main products together, such as cartons, boxes, shipping containers, injection trays, and so on. In the pharmaceutical sector, secondary packaging serves to offer extra protection, confinement, and information for main packaged medical items. It fulfills various critical functions:
 - Secondary packaging gives an additional layer of protection to main packaging, protecting pharmaceutical items throughout shipping, storage, and handling. It aids in the prevention of damage, contamination, and tampering.
 - **Grouping and Convenience:** Secondary packaging frequently combines numerous units of the original packed product together, making transportation and storage easier. Cartons, for example, may contain many blister packs or bottles of medicine.
 - Secondary packaging comprises labeling and product information such as dosing directions, warnings, batch numbers, expiration dates, and barcodes. This makes it easier for healthcare professionals, pharmacists, and patients to select and utilize the appropriate product.
- 3. Tertiary packaging:** Tertiary packaging systems, such as barrels, containers, edge guards, and so forth, are utilized for bulk handling and shipment. The primary goal of tertiary packaging is to protect primary and secondary packing from the outside environment during storage and transit. Plane boxes, cardboards, and shrink wraps are the most commonly used secondary packaging for pharmaceutical products. Examples: Barrel, crate, container, pallets, slip sheet.

V. COMPONENTS OF PACKAGING^[11,12]

- 1. Container:** The containers are the containers in which the product/medicine is put and contained. It is direct drug interaction. These are the primary containers for medicinal goods. The following are examples of common container types:

- **Bottles:** These are commonly used for liquid pharmaceuticals, oral solutions, and solid dosage forms such as tablets and capsules.
 - Vials are most commonly used for injectable drugs and immunizations.
 - **Ampoules:** Single-dose glass vials that is small and sealed.
 - **Blister packs:** Individual dosages of solid drugs are packaged in pre-formed plastic or aluminum foil blister packs.
 - **Tubes:** Creams, ointments, and topical pharmaceuticals are stored in tubes.
 - Syringes that have been pre-filled with a certain dosage of injectable medicine for ease of administration.
2. **Closure and Lids:** It firmly packs the container to keep out oxygen, carbon dioxide, and moisture while also preventing the loss of water and volatile compounds from the goods. These are the caps, stoppers, or lids that seal the containers in order to keep the product intact and avoid contamination. They can be child-resistant, tamper-proof, or include dropper tips or dispensing pumps for precise dosage.
 3. **Carton/outer and Box:** This provides supplementary defense against mechanical and environmental risks. It is the outer layer. Cartons are composed of cardboard, wood pulp, and other materials. Outer cartons or boxes are used to put together many units of a pharmaceutical product, giving further protection during distribution and storage. They are also used for product branding and regulatory compliance.
 4. **Compliance Aids:** In rare situations, packaging may include compliance aids like as pill organizers or dosage reminders to assist patients stick to their recommended prescription regimen.

Pharmaceutical packaging is crucial in assuring medicine safety and efficacy, and regulatory bodies may have precise criteria for packaging materials, labeling, and product information to safeguard public health.

VI. PACKAGING MATERIALS

The packing materials chosen must have the following characteristics:

1. **Chemical Compatibility:** The packaging materials must be chemically compatible with the medicinal substance contained within them. They must not interact with the drug in such a manner that its chemical makeup, effectiveness, or stability are affected.
2. **Moisture and Gas Barrier:** Pharmaceuticals are frequently affected by moisture and oxygen. Packaging materials should have a strong barrier property to prevent moisture and gas transfer, hence preventing product degradation or spoiling.
3. **Light Protection:** Certain wavelengths of light might cause light-sensitive drugs to deteriorate. To retain the product's effectiveness and stability, packaging materials should hide it from light.
4. **Physical Strength:** Packaging materials must be robust enough to endure handling, shipping, and storage without breaking or deforming, hence maintaining the product's integrity.
5. **Tamper Resistance/signs:** Packaging should be intended to display signs of tampering or opening, giving consumers with assurance that the product has not been tampered with.

