1 Introduction to packaging

Packaging is the science, art and technology of protecting and adding value to products. In order to fulfill these tasks, it is necessary to integrate the processes of designing, evaluating and producing packages, which also involves the elements of materials, machinery and people. People have a variety of views on packaging. One of the more limited views is reflected in the question: What packaging material is better than another? In reality, material is only one element of packaging, one which is highly dependent on the product that is about to be packed. This limited view needs to be supplemented by others in order to take in all the different perspectives of packaging and the functions it has throughout its life cycles. To clarify the meaning of packaging, a broad and well-established packaging definition is needed. The definition we use in this book is based on Paine’s (1981) well established version and the EU’s definition (94/62/EC). It is expressed in three statements:

1) Packaging is a coordinated system made up of any materials of any nature, to be used for preparing goods for containment, protection, transport, handling, distribution, delivery and presentation.

2) Packaging is the means of ensuring safe delivery from the producer to the ultimate consumer in sound and safe conditions.

3) Packaging is a techno-economic function aimed at making delivery efficient while maximizing effectiveness.

The package itself is defined as the physical artefact that performs the many functions required from different stakeholders and from the product. This is our jumping off point for further elaboration on the different functions of packaging.

1.1 Multiple functions of packaging

The principal functions that packaging is able to perform are manifold. Several authors and researchers in the packaging field have described and defined them in various ways. Paine (1981), Robertson (1990) and Livingstone and Sparks (1994) emphasize seven fundamental functions of packaging for the product
to be: protection, containment, preservation, apportionment, unitization, convenience and communication of the product. Lockamy III (1995) lists the same functions, but excludes preservation, which mainly relates to food and other perishable products. In Lockamy III's assessment of strategic packaging decisions, the six main functions of packaging are: containment, protection, apportionment, unitization, convenience and communication. These six fundamental functions are the ones that most researchers acknowledge and use, even though some of the functions have been developed and expanded. For example, the protection function can be divided into physical and barrier protection. Others researchers integrate functions by merging the above-mentioned six into broader categories. Lindh et al. (2016) propose three main functions: protect, facilitate handling and communication. Another way of categorizing packaging is to use process-related aspects such as security, marketing and information transmission as specific functions. One can claim, though, that security can be sorted under the protection function, as well as under communication; marketing and information transmission can also be sorted under communication (Lindh et al., 2016).

We could take any of the above-mentioned set of functions as our starting point, but have chosen Lockamy III's (1995) six main functions because they are the most commonly used and referred to. We have also added information as a function of its own.

1.1.1 Containment

The purpose of containment is to hold the content and keep it or the surroundings secure. The second part of this definition is similar to protection, but more clearly signals the activity of collecting things into an assembled unit. Many products need containment because of their nature, the classic example being liquids. Since products come in all shapes and sizes and react in different ways to their surroundings, some kind of containment is necessary. Imagine the process of getting pasta or rice to your dinner table without packaging. Containment highlights the need for the existence of packages in making products available to consumers.

1.1.2 Protection

The protection function of packaging involves safeguarding the contents of the package from external sources and vice versa. Damage can arise from physical, chemical, microbiological and climatic sources. Packaging provides physical protection against many different static and dynamic forces, such as vibration, compression and mechanical shock. It also protects from climatic conditions and hazards, such as temperature and humidity. From a chemical and biological point of view, it protects the product from microbiological or chemical deterioration, which is also a preservation function. Preservation means retaining the quality of the content by stopping or inhibiting chemical and biological changes. It can be regarded as part of the protection function because it is usually managed by choosing a proper packaging material. Preventing damage from external sources is often considered the main reason for having packaging.
But the package also functions as protection of humans and the environment from the internal product. An example of this is in the transport of hazardous materials.

1.1.3 Apportionment

The apportionment function enables a given amount of content to control and support appropriate usage. Apportionment in packaging facilitates the output from today’s large-scale industrial production by dividing products into manageable portions and sizes. This provides retail outlets and consumers with the desired amount and proper dimensions of the product for different users in different situations. Apportionment also helps users to manage inventory and to reduce food waste by using appropriate portion sizes. Apportionment is similar to and meets the same underlying needs as the next function, unitization.

