Food processing: a century of change

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In 1900, the population was beset with poverty, and infectious and deficiency diseases were common. The first half of the century was blighted by world wars, economic depression and post-war austerity. Nevertheless, a combination of enlightened social policy and the application of medical, nutritional and food science, resulted in substantial improvements in health, such that, by 1950, many hitherto common infectious diseases were under control, and the diet was generally nutritionally adequate. The second half of the century saw increasing economic prosperity, and unprecedented social and scientific advances. The impact on food processing was manifold: nascent technologies such as freezing and chilling were increasingly exploited, and the consumer became the major focus of a food industry that became more sophisticated, embracing automation, computerisation and new developments in, for example, drying, heat processing, controlled and modified atmosphere packaging, ingredients and quality assurance. By 1999, this had led to an industry which provided foods that were not only safe, nutritious and palatable, but which were also increasingly convenient and healthy.

1900–1999 – a century of changes

The 20th century has seen unprecedented political, social, and economic changes, and scientific and technological advances have moved at an ever increasing pace. All these factors have impacted on the food processing industry and influenced the way that food is processed and marketed. Table 1 shows some of the century's milestones, and major developments in food processing through the decades of the century.

A calendar century is essentially an arbitrary unit, but it is notable that the 20th century may be divided into two relatively distinct half centuries. The years 1900–1950, or thereabouts, were characterised by profound political, social and economic upheavals, when ensuring an on-going supply of food to sustain the UK population, preventing or alleviating deficiency diseases, and reducing the incidence of food-borne diseases were the major concerns. The relative economic and political

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Table 1 Some political, social, economic and scientific milestones, and developments in food processing 1900–1999

Decade	Milestones	Food developments
1900s		
	Poverty and malnutrition among working classes	First flour bleaching agent
	Infant mortality at around 220 per 1000	Milk pasteurisation
	Existence of vitamins indicated	Drum drying
	Diet–health relationships become clearer	Sanitary can
	Introduction of school meals	Canned baked beans
1910s		
	World War One	Hydrogenation of oils
	Two-thirds of food supply is imported	Higher extraction of flour
	Food shortages and rationing	Post harvest mechanisation
1920s		
	General strike	Vitamins A and D added to margarine
	Stock market crash presages depression	Plate heat exchangers
	Diets of working classes still poor	Tubular blanchers
	Milk promoted for children	Juice extractors
1930s		
	World economic depression	Mechanisation in abattoirs
	Poverty and undernourishment persist	Lacquered can
	Measures to support domestic agriculture	Brine injection technology
	60% of food supply is imported in 1938	Rapid freezing technology
	World War Two commences	Spray drying – instant coffee
	Non-essential imports curtailed	Wrapped, sliced bread
	Measures to control agriculture and food	Milk carton
	2% of homes have refrigerators in 1939	Refrigerated retail cabinets
1940s		
	War-time rationing	Fortification – National loaf
	Consumer food and nutrition education	Preservatives – meat
	National Milk Scheme in 1941	Mass production – chocolate
	World War Two ends	Freeze drying – vegetables
	Establishment of National Health Service	Additives – flour improvers
	Policy to increase agricultural output	HTST[a] milk pasteuriser
1950s		
	Food rationing ends	Dairy herds are 76% TB[b] free
	Food and Drug Act (1955)	Preservatives – baked goods
	Treaty of Rome (1957)	Controlled atmosphere storage
	Consumer spending rises	Aseptic canning
	Concentration of retailing	*Tetra Pak* packaging for milk
	Refrigerators in 8% of homes by 1956	Frozen foods – fish fingers
	First links of cholesterol and heart disease	Tea bag introduced
1960s		
	Computerisation begins	Chorleywood bread process
	Measures to control Salmonella in eggs	Instant mashed potato
	Refrigerators in 23% of homes by 1964	Polyunsaturated margarine
	Trade Description Act (1968)	Meat tenderisation – enzymes
	Intensified competition on price	Ultra-high temperature milk
	Rise of consumerism – residues, irradiation	*Tetra Pak/Brik* packaging (aseptic)
1970s		
	UK accession to EEC[c] in 1973	Growth in convenience food
	Global oil crisis	Automation and computerisation
	Free school milk ceases	Slimming foods
	Fibre-health links popularised	Granary breads
	Freezers in over 40% of homes by 1979	Aseptic filling – pouches

