1 Introduction

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1.1 INTRODUCTION

This chapter, together with Chapters 2 to 4, provides a rationale and a context for considering the numerous types of packaging technology available in today's food and drinks industry. Chapter 1 includes an historical perspective exemplifying packaging developments over the past 200 years and outlines the role of packaging for enhanced sustainability in the food supply system. It highlights the protective, preservation, brand communication, environmental and logistical functions of packaging. Also, it briefly introduces packaging strategy, design and development. Packaging design and technology can be of strategic importance to a company, as it can be a key to competitive advantage in the food and drinks industry. This may be achieved by, for example:

- meeting the needs and wants of the end user better through packaging innovation and design
- enhancing the environmental credentials (or sustainability profile) of a brand and its packaging
- opening up new distribution channels
- providing a superior quality of presentation
- enabling lower costs and/or increasing margins
- enhancing product/brand differentiation
- improving the logistics service to customers

The business drive to reduce costs in the supply chain must be carefully balanced against the fundamental technical requirements for food safety and product integrity as well as meeting the increasing challenge to be environmentally responsible whilst ensuring an efficient logistics service. In addition to protecting the brand, there is a marketing imperative to project brand image through value-added pack design. These often conflicting requirements may, for example, involve design inputs that communicate distinctive, aesthetically pleasing, ergonomic, tamper-evident, convenient, functional and/or environmentally aware attributes. For example, the latter may be illustrated by the rapid growth of compostable bioplastics packaging for use in various niche markets such as organic produce. An overview of bioplastics packaging is presented in Chapter 11.

Thus, there is a continual challenge to provide optimal cost-effective pack performance that satisfies the needs and wants of users across the packaging chain, with health and safety being of paramount importance. At the same time, it is important to minimise the environmental impact

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of products and the services required to deliver them. This challenge is continually stimulated by a number of key drivers – most notably the following:

- the fast-rising number of eco-conscious consumers in advanced economies
- growing legislation and political pressure in response to public concerns over packaging and packaging waste. These concerns are being highlighted by the media and pressure groups
- the impact and financial implications of meeting a raft of wide-ranging environmental legislation and measures such as the EU Directive on Packaging & Packaging Waste (2004/12/EC amending Directive 94/62/EC), the EU Renewable Energy Directive (2009/28/EC) and the EU Landfill Directive (99/31/EC)
- concerns over future availability of resources. For example, the production of oil is likely to peak soon if it has not done so already (Industry Taskforce on Peak Oil & Energy Security – ITPOES, 2010)
- rising expectation by stakeholders for companies to identify sustainability issues, set appropriate targets and demonstrate achievement in accordance with corporate social and environmental responsibility (CSER) policies
- the continued growth of internationally traded products and global brands creating a highly competitive retail environment
- higher energy costs and increasing price volatility of commodities. In response, companies are facing intense pressure to mitigate the cost implications for their manufacturing and distribution operations

In particular, there is a drive to reduce the amount of packaging used and packaging waste to be disposed of. However, this drive to minimise and, in certain cases, eliminate packaging may actually increase the risk of product damage and waste generated, thereby negating the environmental benefits being sought from packaging change. In fact, the environmental impacts due to food and drinks waste are often far greater than those due to the packaging itself when one considers all the resource inputs (including water and fossil fuels) and emissions/waste outputs involved in food and drinks raw materials sourcing, transportation, product manufacture, distribution and use, and final waste disposal. There may be a sound argument to invest in *more* packaging if it reduces food and drinks waste through extending shelf life – for example, by supplying smaller portion packs to meet the needs of single householders who may have irregular consumption patterns due to busy lifestyles. According to research conducted in 2007 by the Waste & Resources Action Programme (WRAP, 2008), approximately one-third of the food purchased by the average UK household is thrown away often with product still in its original packaging, either opened or unopened.

The growing importance of sustainability – interlinking social, economic and environmental considerations – and logistics in the food and drinks supply system means that manufacturing systems, distribution systems and, by implication, packaging systems have become key interfaces of supplier–distributor relationships. Thus, the roles of the market, the supply chain and, not least, society (an integral part of the 'environment') have increasing significance in the area of packaging innovation and design. Ideally, product/packaging innovation should be coupled to design from the end user's perspective whilst adopting a 'design for the environment' approach with sustainability being the philosophy underpinning new product development.

A key challenge for the packaged food and drinks industry is how to adopt sustainable principles and goals whilst addressing cost, performance and market pressures. Ideally, packaging design and innovation should be considered by brand owners at the 'product concept' stage with sustainability specified as part of the design brief. Arising from the above discussion is the need for those involved in packaging design and development to take account of social, economic, technological, marketing, legal, logistical and environmental requirements that are continually changing. Consequently, it is asserted that designers and developers of packaging need to cultivate an integrated view of the influence on packaging of a wide range of functions, including quality, production, engineering, marketing, food and drinks technology, R&D, purchasing, legal issues, finance, the supply chain and environmental management.

1.2 PACKAGING DEVELOPMENTS – AN HISTORICAL AND FUTURE PERSPECTIVE

The last 200 years have seen the pack evolve from being a container for the product to becoming an important element of total product design – for example, the extension from packing tomato ketchup in glass bottles to squeezable co-extruded multi-layer plastic bottles with oxygen barrier material for long shelf life.

Military requirements have helped to accelerate or precipitate some key packaging developments. These include the invention of food canning in Napoleonic France and the increased use of paper-based containers in marketing various products, including soft cheeses and malted milk, due to the shortage of tinplate for steel cans during the First World War. The quantum growth in demand for pre-packaged foods and food service packaging since the Second World War has dramatically diversified the range of materials and packs used. The great variety of food and drinks available today has been made possible by developments since the nineteenth century in food science and technology, packaging materials and machine technology, transport and storage methods. An overview of some key developments in packaging during the past 200 years is given as follows:

- *1800–1850s*: In 1809 in France, Nicolas Appert produced the means of thermally preserving food in hermetically sealed glass jars. In 1810, Peter Durand designed the soldered tinplate canister and commercialised the use of heat preserved food containers. In England, handmade cans of ‘patent preserved meats’ were produced for the Admiralty (Davis, 1967). In 1852, Francis Wolle of Pennsylvania, USA, developed the paper bag-making machine (Davis, 1967)
- *1870s*: In 1871, Albert L. Jones in the United States patented (no. 122,023) the use of corrugated materials for packaging. In 1874, Oliver Long patented (no. 9,948) the use of lined corrugated materials (Maltenfort, 1988). In 1879, Robert Gair of New York produced the first machine-made folding carton (Davis, 1967)
- *1880s*: In 1884, Quaker® Oats packaged the first cereal in a folding box (Hine, 1995)
- *1890s*: In 1892, William Painter in Baltimore, USA, patented the Crown cap for glass bottles (Opie, 1989). In 1899, Michael J. Owens of Ohio conceived the idea of fully automatic bottle making. By 1903, Owens had commercialised the industrial process for the Owens Bottle Machine Company (Davis, 1967)
- *1900s*: In 1906, paraffin wax coated paper milk containers were being sold by G.W. Maxwell in San Francisco and Los Angeles (Robertson, 2002)
- *1910s*: Waxed paperboard cartons were used as containers for cream. In 1912, regenerated cellulose film was developed. In 1915, John Van Wormer of Toledo, Ohio, commercialised the paper bottle, a folded blank box called Pure-Pak®, which was delivered flat for subsequent

folding, gluing, paraffin wax coating, filling with milk and sealing at the dairy (Robertson, 2002)

