A Review of Packaging's Function in the Safety of the Food System: Enhancing the Value of Food Items While Cutting Down Losses and Waste

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ABSTRACT
Food is one of the most basic needs of humans and cannot exist without it. On the other hand, predicting the number of COVID-19 cases in 2020 made the problems with food supply and contamination worse. Customers' concerns about food and the demand for reliable information on food quality are increased by these issues.Food packaging plays an important part in the food supply chain in the food business by acting as a barrier against undesirable elements and preserving the food's quality.he objective of this paper is to emphasize the significance of packaging in the food sector, paying special attention to how packaging affects sustaining enhancing the quality and safety of the product and lowering the rate of food waste and losses after harvest. The focus is on recent developments in clever and smart packaging that minimize some of the harmful effects of packaging on the environment and food waste. We look at how food packaging affects the environment and talk about ways to cut down on packaging waste.In this paper we describe the various formats and types of materials used in food packaging.
KEYWORDS:*packaging,packaging material,food waste,smart packaging*

1. Introduction

Food is one of the most basic needs of humans and cannot exist without it. On the other hand, predicting the number of COVID-19 cases in 2020 made the problems with food supply and contamination worse. Customers' concerns about food and the demand for reliable information on food quality are increased by these issues. An effective method of assessing food safety and quality in the food supply chain must be provided in order to safeguard consumer rights and interests and to standardize the food market system. Food packaging plays an important part in the food supply chain in the food business by acting as a barrier against undesirable elements and preserving the food's quality.

Using the right packaging can preserve product quality and safety while lowering food loss and waste. However, because packaging trash is nonrenewable and non biodegradable, it can affect the environment by accumulating litter or becoming waste in waterways. There is also a serious issue with food contamination brought on by product packaging. The World Health Organization (WHO) reported in 2017 that food contamination is the cause of over 600 million sickness cases and 420,000 fatalities annually . Food packaging has a crucial and urgent role in addressing the issues of sustainability, environmental impact, and safety.

Food packaging is one of the primary means of maintaining the quality of food commodities for export, storage, and final goods. Furthermore, as customer lifestyles change, there is an increasing requirement for hygienic, superior, fresh, and ready-to-eat items with longer shelf lives. This creates a need for current technology and a sense of urgency . Even though several preliminary indications, such color, odor, and texture parameters, are typically taken into account when assessing food quality prior to packaging, outliers make it challenging to assess food quality subsequent to packaging. In such a situation, the most recent advancements in food packaging technology are imperative in order to facilitate real-time communication between packaged goods and customers through active and smart packaging.

Recent advances such as biotechnology, nanotechnology, and material science offer new opportunities within the industry. One of them, Abdus Sobhan et al. (2021) analyze the concept of smart food packaging based on biosensors and biopolymer-based nanocomposites (bionanocomposites) that has piqued the interest of the industrial community in an ever-increasing way . This offer is made to develop packaging materials including product safety and quality, environmental impact, and sustainable packaging. The objective of this paper is to emphasize the significance of packaging in the food sector, paying special attention to how packaging affects sustaining enhancing the quality and safety of the product and lowering the rate of food waste and losses after harvest. The focus is on recent developments in clever and smart packaging that minimize some of the harmful effects of packaging on the environment and food waste. We look at how food packaging affects the environment and talk about ways to cut down on packaging waste. We describe the various formats and types of materials used in food packaging in the next section.

2. Research Objectives

- The objective of this paper is to highlight the role of packaging in the food industry with particular attention to the impacts of packaging in maintaining product quality and safety and reducing the incidence of postharvest food losses and waste.
- Recent advances in smart and intelligent packaging designed to minimise some of the negative impacts of packaging on the environment and food waste are highlighted. The environmental impacts of food packaging are examined and measures to reduce packaging waste are discussed.
- In the next section, we highlight the different types of materials and formats used in food packaging.