Table 1 (*continued*) Some political, social, economic and scientific milestones, and developments in food processing 1900–1999

1980s		
	Food Advisory Committee – additives	Advances in plastic packaging
	Food Act (1984)	Single cell protein – Quorn
	Diet and cardiovascular disease links	Low calorie ingredients
	Food Labelling Regulations (1984)	Nutritional labelling
	Food scare – Salmonella	Chilled prepared foods
	Consumer concerns about diet and health	Monounsaturated margarine
	Bar codes introduced	Modified atmosphere packaging
	Consumer led market place	Aseptic foods – particulates
1990s		
	Food Safety Act (1990)	Increasing company specialisation
	Food scares – allergens, BSE[d], GMOs[e]	Fat substitutes – Simplesse
	Reform of CAP[f]	Limited use of irradiation
	Health of the Nation published	Minimal processing
	Ageing population	Functional foods
	Consumer concern about environment	Growth in organic foods
	Retailing and processing globalisation	Genetically modified foods

[a] High-temperature, short-time
[b] Tuberculosis
[c] European Economic Community
[d] Bovine spongiform encephalopathy
[e] Genetically modified organisms
[f] Common Agricultural Policy
Data from sources in the references cited

stability, and the increasing prosperity of the latter half of the century resulted in changes in emphasis. By 1999, food was no longer in short supply, with the consumer expecting the continuing availability of a wide range of foods with good palatability and increased convenience in terms of storage and preparation. The focus had changed from deficiencies and food-borne diseases to the potential of foods to prevent or alleviate chronic diseases, such as cancers, heart disease, diabetes, and associated conditions such as obesity and hypertension. As the consumers' awareness of the role of food in health has increased, so have concerns about the safety of the new technologies which are being introduced throughout the food-chain.

Food processing – an historical context

Almost all foodstuffs are derived from natural products – from plants and animals. The purpose of the earliest food processing methods was to render these products safe to eat, and to present them in a range of palatable forms. Another important purpose was to preserve food, and thus enable storage or transport. Often these objectives were combined.

For example milk, which provides a nutritious food, deteriorates very rapidly unless processed, and a wide range of traditional methods were developed which both extended the shelf-life, and yielded a range of palatable products such as cheeses, yoghurt and butter. These traditional methods brought about complex transformations involving the use of fermentations, and changes in the structure of the food. It is a tribute to earlier agriculturally based communities that such methods were developed without an understanding of the underlying science and technology.

The aims of modern processing are manifold, and include the prolongation of shelf-life, ensuring safety, improving palatability, increasing variety, improving nutritional value and increasing convenience. There is a large, and increasing number of technologies available and, as is outlined below, combined technologies are often applied. Throughout the 20th century, the development and application of these technologies has been enhanced and informed by the advances in science and engineering. However, the utilisation of the technologies has depended on the prevailing economic and social conditions and, increasingly towards the end of the century, on the attitudes and beliefs of the consumer concerning these technologies and their perceived implications.

Food processes – definition, commercial context, scope

In this article, food processing is defined as any procedure undergone by food commodities after they have left the primary producer, and before they reach the consumer, who may themselves further cook or process the food. Food processes take many forms which vary greatly in the degree of complexity of the technologies employed. At the simplest level, food processing may involve no more than controlled storage such as refrigeration. At more complex levels, commodities may be processed to yield ingredients which are later combined to yield foodstuffs as varied as canned baked beans in tomato sauce, frozen baked products, or chilled ready meals.