- *1920s*: In 1923, Clarence Birdseye founded Birdseye™ Seafoods in New York and commercialised the use of frozen foods in retail packs using cartons with waxed paper wrappers. In 1927, Du Pont perfected the cellulose casting process and introduced their product, Cellophane
- *1930s*: In 1935, a number of American brewers began selling canned beer. In 1939, ethylene was first polymerised commercially by Imperial Chemical Industries (ICI) Ltd. Later, polyethylene (PE) was produced by ICI® in association with DuPont™. PE has been extensively used in packaging since the 1960s
- *1940s*: During the Second World War, aerosol containers were used by the US military to dispense pesticides. Later, the aerosol can was developed, and it became an immediate post-war success for dispensing food products such as pasteurised processed cheese and spray dessert toppings. In 1946, polyvinylidene chloride – originally referred to as Saran – was used as a moisture barrier resin
- *1950s*: The retort pouch for heat-processed foods was developed originally for the US military. Commercially, the pouch has been most used in Japan. Aluminium trays for frozen foods, aluminium cans and squeezable plastic bottles were introduced, e.g. in 1956, the Jif® Lemon squeezable lemon-shaped plastic pack of lemon juice was launched by Reckitt & Colman Ltd. in the United Kingdom. In 1956, Tetra Pak® launched its tetrahedral milk carton that was constructed from low-density polyethylene extrusion coated paperboard
- *1960s*: The two-piece drawn and wall-ironed can was developed in the United States for carbonated drinks and beers; the Soudronic welded side-seam was developed for the tinplate food can; tamper-evident bottleneck shrink-sleeve was developed by Fuji Seal, Japan – this was the precursor to the shrink-sleeve label; aluminium roll-on pilfer-proof cap was used in the spirits market; tin-free steel can was developed. In 1967, the ring-pull opener was developed for canned drinks by the Metal Box Company; Tetra Pak launched its rectangular Tetra Brik® Aseptic (TBA) carton system for long-life ultra-heat treated (UHT) milk. The TBA carton has become one of the world's major pack forms for a wide range of liquid foods and beverages
- *1970s*: The bar code system for retail packaging was introduced in the United States; methods were introduced to make food packaging tamper evident; boil-in-the-bag frozen meals were introduced in the UK; MAP retail packs were introduced to the United States, Scandinavia and Europe; PVC was used for beverage bottles; frozen foods in microwaveable plastic containers, bag-in-box systems and a range of aseptic form, fill and seal (FFS) flexible packaging systems were developed. In 1973, DuPont™ developed the injection stretch blow-moulded polyethylene terephthalate (PET) bottle that was used for colas and other carbonated drinks
- *1980s*: Co-extruded plastics incorporating oxygen barrier plastic materials for squeezable sauce bottles, and retortable plastic containers for ambient foods that could be microwave heated. PET-coated dual-ovenable paperboard for ready meals. The widget for canned draught beers was commercialised – there are now many types of widget available to form a foamy head in canned and glass bottled beers. In 1988, Japan's longest surviving brand of beer, Sapporo, launched the contoured can for its lager beer with a ring-pull that removed the entire lid to transform the pack into a handy drinking vessel
- *1990s*: Digital printing of graphics on carton sleeves and labels for food packaging was introduced in the UK; shrink-sleeve plastic labels for glass bottles were rapidly adopted by the drinks industry; shaped can technology became more widely adopted in the United States and Europe as drinks companies sought ways of better differentiating their brands

- *2000–2010*: In 2006, nanotechnology was used to modify the internal surface properties of a squeezable plastic bottle for a global brand of mayonnaise to enable easier product removal thereby reducing product waste. In 2007, the world's first 100% recycled PET bottle for the UK's 'innocent®' brand of 'Smoothie' fruit drinks. In the United States, manufacture of the world's first commercially compostable maize starch-derived polylactide or polylactic acid (PLA) bottles used for water. In the UK, Walkers™ Crisps became the first company in the world to display a carbon footprint reduction label on a consumer product

Since the advent of the food can in the nineteenth century, protection, hygiene, product quality and convenience have been major drivers of food technology and packaging innovation. In recent years, there has been a rising demand for packaging that offers both ease of use and high quality food to consumers with busy lifestyles. The 1980s, in particular, saw the widespread adoption by the grocery trade of innovations such as gas barrier plastic materials utilised in aseptic FFS plastic containers for desserts, soups and sauces; plastic retail tray packs of premium meat cuts in a modified atmosphere; and retortable plastic containers for ambient storage ready meals that can be microwave heated.

Technological developments often need to converge in order for a packaging innovation to be adopted. These have included developments in transportation, transport infrastructures, post-harvest technology, new retail formats and domestic appliances such as refrigerators, freezers and microwave ovens. For example, the development of the microwave oven precipitated the development of convenience packaging for a wide range of foods. In addition, the sociocultural and demographic trends, consumer lifestyles and economic climate must generate sufficient market demand for an innovation to succeed.

In the future, it is likely that packaging will need to become smarter to more effectively communicate with consumers, improve convenience, augment brand identification/value and enhance sustainability credentials. For example, data matrix barcodes consisting of black and white modules in a two-dimensional square or rectangular pattern and printed electronics can help address rising consumer demand for more product information – such as origin, GM, organic, Fairtrade® mark, food preparation and pack recyclability. The pattern is decoded by camera phone to communicate more detailed information about the brand/product to the consumer. As environmental concerns grow, packaging will play an increasingly important role in the sustainability agenda of the food and drinks industry. Increasingly, consumers are deciding for or against brands on the basis of ecological or social criteria. In order to win and retain their custom, companies will need to develop and effectively implement sustainable development policies that include addressing climate change, resource management, pollution and waste.

1.3 ROLE OF PACKAGING FOR ENHANCED SUSTAINABILITY OF FOOD SUPPLY

Consumer demand for pre-packaged food and drinks, much of which is sourced on a global basis, continues to rise in advanced economies and a growing global population is also increasing the demand. This consumption trend is being reflected in emerging economies and lesser developed countries experiencing rapid urbanisation. In response to changing consumer lifestyles, large retail groups and food service industries have evolved. Their success has involved a highly competitive mix of logistical, trading, marketing and customer service expertise, all of which is dependent on quality packaging. They have partly driven the dramatic expansion in the range of products available, enabled by technological innovations, including those in packaging.

The retailing, food and drinks manufacturing and packaging supply industries are continuing to expand their operations internationally. The sourcing of products from around the world is increasingly assisted by a reduction in trade barriers. The effect has been an increase in competition and a downward pressure on prices. Increased competition has led to a rationalisation in industry structure, often in the form of mergers and takeovers. For packaging, it has meant the adoption of new materials and shapes, increased automation, extension of pack size ranges and a reduction in unit cost. Another effect of mergers among manufacturers and retailing groups on packaging is the reappraisal of brands and their pack designs.

Increasing market segmentation and the development of global food and drinks supply chains have encouraged the adoption of sophisticated logistical packaging systems – Chapter 4 discusses 'Logistical packaging for food marketing systems'. Packaging is an integral part of the logistical system and plays an important role in preventing or reducing the generation of waste in the supply of food. Fig. 1.1 illustrates the distribution flows of food from the farm to the consumer. It should be noted, however, that some parts of the chain permit the use of returnable packages.

Globally, the food and drinks industry makes a significant contribution to climate change and other environmental issues. The industry is a major user of fresh water, non-renewable fossil fuels and other non-renewable natural resources such as metals. Increasingly, however, business leaders are becoming aware of the connections between climate change, energy, fresh water availability and the demands of their stakeholders for corporate accountability. The main

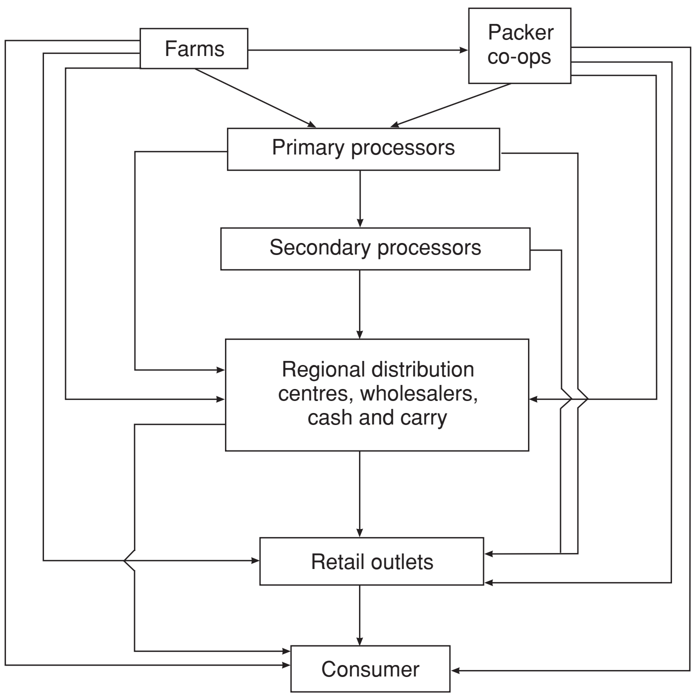

Fig. 1.1 Food distribution systems. (Adapted from Paine & Paine, 1983.)

environmental challenge for society and industry generally is to meet targets for reducing carbon dioxide (CO_2) and other greenhouse gases (GHGs) to address the growing global issue of climate change. Ecological and social impacts linked to climate change include decreasing per capita availability of fresh water, increasing stress on food supply, rapid deforestation, adverse effects on human health, pollution and loss of biodiversity.