1.1.4 Unitization

Unitization involves the consolidation or reconciliation of units. Most often small units are grouped into bigger ones to improve efficiency. However, large units are regularly divided into smaller units to be assembled later and elsewhere. Like apportionment, it helps to make the handling of packaging suitable for different stakeholders in different situations and at different locations. The primary function of the famous shipping container, sometimes called “the box that made the world smaller and the world economy bigger”, is unitization. Unitization is sometimes used as a synonym for agglomeration.

1.1.5 Convenience

The primary purpose of the convenience function is to make it easy and convenient to use the packaging and its contents. Convenience relates to unitization and apportionment. The main task of all three is to facilitate handling and to package the product in appropriate sizes and amounts for its use at different stages in its life cycle. This can be done in practically endless ways. Aspects of the convenience function in packaging throughout all stages in production and distribution to the final consumption and recovery include:

- the ability to consume products at any time and any place;
- the perception of the packages as being easy to open, carry and empty;
- providing accurate and safe dispensing;
- ease of disposal.

1.1.6 Information

The package is the interface between the product and the logistics, and between the product and the consumer or other users. This means that the role of the package as the information carrier is essential. Information on packages is often taken for granted, but sometimes underestimated and forgotten. We need to keep in mind that information constitutes a fundamental function of packaging.
The two major roles of packaging information are to help users identify the content, and to provide them with instructions on how to use it. Barcode technology is a ubiquitous element of modern civilization and an integrated part of packaging information. Other technologies applied to packaging indicate tampering. These include authentication seals, security printing and other anti-theft devices on packaging that tell you the package and content are not counterfeit or stolen; they also serve as a measure of loss prevention. The interactive information achieved through this technology development is part of the communication function in packaging, which is a type of two-way information between the producer and the user.

1.1.7 Communication

The package is a medium for communication between the brand owner and the consumer. This kind of communication is regarded as marketing. Packaging is sometimes called “the silent salesman”, especially when it comes to groceries. Packaging is often the first and most regular contact consumers have with a product, attracting the eye and whetting the appetite. More than just giving a face to the brand, packaging is a powerful sales and commercial tool. It influences market position and consumer behaviour by triggering purchase and creating identity and loyalty. Marketing communication in the form of physical and graphical design is often applied to the package in order to bring products to life in accessible and engaging ways from the way they look, feel and function, to how the content is perceived.

But just as packaging can be seen from different points of view than those of the product and packaging developers, so can its functions. For example, packaging directly and indirectly impacts different organizational business functions such as:

- logistics (handle, transport, store, distribute, inform);
- marketing (sell, differentiate, promote, provide value, inform);
- production/manufacturing (produce, make, assemble, fill);
- information systems (perform, inform);
- environment (reduce, reuse, recover, dispose, inform).

It can thus be argued from an organizational business perspective that these processes are the main functions of packaging.

1.2 Packaging legislation and regulations

The legal ramifications of the initiatives taken by governments and authorities can impact the way actors relate to the packaging functions described in section 1.1. The legislation that affects packaging comes in many forms and subjects because there is no separate branch of “packaging law”. Examples of the legislation concerned with packaging cover the sale of goods, transport, environmental issues, food and drugs, food safety and waste management. The legislation and regulations are constantly under revision and updated frequently.
Corner and Paine (2002) provide an excellent overall categorization of the areas in which many countries have packaging legislation. The most important areas fall under the following four categories:

1) **Administrative needs**: For example, regulation for food packaging, pharmaceutical and medical packaging and dangerous substances.
2) **Requirements to protect the public**: For example, child-resistant packaging, tamper-evident packaging, fraud, and weight and measurement directives.
3) **Protection of packaging designs**: For example, copyright laws, intellectual properties, trademarks and patents laws.
4) **Environmental protection**: For example, packaging and packaging waste directives and producer responsibility

The intention here is not to give a complete list or description of laws and regulations, but to provide examples of significant legislation and regulations found in the categories that apply to packaging. Hence, an overall description is presented.