Although small companies play a role, often in the production of niche products, food processing has become increasingly undertaken by large enterprises which have progressively mechanised, automated, specialised and internationalised throughout the 20th century. The major aim of the commercial food processor has been to run a viable and profitable enterprise. In order to achieve this, the processor has had to conform to increasingly stringent legal standards, and to the standards laid down by large retailers who dominated the food market at the end of the 20th century. Public health and related consumer needs have been central to these standards.

It is beyond the scope of this paper to review all the changes that have occurred in the food-chain during the past 100 years. Past and on-going changes in areas such as biotechnology and food safety are reviewed in subsequent papers. Taking a UK perspective, the focus here is on changes in post-harvest processing, and on the way in which the exploitation of technological advances in the processing of selected commodities has enabled the food industry to respond to the changing social, economic and political conditions of the century in order to satisfy the changing needs and expectations of the population.

The food-chain in 1900 and 1999, an overview

Basic steps in the food-chain for 1900 and for 1999 are shown in Figure 1. In 1900, the food raw materials, which are mostly the products of plant and animal husbandry and fishing were consumed as 'fresh' produce, processed into foodstuffs, or into ingredients for processing.

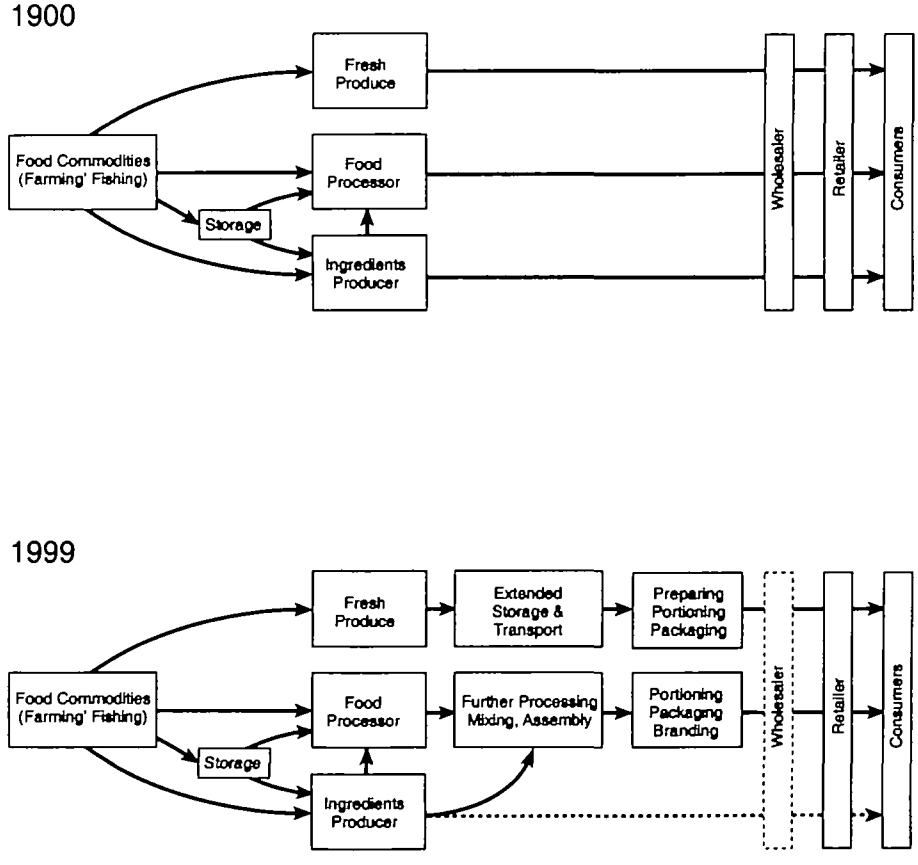

Fig. 1 Simplified diagrammatic representations of the food-chain in 1900 and in 1999 (dotted lines indicate lesser importance).