The food and drinks industry is aware of rising environmental concerns and, for some years, has launched a range of initiatives to respond to these concerns. Initiatives have focused on, for example:

- the environmental impacts of transportation, particularly with regard to pollutants such as CO_2, oxides of nitrogen and other GHG emissions
- packaging litter and the volume of packaging waste in municipal waste
- pollution associated with methods of disposal, particularly landfill and incineration
- the sustainability of groundwater abstraction and use
- health risks to wildlife from discarded packaging
- sustainable sourcing of packaging materials, e.g. Forest Stewardship Council® (FSC) certified paper and pulp

Over several decades, packaging has attracted much adverse attention and scrutiny by the media and public many of whom perceive packaging to be a waste of resource and believe that used packaging represents a much larger contribution to the solid waste stream than is actually the case. An industry survey involving interviews with European packaging company senior executives reported that the packaging sector was ‘a highly visible and growing contributor to the waste stream’ (PricewaterhouseCoopers, 2009). The general consensus was that a common definition of ‘sustainable packaging’ would represent significant progress. In this regard, there is a number of industry initiatives in place to define ‘sustainable packaging’, e.g. the Consumer Goods Forum’s Global Packaging Project (www.theconsumergoodsforum.com), the Sustainable Packaging Coalition® (www.sustainablepackaging.org), the Sustainable Packaging Alliance (www.sustainablepack.org) and the Greener Package Guidelines for Sustainability (www.greenerpackage.com).

Packaging’s role in helping to achieve greater sustainability in the food supply system has fast become a strategic issue for both industry and government, which need to take account of the economic consequences of climate change and the serious resource implications of growing global demand for products, including food and drinks. Economic considerations affecting product (and packaging) costs include the price of oil, the economic climate, energy and raw material costs/availability. Numerous case studies on packaging from across the food and drinks industry have demonstrated that a ‘greener’ business can deliver not only environmental benefits but also economic benefits and enhanced marketing opportunities, e.g. refer WRAP’s Envirowise (www.envirowise.wrap.org.uk).

The *total product cost* should take account of the impact of *environmental value* on cost because of the opportunity this value presents to significantly reduce costs. For example, these may include energy, transport, waste disposal and water costs. It may also enable companies to minimise the financial impact of changing legislation and other economic instruments relating to matters such as packaging and packaging waste. A value chain perspective integrating environmental solutions from across the supply chain will serve to improve the environmental profile (including carbon footprint) of a company, thereby enhancing its brand image. Examples include:

- adopting packaging which extends product shelf life and reduces food and drinks waste
- selecting pack designs by brand owners that facilitate recycling or reuse
- action by retailers and brand owners to help develop recycling infrastructure
- obtaining packaging materials from environmentally responsible suppliers and raw materials from sustainable sources
- adopting low carbon and renewable energy technologies for packaging production, product manufacturing, distribution and retail operations e.g. the provision of more energy efficient machinery by packaging manufacturers
- using space-efficient pack designs for more energy efficient distribution and lower emissions per unit load of packaged product
- providing reduced weight/volume containers, wrappings and closures by packaging material suppliers and converters
- reducing the number of components in a pack, e.g. two-piece instead of three-piece closure
- increasing the level of post-consumer recycled (PCR) and recycled industrial scrap content of packaging
- more environmentally responsible print processes
- reducing the weight of labels or increasing the recycled content
- improving energy efficiency and water management in food and drinks packaging operations
- reducing the energy/GHG emissions and thereby reducing the carbon footprint associated with packaging materials manufacture, supply, on the packaging line, in the factory and the warehouse
- adopting packaging that effectively communicates brand values and green credentials to consumers

Environmental policy on packaging should focus on resource efficiency and not just waste and recycling. A full strategic response to the environmental issue would include:

- minimising energy and raw material use
- minimising the impact on the waste stream
- not causing environmental damage

There are many alternative routes to achieve these objectives but the key possibility for a retailer or manufacturer to gain competitive edge is repositioning all products to satisfy a comprehensive audit. The risk and uncertainty involves the relative strength of environmental concerns and other key consumer attributes.

There are management tools to reduce or compare the environmental impacts of industrial systems, and these include life cycle assessment (LCA). LCA is a management tool involving a detailed examination of the environmental impact of a product at every stage of its existence, from extraction of materials through to production, distribution, use, disposal and beyond. The International Organization for Standardization (ISO) has responded to the need for an internationally recognised methodology for LCA (ISO: 14040 and ISO: 14044).

Environmentally compatible packaging that is resource efficient, and/or enables greater resource efficiency in product use and distribution, assists the preservation of the world's resources. It also assists by preventing product spoilage and wastage, and by protecting products until they have performed their function.

A Tetra Pak® motto is that a *'package should save more than it costs'*.

Generally, food and drinks packaging contributes only a relatively small proportion of the total energy consumed and GHG emissions involved in the food supply system, product use and waste disposal. Emissions of GHGs from manufactured foods tend to be dominated by emissions from the production stage, i.e. agriculture. For example, it was estimated using 2007 data (Millstone & Lang, 2008) that packaging contributes around 5% of UK food-related GHG consumption in contrast to impacts from fertiliser production (5%), agriculture (39%), food processing (12%), transport from overseas (6%), retailing (5%), catering (8%), food preparation in the home (11%) and waste disposal (2%).

In conclusion, the value of food packaging to society has never been greater nor, paradoxically, has packaging attracted so much adverse media publicity and political attention. In response, stakeholders in the food and drinks industry need to fully appreciate and actively promote the positive contributions that their packaging makes to society. It is also crucial that they actively innovate and redesign packaging – ideally, through collaborative partnerships in their supply chains – to effectively meet the sustainability challenge and the changing needs/values of their consumers. At the same time, they need to satisfy the mass of laws, regulations, codes of practice and guidelines that govern the industry.

1.4 DEFINITIONS AND FUNCTIONS OF PACKAGING

The principal roles of packaging are to contain, protect/preserve the product and inform the user. Thereby, food and drinks waste may be minimised and the health of the consumer safeguarded. Packaging combined with developments in food science, processing and preservation techniques, has been applied in a variety of ways to ensure the safety of the consumer and integrity of the product. The success of both packaging and food technology in this regard is reflected by the fact that the contents of billions of packs are being safely consumed every day.

There are many ways of defining packaging, reflecting different emphases. For example, packaging can be defined as:

- a means of ensuring safe delivery to the ultimate consumer in sound condition at optimum cost
- a coordinated system of preparing goods for transport, distribution, storage, retailing and end use
- a techno-commercial function aimed at optimising the costs of delivery whilst maximising sales (and hence profits)

  However, the basic functions of packaging are more specifically stated as follows:
  - *containment*: depends on the product's physical form and nature, e.g. a hygroscopic free-flowing powder or a viscous and acidic tomato concentrate
  - *protection*: prevention of mechanical damage due to the hazards of distribution
  - *preservation*: prevention or inhibition of chemical changes, biochemical changes and microbiological spoilage
  - *information about the product*: legal requirements, product ingredients, use, etc
  - *convenience*: for the pack handlers and user(s) throughout the packaging chain
  - *presentation*: material type, shape, size, colour, merchandising display units, etc
  - *brand communication*: for example pack persona by the use of typography, symbols, illustrations, advertising and colour, thereby creating visual impact
  - *promotion (selling)*: free extra product, new product, money off, etc
  - *economy*: for example efficiency in distribution, production and storage
  - *environmental responsibility*: in manufacture, use, reuse or recycling and final disposal

1.5 PACKAGING STRATEGY

Packaging may also be defined as follows: *'A means of safely and cost effectively delivering products to the consumer in accordance with the marketing strategy of the organisation.'* A packaging strategy is a plan that addresses all aspects and all activities involved in delivering the packaged product to the consumer. Packaging strategy should be allied to clearly defined marketing, manufacturing and sustainability strategies that are consistent with the corporate strategy or mission of the business.

Key stakeholders in the strategic development process include management from technical/quality, manufacturing, procurement, marketing, supply chain, legal, environmental and finance functions.

Packaging is both strategically and tactically important in the exercise of the marketing function. Where brands compete, distinctive or innovative packaging is often a key to the competitive edge companies seek. In the UK, for example, the development of the famous widget for canned draught beers opened up marketing opportunities and new distribution channels for large breweries. The packaging strategy of a food manufacturer should take into consideration the factors listed in Table 1.1.

Table 1.1 Framework for a packaging strategy.

Technical requirements of the product and its packaging to ensure pack functionality and product protection/preservation throughout the pack's shelf life during distribution and storage until its consumption
Customer's valued packaging and product characteristics, e.g. aesthetic, flavour, convenience, functional and environmental performance
Marketing requirements for packaging and product innovation to establish a distinct (product/service) brand proposition; protect brand integrity and satisfy anticipated demand at an acceptable profit in accordance with marketing strategy
Supply chain considerations such as compatibility with existing pack range and/or manufacturing system
Legislation and its operational/financial impacts, e.g. regulations regarding food hygiene, labelling, weights and measures, food contact materials and due diligence
Ethical/environmental requirements or pressures and their impacts, e.g. light-weighting to reduce impact of taxes or levies on amount of packaging used; sustainable sourcing of materials, responsible labour policies of suppliers

1.6 PACKAGING DESIGN AND DEVELOPMENT

Marketing 'pull' is a prerequisite to successful innovation in packaging materials, forms, designs or processes. The most ingenious technological innovation has little chance of success unless there is a market demand. Sometimes, an innovation is ahead of its time but may be later adopted when favoured by a change in market conditions. Specialist technical research, marketing research and consumer research agencies are employed to identify opportunities and minimise the financial costs and risks involved in the development, manufacture and marketing of a new product.

