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Eco-Friendly Biological Materials for Healthy Food Packaging

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Abstract

Packages of food products are interested in protecting food during shipping. To achieve the goal of packaging food products, the rules governing them must be followed. There are many materials for food packaging, some of which pose risks to human health. Therefore, the use of biopolymers and starch-based compounds has been developed. Food packaging is essential for preserving the quality and safety of food, but it has raised concerns regarding waste and environmental impact. However, to meet the increasing demand for food, both the quality and quantity of packaging need to improve. Certain packaging materials can emit harmful chemicals when heated, posing risks to consumers. Packaging serves as both an art and a science, attracting buyers and ensuring product safety. Factors such as food type, manufacturing process, shelf life, and environmental considerations influence packaging choices. It is crucial to prioritize food-grade materials and consider aspects like shape, size, color, labeling, cost, and recyclability.
Keywords: Materials, Healthy, Food Packaging

Introduction

The current food market is centered on food packaging, with very few goods being offered without packaging. Effective packaging guarantees that food keeps its target quality for its shelf life and reduces waste. Despite its significance and the vital role that packaging performs, it is frequently considered to be, at worst, a major resource waster and a threat to the environment. However, if the world is ever going to be able to feed 9 billion people, then the quality and quantity of food packaging is going to have to increase considerably.

While food packaging is an essential component of the food business and aids in the safe storage of food and drinks, it may also be a source of worry for food safety. When heated, some packaging materials, such as certain types of plastic, Polyethylene, and Styrofoam, can emit chemicals that are hazardous to consumers. Irradiated packaging materials (together with food) can introduce harmful nonfood substances into the food. Food packaging contains a range of materials, such as dyes for printing colorful labels and glues and adhesives to keep packaging tight and successfully safeguard customers Packaging has now evolved into both an art and a science. Packaging courses and institutes exist to educate about packaging technologies. While its primary function is to enclose or protect things for storage, delivery, sale, and consumption, beautiful packaging now attracts buyers to the product. It also pertains to the design, assessment, and production processes of packets. While proper packaging is vital for preserving fundamental food characteristics (temperature, color, taste, texture, and so on), ensuring food safety is critical.

Packaging serves a crucial purpose. It is equally critical that the packaging material is food-grade and does not threaten food safety.

The type of packing depends on a variety of factors such as the food item, the manufacturing process, the quality of the food, the desired shelf life, transport considerations, and so on. It is important to consider the shape, size, color, stacking options, label printing, cost, and environmental attributes (e.g., recyclability). [1-9]

The role of packaging in food protection

Food packing has several advantages. Good packing protects against breakage, vibrations, temperature, heat, and humidity. Packaging works as a barrier against water, dust, pollutants, direct contact, bacteria, and so on. All of these characteristics improve the food product's shelf life.

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The packaging enhances the appearance and glamorization of the packets for marketing purposes, in addition to making them more handy for the user. Labels on the packets include particular information about the contents, dates of manufacturing and expiration, nutritional values, manufacturer data, and so on. Furthermore, certain programs, such as antitheft devices, may be present on select packets. Suitable packaging also aids in the categorization, grouping, and storing of items. [10]

Protection/preservation

Food packaging can slow product deterioration, preserve the benefits of processing, extend shelf life, and maintain or improve food quality and safety. Packaging protects against three key types of external influences: chemical, biological, and physical. [11]

Chemical protection reduces compositional changes caused by external factors such as gas (usually oxygen), moisture (gain or loss), or light (visible, infrared, or ultraviolet). A chemical barrier can be provided by a variety of packing materials.

Glass and metals provide a virtually impenetrable barrier to chemical and other environmental agents, however, few packages are entirely made of glass or metal since closing mechanisms are used to allow both filling and emptying. Closure devices may be made of materials that allow for very low degrees of permeability. Plastic caps, for example, have some gas and vapor permeability, as do the gasket materials used in caps to aid closing and in metal can lids to allow sealing after filling. Plastic packaging has several barrier qualities, however it is typically more porous than glass or metal. [12]

Insects, rodents, bacteria, and other microorganisms as well as other animals are kept at bay by biological protection, which keeps illness and rotting at bay. Additionally, ripening and aging are controlled by biological barriers that preserve certain conditions. These barriers work in many different ways, such as keeping the inside environment of the package intact, limiting odor transfer, and restricting access to the contents.