Some raw materials or ingredients were stored prior to processing. In 1900, these fresh and processed foods, and the food ingredients were essentially commodities, going on to wholesale markets and thence to retailers and the consumer, with little packaging or branding. By 1999, the food-chain had become much more complex. Fresh produce is subjected to extended storage and to prolonged transport, and may be prepared, portioned and packaged before supply to the market. Processed foods and ingredients are subjected to further processing to yield a range of even more complex foodstuffs designed for specific market niches. Conversely the supply of ingredients to the consumer had declined (Fig. 1). These changes have resulted in very large increases in both the range of products available, and in the ease with which these products can be made ready for consumption by the consumer. In 1900, there were national grocery chains which had been developed by entrepreneurs such as Julius Drew, Thomas Lipton and John James Sainsbury; their stores, like those of the numerous independent food retailers, for the most part portioned and packaged the commodities supplied through wholesalers[1]. By 1999, the supermarket chains, buying directly from primary producers and processors, dominated the market, and the role of the wholesaler had declined. Furthermore, by 1999, an increasingly complex regulatory and legal framework had evolved with the aim of improving and ensuring the safety and probity of the food-chain for the consumer.

Developments in food processing during the 20th century

Many of the food processes in use in 1999 were developments of processes extant in 1900. This section outlines these developments, and the range of new processes developed since 1900. Changes in the processing of specific foodstuffs are outlined in the next section.

Drying

Drying (dehydration) preserves food by reducing the water activity, thus inhibiting the activity of micro-organisms and enzymes. Drying not only prolongs storage life, but it also reduces bulk which facilitates storage and transport. Traditionally, drying was applied to both animal and vegetable products and relied primarily on the action of the sun and wind. However, a wide range of commercial driers suitable for both solid and liquid foods have been developed[2]. For example, the drum roller drying of milk was introduced in the first decade of the century.

The dried product was easily reconstituted and represented a significant advance on the products from earlier crude evaporation techniques. Further advances in the first half of the century include spray drying which was used for milk, and for other liquids including coffee, to give the first instant coffee powder. The utilisation of these procedures under partial vacuum yielded dried products with less heat damage, and which were consequently of higher quality. Heat damage, which can occur in both drying and heat processing, includes the development of unpleasant aromas and colours, the loss of nutrients, a decrease in solubility for liquid foods, and undesirable structural changes in solid foods[2]. Dried milk and dried egg were imported in substantial quantities during the Second World War and helped to provide an adequate diet.

Freeze drying involves freezing followed by the sublimation of the ice under reduced pressure. This technique, pioneered in the 1940s and popularised in the 1960s, can be applied to prepared foods and to ingredients such as vegetables, fruit and meat[2,3]. There is no heat damage, and the sensory, structural and nutritional characteristics of the foods are well maintained with the result that freeze-dried products combine good quality with convenience[2,3]. The variety of dried products increased until the 1970s when other processes gave the consumer access to other convenience products of even higher quality.

Heat processing

Heat processes inactivate enzymes, reduce or eliminate microbial contamination, and may also bring about desirable changes in palatability. As with drying, heat damage can also occur. However, advances during the 20th century have enabled the consumer to capitalise on the advantages while minimising the disadvantages.

Canning is a heat process introduced in the early 19th century[4], and is applicable to a wide range of foodstuffs[2,5,6]. However, the underlying principles of sterilisation and air exclusion were not appreciated until after the work of Pasteur. The sanitary can with improved sterilisation efficiency was introduced in the 1900s. The canned baked bean also made its first appearance in this decade. However, this nutritious and convenient foodstuff did not gain general popularity until the 1940s. Improved cans with internal lacquering were developed in the 1930s, and large quantities of canned foodstuffs were imported during the Second World War. Aseptic canning, whereby the food is sterilised before being put into a sterile can was introduced in the 1950s. Aseptic canning enables the food to be sterilised by heating to high temperatures and for a shorter time than would be used in conventional canning which is usually carried out at 115–120°C[7]. Aseptic processing (also