During the 1980s in the UK, for example, the radical redesign of traditional plastic film overwrapped, flat-shaped cartons with flip-open lids for retail packs of tea bags was based on focus group consumer research for a leading branded tea supplier. It was motivated by the rapidly growing competitive threat from packaged instant coffees in the hot drinks market. The result was a rigid upright carton with an integral easy tear-off board strip but without the traditional plastic film overwrap that was difficult to open. Metalized polyester pouches are used to contain 40 tea bags for convenient tea caddy or cupboard storage. Carton designs may contain either a single pouch or multiple pouches. The pouch prevents spillage of tea dust, provides freshness and conveys an image of freshness that is often reinforced by the promotional on-pack message of 'Foil packed for freshness'. The carton shape, label and colour combinations were also redesigned for extra on-shelf impact. This packaging innovation was widely adopted by retailers and other manufacturers for their branded teas. This pack format is still commonplace today on supermarket shelves although a tea packaging innovation called the 'softpack' has been successfully introduced by a leading tea brand in recent years. A new tea packaging innovation adopted by a major tea brand in 2009 is a pouch made using metalized biodegradable cellulosic-based film that is suitable for home composting because of its low aluminium metal content at less than 0.02%.

Generally, more successful new product developments are those that are implemented as a 'total product concept' with packaging forming an integral part of the whole. An example of the application of the 'total product concept' is the distinctive white bottle for the 'Malibu'® brand of rum-based spirit drink that reflects the coconut ingredient. There are many examples such as cartons with susceptors for microwave heating of frozen chips, pizzas and popcorn, and dispensing packs for mints.

Ideally, package design and distribution should be considered at the product concept stage. Insufficient communication may exist between marketing and distribution functions; a new product is manufactured and pack materials, shape and design are formulated to fulfil the market requirements. It is only then that handling and distribution are considered. Product failure in the marketplace due to inadequate protective packaging can be very costly to rectify. Marketing departments should be aware of distribution constraints when designing a total product concept. With high distribution costs, increased profitability from product and pack innovation can be wiped out if new packaging units do not fit in easily with existing distribution systems. It is necessary to consider whether packs are designed more for their marketability or for their physical distribution practicability. This would not necessarily be so important if it were not for the growing significance of distribution costs and environmental performance, in particular those for refrigerated products that require high energy input throughout the cold chain.

The development of packs is frequently a time-consuming and creative endeavour. There may be communication difficulties between business functions and resource issues that impede pack development. The use of multidisciplinary teams may expedite the packaging development process. This has the effect of improving the quality of the final product by minimising problems caused by design consequences that can result from sequential development. Computer assisted design and rapid prototyping facilities for design and physical modelling of packs give packaging development teams the ability to accelerate the initial design process. In packaging development, thorough project planning is essential. In particular, order lead times for packaging components need to be carefully planned with suppliers at an early stage in order to ensure a realistic time plan. For example, the development of a plastic bottle pack for a juice drink may involve typical stages listed in Table 1.2. There may be issues such as a supplier's availability of injection stretch blow-moulding machines due to seasonal demand for drinks containers and consequent lack of spare production capacity.

With reference to the definition *'Packaging in product distribution is aimed at maximising sales (and repeat sales, and so profits), while minimising the total overall cost of distribution from the point of pack filling onwards and, possibly, extending to used packaging reuse, disposal or recovery',* packaging should be regarded as *'a benefit to be optimised rather than merely a cost to be minimised'* (Paine & Paine, 1983).

Table 1.2 Typical stages in the design and development of a new plastic bottle pack.

Define packaging strategy
Prepare packaging brief and search for pack design concepts: functional and graphical
Concept costing, screening and approval by cross-functional packaging team
Pack component supplier selection through liaison with purchasing
Cost tooling: design and engineer new moulds for bottles and caps with suppliers
Test pack prototype: dimensional, drop impact, leak, compression, cap fit, etc.
Commission artwork for labels
Shelf life testing; barrier performance evaluation
Model and sample production: filling system; labelling; casing, etc.
Market test prototype
Design, cost and evaluate transit pack performance for prototype: drop, compression, etc.
Determine case arrangement on pallets and assess influence of factors affecting stacking performance: brick or column stacking, relative humidity, moisture, pallet design, etc.
Define quality standards and packaging specifications
Conduct production and machine trials: efficiency and productivity performance
Plan line changeovers
Develop inspection methods and introduce a quality assurance service
Commission production line for new or changed packaging systems
Fine-tune packaging operations and specifications

'Packaging optimisation' is a main concern of the packaging development function. The aim is to achieve an optimal balance between performance, quality and cost, i.e. value for money. It involves a detailed examination of each cost element in the packaging system and an evaluation of the contribution of each item to the functionality of the system (Melis, 1989).

Packaging should be considered as part of the process of product manufacturing and distribution, and the economics of the supply chain should take into account all those operations – including packaging – involved in the delivery of the product to the final user. Increasingly, the costs involved in reuse or waste collection, sorting, recovery and disposal are being taken into account. For example, a take-away food service may decide to adopt an easily collapsible aseptic fill bag-in-box system for long life or extended shelf life drink to reduce product wastage, minimise waste packaging storage and reduce waste disposal costs. The overall or 'total packaging system' cost stems from a number of different components, including materials utilisation, machinery and production line efficiency, movement in distribution, management and manpower. They may include some of the operations listed in Table 1.3.

Table 1.3 Typical handling operations for an ambient storage retail pack.

Production line container forming, de-palletising or de-nesting
Container transfer on conveyor system and container inspection (cleaning)
Filling, sealing (processing) and labelling
Casing, case sealing and coding
Palletising and stretch-wrapping
Plant storage
Transport to warehouse
Lorry transport to retail regional distribution centre (RDC)
RDC storage
Pallet break-bulk and product order pick for stores at RDC
Mixed product load on pallets or roll cages to RDC dispatch
Loaded pallets or roll cages delivered by lorry to retail stores
Loads moved to back of store storage area for a short period
Load retail cabinet or fill shelf merchandising display

Adopting 'a systems approach to packaging' can yield significant benefit other than just cost. Savings can be functionally derived by, perhaps, even increasing packaging costs for better pack performance and recouping savings in other areas such as more productive plant operations or cheaper handling, storage and transportation. This is known as a 'total systems approach to packaging optimisation' (Melis, 1989).

1.6.1 The packaging design and development framework

The framework presented in Table 1.4 ideally models the information requirements for packaging design and development. It considers all the tasks a pack has to perform during production and in distribution from the producer to the consumer, taking into account the effect on the environment.

Each of the aspects listed in Table 1.4 is discussed and a checklist of factors for each aspect presented. The market selected for discussion here is the multiple retail market that dominates the food supply system of many advanced economies such as the UK.

Table 1.4 The packaging design and development framework.

Product needs
Distribution needs and wants
Packaging materials, machinery and production processes
Consumer needs and wants
Market needs and wants
Environmental performance

Source: Developed from Paine (1981).

1.6.1.1 *Product needs*

The product and its package should be considered together, i.e. 'the total product concept'. A thorough understanding of a product's characteristics, the intrinsic mechanism(s) by which it can deteriorate, its fragility in distribution and possible interactions with packaging materials – i.e. compatibility – is essential to the design and development of appropriate packaging. These characteristics concern the physical, chemical, biochemical and microbiological nature of the product (see Table 1.5). The greater the value of the product, the higher is the likely investment in packaging to limit product damage or spoilage, i.e. there is an optimum level of packaging.

1.6.1.2 *Distribution needs and wants of packaging*

A thorough understanding of the distribution system is fundamental for designing cost-effective packaging that provides the appropriate degree of protection to the product and is acceptable to the user(s). Distribution may be defined as 'the journey of the pack from the point of filling to the point of end use'. In some instances, this definition may be extended to include packaging reuse, waste recovery and disposal. The three distribution environments are climatic, physical and biological (Robertson, 1990). Failure to properly consider these distribution environments will result in poorly designed packages, increased costs, consumer complaints and even avoidance by the customer.

Climatic environment is the environment that can cause damage to the product as a result of gases, water and water vapour, light (particularly UV), dust, pressure and the effects of heat

Table 1.5 Product needs.