6. To limit the danger of unintended ingestion, some pharmaceuticals that may pose hazards if mistakenly consumed by children should be packed in child-resistant containers.
7. Packaging should be user-friendly, providing quick access to the drug and concise dosing instructions, especially for older patients or those with limited dexterity.
8. **Regulatory Compliance:** Packaging materials must adhere to applicable pharmaceutical rules and standards, ensuring that the product satisfies all legal criteria.
9. **Inertness:** The packing materials should be inert and not leach dangerous elements into the drug, preserving the purity and safety of the product.
10. **Sealing Integrity:** To avoid leakage or contamination during transit and storage, the packaging must offer a secure seal.
11. **Environmental Considerations:** To decrease waste and limit the environmental effect of pharmaceutical packaging, there is a growing emphasis on adopting sustainable and ecologically friendly packaging materials.
12. **Printability and labeling:** Packaging materials should allow for the clear and accurate printing of critical information such as product name, dose, expiration date, and usage directions.
13. **Compatibility with Pharmaceutical production procedures:** The materials should be compatible with pharmaceutical production procedures such filling, sealing, and labeling.
14. **Cost-Effectiveness:** In addition to assuring high-quality packaging, producers consider cost-effectiveness to keep overall manufacturing costs low.

VII. TYPES OF PACKAGING MATERIALS

Glass containers for pharmaceutical preparations are designed to be in close touch with medicinal preparations. A good closing method for glass containers is required. The containers are built in such a way that removing the contents is simple and suited to the intended use of the preparation. Glass containers provide varied degrees of protection based on the type of the product and environmental dangers, and limit ingredient loss. Glass containers used for pharmaceutical packaging must not interact physically or chemically with the contents in a way that compromises medication product quality. According to the USP, the following glass kinds are used for pharmaceutical packaging:

1. **Glass:** Glass preparation: Glass is primarily made of sand, soda ash, and lime stone. Pure silica glass is composed of a three-dimensional network of silicon atoms, each of which is surrounded by four oxygen atoms in a tetrahedral arrangement to form the network.
 - **Type I Borosilicate Glass:** Borosilicate glass, also known as neutral glass or Type I glass, is extremely resistant to chemical assault and provides good protection against leaching of contaminants from the glass into the product. It is utilized in the packing of parenteral medications, injectables, and other sensitive medicines.
 - **Composition:** Type I Borosilicate Glass is comprised largely of silica (SiO_2), boron oxide (B_2O_3), and trace quantities of alkali and alkaline earth metals. Boron oxide is added to the glass composition to provide it distinctive features such as excellent chemical durability and thermal shock resistance.
 - **Properties**
 - **Chemical Resistance:** Chemical resistance is one of the most important characteristics of Type I Borosilicate Glass. Because it is very resistant to

leaching, it is an excellent choice for medicinal items that may react with or absorb contaminants from the glass container.

- **Thermal Stability:** Because of its exceptional thermal shock resistance, this type of glass can tolerate fast temperature fluctuations without splitting or shattering. This attribute is critical throughout the pharmaceutical product sterilizing procedure.
 - **Hydrolytic Resistance:** Type I Borosilicate Glass has a strong hydrolytic resistance, which ensures that it retains its physical and chemical integrity when exposed to water or aqueous solutions.
 - **Inertness:** Because the glass is inert, it does not impart any undesired taste, odor, or chemical reactions with the medicinal medication contained within it.
 - **UV and light protection:** While not as effective as amber glass, Type I Borosilicate Glass still provides some UV and light protection, minimizing the possibility of light-sensitive drugs degrading.
- **Pharmaceutical Applications:** The following medicinal drugs are often packaged using Type I Borosilicate Glass:
 - **Injectables:** It is commonly used to describe ampoules, vials, and prefilled syringes containing injectable drugs, vaccinations, and biologicals.
 - **Infusions:** Glass containers used for intravenous infusions and parenteral nutrition solutions are frequently made of Type I Borosilicate Glass.
 - **Parenteral Packaging:** Because of its great chemical stability and resistance to leaching, it is the ideal choice for packaging parenteral goods, preserving the integrity and safety of the drugs.
 - **Highly Sensitive Medications:** Pharmaceutical medicines that are sensitive to interactions with standard glass compositions frequently need Type I Borosilicate Glass containers.
 - **Laboratory Applications:** Type I Borosilicate Glass is also utilized in laboratory glassware and equipment, such as glass containers used to store and handle pharmaceutical intermediates and raw materials.
 - **Type II Amber Glass** is a form of soda-lime glass that has iron and sulfur added to give it an amber or brown tint. It offers light protection, making it useful for light-sensitive medications that deteriorate when exposed to specific wavelengths of light.
 - **Main Constituents:** The main ingredients are soda lime glass. At elevated temperatures and wetness, the surface is treated with acidic glass such as SO_2 .
 - **Uses:** Large capacity container for alkali sensitive items, infusion fluids, blood, and plasma.
 - **Properties:** For a length of time, the surface of glass is resistant to water assault.
 - **Type III Soda-lime** glass is a typical form of glass used for non-parenteral pharmaceutical containers such as oral liquid pills, lotions, and ointments. It is not ideal for medications that are particularly sensitive or reactive.