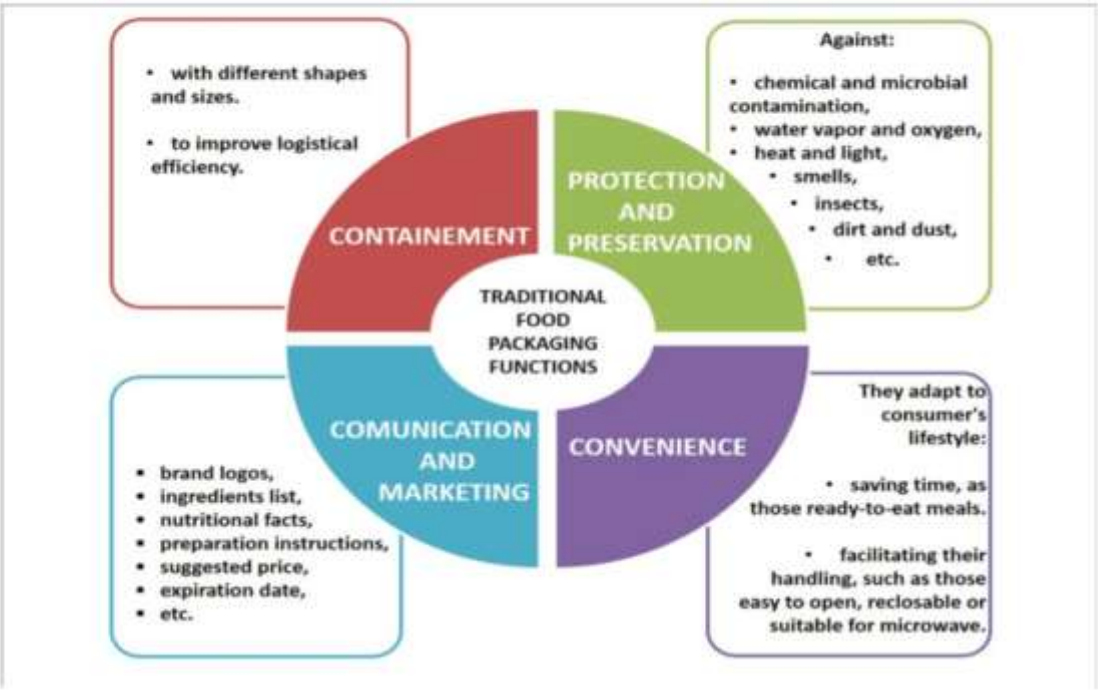
3. Types of packaging materials and formats used in the food industry

The type of packaging a manufacturer chooses depends on what they need. For something lightweight, paper and plastic fit the bill. Materials like metal or glass are heavier but more durable. Ultimately, choosing a packaging type comes down to stylistic choices, shipping conditions, shelf stability, and the product's end user.
According to the World Packaging Organization (2008 the most important consumer packaging are made of paper and board (38%), followed by plastic (30%) with rigid plastics alone taking an 18% share, metal (19%), glass (8%), and others (5%). Moreover, approximately 70% of overall consumer packaging are used in food industry where 48% of all the packaging are made from paperboard. the different types of materials and formats used in food packaging are traditional packaging and smart packaging.

3.1 Traditional packaging

Conventional food packaging is an inert system that gives food products physical support and defense from stimulants and conditions from the outside world . All that this packaging needs to do is safeguard a product while it is being distributed, transported, and stored. The packaging system must effectively handle the following four essential duties in order to efficiently incase and protect a product: containment, protection, convenience, and communication. Containment, or just preventing product loss and pollution during transit, is the most fundamental role. Food packaging's main purpose is to keep food products safe. Effective packaging protection acts as a physical barrier against microbiological, physio chemical, and physical damage, which frequently helps to preserve and extend shelf life.

3.1.1 Plastic.



| Traditional food packaging functions.

FIG1:-Traditional food packaging function

Polymers are the main ingredient of this synthetic material. When it comes to packaging, plastic may be flexible — as is the case with bags, wrappers, and stickers — or rigid — such as bottles, jars, and tubs, holding foods, drinks, detergents, pharmaceuticals, and more.Plastic is also used inside other types of packaging in the form of packing peanuts or bubble wrap.Plastic is lightweight, inexpensive, and strong enough to protect items during shipping. As a tape, it can bind packages together. Manufacturers can make it in a variety of colors and opacities.However, it's could be difficult to recycle plastic, so most of it ends up in landfills or the environment. It could break down into tiny pieces called microplastics that often contaminate waterways and food.Researchers have discovered a way to turn some plastics into fuel, which could hopefully make it a more sustainable material in the future.Figure 1 resumes these functions, that traditionally, these have been fulfilled minimizing the interactionbetween food and package (Lee et al., 2015)