Nature of the product	
Physical nature	Gas, viscous liquid, solid blocks, granules, free-flowing powders, emulsions, pastes, etc.
Chemical or biochemical nature	Ingredients, chemical composition, nutritional value, corrosive, sticky, volatile, perishable, odorous, etc.
Dimensions	Size and shape
Volume, weight and density	Method of fill, dispense, accuracy, legal obligation, etc.
Damage sensitivity	Mechanical strength properties or fragility/weaknesses
Product deterioration: intrinsic mechanism(s) including changes in	
Organoleptic qualities	Taste, smell, colour, sound and texture
Chemical breakdown	For example, vitamin C breakdown in canned guavas
Chemical changes	For example, staling of bread
Biochemical changes	For example, enzymatic and respiratory
Microbiological status	For example, bacterial count
Product shelf life requirement	
Average shelf life needed	
Use-life needed	
Technical shelf life	For example, is migration within legal limits?

or cold. The appropriate application of technology will help prevent or delay such deleterious effects during processing, distribution and storage (see Table 1.6).

Physical environment is the environment in which physical damage can be caused to the product during warehouse storage and distribution that may involve one or more modes of transportation (road, rail, sea or air) and a variety of handling operations (pallet movement, case opening, order picking, etc.). These movements subject packs to a range of mechanical hazards such as impacts, vibrations, compression, piercing, puncturing (see Table 1.7). In general, the more break-bulk stages there are, the greater is the opportunity for manual handling and the greater is the risk of product damage due to drops. In the retail environment, the ideal is a through-distribution merchandising unit – for example the roll cage for cartons of fresh pasteurised milk.

Biological environment is the environment in which the package interacts with pests – such as rodents, birds, mites and insects – and microbes. For pests, an understanding of their survival needs, sensory perceptions, strength, capabilities and limitations is required.

Table 1.6 The climatic environment.

Protection requirement against the climatic environment includes:	
High/low temperature	Small or extreme variations
Moisture	Ingress or egress
Relative humidity	Condensation, moisture loss or gain
Light	Visible, infrared and UV
Gases and vapour	Ingress/egress: oxygen, moisture, etc.
Volatiles and odours	Ingress or egress – aromas, taints
Liquid moisture	For example corrosion due to salt-laden sea spray
Low pressure	External pressure/internal pack pressure variation due to change in altitude or aircraft pressurisation failure
Dust	Exposure to wind-driven particles of sand, grit, etc.

Table 1.7 The physical environment.

Protection against mechanical hazards of storage and transportation by:	
Shocks	Vertical and horizontal impacts, e.g. from drops, falls, throwing
Vibration	Low-frequency vibrations from interactions of road or rail surfaces with vehicle suspension and engines; handling equipment; machinery vibration on ships
	High-frequency aerodynamic vibration on aircraft
Compression/crushing	Dynamic or static loading; duration of stacking; restraint etc.
Abrasion	Contact with rough surfaces
Puncture	Contact with sharp objects, e.g. hooks
Racking or deformation	Uneven support due to poor floors, pallet design, pallet support
Tearing	Wrong method of handling

Table 1.8 The biological environment.

Microbes	Bacteria, fungi, moulds, yeasts and viruses
Pests	Rodents, insects, mites and birds

For microbes, an understanding of microbiology and methods of preservation is necessary (see Table 1.8).

Other factors that need to be considered when designing packaging for distribution purposes include convenience in storage and display, ease of handling, clear identification and security. There are trade-offs among these factors. These trade-offs concern the product and distribution system itself. For distributors, the package is the product and they need characteristics that help the distribution process (see Table 1.9). Any change in distribution requirements for certain products affects the total performance of the pack.

Identifying the optimum design of a packaging system requires a cost-benefit trade-off analysis of the performance of the three levels of packaging:

- *primary pack*: packaging that is in direct contact with the food or beverage – e.g. a bottle and its cap or a drinks carton – and also any outer packaging designed for retail sale that the consumer is intended to purchase and take away, e.g. a plastic film stretch-wrapped multi-pack of small cartons containing vertical form/fill & seal plastic bags for a variety of single-serve breakfast cereal portions – the well-known 'variety pack'
- *secondary or transit package*: packaging that contains and collates primary packs for storage and distribution purposes, e.g. a plastic film shrink-wrapped corrugated fibreboard tray or case for cans of food or drinks
- *tertiary package*: for example a wooden pallet, a roll cage and the plastic stretch-wrap film around a pallet

An example is the multi-pack made from solid unbleached board (unbleached sulphate or Kraft board) used to collate 12 cans of beer. It can offer benefits such as enhanced promotional capability, more effective use of graphics, better shelf display appearance (no discarded trays), significant saving in board usage, increased primary package protection, better print flexibility during production, improved handling efficiency in retail operations (e.g. faster shelf fill), tamper evidence, stackability, ease of handling by the consumer, faster product scanning at the store retail checkout, thereby improving store efficiency and/or customer service.

Table 1.9 Special packaging features for distribution.

Ease of distribution: handling, stocking and shipment
Protection against soiling, stains, leaks, paint flakes, grease or oil and polluted water
Security in distribution for protection against pilferage, tampering and counterfeiting
Protection from contamination or leakage of material from adjacent packs

In terms of the physical nature of a product, it is generally not presented to the distribution function in its primary form, but in the form of a *package* or *unit load*. These two elements are relevant to any discussion concerned with the relationship of the product and its package. The physical characteristics of a product, any specific packaging requirements and the type of unit load are all-important factors in the trade-off with other elements of distribution when trying to seek least cost systems at given service levels (Rushton & Oxley, 1989).

For example, individual one litre cartons of fresh pasteurised milk may be assembled in shrink-wrapped collations of eight cartons, which in turn are loaded onto pallets, stretch-wrapped and trans-shipped on lorries capable of carrying a given number of pallet loads. At the dairy depot, the shrink-wrapped multi-packs may be order picked for onward delivery to small shops. In the case of large retail stores, the individual cartons of milk may be automatically loaded at the dairy into roll cages that are delivered to the retailer's merchandising cabinet display area without an intermediate break-bulk stage.

1.6.1.3 *Packaging materials, machinery and production processes*

Packaging is constantly changing with the introduction of new materials, technology and processes. These may be due to the need for improved product quality, productivity, logistics service, environmental performance and profitability. A change in packaging materials, however, may have implications for consumer acceptance. The aim is a 'fitness for purpose' approach to packaging design and development that involves selection of the most appropriate materials, machinery and production processes for safe, reliable, environmentally sound and cost-effective performance of the packaging system.

Some key properties of the main packaging media are listed in Tables 1.10, 1.11, 1.12 and 1.13, though it should be remembered that, in the majority of primary packaging applications, they are used in combination with each other in order to best exploit their functional and/or aesthetic properties.

Most packaging operations in food manufacturing businesses are automatic or semi-automatic operations. Such operations require packaging materials that can run effectively and efficiently on machinery. Packaging needs to be of the specified dimensions, type and format within specified tolerances. The properties of the material will need to take account of

Table 1.10 Key properties of glass.

Inert with respect to foods
Transparent to light and may be coloured
Impermeable to gases and vapours
Rigid
Can be easily returned and reused
Brittle and breakable
Needs a separate closure
Widely in use for both single- and multi-trip packaging

Table 1.11 Key properties of tinplate and aluminium.

Rigid material with a high density for steel and a low density for aluminium
Good tensile strength
An excellent barrier to light, liquids and foods
Needs closures, seams and crimps to form packs
Used in many packaging applications: food and beverage cans, aerosols, tubes, trays and drums
Can react with product causing dissolution of the metal

the requirements of the packing and food processing operations. Therefore, they will need to have the required properties such as tensile strength and stiffness, appropriate for each container and type of material. For example, a horizontal form/fill/seal machine producing flow-wrapped product will require roll stock film of a particular width and core diameter, with a heat or cold sealing layer of a particular plastic material of a defined gauge, and film surfaces possessing appropriate frictional, anti-static and anti-blocking properties to provide optimum machine performance.

Packaging machinery is set up to run with a particular type of packaging material and even minor changes in the material can lead to problems with machine performance. The introduction of new packaging materials and new designs must be managed with care. Materials should be selected after machine trials have shown that the required machine efficiency and productivity can be realised.

New designs may require minor or major machine modification that will add direct costs in new forming tools. Indirect costs may result from machine downtime, prolonged changeover times and additional training costs for operators. Design changes in primary packs can have a knock-on effect on secondary packs and volume (cube) efficiencies during distribution and storage that result in height and diameter modifications.