- **Main constituents:** SiO_2 , Na_2O , CaO .
- **Properties:** Flakes separate easily, many crack due to sudden change of temperature.
- **Uses:** Topical use, For oral use, Not for ampoules.
- **Type NP (Type IV) Glass:** Also known as general-purpose soda-lime glass, Type NP glass is used for non-parenteral pharmaceutical applications that do not require a high level of chemical resistance.
 - **Tubular glass** is used in the production of ampoules, vials, and cartridges for injectable pharmaceuticals. It is made by pulling molten glass into tubes and then cutting them to length.
 - **Moulded Glass:** Moulded glass is used to make pharmaceutical containers such as bottles and jars. Molding molten glass into specified forms produces it.
 - **Pharmaceutical Glass Coatings:** Some pharmaceutical glass containers may have specialist coatings or treatments to improve their barrier qualities, chemical resistance, and stability.

Because of its inertness, transparency, and capacity to retain the integrity of the contained substance, glass is a desirable material in pharmaceutical packaging. It acts as a good barrier against oxygen, moisture, and other environmental variables that might jeopardize the purity and efficacy of the medicine. Glass is both recyclable and ecologically benign, making it a viable option for pharmaceutical packaging.

2. Plastic

- **Properties:**
 - High-molecular-weight synthetic polymers
 - They are heat-sensitive; many of them may melt or soften at temperatures of or below 1000 °C. However, some polymers, including nylon, polycarbonate, polypropylene, high-density polyethylene (HDPE), etc., can be autoclaved.
 - Because plastic containers are lightweight, handling them is simple
 - Because of their mechanical strength, containers made of plastic can have thinner walls than those made of glass.
 - If the contents are to be autoclaved, they are poor heat conductors
 - In general, they are resistant to inorganic compounds but frequently come into contact with organic chemicals, such as organic solvents and oils.
- **Additives used in Plastics:**
 - Anti-oxidants
 - Stabilizers
 - Fillers
 - Pigments
 - Cross-linking agents
- **Merits:**
 - Light weight hence, low transportation cost.
 - Chemically inert in nature.
 - They are easily shaped into the required shape.

- Odorless
- Unbreakable
- They come in a variety of sizes and forms

- **Demerits:**

- **Permeation:** Permeation is the movement of gases, vapors, or liquids from the environment around them into a plastic container. Permeation can cause serious problem if the drug is sensitive to hydrolysis/oxidation
- **Leaching:** Leaching is the process by which a component gets released into the formulation from the container's plastic substance.e.g., Dye used as coloring agent
- **Sorption:** Sorption is the process by which one or more of the elements from the formulation are extracted or removed by the packing material.
- **Chemical reactivity:** Chemical reactions between some substances used in the production of plastic containers and one or more drug product components are possible.
- **Modification:** Modification refers to the physical or chemical change made to the package by the drug product.

- **Types:**

- **Thermoplastic type:** These materials soften into a viscous fluid on heating and then harden once more on cooling.Examples include polyethylene, polypropylene, polyvinyl chloride, polystyrene, nylon (polyamide), polycarbonate
- **Thermosetting type:** These may become flexible when heated but do not turn liquid. They are often hard and brittle at room temperature because of a high level of cross-linking.Examples-phenol-formaldehyde,urea-formaldehyde, and melamine-formaldehyde.

3. **Metal:** Metals are very commonly used as packaging material for pharmaceutical containers. Examples of metals used for this purpose include mainlyaluminum, lead, tin, etc.

Metals have advantages.

- They are less heavy than glass.
- They are powerful.
- They resist gases, moisture, and light.
- They have an elegant appearance.
- Labels can be printed directly on surfaces, so they don't need to be adhered to.

Disadvantages

- They may introduce metal ions into the final product.
- They could react with specific drugs or chemicals and create a harmful result.
- The cost is higher than that of plastic.