Food is shielded from mechanical harm by physical protection, which also includes cushioning against shock and vibration during distribution. Physical barriers, which are often made of paperboard and corrugated materials, are frequently used as shipping containers and as packaging for perishable goods like eggs and fresh fruit because they are resistant to impacts, abrasions, and crushing damage. Proper physical packing shields customers from a variety of risks. Child-resistant latches, for instance, make it more difficult to obtain things that can be harmful. Additionally, the risk posed by shattered glass containers has decreased as a result of items like shampoo and soda bottles switching to plastic packaging. [13]

Temperature Control

To guarantee that food remains at the ideal temperature throughout storage and transit, certain packaging materials and techniques are made to regulate or insulate against temperature fluctuations.

Reduction of food waste and containment

The benefits of reducing food waste along the whole supply chain must be taken into account in any evaluation of the environmental effects of food packaging. Many nations have reported significant food waste, with percentages ranging from 25% for food grains to 50% for fruits and vegetables (FAO 1989). Food waste has been attributed to inadequate storage, transportation, and preservation/protection. By keeping food fresher for longer and increasing its shelf life, packaging helps cut down on waste overall. discovered that compared to similar U.S. cities, Mexico City's per capita garbage created had one-third more total waste, more food waste, and less packaging.

Furthermore, Rathje and colleagues (1985) found that, compared to fresh meals, packaged foods yield 2.5% of total waste, partly because agricultural by-products gathered at the processing facility are put to other uses, whereas those created at home are usually thrown away. Packaging may therefore help to lower the overall amount of solid waste. [12]

Marketing and information

Before a buyer makes a purchase, they frequently only see a product's packaging, which serves as its face. So, in a market where competition is fierce, unique or creative packaging might increase sales. Package design may be used to improve the product's reputation and/or set it apart from rival offerings. To accommodate recipes, for instance, bigger labels could be utilized. Additionally, consumers can obtain information from packaging. Packaging labels, for instance, fulfill regulatory requirements for product identity, net weight, nutritional value, ingredient disclosure, and manufacturer details. Furthermore, the packaging communicates crucial details about the product, such as how to prepare it, how to recognize the brand, and how much it costs. The disposal of garbage may be impacted by all of these upgrades.

Monitoring

The capacity to track the movement of food through specific stages of production, processing, and distribution is known as traceability, according to the Codex Alimentarius Commission (Codex Alimentarius Commission 2004). The triple goals of traceability are to enhance supply chain management, expedite the process of tracing food safety and quality history, and promote and distinguish food items with imperceptible or subtle quality characteristics[14]. To trace their products during the distribution process, food manufacturing businesses include unique numbers on the labels of their product packaging. Barcodes can be scanned manually or automatically. They come in several formats (e.g., printed barcodes, electronic radio frequency identification).

Importance Of Food Labels

Food safety is not the exclusive purview of the food sector, the regulatory agency, or one individual. It is a shared duty of consumers, industry, producers, and the government. One such legal duty to guarantee that customers can comprehend the food they are consuming is food labelling. Since the label serves as a primary means of communication between the manufacturer and the customer, it must be accurate, open, and clearly state what is included in the package that the customer plans to purchase.

It is your responsibility as a customer to always read the labels before purchasing food items. Knowing able to read and comprehend the context is crucial if you want to know what you're consuming. What information ought to be on the labels?

When selecting a product from the grocery store shelf, make sure to check for details like the list of ingredients, the production date, the expiration or use-by date, the allergy declaration, the storage guidelines, the nutritional facts, and any product claims. With the aid of all this information, you will be able to identify the type of food you are purchasing and make wise decisions.

Date Indications

Food labels with date stamps make it easier for customers to determine how long a product is safe to consume. Between "Best Before" and "Use By" or "Expiry Date," people frequently become confused. The phrase "Use By" or "Expiry Date" refers to the last day that a product may be safely consumed. Food that has passed its Use-by or expiration date should not be consumed, even if it seems and smells fine. Date markers contribute to less food waste.

finest A food item may simply lose its freshness, flavor, fragrance, or nutrients after the expiration date. However, this does not imply that the food is inherently unsafe to consume. It is best to focus on sensory factors such as product look, taste, and smell when determining if food is still edible.