3.1.2 Paper.

Pulp from wood or other sources, such as hemp or bamboo, makes up this type of packaging. Manufacturers often use it as a wrapper, paper box, shredded packing material, or in the form of paperboard. Corrugated boxes are made of two or more layers of paper stuck together by adhesive.Paper is 100% recyclable, which can make it a sustainable choice of packaging material. Making it out of wood is less eco-friendly, but there are numerous up-and-coming alternatives that have a smaller carbon footprint. Bamboo, for example, grows quickly and comes back repeatedly after being cut down.Paper can be less sturdy than other packaging materials, but it is durable in the form of board, and it's lightweight.

3.1.3 Metal.

Aluminum, steel, and other types of metal packaging are made by mining raw materials from the earth, then refining them. Metal can be more durable than glass or plastic, although thin metal is usually pliable and subject to bending out of shape.Manufacturers use metal cans to package products as diverse as soda, green beans, paint, and shoe polish. Metal cans prevent food from spoiling, allowing it to be stored longer. Steel drums also transport large quantities of liquids, such as oil, for commercial use.Metal can be dropped or subjected to high heat without breaking. Obtaining metal by mining is often an ecologically destructive process, but it's easier to recycle than plastic. Metal packaging ranges from light to heavy depending on its thickness.

3.1.4 Multi-Material.

Also called multi-layer packaging, multi-material packaging is just what it sounds like — a combination of different material types. For example, juice boxes are made of layers of polyethylene, aluminum, and paper. Fertilizers and cement may be packaged in a structure made of paper and plastic, since paper by itself cannot withstand being wet.Multi-material packaging can be engineered to guard products from moisture, like a metallized plastic bag that keeps potato chips crisp.Unfortunately, this type of packaging is hard to recycle due to the mix of materials unless specifically designed to be easily separated.

3.2 Smart packaging

Smart packaging, also known as connected packaging, is packaging that utilizes unique QR codes, barcode, or other digital identities to engage with consumers, verify authenticity, and trace a product's journey.it is classified into two categories;-Active packaging and intelligent packaging.Currently novel food packaging technologies seek to meet new consumers' and industrial demands in FIG2