For example, a minor change in container profile can impact on machine operations from depalletising through conveying, rinsing, filling, sealing, labelling, casing and palletising. Depalletisers will need adjustment to cope with the new profile of containers. Conveyor guide rails may require resetting. Filler and labeller in-feed and out-feed star-wheels spacing screws may need replacing or modification. Fill head height may require adjustment and new filler tubes and cups may be required. Closure diameter may be affected having an effect on sealer heads that might necessitate adjustment or modification. New labels may be needed that will require modifications and possibly new components such as label pads and pickers. Casing machines

Table 1.12 Key properties of paper and paperboard.

Low-density materials
Poor barriers to light without coatings or laminations
Poor barriers to liquids, gases and vapours unless they are coated, laminated or wrapped
Good stiffness
Can be grease resistant
Absorbent to liquids and moisture vapour
Can be creased, folded and glued
Tear easily
Not brittle, but not so high in tensile as metal
Excellent substrates for inexpensive printing

Table 1.13 Key properties of plastics.

Wide range of barrier properties
Permeable to gases and vapours to varying degrees
Low-density materials with a wide range of physical and optical properties
Usually have low stiffness
Tensile and tear strengths are variable
Can be transparent
Functional over a wide range of temperatures depending on the type of plastic
Flexible and, in certain cases, can be creased

may need readjustment to match the new position of containers. A redesigned case may be required and a new pallet stacking plan needed to optimise pallet stability.

The direct costs of new package design and machine modification and the indirect costs of reduced productivity prior to packaging lines settling down can be significant. It is important to bring machine and material suppliers into the design project and keep line operations informed at all stages of implementation. Packaging machinery has developed into a wide range of equipment and integrated systems to achieve a complete range of operational, filling and sealing techniques steered by computerised microelectronic systems. Technical considerations in packaging materials, machinery and production processes are listed in Table 1.14.

1.6.1.4 *Consumer needs and wants of packaging*

The overall implications of social and economic trends relating to nutrition, diet and health can be summarised concisely as quality, information, convenience, variety, product availability, health, safety and the environment. Consequently, the food processing and packaging systems employed need to be continuously fine-tuned to meet the balance of consumer needs in particular product areas (see Table 1.15).

A branded product is a product sold carrying the product manufacturer's or retailer's label and generally used by purchasers as a guide in assessing quality. Sometimes, the qualities of competing branded products are almost indistinguishable, and it is packaging that makes the sale. An interesting or visually attractive pack can give the crucial marketing edge and persuade the impulsive consumer. Packaging should, however, accurately reflect product quality/brand values in order to avoid consumer disappointment, encourage repeat purchase and build brand loyalty. Ideally, the product should exceed customer expectations.

Packaging is critical to a consumer's first impression of a product, communicating desirability, acceptability, healthy eating image, etc. Food and drinks are available in a wide range of product and pack combinations that convey their own processed image perception to the consumer, for example freshly packed/prepared, chilled, frozen, UHT aseptic, in-can sterilised and dried products. Food biodeterioration and methods of preservation are discussed in Chapter 2.

One of the most important quality attributes of food and drinks, affecting human sensory perception, is flavour, i.e. taste and smell. Flavour can be significantly degraded by processing and/or extended storage. Other quality attributes that may also be affected include colour, texture and nutritional content. The quality of a food depends not only on the quality of raw ingredients, additives, methods of processing and packaging, but also on distribution and storage conditions

Table 1.14 Packaging materials, machinery and production processes.

Product/packaging compatibility	
Identify any packaging material incompatibilities, e.g. migration and environmental stress cracking of plastics	
Is there a need to be compatible during all conditions of distribution and use?	
Must the package allow gaseous exchange? For example, to allow respiration of fruits and vegetables	
Method of processing the product either in the package or independent of it	
Elevated thermal treatment	For example retort sterilisation and pasteurisation, cooking, hot filling, drying, blanching, UHT aseptic, ohmic heating, microwave processing
Low temperature treatments	Freezing, chilling and cooling
Gas change or flush	Modified atmosphere gassing
Removal of air	Vacuumising
Chemical	Smoking, sugaring, salting, curing, pickling, etc.
Fermentation	For example bacterial fermentation of carbohydrates for yoghurt production
Irradiation	For example gamma rays to kill pathogens in poultry, herbs and spices
Others: Electron beam pasteurisation and sterilisation, gas sterilisation, high pressure processing and membrane processing	
Closure performance	
Does the seal need to provide the same degree of integrity as the packaging materials?	
Re-closure requirement to protect or contain unused portion?	
Degree of protection required against leakage or sifting?	
Degree of seal strength and type of seal testing method employed?	
Application torque and opening torque requirement of caps and closures	
Performance requirements of packaging in production may concern	
Machinery for container forming	
Materials handling	
Filling, check-weighing and metal detection	
Sealing, capping or seaming	
Food processing treatments	
Labelling/coding	
Casing	
Shrink-wrapping; stretch-wrapping	
Palletisation	
Labour requirements	

Table 1.15 Consumer needs and wants of packaging.

Quality	Processing and packaging for flavour, nutrition, texture, colour, freshness, acceptability, etc.
Information	Product information, legibility, brand, use, etc.
Convenience	Ease of access, opening and disposal; shelf life, microwaveable, etc.
Product availability	Product available at all times
Variety	A wide range of products in variety of pack sizes, designs and pack types
Health	For example, it enables the provision of extended or long shelf life foods, without the use of preservatives
Safety	The prevention of product contamination and tampering
Environment	Environmental compatibility

encountered during its expected shelf life. Increasing competition amongst food producers, retailers and packaging suppliers; and quality audits of suppliers have resulted in significant improvements in food quality as well as a dramatic increase in the choice of packaged food. These improvements have also been aided by tighter temperature control in the cold chain and a more discerning consumer.

One definition of shelf life is: *'the time during which a combination of food processing and packaging can maintain satisfactory eating quality under the particular system by which the food is distributed in the containers and the conditions at the point of sale'*. Shelf life can be used as a marketing tool for promoting the concept of freshness. Extended or long shelf life products also provide the consumer and/or retailer with the time convenience of product use as well as a reduced risk of food wastage. The subject of 'Packaged product quality and shelf life' is discussed in detail in Chapter 3.

Packaging provides the consumer with important information about the product and, in many cases, use of the pack and/or product. These include facts such as weight, volume, ingredients, the manufacturer's details, nutritional value, cooking and opening instructions. In addition to legal guidelines on the minimum size of lettering and numbers, there are definitions for the various types of product. Consumers are seeking more detailed information about products and, at the same time, many labels have become multilingual. Legibility of labels is an issue for the visually impaired, and this is likely to become more important in countries with an increasingly elderly population.

A major driver of food choice and packaging innovation is the consumer demand for convenience. There are many convenience attributes offered by modern packaging. These include ease of access and opening, disposal and handling, product visibility, resaleability, microwaveability, prolonged shelf life, etc. Demographic trends in the age profile of a number of advanced economies, such as the UK, reveal rapid growth of a relatively affluent elderly population who, along with a more demanding young consumer, will require and expect improved pack functionality, such as ease of pack opening and pack legibility.

There is a high cost to supplying and servicing the retailer's shelf. Failure to stock a sufficient variety of product or replenish stock in time, especially for staple foods such as fresh milk, can lead to customer dissatisfaction and defection to a competitor's store, where product availability is assured. Modern distribution and packaging systems allow consumers to buy food when and where they want it.

Since the 1970s, food health and safety have become increasingly major concerns and drivers of food choices. Media attention has alerted consumers to a range of issues such as the use of chemical additives and food contamination incidents. These incidents have been both deliberate, by malicious tampering, and accidental, occurring during the production process. However, many consumers are not fully aware of the importance of packaging in maintaining food safety and quality. One effect has been the rapid introduction of tamper-evident closures for many pre-packaged foods in order to not only protect the consumer but also the brand. Another impact has been to motivate consumers to give more attention to the criteria of freshness/shelf life, minimum processing and the product's origin (OECD, 2001).

Consumers have direct environmental impact through the way they purchase and the packaging waste they generate. Consumers purchase packaging as part of the product and, over the years, the weight of packaging has declined relative to that of the product contained. However, consumption patterns have generated larger volumes of packaging due to changing demographics and lifestyles. It is the highly visible volume of packaging rather than the weight of packaging that is attracting critical public attention. In addition, the trend towards increased pre-packaged foods and food service packaging has increased the amount of packaging litter in public spaces and the amount of plastics packaging waste entering the solid waste stream.

One of the marketing tactics used by retailers and manufacturers is ‘environmental compatibility’. However, consumers are often confused or find it difficult to define what *is* ‘environmentally responsible’ or ‘environmentally friendly’ packaging. It is this lack of clarity that has so far prevented many retailers and packaging companies from taking advantage to gain a competitive edge. Consumers need clear information and guidance on which of their actions make the most difference. Each sector of the packaging chain takes responsibility for explaining the functions and benefits of its own packaging. The manufacturers sell the virtues of their packaging to their customers, the product manufacturers, but relatively little of this specific information reaches the ultimate customer.