known as ultra-high temperature or UHT) results in less heat damage and gives better quality products[2,5,6,8]. New packaging materials for aseptic processing were introduced in the 1970s and included plastic retortable pouches in which foods could be sealed and heat sterilised[2,6–8]. Although canning declined somewhat in the 1980s with the introduction of other processes, the safety, long ambient shelf-life and convenience of canned foods has ensured that their popularity has continued to the end of the 20th century. Pasteurisation is a milder heat treatment designed to eliminate vegetative pathogens, such as *Salmonellae*, often combined with refrigerated storage, which is applicable to many foodstuffs. Milk pasteurisation is described below. A number of other processes such as blanching, baking and frying which also involve the use of heat have been increasingly refined throughout the 20th century[2].

Freezing and chilling

Freezing inhibits enzymic action and microbial growth. However, slow freezing of the water in foodstuffs results in the formation of large ice crystals and osmotic imbalances which damage the structure of the food and lead to unacceptable products on thawing[2]. In the 1930s, rapid freezing was shown to substantially mitigate this damage and this consequently enabled the development of the market in frozen foods, which has now extended from commodities such as fish and vegetables to fully prepared convenience foods[2,6,9,10]. On the other hand, chilling (or refrigeration) only reduces the activity of enzymes and micro-organisms; chilling does not extend storage life as much as freezing, but the structure of the food remains intact[2,10–13]. Although the potential of freezing and chilling had long been appreciated, it was not until the latter half of the 20th century that technologies became sufficiently available to permit their extensive use. Freezing and chilling equipment is not only needed for processing, but also for transport, retail display and storage in the home. Before the Second World War, the only products subjected to below ambient temperatures for storage and transport were fish, which used ice, and ice cream which used solid carbon dioxide (dry ice) to maintain the low temperatures required[14]. The first refrigerated cabinets appeared in retail outlets in 1939, but only 2% of homes had refrigerators, and fewer had freezers. As prosperity increased in the 1950s, so did the supply of frozen foods, with peas and fish fingers among the first available. Vehicles that did not have to rely on ice or dry ice became available in the 1960s and the increasing availability of freezers and refrigeration units for storage in retail premises and the home enabled a rapid expansion in the market for frozen and chilled foods[14].

The application of low temperature technologies is a major change in food processing in the 20th century. The majority of the so-called 'fresh' fruit and vegetables on sale by 1999 was the culmination of the 'cold chain' by which freshly harvested crops are stored and transported to the retailer[14]. Coupled with the sourcing of supplies from around the world, this has enabled the year round availability of once seasonal crops, and the introduction of exotic 'fresh' foods. Chilling is also used extensively for prepared foods including cooked meats, sandwiches and complete dishes and meals.

Controlled and modified atmospheres

The use of controlled atmospheres (CA) or modified atmospheres (MA) to extend the storage life of foods is a late 20th century development. The atmospheres used vary, but generally carbon dioxide is increased and oxygen is reduced; this reduces respiratory and other enzymic changes in unprocessed foods such as fruit, vegetables and meat, and will also limit oxidative changes[2]. In MA, a single change is made to the atmosphere. In CA storage, the atmosphere is modified, and the modification is maintained by monitoring and making appropriate adjustments. Bulk MA and CA storage were introduced in the 1950s. Following that, MA was introduced for individual packages. The availability of packaging materials that allow the selective exchange of gases enabled CA to be used in individual packages from the 1980s. The use of combined technologies is increasing, and MA and CA are generally combined with chilling[12,15].