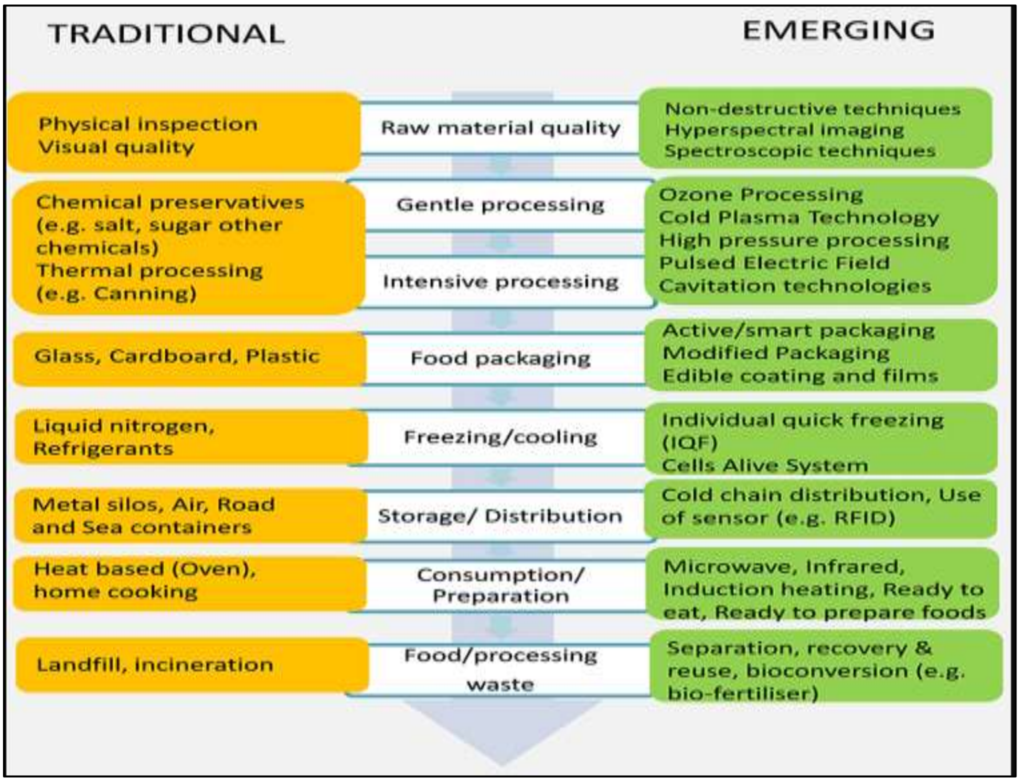


Fig2:-Outline of the driving forces that lead to the development of smart food packaging.

3.2.1 ACTIVE PACKAGING

The term "active packaging" refers to packaging in which additional constituents have been purposefully incorporated into the packaging material. Active packaging improves the system's performance by discharging compounds or absorbing spoiling agents present in or around the food . The types of AP that are often encountered are scavengers (oxygen scavenger, ethylene scavenger, moisture absorber) and diffusion systems (ethanol emitters, sulfur dioxide emitters, carbon dioxide emitters) .

For semi-solid food, active packaging can be classified into two main types: Active inhibitor packaging (such as moisture absorbent, carbon dioxide absorbent/absorbent and antioxidant packaging) and active release packaging (such as carbon dioxide producing packaging and antimicrobial packaging).