1.6.1.5 *Multiple food retail market needs and wants*

Packaging has been a key to the evolution of modern fast-moving consumer goods (FMCG) retailing that in turn has spurred on packaging developments to meet its requirements. The most significant development for the food and drinks packaging supply industries has been the emergence of large retail groups. These groups exert enormous influence and control over what is produced, how products are presented and how they are distributed to stores. The large retailers handle a major share of the packaged grocery market and exert considerable influence on food manufacturers and associated packaging suppliers. It is, therefore, important for packaging suppliers to be fully aware of market demand and respond quickly to changes. In addition, the concentration of buyer power at the retail level means that manufacturers may have to modify their distribution and packaging operations in response to structural changes in retailing.

Packaging for FMCG has been referred to as part of the food retail marketing mix and thus closely affects all the other marketing variables, i.e. product, price, promotion and place (Nickel & Jolsen, 1976; see Fig. 1.2).

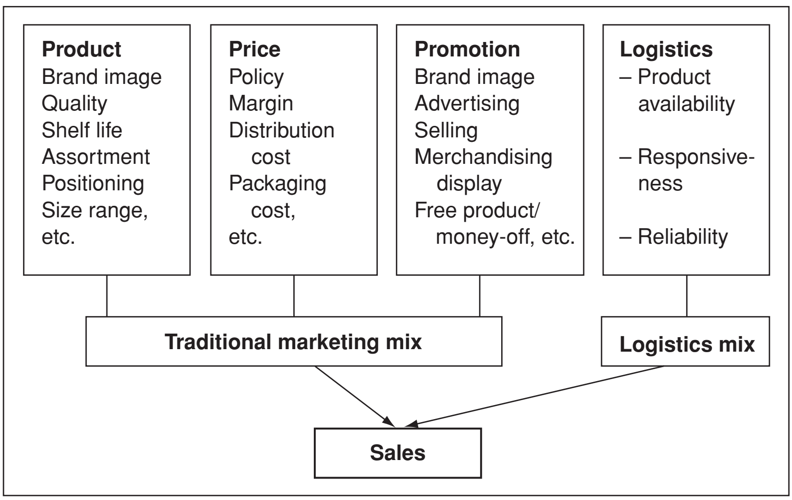

Fig. 1.2 Model of the ‘Marketing Mix’ for FMCG products. (Adapted from Darden, 1989.)

The discussion on packaging in the multiple food retail environment may be considered in terms of its role in (a) brand competition and (b) retail logistics.

The role of packaging in brand competition

Packaging plays a vital role in food marketing representing a significant key to a brand's success or mere survival in a highly competitive marketplace. Packaging innovation and design are in the front line of competition between the brands of both major retailers and product manufacturers, having been driven in recent years by dramatic retail growth, intense industry competition and an increasingly demanding and sophisticated consumer. On an individual product/brand basis, success is dependent on the product manufacturer's rapid innovative response to major trends. One of the most effective ways to respond is through distinctive packaging, and this has become one key factor in the success of a brand. The retailers' own brand products compete intensely with manufacturers' brands in virtually every product category. Brand differentiation can be enhanced by innovative packaging designs that confer aesthetic and/or functional attributes. Table 1.16 lists factors influencing retail trade acceptability of packaging.

Packaging plays an important supporting role in projecting the image of the retailer to gain competitive advantage. The general purpose of the image of retailers' own brands is to support the overall message such as *high quality, healthy eating, freshness, environmentally aware* or *value for money*. For example, retailers who are keen to be seen as environmentally aware in part drive the growing niche market for biodegradable and compostable packaging. They are using it as a point of communication with their customers.

Packaging is closely linked to advertising but it is far more focused than advertising because it presents the product to the consumer daily in the home and on the retail shelf. Merchandising displays that present the pack design in an attractive or interesting way and media advertising consistent with the pack's image also serve to promote the brand. The brand owner is frequently responsible for the merchandising operation. A key to promotional activities is through the

Table 1.16 Factors influencing retail trade acceptability of FMCG packaging design.

Sales appeal to target customer	Consumer profile: demographics and psychographics; product usage and perceptions
Retail competition	Local, regional retail formats and offerings
Retail environment	Lighting, aisle, shelf depth/spacing, etc.
Brand competition	Retailer's own brands versus manufacturers' brands
Brand image/positioning	Quality, price, value, healthy, modern, ethical, etc.
Brand 'persona'	Combined design elements match the psychographic/demographic profile of the targeted customer
Brand impact/differentiation	Aesthetic: colour, shape, material type, etc. Functional: dispensing, pouring, opening, etc.
Brand promotion	Character merchandising, money-off, free extra product, competitions, etc.
Brand communication/presentation	Advertising, merchandising, labelling, typography, logos, symbols, etc.
Consumer and brand protection	Tamper-evident/resistant features
Retail customer service	For example efficient bar code scanning and pack unitisation for fast service at checkout, hygiene and ease of access to pack units.
Retailer's margin	For example packaging design to increase display area on shelf for a minimum turnover of money per unit length of shelf space

effective use of packaging, and there exist many kinds of on-pack promotions such as *free extra product, money-off, special edition, new improved product* and *foil packed for freshness.*

Bar code scanning information linked to the use of retailers' loyalty card schemes has made a big impact on buying and marketing decision-making by retailers. Their task is to make better use of this information on consumer behaviour for promotional purposes and to build store brand loyalty. Retailers can also use this information to evaluate the effectiveness of new pack designs, on-pack promotions and the sales appeal of new products.

The role of packaging in multiple retail logistics

There are tight constraints on physical distribution and in-store merchandising. The retailer is receptive to packaging that reduces operating costs, increases inventory turnover, transforms to attractive merchandising displays – such as pre-assembled or easy-to-assemble aisle displays – and satisfies logistics service levels (reliability, responsiveness and product availability). For example, combined transit and point-of-sale packaging saves store labour through faster shelf loading, provides ease of access to product thereby obviating the need to use potentially dangerous unsafe cutting tools, and presents an opportunity for source reduction.

The total distribution cost affects the total volume of demand through its influence on price (McKinnon, 1989). For some fast-moving commodity type products, such as pasteurised milk, the cost of distribution and retail merchandising is usually a sizeable proportion of total product cost representing up to 50 per cent or more of the sales price. The cost of packaging materials and containers also adds slightly to the cost but design of the optimal packaging system can significantly reduce cost in the retail distribution chain. The development of global food supply chains has meant that many points of production have located further away from the points of consumption, often resulting in higher distribution cost.

Controlling distribution cost through improved operational efficiency in the supply chain is a key to competitive advantage for a retailer. The retailer must maximise operational efficiency in the distribution channel (West, 1989). The goal of distribution is to deliver the requisite level of service to customers at the least cost. The identification of the most cost-effective logistical packaging is becoming more crucial. Cost areas in distribution include storage, inventory, transport, administration and packaging. Storage, inventory, transport and store labour are major cost areas for the retailer whilst transport, storage and packaging are the main cost areas for the food manufacturer.

The efficiency of the multiple retail food supply chain relies on close communication between retailers, food manufacturers and packaging suppliers. It also relies on accurate order forecasting of likely demand. Massive investment in information technology has enabled closer integration of the supply chain and, through electronic data interchange, has ensured that stock moves to stores on a just-in-time (JIT) basis, and is sold well before the expiry date. The bar code is a code that allows the industry-wide identification of retail product units by means of a unique reference number, the major application being the electronic point-of-sale system at the retail checkout. The use of the bar code for identification of primary, secondary and tertiary packaging has enabled efficient distribution management and stock control.

Packaging is a means of ensuring the safe delivery of a product to the consumer at the right time in sound condition at optimum cost. The need for safe delivery of products at the right time and optimum cost demands cost-effective protective packaging that facilitates high logistics performance. The objective is to arrive at the optimum protection level that will meet the customer's service requirements at minimal expense. Other issues that concern the distributor and store manager are cleanliness and hygiene.

The retailer's challenge is to make the most profitable use of shelf space. There is a need to maintain availability of a wide range of high turnover goods on the retail shelf with good shelf life or freshness. This often conflicts with the requirement to minimise product inventory in the retail distribution channel. Consequently, effective supply chain management and a well-integrated food packaging chain are necessary. For packaging material suppliers and converters, the implications of an increasing range of products, often involving shorter runs and lead times, are higher stockholding of materials at extra cost, more frequent deliveries or developing JIT techniques.