### 1.2.1 Administrative legislation and regulations

Two areas with extensive legislation on the interactions between the packed product and the materials in which it is packed are food and packaging compatibility, and food and drug material contact. Currently, one major material is plastic and the legislation is mostly concerned with the contact plastic has with food; but in principle other materials are also applicable. The legislative concerns are primarily if substances migrate from the packaging into the foodstuff or drugs, and are either harmful for the consumer or have an adverse effect on the contents’ deterioration properties – such as taste and aroma. However, any kind of inert migration and contamination is undesirable. The US Food and Drug Administration and the European Union are authorities that regulate this important legislation.

### 1.2.2 Legislation and regulations for protecting the public

There are laws that regulate labelling and consumer information to protect the public. Consumer information must not mislead the consumer in regard to the contents’ nature, properties, composition, quantity, origin and durability. In the European Union, the Energy Labelling Directive (2010/30/EU) and the Ecolabel Regulation (EC, No. 66/2010) concern packaging, or at least the content inside the package. Another important law is that of child-resistant closures for packages containing dangerous substances sold to the general public. For some products, there are regulations about tamper-resistant packaging, which means that it must have an indicator or barrier to entry that is distinctively designed, or must employ an identifying characteristic (a pattern, name, registered trademark, logo or picture).

### 1.2.3 Legislation and regulations for protecting designs

Some copyright, intellectual properties, trademarks and patent laws fall into the category of protecting packaging designs and technologies. Trademarks may comprise words, letters, numerals, names, designs, or the shape of goods or their
packaging. To be entitled to packaging trademark protection, a trademark has to be distinctive enough so customers can identify the packaging with a company product or service and not a competitor’s. Patents are registered in specific countries and are valid for a set period of time before they are released for use by others.

1.2.4 Legislation and regulations for protecting the environment

There are two major established environmental policies related to packaging in Europe. Their underlying principles are that preventive action should be taken, environmental damage should be managed at the source, and the polluter should pay. The EU Packaging and Packaging Waste Directive (EU, 2015/720) seeks to provide environmental protection and to ensure the functioning of the internal EU market. According to the Directive and its appendix, packaging must meet certain essential requirements and member states must ensure that packaging placed on the market complies with these requirements:

- to limit the weight and volume of packaging to a minimum in order to meet the required level of safety, hygiene and acceptability for consumers;
- to reduce the content of hazardous substances and materials in the packaging material and its components; and
- to design reusable or recoverable packaging.

Another major environmental policy related to packaging is the Extended Producer Responsibility (EPR). This is defined and described by the OECD as:

...an environmental policy approach in which a producer’s responsibility for a product is extended to the post-consumer stage of a product’s life cycle. An EPR policy is characterized by: 1. the shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities; and 2. the provision of incentives to producers to take into account environmental considerations when designing their products. While other policy instruments tend to target a single point in the chain, EPR seeks to integrate signals related to the environmental characteristics of products and production processes throughout the product chain.

With the Extended Producer Responsibility, the producer pays in advance for the pollution the future owner will generate. In this way, consumers are relieved of the responsibility for the disposal of packaging.

In contrast to Europe, the US Federal Government has not published any national environmental packaging regulations or introduced extended producer responsibility. In the 1990s, the US President’s Council on Sustainable Development introduced the term extended producer responsibility to mean that all participants in the product life cycle (governments, companies with economic interest in the product, consumers, and those handling waste) share the responsibility for the environmental effects of products. This difference in definition and use of the extended producer responsibility concept from the Europe version has yet to find its way to any legislation.
1.3 Packaging terminology

In order to gain a coherent understanding of packaging as defined by Paine, it is best classified as primary, secondary or tertiary (Paine, 1981). This classification should be used when packaging is regarded as a system and illustrates the levels of hierarchy in the packaging system (Figure 1.1).