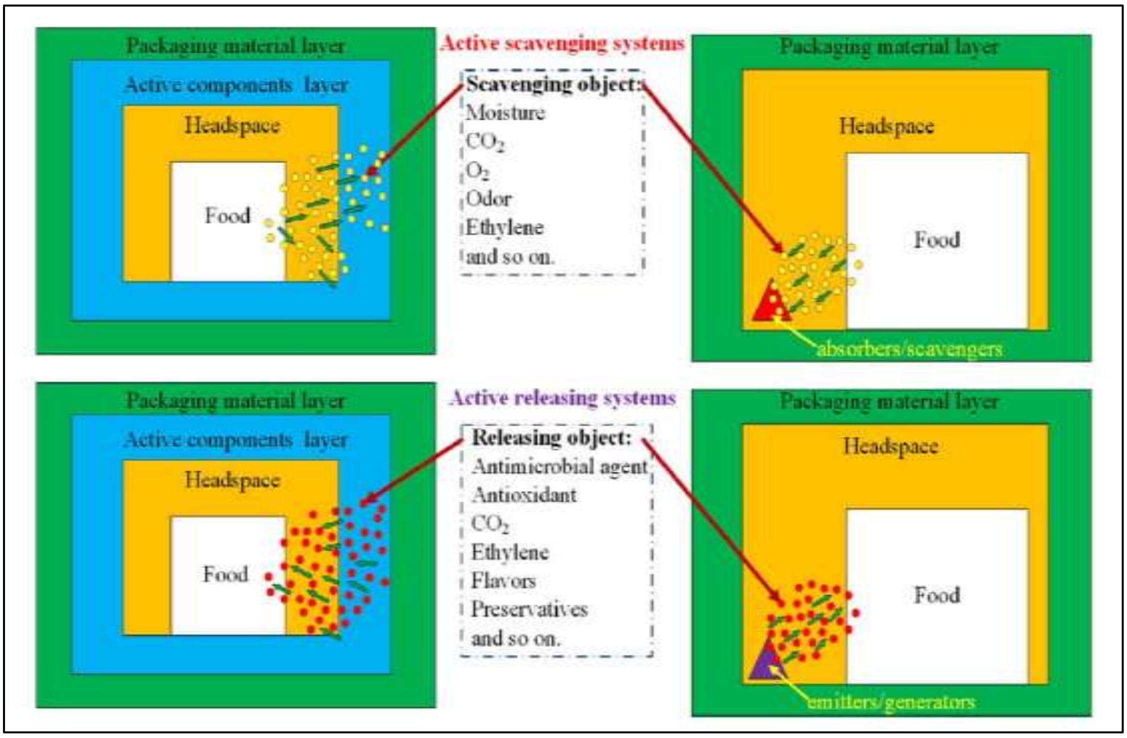


Fig3:-Schematic diagram for active food packaging systems

3.2.2 INTELLIGENT PACKAGING

An intelligent package as the packaging system capable of carrying out intelligent functions, such as detecting, registering, locating, communicating and applying scientific logics, in order to ease decision-making, extend shelflife, improve safety and quality, provide information andwarn of possible problems. These systems, which are attached as labels or incorporated or printed on the food packaging material, offer better possibilities to check product quality, track critical items and provide more detailed information during all the food supply chain (storage, transport, distribution and sale) . They can also inform about product history such as storage.Intelligent packages do not act directly to extend food shelflife and do not aim at releasing their components onto the food, as active packaging does. Instead, intelligent packages have the aim to convey information related with food quality to manufacturers, retailers, and/or consumers.

IMPACT OF PACKAGING ON FOOD QUALITY,SHELF LIFE &FOOD SAFETY

4.1 Sensory and nutritional quality

The way that produce is packaged has a big impact on how it tastes. For example, compared to fruit packed in BOPP-1 and BOPP-2 with less polypropylene layer, litchi (cv. 'Mauritius') packaged in bi-orientated polypropylene (BOPP-3) were shown to be of remarkable nutritional and sensory quality . Additionally, based on superior sensory evaluations for crunchiness, juiciness, and overall fruit quality, non-perforated polypropylene plastic bags were judged to be more appropriate for table grapes than perforated plastic bags. Prior research has indicated that packaging has the ability to impact food's nutritional composition in a bad or positive way. While certain forms and materials for packaging can help retain nutrients during storage, others encourage nutrient loss . High losses of fragrance molecules, for example, have

4.2 Shelf life

Particularly for fresh fruit, packaging is frequently used as a strategy to increase shelf life by avoiding or minimizing water loss. Polyethylene bags decreased water loss and increased the shelf life of different fruits and vegetables, according to studies by Miller and Krochta (1997). Foods that are not packaged are frequently exposed to a variety of bacteria that may shorten their shelf life. Shelf-life is also impacted by the type and substance of packaging chosen. For example, Lee et al. (2002) found that red pepper paste packed on polyethylene plastic had a longer shelf life than other types of plastics, and Mexisetal. (2009) found that shelled walnuts packed on polyethylene terephthalate/polyethylene had a longer shelf life and less microbial growth than those packed in polyethylene pouches.

4.3 Food safety

When humans eat unpackaged food that has been contaminated by harmful microbes, it can lead to illness, even death, including food poisoning . It's critical to practice good hygiene when handling food in order to protect customer safety and extend the shelf life of food items. While studies have indicated that packaging (and its related components) is a possible source of food contamination, proper packaging also helps to reduce spoilage and maintain food quality. It has been shown that several chemicals used in food packaging, such bisphenol, contain endocrine disrupting molecules that are extremely harmful to biological systems. Muncke (2009) explained that temperature-dependent diffusion-controlled processes govern how contaminated food is when it comes to packing.