Thus, The Manufacturing Date and the Expiry / Use-by Date must now be stated on food labels, per FSSAI regulations. The maker now has the choice to insert the Best Before date on the label, but it is not required.

Components and Allergy Information:

All food product labels include an ingredient list, with the exception of meals that are made with just one ingredient. The composition of this list is presented in descending order based on weight or volume. The food additives included in this list can also be found as INS numbers or E numbers. This list also includes percentages of components that are highlighted with words, graphics, or pictures on the label.

Cereals containing gluten, crustaceans, milk, eggs, fish, peanuts and tree nuts, soybeans, and sulfite have been identified by the FSSAI as eight main allergens that require label disclosure.

Few labels include the phrase "May Contain" in the allergen declaration, indicating that there's a chance that food may inadvertently contain traces of an ingredient that causes allergies as a result of cross-contamination. [15]

Evidence of a tamper

Special package features intended to lower or eliminate the danger of tampering and adulteration have been developed as a result of deliberate tampering with food and pharmaceutical items. Tamper-evident features are difficult to replace, even if any package can be compromised. Features that are designed to prevent tampering include banding, unique membranes, breakaway closures, and printing on bottle liners or composite cans that change irrevocably when opened, such as text or artwork. Holograms that are difficult to copy are another feature of special printing.

Although tamper-evident packaging typically necessitates extra packing materials, which makes disposal problems worse, the advantages usually exceed any disadvantages. One instance of a tamper-evident characteristic that doesn't need extra packing materials is the heat seal seen on medical packaging which is designed to change color when opened chemically. [15]

History of food packaging

Food packaging has a long history and has changed over the ages in response to numerous economic, technical, and cultural shifts. Here is a quick synopsis along with some resources for

Early and Ancient History

Many ancient societies packaged their food with natural materials. For instance, the Chinese employed bamboo and leaves as packing, while the ancient Egyptians kept food in clay jars.

The 19th century and the Industrial Revolution

Packaging materials have advanced as a result of the Industrial Revolution. The invention of canning in the early 1800s completely changed how food was preserved. Tin cans were first widely utilized for civilian use after being employed to package food for the military.

The early 20th century

The early 20th century was defined by the invention of glass bottles, paperboard boxes, and cellophane. Better protection and visibility for packaged goods were offered by these materials. [16]

in the middle of the 20th century

The mid-20th century saw the widespread usage of plastics, which provided flexible, lightweight, and adaptable packaging choices. During this time, packaging and branding also became more popular. [17]

Late 20th century

Innovations in the late 20th century included the invention of packaging materials with barrier qualities for improved food preservation, vacuum packing, and modified atmosphere packaging (MAP). [18]

The twenty-first century

In the twenty-first century, environmental issues and sustainability have emerged as major forces behind innovation in food packaging. Recycling programs, environmentally friendly package designs, and biodegradable materials have all gained popularity.

Present Patterns and Potential Futures:

The use of antimicrobial packaging to improve food safety, smart packaging with sensors for freshness monitoring, and ongoing attempts to develop sustainable and circular packaging solutions are some of the current trends. [19]

Principles of Packaging

A thorough understanding of food packaging principles necessitates taking into account several aspects of the display, preservation, and protection of food items. The following essential ideas are listed with sources for more study

Safeguarding and Preserving

Food should be packaged to keep it safe and fresh by shielding it from the elements and light, moisture, air, and pollutants.[20]

Defensor Features:

To stop food from deteriorating, packaging materials should have the right barrier qualities to regulate the permeability of gases, moisture, and light. [21]

Sterile packaging

To prolong the shelf life of perishable goods, aseptic packaging principles call for the use of sterile packing materials and aseptic processing methods. [22]

Sensory Conservation:

Throughout its shelf life, food's sensory qualities—such as flavor, fragrance, and texture—should be preserved via packaging. [23]

Practical Design

To improve customer convenience, packaging design should be practical and take into account factors like portion control, simplicity of use, and resealability.

Details and Labeling:

Consumers should be able to easily access information on packaging, such as ingredients, expiration dates, nutritional facts, and allergy warnings.