However, several other terms than the above-mentioned levels are used by practitioners in different industries when discussing different types and levels of packaging. This incoherent use does not make communication easier and often causes miscommunication and difficulties in understanding packaging. Table 1.1 summarizes some of these terms and shows that a term often describes both its primary function and use.

Other terminology used in the description of the package relates to the type of product it contains: food packaging, pharmaceutical packaging, etc. In short, there are numerous viable terms used in packaging. This calls for a more homogeneous and systematic terminology for classifying packaging: primary, secondary and tertiary packaging.

Theses broad classifications of packaging components are based on viewing packaging as a system, and are somewhat arbitrary. For example, is the shrink wrap of a six pack of soda cans primary or secondary packaging? There is no clear-cut definition or borderline between the three different levels of the hierarchy,

![Figure 1.1 The levels of packaging: primary, secondary and tertiary packaging.](image)
and thus no exact right or wrong. In many cases it is all up to what you define as being included in each component of the packaging system.

### 1.4 Packaging as a system

In trying to understand and explain the world of packaging, we consider it as a system represented by the product and different levels of packaging – primary, secondary and tertiary. These levels are interrelated and affect each other (Figure 1.2), which means that the levels and the interactions cannot be regarded or assessed on their own. So if any changes are made in the primary packaging, it may not only affect the product and secondary packaging, but the tertiary packaging as well. This line of thinking is found in systems theory, which plays a central role in a wide range of scientific fields. The concept of a system is described by Checkland (1999: 3):

> The central concept “system” embodies the idea of a set of elements connected together which form a whole, this showing properties which are properties of the whole, rather than properties of its component parts.

Systems theory stresses holistic thinking in order to prevent reductionism, and is based on the assumption that the whole (system) is not necessarily equal to the sum of its parts (Churchman, 1968; Von Bertalanffy, 1969). The interactions among the parts forming the system can make the sum of the system greater or lesser than the sum of the parts; a change in one part can have a negative or
positive impact on other parts of the system. So if you want to gain insight into the performance of a system, you need to understand the interactions among its parts. Do this rather than reduce the system to separate parts to be analysed on their own. The core of systems theory is how different parts interact with other parts of the system and what this means for the entire system.

By applying systems theory to packaging, the interactions between the different packaging components are highlighted. It explains and helps us understand the interdependence among the components. The performance of the packaging system is not only affected by the performance of each individual packaging component, but also by the interactions among them. Considering these interactions is critical to the overall performance of the packaging system.

In line with this reasoning, you need to remember that the product is an interactive component in the packaging system (Esse, 1989; Griffin et al., 1985). It obviously interacts physically with the primary packaging, but it also interacts in several other ways with the other two packaging components. A paper-based package of crackers or a bag of potato chips, for example, require a rigorous secondary package to protect the content from mechanical damage, because the primary packages are too weak for that purpose.

Being able to distribute the functions so that they are not equally performed across all packaging components is a typical example of how the components are interrelated and must be seen as a “whole”. As in the example of the crackers and chips, the primary packaging is able to preserve the product while the secondary packaging provides the mechanical protection. In this sense, certain choices/decisions made at one level are likely to affect all the other components.
1.5 Packaging goes beyond a single discipline

Packaging is a multidisciplinary academic field. This means that experts from different disciplines meet and work together based on their perspectives and expertise in packaging related issues. They retain their discipline's methods and assumptions and contribute with in-depth knowledge linked to that of the other disciplines in the multidisciplinary relationship. In academia, the field of packaging is becoming increasingly attractive to students and scientists in the engineering sciences (including but not limited to industrial management, mechanical engineering, production, chemistry, and product development), food sciences, pharmaceutical sciences, social sciences, materials science, design sciences, environmental science and business-related disciplines (including business administration, marketing and management sciences).