5 . ROLE OF PACKAGING IN REDUCING FOOD LOSSES AND WASTE

Reducing food loss and waste is also critical in the fight against climate change. Yet, it's an issue that is often overlooked. When we throw away our leftovers, it's not just food we're wasting, it's our resources too. The production of food lost or wasted not only accounts for seven per cent of greenhouse gas emissions globally, but also uses 30 per cent of the world's agricultural land and six per cent of total surface and groundwater withdrawals. We all have a role to play - waste occurs throughout the value chain. In the developed world it is most prominent during consumption, with around 52 per cent of European food loss and waste occurring with consumers, restaurants and caterers. As we look to address this issue and mitigate the problem, sustainable packaging can play a vital role. It can reduce the environmental impact of the food industry by preventing food from spoiling before it reaches the table. This is required now more than ever. Innovations in paper and plastic packaging can extend shelf life considerably, providing convenience and portion control for consumers, for example fruit, meat, flour and pasta. During handling and processing, food is often lost due to temperatures not being optimal, inadequate protection of delicate produce, and wrong size or damaged packaging. However, the right packaging provides barriers against moisture and gases, preventing spoilage, as well as protecting food from physical damage as it is transported.Today, more than 30% of all food produced globally is not consumed, while at the same time people are starving due to famine. Additionally, the unnecessary production of food that is wasted, is a significant contributor to global warming. Food waste is both an environmental and human issue, that could be partly solved by packaging.Between 30 and 40 percent of all food produced around the world is not eaten. If a geographical area would reflect where we grow the food that we don't eat – the area would be as big as China. If this global issue could be solved, then the world population of 2050, estimated to nine billion people, could be fed without the need to further increase today's level of food and agricultural production. This is the reason why the Save Food Initiative was started in 2011, which is one of many organizations committed to reduce food waste. Today, the organization has 300 member organizations supporting it, including the United Nations Environment Program.Foods that are often wasted are meat, bread, vegetables and cheese. One step in the process of reducing food waste is awareness. If people don't realise how much we waste, there will be no change. Only in Europe, a consumer's food loss equal approximately ten percent of that person's annual CO_2 emissions. When you throw away food, you don't only throw away that product, but also the amount of work put into producing the product, as well as the effect the production has had on the environment. The packaging generates between two and ten percent of the CO_2 footprint of a product. But if packaging leads to consumption of food and thus avoid food waste, 90 to 98 percent of the CO_2 footprint of that product will not be in vain.0 percent of fresh food becomes waste but only ten percent of packaged food becomes waste. The problem is – no one wants more packaging. As much as 89 percent of the consumers believe that the problem is packaging and that investment in packaging is harmful to the environment, but it really is the other way around. Packaging must play a key role in facilitating the supply of food to preserve our environmental resources and to help drive a more sustainable consumption.FIG4 shows where losses occur along the value chain and where there is potential for improvement

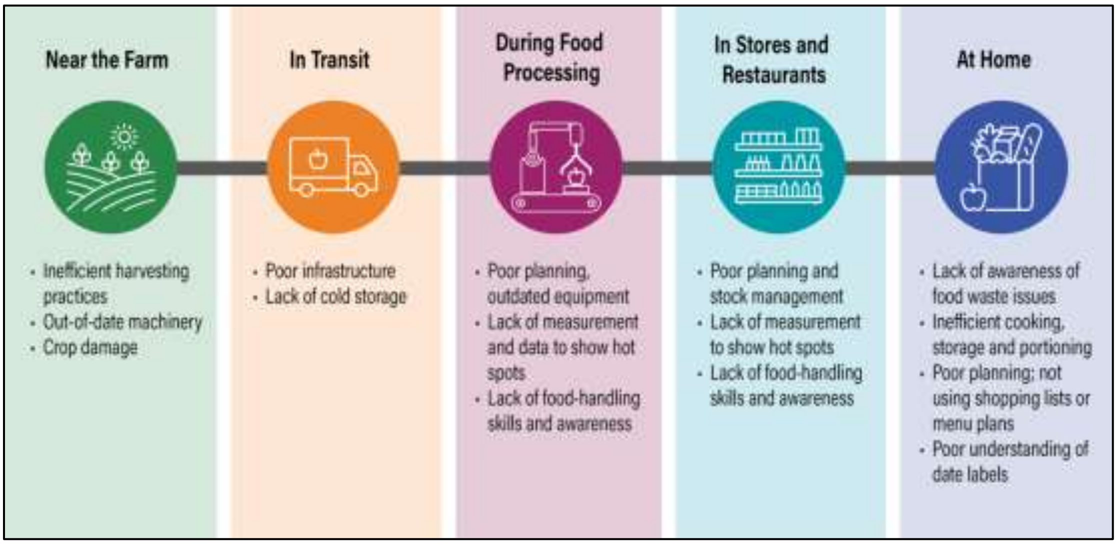


Fig 4:-Cause of Food Loss and waste

5.1 IMPACT OF PACKAGING ON FOOD PRICE

Although, packing is an issue affecting sales, it also has an cost-increasing effect. The place of packing cost in total cost is very changeable. Characteristics of the product are also an important factor on that cost. Any product or good can be sold without packing. Unpacked products are cost-advantageous than the packed ones. Because, they cost low. Unpack products are called as "bulk". Bulk oil, bulk cement, bulk olives, bulk wheat, bulk bait and etc. However, goods or products acquire qualification by packing. Packing costs can be divided into two groups for costing studies.