A key to competitive edge for a product manufacturer may depend on how quickly and effectively it responds to the retailer's need for:

- minimal stockholding
- high product turnover
- optimal level of fill on shelf
- efficient handling practice
- product integrity

Increasingly, the manufacturer's packaging line must respond rapidly to promotional needs and shorter order lead times whilst ensuring minimal downtime. Packaging systems may need to be not only reliable but also flexible, to change the shape, volume, design and message with relative ease. Flexibility is equally important when there is regional marketing need, sudden seasonal demand or where there has been product failure in the marketplace.

Modular or standardised packaging systems enhance the logistical value of products. Modular systems allow pallets, roll containers and transport containers to be better utilised, and enable packs to be bundled in trays and outer cases to fit supermarket shelves more efficiently. Outer packaging is being minimised for the direct transfer of the product from lorry to shelf display. The consequent requirement for increased quality of primary packaging presents innovation opportunities.

Food packaging and the shelf life issue can be strategically important in logistics because of the new distribution channels it can open up and their impact on industry structure. Any process that can extend shelf life – even by only one or two days – can bring about effective rationalisation in distribution and finished goods stock levels.

Retailers are striving to adopt packaging systems that integrate the requirements of improved environmental performance along with marketing and operational efficiency. Examples include the use of returnable plastic trays, refillable packs and the collection for recycling of corrugated cases with increased recycled fibre content. The significant moves towards centralised warehouses controlled by retailers, temperature-controlled delivery systems and JIT manufacture/delivery, all contribute to the potential for reducing the amount of packaging used. Table 1.17 lists some packaging characteristics valued in multiple retail logistics and distribution.

1.6.1.6 *Environmental performance of a product and its packaging*

In the United States and European Union, leading retailers and branded goods manufacturers have moved towards incorporating sustainability goals in response to a rapidly growing number of eco-conscious or environmentally aware consumers. They are also striving to minimise the impact of rising energy costs in order to better control the cost of goods they sell. Increasingly,

Table 1.17 Packaging characteristics valued in multiple retail logistics and distribution.

Meets the retailer's guidelines for acceptable transit packaging	Pallet type, size and security; pack stability, handling, opening features, bar code scan, ease of read, minimum pack damage, hygiene, etc.
Minimise overall distribution cost	Storage, inventory, transport, store labour costs, etc.
Facilitates logistics service requirements to be met	Product availability, reliability and responsiveness, e.g. efficient consumer response, just-in-time delivery, and modular packaging systems for efficient distribution, retail shelf space utilisation and ease of merchandising operations
Returnable packaging systems	Waste minimisation, e.g. plastic tray systems for fruit, vegetables, meat and baked products
Shelf life extension	For example perishable product availability, reduced spoilage, expansion of chilled product range, stock rationalisation and reduced inventory costs

commitment to improved corporate social and environmental responsibility (CSER) is being demonstrated through a variety of initiatives, including those in packaging, such as:

- a reduction in packaging weight and volume
- reusable packaging and refillable packaging
- post-consumer recycled (PCR) content packaging
- biodegradable and compostable packaging
- automated packaging recycling facilities
- clearer labelling to communicate sustainability credentials such as recyclability and composability
- reduced environmental footprint in terms of resources used and emissions to air and water. For example, the labelling of carbon footprint of pre-packaged products through a comprehensive environmental audit using life cycle analysis

An important strategic issue facing the food and drinks industry is the political and public pressure over the environment, particularly in relation to concerns over the amount of packaging and packaging waste. An evaluation of the packaging system should take account of factors such as total energy, use of sustainable resources, lower impact alternatives and the need to minimise product waste. Options to reduce packaging's environmental impact in the supply chain are summarised in Table 1.18.

Table 1.18 Options to reduce packaging's environmental impact in the supply chain.

Optimise the packaging system to minimise material/product wastage in manufacture, distribution and use by the customer
Increase resource efficiency (energy, water and materials) in pack manufacture through source reduction, product redesign and use of renewable/low carbon energy.
Reuse, compost or recycle packaging
Use more sustainably managed resources; higher levels of post-consumer recycled (PCR) content packaging materials
Waste-to-energy where other used packaging recovery options unavailable

In the UK, carbon footprinting is being used to influence companies throughout the supply chain to reduce their GHG emissions. The UK's Carbon Trust defines a 'carbon footprint' as a 'measure of the total greenhouse gas emissions caused directly and indirectly by a person, organisation, event or product'. A carbon footprint is measured in *tonnes of carbon dioxide equivalent* (tCO_{2e}). The carbon dioxide equivalent (CO_{2e}) allows the different GHGs to be compared on a like-for-like basis relative to one unit of CO_2. CO_{2e} is calculated by multiplying the emissions of each of the six main GHGs by its 100 year global warming potential. Rather than just packaging and its transport, it is argued that carbon calculations should take into account the whole supply chain, product use and final waste disposal or waste recovery.

The EU Eco-management & Audit Scheme (EMAS), introduced in 1995, is a voluntary management tool for companies and other organisations to evaluate, report and improve the environmental performance of processes, though it may also be applied to products. In 2001, EMAS was integrated with ISO 14001, the international standard for environmental management systems (EMS). An Environmental Management System (EMS) provides a systematic approach to monitoring, improving and controlling environmental performance within an organisation. Independent bodies audit the environmental work of organisations with EMAS-approved EMS. ISO 14001 is a member of the ISO 14000 family of international standards which is concerned with minimising an organisation's environmental impacts and providing a consistent approach to communicating environmental management issues to key stakeholders such as customers, regulators and the public. Increasingly, supplier accreditation schemes, such as ISO 14001, are being specified for tenders from buyers in response to corporate social and environmental responsibility (CSER) initiatives.

1.6.2 Packaging specifications and standards

The packaging assessment must include a definition of the optimum quality standards, and these standards should not be compromised by cost. Ideally, packaging supplier selection is a techno-commercial decision agreed during discussions between the purchasing function and packaging technologists. Buyers are becoming more discerning and now expect suppliers to have quality assurance schemes that are accredited by a third party. Widely used quality management systems are those based on ISO 9000. The BRC/IOP Global Standard for Packaging and Packaging Materials (Issue 4) covers some of the core elements of ISO 9001 and provides a common basis for the certification of companies supplying packaging to manufacturers and retailers (BRC/IOP, 2011).

Total quality management (TQM) is a technique that examines the overall quality image as perceived by suppliers and customers. There has been a change in focus from inspecting production outputs to monitoring process variations. TQM can be regarded as a source of competitive advantage, especially where quality is perceived to be a problem by the customer (Christopher *et al*., 1993).

Quality assurance on production and packaging lines has been facilitated by the use of integrated computerised microelectronic control systems that can detect a range of defects and automatically eject reject packs. For example, there are automatic check-weighers, metal detectors, fill-level sensors, pack-leak detectors, label detectors, pack-dimension sensors, light-transmission sensors and odour detectors.

Any packaging innovation or change in packaging should take account of the entire supply chain from materials supply through to retail customers whose distribution channels may demand different levels of performance from a package. A retailer's own brand products, delivered by the manufacturer to the retailer's centralised distribution system, may have packaging specifications that are tailored to meet the rigours of that retailer's specific system. The packaging specifications for a national, pan-European or global brand, however, may require packaging that needs to provide a higher degree of protection due to the wide variation in storage conditions and distribution hazards experienced during a pack's delivery through several retailers' distribution channels. Thus, the rigours of the distribution system and a lack of control over it by food and drinks manufacturers often lead to specifications that generate extra cost and use up resources. Packaging specifications are geared to ensuring that a very high percentage of products arrive in pristine and safe condition, despite the rigours of the journey. However, this approach to packaging may be in conflict with the significant pressure to minimise packaging.

The main testing methods for materials are available from a wide range of sources including ISO, American Society for Testing and Materials (ASTM), British Standards Institute (BSI), DIN, etc.

1.7 CONCLUSION

This chapter has introduced the subject of packaging design and innovation that is driven by the need of industry to create and sustain competitive advantage, changes in consumer behaviour, industry's cost sensitivity, shorter product life cycles, new legislation, growing environmental pressures, availability of new materials and technological processes.

A framework has been used to analyse and describe key considerations in the design and development of packaging. It has emphasised the importance of adopting an integrated approach to packaging by those involved in product design and development, materials and machinery development, production processes, logistics and distribution, quality assurance, marketing, environmental management/sustainability and purchasing. An integrated approach to packaging design and innovation requires consideration of key issues and values throughout the packaging chain.

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Campden-BRI, Station Road, Chipping Campden, Gloucestershire GL55 6LD, UK. Website: www.campden.co.uk.
The Carbon Trust, Customer Centre, PO Box 89, Witney, OX29 4WB, UK. Website: www.carbontrust.co.uk.
Deutsches Institut fur Normung e.V. (DIN), Burggrafenstrasse 6, 10787 Berlin, Germany. Website: www.din.de.
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