In contrast to academicians, packaging professionals usually interact multidisciplinarily with people in different organizational functions such as R&D, production, marketing, sales, finance, purchasing, logistics, regulatory and more. These interactions occur internally in an organization and externally with consultants, suppliers, customers and end users. A majority of the professionals working with packaging or making packaging decisions, however, do not see themselves as being packaging professionals. This is because they have an affiliation and sense of belonging to other organizational departments such as product development or marketing. These professionals have different views, sometimes even conflicting opinions, on the packaging system and the functions it should carry out, depending on what department they represent. For example, primary packaging has always been in the realm of the marketing department, while secondary and tertiary packaging have been in the realms of the production, manufacturing or transport departments. Outside of their organizational affiliations, they rarely understand the impact their packaging decisions have on the whole packaging system or on suppliers, customers and end users along the entire supply chain. A package might look great, perform excellently in the production line, but the impact it has on a bigger scale, such as that of sustainable development, is seldom reflected on and yet it is one of the major challenges facing packaging design. Clearly, packaging needs to function properly in all stages from production to consumption and recycling in order to contribute to the greater whole. If the packaging is difficult to produce, fill, close and collect in the packaging line, it does not matter that it has an effective structural design from a protective point of view or good graphics that promote and sell the product.

There is no question that packaging has many facets. Apart from its material, physical properties and structural design, it is in itself a valuable tool, especially in logistics and marketing. It is an essential link between the producer and the consumer, where it contributes to the positioning and presentation of the product; and on many occasions, the use of the product after purchase. These many facets need to be represented by multiple roles in businesses, since packaging needs to meet the requirements placed on it from logistics, marketing, production, product development, and from the environment. This calls for an interdisciplinary approach to the study of packaging systems, where disciplines are interrelated both in content and methods. Five aspects of a single but
interdisciplinary process are developing a product, designing a packaging system, producing, distributing and marketing the product. This is the foundation on which the interdisciplinary field of packaging logistics has been established.

1.6 Going multidisciplinary – packaging logistics

Packaging logistics primarily brings together different packaging disciplines with logistics and supply chain management disciplines to complement and support one another. This multidisciplinary field of study crosses the traditional boundaries between academic disciplines and schools of thought as new needs and professions have emerged. Packaging logistics focuses on the synergies achieved by integrating the systems of these disciplines, with the aim of adding value to the combined, overall, system. The core of packaging logistics covers the design of a product and its packaging system, throughout the whole supply chain from raw product, via various actors, to the end user, and on to recycling and recovery. It would be difficult to develop a sustainable logistics system without packaging that supports it or, vice versa, to create a sustainable packaging system without the support of the logistics and supply chain management.

Logistics is an application-oriented management discipline of the “flow of things”. According to the Council of Supply Chain Management Profession (CSCMP), formerly the Council of Logistics Management, logistics management is defined as:

...that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers’ requirements.

In a simple description, logistics aims to achieve “The 7 Rights of Logistics”: having the right item in the right quantity at the right time at the right place for the right price in the right condition to the right customer. Logistics management is one part of supply chain management, and that has a larger scope. The CSCMP definition is as follows:

Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.

Even though packaging is included in logistics and supply chain management to varying degrees, it is recognized by scholars as having a significant impact on logistics costs and performance (Ebeling, 1990; Twede, 1992). Bowersox and Closs (1996) concluded that packaging affects the performance of every logistical activity throughout the supply chain, either directly (material handling and
transportation) or indirectly (as information carrier, product protection, etc.). Nevertheless, packaging is often regarded in logistics as an unavoidable non-value-added cost containing little to no strategic value (Lockamy III, 1995). This has resulted in the packaging-dependent costs in the logistics system being frequently overlooked by packaging and logistics professionals (McGinnis and Hollon, 1978; Twede, 1992).

Gattorna (1990) presents the role of packaging in logistics as “this long-neglected but fundamental part of our activities” and states that packaging is a source of profit and, in fact, also has an impact on the environment. In the logistics and supply chain management literature, these have essentially become the two main packaging themes: source of profit and environmental impact.

References


Checkland P. (1999), System Thinking, System Practice – includes a 30-year Retrospective. John Wiley & Sons, Chichester, UK.


CSCMP, Council of Supply Chain Management: https://cscmp.org/