Adherence to Regulations:

Regulations and standards about food safety, labeling, and environmental effects must all be met by food packaging. [24]

Durability

The three pillars of sustainable packaging are encouraging the use of eco-friendly materials, cutting waste, and limiting the impact on the environment.

Technological Advancements:

To improve food safety and quality, food packaging principles call for keeping up with technological developments and innovations, such as smart packaging and active packaging. [20]

One of the most important aspects of life cycle assessment (LCA) in the context of sustainable packaging and food systems is the link between food waste and shelf life. From the extraction of raw materials to the disposal of a product at the end of its useful life, life cycle assessment (LCA) takes the environment into account. The following are important details on the connection between shelf life, life cycle assessment, and food waste.

Innovation and Technology

Packaging principles involve staying abreast of technological advancements and innovations, such as smart packaging, active packaging, and novel materials that enhance product safety and freshness.

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Food Packaging and Shelf Life

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Packaging's Effect on Shelf Life:

Food shelf life can be greatly impacted by packaging, which shields food from environmental elements including light, moisture, and air. The possibility of food waste is decreased by the selection of packing materials and design, which is essential for preserving the product's quality and safety.

Increased Shelf Life and Decreased Food Waste:

One way to help reduce food waste is to extend the shelf life of food goods with efficient packaging. Food goods may be kept viable for extended periods using packaging that inhibits degradation, contamination, and spoiling, which lessens the need for premature disposal. [25]

Packaging Techniques to Cut Down on Waste:

Utilizing materials with improved barrier qualities or active packaging technologies are examples of sustainable packaging techniques that can reduce waste and reduce the requirement for over-packing. Packaging may best combine protection and resource efficiency when it is designed to meet the unique needs of the food product." Environment: Alternatives, Trends, and Solutions." Press CRC.

LCA Points to Remember

Examining a system's or product's environmental effect at every stage of its life cycle is known as life cycle assessment. Food packaging's contribution to lowering food waste and related environmental effects must be taken into account when evaluating its environmental performance, in addition to its manufacture and disposal.

End-of-Life Considerations:

The environmental effect of packing materials after their life cycle should be taken into account by LCA. The total sustainability of packaging solutions is influenced by elements like ease of disposal or recycling, biodegradability, and recyclability. [26]

Food waste and consumer behavior:

Food waste is influenced by consumer behavior, which includes ideas about expiry dates and shelf life. Reducing waste can be aided by packaging that offers precise information about the amount of shelf life left and promotes responsible consumption.

Materials for packaging foods

The majority of materials used to package food are classified as metals, glass, polymers, and paper. A mix of two or more materials from the aforementioned classifications makes up certain packaging medium. Common examples of these composite materials include enameled (lacquered) metal and laminates made by binding layers of polymer, paper, and aluminum foil together.

The capacity of packing materials to perform the many roles required of them is determined by their physical and chemical makeup. Transport, optical, mechanical, and chemical reactivity qualities are the most crucial ones to take into account in this situation.

Metals

Metal containers provide excellent mechanical strength, good thermal conductivity, resilience to relatively high temperatures, and impermeability to mass transfer and light. Metal packages are especially well-suited for in-package thermal processing due to the latter two characteristics.

Tinplate, a thin sheet of steel covered with tin, was the original material used to create metal cans and canisters. The tin coat's objective is to lower the chance of corrosion.

Sometimes the tin's shielding is insufficient to keep the can from corroding within or externally. A coating of polymeric lacquer or enamel is put on the tin to protect areas where the can is subjected to extremely harsh corrosive conditions.

Aluminum is the second most important metal packing material. Aluminum does not need to have a protective coat applied like steel does since the metal is attacked by alkali but is shielded from additional corrosion by oxygen and mild acids by the thin layer of aluminum oxide that forms on the surface. Although it costs more, aluminum is far lighter and more ductile than tinplate. metal cans and foil are the two types of metal used as packaging materials. Since it is the most ductile, the purest form of aluminum is utilized to make foil and containers.