Radiation

Various parts of the electromagnetic spectrum are of use in food processing. UV light can be used to help maintain sterility in food processing plants. Ionising radiation (irradiation) can be used for various purposes including inhibition of sprouting, disinfestation, prolonging shelf-life, and for total sterilisation[16,17]. Although first proposed as a method of food preservation in the 1920s, food irradiation met with substantial consumer opposition in many countries (see also chapter by Gould), and was only approved for a limited range of foods in certain countries (*e.g.* the UK has given clearance of all foods up to treatments of 10 kGy) during the 1990s. Microwave radiation is useful for heating, but cost precludes its widespread use within the food processing industry[2]. However, by 1996–7, the presence of microwave ovens in over 75% of homes enabled the consumer to take advantage of the convenience offered by ready-prepared chilled and frozen foodstuffs[18].

Other advances

A number of other important advances in food processing technology have been made in the 20th century, and examples are given below. Extrusion is used for a wide range of products including pastas, texturised vegetable protein and ready-to-eat breakfast cereals[21]. Developments in microbiology and biotechnology have resulted in advances in fermentation technologies valuable in the production of cheese, butter, yoghurt and beer, and food ingredients such as enzymes and gums. Low temperature and high pressure technologies have enabled the use of supercritical fluids, such as liquid carbon dioxide, for the extraction of caffeine from coffee beans and cholesterol from eggs[20]. Extremely high pressures have been shown to extend the shelf-life of foods such as fruit juices with minimal effects on the sensory qualities[21]. The increasing demand by consumers for 'fresh' foods with increased shelf-life has led to the development of minimal processing techniques. Such techniques often use a combination of technologies, such as CA and chilling or MA, irradiation and chilling[22].

New ingredients

Wheat flour and sugar were the main ingredients in the food supply chain in 1900; while these remained important in 1999, the range and applications of ingredients had expanded substantially. Technological innovations throughout the century have produced new ingredients, including refined starches, gums, fats, proteins and sweeteners with well-defined functionalities and applications[23]. For example new sweeteners, including aspartame and acesulfame-K, were introduced in the 1980s as consumer interest in 'slimming' foods intensified[24]. However, the production of low-calorie soft drinks required not only the substitution of sugar by an artificial sweetener, but also the replacement of the texture or 'mouth-feel' provided by the sugar. A range of food gums are used for this purpose. Food gums are also used as stabilisers to improve the sensory and storage characteristics of a wide range of normal and low-calorie foodstuffs as diverse as frozen prepared products, salad dressings, low-fat spreads, ready prepared sauces and ice cream. A wide range of other additives have also become available and are used under controlled conditions to improve the sensory and keeping qualities of many processed foods[25]. A number of fat replacers have been developed and evaluated for safety and efficacy, and became available in the 1990s. These include the protein-based Simplesse, and the sucrose polyester, Olestra[24,26].

Mechanisation, automation, standardisation and safety

Food processing has seen prodigious advances in mechanisation and automation throughout the 20th century. The utilisation of the advances in engineering and in computer and information technology has turned a labour-intensive industry into a capital-intensive industry. Mechanisation of fruit and vegetable processing started in the 1910s[27]. Mechanisation of primary processing of meat and poultry, and the brine injection technology for meat, were introduced in the 1930s[28]. The ongoing computerised automation started in the 1960s when the first automated bakery was opened[28]. With the rise in automated processing and in the promotion of branded foodstuffs came an increased need for quality control and the standardisation of products. This has led to increasingly sophisticated management procedures for all forms of food processing. However, food safety remains a priority. Any food processor who fails to maintain consumer product safety risks serious, even terminal, financial losses. The major hazard in most food processing operations is microbial contamination, and effective design, operation and control is essential to minimising risk. Starting in the late 1950s, management and operating procedures including cleaning-in-place[29], and hazard analysis critical control point (HACCP) have been developed and implemented [29–32]. However, the marketplace is dynamic and unpredictable, and to remain viable the food processor has to respond adequately to consumer issues such as potential food allergies, or the use of genetically modified raw materials.