5.2 Returnable Packages

Such packages are delivered to consumers with the products. Particular amount of deposit for the package is collected from consumers as well as the product price. After, consumer empties that package, returns it to the seller and consumer is reimbursed his/her deposit. Large industrial containers,bottles of alcoholic and non-alcoholic beverages are among them. In this practice, it is important how the cost of that package material affects the cost of the manufactured and/or sold product. When, this packing is purchased, it will be required to activate it as an "Other Tangible Asset" and allocate depreciation for them throughout their life cycle. In the meantime, the deposit collection and refund activities will be continued as products are sold and packages are returned.While, allocating the cost of packing and reflecting on the product manufactured by allocating depreciation; the factory overhead account becomes debtor while the accumulated depreciation account becomes the debt.

5.3. Nonreturnable Packages

Nonreturnable packages are delivered to consumers with the products. They are not taken back. Packing cost is inside the sales price of the product and no additional packing price or deposit is collected. Nonreturnable packages should be considered in two groups. Low-cost packages and high-cost packages: • Low-Cost Packages Low-cost packages are cheap packages which are usually manufactured from paper and nylon. For instance; legume packages. Because, any legume is put in simple and cheap packing such as nylon and paper, cost of packing material should be reflected on the manufactured product. When the packing material is purchased, it is monitored in the stock account and when it is used, the cost of it is reflected on the cost of manufactured product through the factory overhead account. The cost of packing is so low or causes minimum difference between the products that it may not be required to consider packing cost as the first direct article or material cost. • High-Cost Packages Packing of some products are high-cost. Even, they are so high-cost that sometimes the cost of these packages may be higher than the products they pack. For instance, packing of potable water, long life milk and fruit juices and etc. As the same, packing cost of luxurious alcoholic drinks, perfumes and cosmetic products with brand value, wine and various oils can be more valuable than the cost of these products. Packing costs of these products can be very high for some products while can be very low for some. For instance; alcoholic drinks or perfumes can be sold in simple plastic, tin or glass packages, same products can also be sold in stoneware, decorative glass, metal and antique-looking packages. Shortly, while it is possible to sell the same product in packages worth 1 TRY, it can also be sold in packages worth 100 TRY.Therefore, packing cost can directly affect the sales price and profitability of that product. Because of that, it is advantageous to follow such kind of packing costs through the raw material and material costs account rather than factory overhead account. Thus, each packing cost will affect the cost of its product. Sometimes, it is seen that some implementers do not accept to follow packing costs through the raw material and material costs account (such as raw materials and etc.). However, it is the only way out to consider the packing material costs as the raw material and material costs in order to reflect the costs of a valuable packing material and various packing materials correctly on the costs of the products. Such kind of materials should not be taken into consideration as factory overhead. Because, they have direct and excessive influence on the product costs.

6. FUTURE PROSPECTS AND CONCLUSION

Food and other agro-industrial raw materials must be contained, protected, and preserved, therefore packaging is a vital part of the food chain to the final user from the field. According to research, using the right packaging can help maintain product safety and quality while lowering food waste and losses. Nonetheless, food packaging plays a significant role in the price of food, and waste from packaging has been identified as a primary contributor to the municipal waste stream. It is necessary to address the problem of food pollutants linked to packaging, especially when recyclable paper is used. Requirements for sustainability and safety can only be met with the help of economical and resource-efficient packaging design. The use of cutting-edge technologies in packaging design creates new opportunities for sophisticated quality control using electronic tools that track and report in real time details about food safety and nutritional value. The convergence of biotechnology, nanotechnology, and material science breakthroughs presents a novel prospect for the creation of innovative packaging materials and designs that tackle industry shifts such as product safety, environmental effects, and package sustainability. The development of highly advanced packages incorporating nano-sensors to capture and analyze environmental signals and adjust stress response treatments on fresh foods through a series of controllers to maintain storage quality and subsequently prevent food spoilage has become more of a reality than a science due to the advancements in information and communication technologies.

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