4. Tin

- **Properties:**
 - Malleable
 - Silvery whitish
 - Crystalline
 - Ductile
- **Merits:**
 - This metal has excellent chemical resistance.
 - Many metals can be easily coated, such as tin-coated lead tubes
- **Demerits:**
 - **Costly**
Pharmaceutical use: food containers, tubes contains eye ointment are made up of tin .

5. Aluminum

- **Merits:**
 - light weight, attractive appearance
 - Low cost
 - Its surface develops a clear oxide layer after reacting with atmospheric oxygen, preventing further oxidation of the metal.
- **Demerits:** Some complexing agents and products with high or low pH can induce corrosion when they react with the oxide coating.

Pharmaceutical use: Aluminum is used in the manufacture of ointment tubes, tablet and pill strips, screw caps.

6. Lead

- **Merits:**
 - Soft in nature
 - less expensive than any other metals
- **Demerits:**
 - lead poisoning
 - should be coated with some kind of inert polymer or metal before use
Use: paint,ink,lining of some toothpaste

7. **Rubber:** Natural rubber is made up of long-chain polymers of isoprene units that are linked together in the cis position. Its primary source is the tree *Hevea braziliensis*, from which latex emerges when shallow cuts are made, containing 30 to 40% rubber in colloidal suspension.

Some of the characteristics of raw rubber (for example, poor elasticity and temperature sensitivity) make it unsuitable for the fabrication of most rubber goods. This can be corrected using:

- **Vulcanizing agent:** Due to poor elasticity and strength, it becomes soft and sticky when hot and becomes hard when cold. Vulcanizing considerably expands the stress and temperature ranges over which the material is elastic. Sulfur acts as a vulcanizing agent, forming cross-connections between long rubber molecules.
- **Accelerators:** This shortens the vulcanization period and reduces the amount of sulfur required. e.g., 2-mercapto benzthiazol (MBT).
- **Activators:** These are used to enhance the accelerator action. e.g., Stearic acid or zinc stearate for MBT.
- **Fillers** There are two kinds of fillers employed. Reinforce example –Carbon Black and Non-Reinforces example –Calcium Carbonate.
- **Pigment:** These are employed as coloring agents in rubber composites e.g. Iron
- **Softeners:** This makes the compound easier to manufacture by facilitating the integration of fillers. Example –Pine oil, mineral oil.

8. Paper:

- Paper-based materials include labels, cartons, bags, outers, shrink-wrap trays, layer boards on pallets, and so on.
- Carton applications and benefits include.
Increases display area - Provides better stacking for the display of stock items - Assembles leaflets - Provides physical protection, especially to items like metal collapsible tubes.
- Fiberboard outers, either solid or corrugated, have significant applicability for bulk shipments.
- Regenerated cellulose film, often known as Cellophane and Rayophane, is used for individual cartons or to construct a number of cartons.

VIII. TYPES OF PHARMACEUTICAL PACKAGING

1. **Tamper-resistant packaging^[14]:** Tamper-resistant packaging is customized packaging meant to prevent unwanted access, interference, or tampering with a product's contents. This packaging is purposefully designed to display visual evidence of disturbance if the item is opened, altered, or compromised. Tamper-resistant packaging's major purpose is to improve consumer safety and protect product integrity.

- **Strip Pack:** A strip package is a type of unit-dose packaging that is widely used to enclose tablets and capsules. A strip package is created by passing two heat-sealable flexible film webs through a heated crimping roller or a heated reciprocating plate. The product is inserted into the formed pocket before the completion of the final seals. The end product is a continuous strip of pockets, frequently spanning numerous pockets in width, depending on the packing machine's capabilities. This continuous strip is then trimmed to the desired length, which determines the number of packets. Strip packaging materials are chosen based on their features, especially for applications needing high-barrier properties.