Food processing 1900–1999: examples of change

The implementation of scientific and technological advances in response to economic opportunities and consumer demand has led to substantial changes in all areas of food processing. Changes in the processing of two staples, bread and milk, are briefly described, and changes in other sectors are outlined. The implications for health are considered in the next section.

Bread

The quality of bread in 1900 reflected changes in the latter part of the 19th century. The displacement of stone-grinding mills by roller mills which commenced in 1877, was complete by 1890. With this change, the extraction rate (the percentage of the whole grain retained in the

flour) fell from 75–80% to 70–73%, and the germ was lost. However, sensory qualities were good and the nutritional significance of this change was not realised[4]. The First World War resulted in food shortages and rationing. In order to increase the amount of bread flour available, legislation was introduced to increase the extraction rate to 76% in 1916, 81% in 1917 and to 91% in 1918 and admixtures of coarse grains, potato flour and soya were also permitted. Bread was grey and of reduced palatability, but this strategy was undoubtedly preferable to the introduction of rationing[4]. Between 1918 and the outbreak of the Second World War in 1939, extraction rates fell to about 70% which gave the millers an optimum yield of white flour[33]. Shortages in the Second World War again led to changes in bread processing. However, the new discoveries in nutritional and cereal science were thoughtfully applied. Bread flour was enriched with thiamin (vitamin B1) in 1940. This ceased in 1942 when 85% extraction National Flour was introduced. National Flour was milled to contain the maximum possible levels of thiamin, riboflavin, niacin and protein and the minimum possible levels of bran, and was enriched with calcium to combat potential deficiencies due to decreased intakes of calcium from cheese and milk[33]. In 1945, the extraction of National Flour was decreased to 80%. However, in 1946, post-war austerity necessitated the introduction of bread rationing and extraction rates were raised briefly to 90% before decreasing to 85%. Bread rationing ended in 1948, extraction rates fell to 82% in 1950 and National Flour ceased in 1953. However, since then, flours with extraction rates below 82% have been enriched with thiamin, niacin, calcium and iron to ensure minimum levels of these nutrients. The first wrapped sliced bread which had been introduced in the 1930s, was re-introduced in the 1950s and gained in popularity throughout the 1960s and 1970s. Most of this bread was made by the Chorleywood bread process developed in the 1960s. In this process, the previous lengthy bulk fermentation is replaced by an input of intense mechanical energy using special mixers which develop the dough matrix in a few minutes. Fat is added (0.7%), and somewhat increased levels of yeast and water are used, with ascorbic acid (100 mg/kg) as an improver. Gluten is the visco-elastic protein in wheat responsible for the establishment of the dough matrix. During the 1970s, commercial processes were developed for the separation of gluten from wheat without loss of functionality[34]. This freeze-dried material is known as vital gluten. Since the accession of the UK to the European Union, imports of American and other high quality bread wheats have been curtailed and thus vital gluten is often added to bread flours made from home-grown wheats. The increased demand for convenience, and for freshly baked breads in the 1980s and 1990s led to the development of part-baked frozen bread products. These are baked off in the home, or in bakeries often located within supermarkets.

