FOOD AND BEVERAGE PACKAGING TECHNOLOGY

SECOND EDITION

EDITED BY
RICHARD COLES AND MARK KIRWAN

WILEY-BLACKWELL

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Colour Plate

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Preface

This book informs the reader about product preservation processes and techniques, product quality and shelf life, and the logistical packaging, packaging materials, machinery and processes, necessary for a wide range of packaging presentations and methods of distribution used for the production and marketing of food and beverage products. The role of packaging in enhancing the sustainability of the food and beverage supply system is also emphasised.

It is essential that those involved in packaging innovation and design have a sound understanding of the fundamental requirements for consumer safety, product protection, preservation, together with a broad appreciation of the multi-dimensional role of packaging. Business objectives may include:

- the launch of new products or the re-launch of existing products
- the provision of added value to existing products or services
- cost reduction in the supply chain
- improved sustainability credentials of a product and its packaging

This book sets out to assist in the attainment of these objectives by informing designers, technologists and others in the packaging chain about key food and beverage packaging technologies and processes. To achieve this, the following five principal subject areas are covered:

i. Packaging innovation and design (Chapter 1).

ii. Bio-deterioration and methods of preservation (Chapter 2).

iii. Packaged product quality and shelf life (Chapter 3).

iv. Logistical packaging for food marketing systems (Chapter 4).

v. Packaging materials and processes (Chapters 5–10).

Chapter 1 introduces the subject of food and beverage packaging and its design and development. Strategically, packaging innovation can be an important source of competitive advantage for retailers and product manufacturers seeking to promote and differentiate their brands. Chapter 2 discusses bio-deterioration and methods of product preservation that are fundamental to conserving the integrity of a product and protecting the health of the consumer. Chapter 3 discusses packaged product quality and shelf life issues that are the main concerns for product stability and consumer acceptability. Chapter 4 discusses logistical packaging for food marketing systems – it considers supply chain efficiency, distribution hazards, opportunities for cost reduction and added value, communication, pack protection and performance evaluation. Chapters 5, 6, 7 and 8 consider metal cans, glass, plastics and paper and paperboard, respectively. Chapters 9 and 10 discuss active packaging and modified atmosphere packaging respectively – these techniques are used to extend/optimise the shelf life and/or guarantee quality attributes such as nutritional content, taste and the colour of many types of fresh, processed and prepared food and beverage products. Chapter 11~discusses the relatively new subject of~bioplastics, which are being rapidly adopted for a wide range of food and beverage products in predominantly niche markets.

The editors are grateful for the support of authors who are close to the latest developments in their technologies, and for their efforts in making this knowledge available.~We also acknowledge the support given to us and our authors by~the companies,~government agencies, packaging trade

bodies, universities and other research organisations named in the book.

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1

Introduction

Richard Coles

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 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.

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