- **Blister pack:** The creation of a blister package involves softening a thermoplastic resin sheet using heat, then utilizing a vacuum to shape the softened plastic sheet into a contoured mold. Once the plastic sheet has cooled and acquired shape, it is removed from the mold and guided to the filling station of the packaging machine. This pre-formed, slightly hard blister is then filled with the desired product and sealed with a heat-sealable backing material. The backing material is usually peelable and is constructed of heat-seal coated aluminum foil. The foil's coating must be compatible with the blister substance to ensure successful sealing. This sealing protects the contained product while also providing tamper resistance. Polyvinyl chloride (PVC) and mixtures of PVC and polyethylene are two materials that are often used for forming blisters.
- **Bubble Pack:** The bubble pack can be made in a variety of ways, the most common of which is to sandwich the product between a plastic film that can be formed by thermoforming, stretching, or heat shrinking and hard backing material. Typically, this entails warming the plastic film to a malleable condition and utilizing suction to produce a pocket within the film, similar to how blisters for blister packages are made. The product is then placed in this pocket, which is then sealed against a strong substance, often paperboard coated with a heat-sealing coating. When, a heat-shrinkable material is used, the package is transported through a heated tunnel. The film shrinks and conforms around the product during this process, generating a protective "bubble" or seal.
- **Film Wrapper:** A translucent film with a unique design is firmly wrapped around an object or its container. The film must be cut or ripped to have access to and extract the product. Films that are extremely prone to degradation, as well as films that leave a visible imprint or image upon removal, are among the substrate options available. Solvent-sensitive paper is an example of the latter.
- **Breakable cap:** These caps fracture when you try to open them. These caps provide visual signals of external tampering and can be used in conjunction with inner seals to provide an additional degree of security.
- **Shrink Tubing:** Packaging covers the design of a package that not only prevents tampering but also, via careful material selection, provides significant environmental protection. This type of packaging is called a flexible pouch. A flexible pouch typically gains shape during the product filling phase, which is accomplished using vertical or horizontal forming, filling, and sealing procedures (abbreviated f/f/s).
- **Sealed Tubes:** The tube's mouth is sealed, and the seal must be punctured in order to get the product.
 - **Single Dose Containers:** Containers of this kind hold individual doses of medication example: Glass Ampule
 - **Multi Dose Containers:** These containers, are made to hold more than one dose, and their contents are taken out at various times. Example: Vials

- **Air Tight Containers:** These containers provide protection against environmental threats. They maintain an airtight seal upon reclosure if they are supposed to be opened several times. They are also known as hermetically sealed containers.
- **Light Resistant Containers:** These containers protect the contents from light, particularly UV radiation. They are made of materials that inhibit UV radiation from passing through to the content. Example: Amber coloured glass container
- **Collapsible Metal and Plastic Tube:** The majority of collapsible tubes are made of aluminum, although they can also be made of tin, lead, tin-coated lead, and polymers. Because of the existence of an oxide deposit on their surface, aluminum tubes have high corrosion resistance. The container's narrow aperture prevents severe contamination of the unused sections of the contents. There is less wastage because the consumer is less likely to remove the product excessively. Unlike in other containers, expelled pieces are not replaced with an equivalent volume of air
- **Aerosol:** Aerosol packaging is a type of packaging that uses pressurized gases or propellants to dispense items in the form of a thin mist, foam, or spray. It is possible to remove a dose without contaminating the materials. Stability is improved for certain chemicals that are negatively impacted by oxygen and/or moisture^[15].

IX. CLOSURES^[13]

This is the most important aspect of a container. An effective closure system reduces material loss from the container and product contamination in the environment:

1. **Threaded Screw Type:** These closures are crafted from aluminum, tin, or plastic. They have threads that interlock with the threads on the container's neck, as the name implies. These closures provide a strong seal that protects the product from both physical and chemical reactions. Because of their corrosion resistance, plastic caps are preferred over metal caps.
2. **Lug Cap:** The difference between lug caps and thread caps is the threading style. Thread caps have continuous threads, whereas lug caps have intermittent threads. Another distinction is that lug caps, which are commonly used to store food, require only a quarter turn.
3. **Crown Caps:** These metal caps are widely used on beverage bottles. These also offer an effective seal and cannot be opened with hands.
4. **Roll on Closures:** Roll-on closures include an aluminum roll on cap that is easily sealed, opened, and closed. These are available in resealable, non-sealable, and pilfer-proof varieties. These can be used on glass or plastic bottles.
5. **Pilfer Proof Closures:** The pilfer proof closure is identical to the ordinary roll on closure, except it has a longer skirt. This extra length continues below the threaded portion to form a bank that is held to the basic cap by a series of narrow metal "bridges." When the pilfer proof closure is removed, the bridges break and the bank remains on the container's neck. The closure is easily resealable.

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