Glass

Soda-lime glass, which contains 68–73% SiO2, 12–15% Na2O, 10–13% CaO, and other oxides in smaller amounts, is the type of glass used to make food packing containers (bottles, jars) Transparency, inertness, impermeability, stiffness, thermal resistance (when heated appropriately), and overall consumer appeal are the benefits of using glass as a packaging material. Weakness and weight are its drawbacks. Compared to metal cans, glass containers are far less standardized. The majority of bottles and jars are custom-made for a single product or producer. Glass container closures, however, have a little more uniform design. Glassware is recyclable or reusable, reuse presents challenges, but recycling—or remelting—is both practically and financially possible.

Paper and Paperboard

Paper goods are frequently used to package food. In actuality, one of the first materials used for food packing must have been paper in some shape or another. Paper's low cost, wide availability, lightweight, printability, and mechanical strength are its key benefits as a packing medium. Its vulnerability to moisture is its most significant drawback. Paper's characteristics may be altered by adjusting the pulp's composition, how it is made, and applying different surface treatments. Wax (waxed paper) can be used to limit the permeability to fat and moisture. One of the main ingredients of laminated packaging materials is paper. It is the main component of secondary packaging (corrugated cardboard boxes) and is utilized as a primary package (boxes, wraps, and pouches). [27]

Polymers

A vast variety of foods are packaged using several types of plastics, including polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), and others. Plastics provide a range of barrier qualities, flexibility, and adaptability. [28]

The most well-researched element of polymeric food packaging materials is their transport qualities. Polymers have varying degrees of permeability to tiny molecules in comparison to metal or glass. This property has two particularly interesting effects: the package's permeability to gases and vapors, especially water vapor and oxygen, and the migration of low molecular weight substances from the food to the packaging material and back (aroma components) or from the food to the package and back (monomers, stabilizers, plasticizers). The next section goes over both of these phenomena.

Packaging plastics are composed of synthetic polymers, with the noteworthy exception of materials derived from cellulosic sources (such as cellophane). Chemically, they differ in terms of the monomers that make up the polymer chain, their molecular weight, and the chain's shape (branched vs linear, cross-linked, etc.). These are some of the most significant polymers.

A polymer of the olefin ethylene, $CH_2{=}CH_2$, is polyethylene (PE). Four varieties of polyethylene exist.

1. Low-density polyethylene (LDPE) is a polymer that is highly branched, with branches made up of either long or short side chains. Long chains provide the molten polymer its viscoelastic characteristics, whereas short chains give the substance some crystallinity. Its usage as the heat-sealable layer in laminates is made possible by its comparatively low melting range of 105–115°C.
2. There is minimal branching in the linear polymer known as high-density polyethylene (HDPE). It is less transparent and more stiff than LDPE because it is significantly more crystalline. It melts at a higher temperature (128–138°C).
3. In between the qualities of LDPE and HDPE, medium-density polyethylene (MDPE) possesses intermediate qualities.
4. Linear low-density polyethylene (LLDPE) is an ethylene copolymer having regular branching at regular intervals throughout the main chain, along with trace amounts of higher olefins. It is a superior heat-sealable component and stronger than LDPE. [29]

Risks that some hazards

Food can absorb chemicals from packing materials, particularly if it is stored for an extended amount of time or is exposed to high temperatures. Materials such as plasticizers, antioxidants, and leftover monomers may migrate.

Migration is the term for the chemical process by which food separates from its packaging. Smaller molecules and ions (less than 1000 Da) are relevant to migration. A substance's physicochemical characteristics, the kind of packaging, the food (such as its fat content), the temperature, and the length of storage time all affect how much a substance migrates. Greater contamination of lipophilic compounds with higher fat content is observed in foods compared to watery foods. With smaller packaging having a bigger surface-to-volume ratio and hence a higher probability of food contamination, the size of the packaging about the quantity of food is also important.

Chemical Migration

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Additives and Adhesives:

Several stabilizers, colorants, and adhesives used in food packaging may have ingredients that might contaminate food and be harmful to humans.

Heavy Metals

Lead, cadmium, and mercury are examples of heavy metals that can migrate into food and eventually build up in the body. These metals may be present in some packaging materials. [31]

Recycled Materials:

If the recycling process is not adequately managed, recycled materials in packaging may introduce pollutants. The new food packaging may come into contact with contaminants from previous applications of recycled materials.

Biological Hazards

The development of microbes on packaging surfaces or in packaging materials may result in biological dangers. When packing materials come into touch with wet or polluted surroundings, this can happen.

Allergens

Those with food allergies may be in danger from cross-contamination or residual allergens from the production process. Trace levels of allergens may find their way into food packaging materials that come into touch with them.

Using green composites for food packaging

Biodegradable or renewable resource-based materials are used to create green composites, sometimes referred to as bio-composites. To solve environmental issues with conventional packaging materials, these materials are being investigated more and more for use in food packaging.

A. Biopolymer Matrix

The word "bio" is frequently used to denote that the substances are materials that decompose naturally found in polymers, composites, and packaging. It can also be used, nonetheless, to designate materials made from naturally replenishable resources. [1-9, 32-52]

Additionally known as green polymeric matrices, biodegradable polymers derived from petroleum are also available. Three prerequisites separate the broad definition of "bioplastics" provided by the European Bioplastics Association: One of three options exists: 1) bio-derived and compostable; 2) bio-derived and biodegradable; or 3) bio-derived and non-biodegradable. Not all biopolymers are biodegradable, and biodegradable polymers do not always imply bio-based materials. The term "bio" in "biopolymers" is defined in this research as "bio-based," indicating that the components are sourced from sustainable resources.

Polylactic Acid (PLA) Composites

PLA is a biodegradable polymer made from sugarcane or maize starch, two renewable resources. To improve its mechanical prop, it is frequently combined with natural fibers (such as jute or sisal) or nanofillers. [53-56]

Composites Based on Starch

Frequently utilized as a matrix in biodegradable composites for food packaging, starch is an abundant and renewable material. To enhance qualities, additives like fibers, plasticizers, or nanoparticles can be added. [5, 57, 58]

Chitosan-Based Composites

Chitosan, derived from chitin found in the exoskeleton of crustaceans, can be used in combination with natural fibers or nanofillers to create bio-composites with antimicrobial properties suitable for food packaging. [38, 44, 46, 48-52]

Composites Based on Cellulose

Eco-friendly composites may be made by combining cellulose—which can be found in wood or agricultural residues—with other biopolymers. Particularly nanocellulose has drawn interest because of its reinforcing qualities.

Composites Made of Hemp Fiber

Because hemp fibers are biodegradable and renewable, they may be used in composites to reinforce biopolymers. Applications for hemp-based composites in food packaging have been investigated. [51, 59]

Composites made with wheat gluten

A protein produced from wheat called wheat gluten has been utilized in bio-composites as a matrix. It can be mixed with fibers or nanofillers to make materials that are appropriate for use in food packaging.

Conflict of Interest

There is no conflict of interest in the publication of this article.

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مواد بيولوجية صديقة للبيئة لتغليف المواد الغذائية الصحية

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المستخلص:

مجموعات من المنتجات الغذائية تهتم بحماية المواد الغذائية أثناء الشحن. لتحقيق هدف تعبئة المنتجات الغذائية، يجب اتباع القواعد المنظمة لها. هناك العديد من المواد المستخدمة في تعبئة المواد الغذائية، وبعضها يشكل مخاطر على صحة الإنسان. ولذلك، تم تطوير استخدام البوليمرات الحيوية والمركبات القائمة على النشا. يعد تغليف المواد الغذائية ضروريًا للحفاظ على جودة الأغذية وسلامتها، ولكنه أثار مخاوف بشأن النفايات والأثر البيئي. ومع ذلك، لتلبية الطلب المتزايد على الغذاء، يجب تحسين جودة وكمية التغليف. يمكن لبعض مواد التعبئة والتغليف أن تنبعث منها مواد كيميائية ضارة عند تسخينها، مما يشكل مخاطر على المستهلكين. يعد التغليف بمثابة فن وعلم في نفس الوقت، فهو يجذب المشترين ويضمن سلامة المنتج. تؤثر عوامل مثل نوع الطعام وعملية التصنيع ومدة الصلاحية والاعتبارات البيئية على خيارات التغليف. من الضروري إعطاء الأولوية للمواد الغذائية والنظر في جوانب مثل الشكل والحجم واللون ووضع العلامات والتكلفة وإمكانية إعادة التدوير.

الكلمات المفتاحية: مواد، صحية، تغليف المواد الغذائية