Milk

Milk is potentially a highly nutritious and wholesome foodstuff. However, the shelf-life of unprocessed milk is short, it is easily adulterated, and it may carry a number of infectious diseases. Throughout the 19th century, the quality of milk was very poor, particularly in the industrialised cities. In 1850, most milk in London was contaminated with blood or pus, cattle were poorly housed and disease-ridden, and adulteration was commonplace[4]. Brucellosis and bovine tuberculosis were common and often transmitted to those drinking unpasteurised milk. Pasteurisation was first introduced in the 1900s, since it increased shelf-life by reducing the level of spoilage organisms. However, it was soon appreciated that pasteurisation destroyed most of the pathogens associated with milk and, despite opposition from some farmers and consumers, its use has been increased to the point where the sale of non-pasteurised milk has been prohibited in Scotland on public health grounds. The major change in pasteurisation since 1900 has been from a batch process using lower temperatures for a longer time (63.5°C for 30 min) to a high-temperature, short-time (HTST) process (71.7°C for 15 s)[35]. The HTST process uses more efficient, flow-through equipment; it also reduces prolonged heat exposure and the concomitant undesirable sensory and nutritional changes. These changes are even more pronounced on sterilisation, and it was not until the introduction of ultra-high temperature (UHT) treatment that sterilised milk was successful as a consumer product. UHT uses temperatures of 135–150°C for 1–4 s using flow through heat exchangers as for pasteurisation. Homogenisation is essential for the stability of UHT milk[36]. Homogenisation involves the reduction in the size of the fat globules so that a cream layer does not form, and it is also applied to whole milk and to the reduced fat milks that have been introduced. Developments in aseptic packaging have also been important to the success of UHT milk; in this process, the sterile milk is packaged into sterile plastic or laminated containers[35].

Some other important changes in food processing

Many other important changes in food processing occurred in the 20th century. Advances in meat and poultry processing include the production of re-formed, low-fat and convenience products[34–39]. In the spreadable fats' market, the development of hydrogenated fat margarine in the 1910s was followed by their enrichment with vitamins A and D in the 1920s[27]. In the latter half of the century, a wide range of spreadable fats became available, including low-fat products, products high in polyunsaturated or monounsaturated fats and, latterly, functional food products with

novel cholesterol-lowering ingredients[40]. Yoghurt, which in 1900 was an exotic curiosity, acquired fruit flavourings in the 1950s. Since then, a range of flavours, low-fat and no-fat varieties have been developed; a number of brands are available which contain probiotic bacteria, which are claimed to confer a number of health benefits[41].

Health implications of changes in food processing

It is pertinent here to consider the degree of understanding of disease aetiology, and of the complex relationships between diet and disease processes. In 1900, infectious and dietary deficiency diseases were still poorly understood. Tuberculosis and other infectious diseases were common causes of morbidity and mortality. The role and significance of the micronutrients had yet to be discovered. General malnutrition and scurvy were common, rickets was almost universal among the children of the working poor, and anaemia was common among working women[4,42]. It has been estimated, with hindsight, that the roller milled flour, whose introduction was complete by 1890, had only about 50% of the iron, and 33% thiamin and niacin, of that found in the stone-ground flour which it had displaced. This change almost certainly accounts for the fact that the working classes, for whom bread was the main source of sustenance, were more malnourished in 1900 than at any time since Tudor times[4,42]. Malnutrition also increases susceptibility to infectious diseases. In 1900, lack of hygiene meant that many foodstuffs were sources of pathogens. This was particularly true for milk and milk products, which are potential sources not only of tuberculosis, but also brucellosis, typhoid, diphtheria, salmonellosis and streptococcal infections[25,36]. The increasing appreciation that heat processing, and in particular pasteurisation, will destroy pathogens in milk, and the increasing use of pasteurisation and other measures led to a rapid decline in milk-borne diseases in the first half of the century.

Economic factors are also important. In 1930, there was economic depression and, although the causes of deficiencies and infectious diseases were more fully understood, the health of the working classes was little better than in 1900[4]. Nevertheless, by 1939, the advances in nutritional, medical and food sciences were being consolidated and adopted; despite stringent food rationing, the general health of the population increased during the Second World War when diets became generally adequate[43]. Food rationing continued after the war until 1954, but this was contemporary with the establishment of the National Health Service, and the continued provision of nutritional supplements, such as cod liver oil and concentrated orange juice, to the young and to

pregnant women. Antibiotics and immunisation also led to the control of the serious infectious diseases. The austerity of the post-war years gave way to the social and economic changes which commenced in the late 1960s. Women had access to the contraceptive pill, and also began to work outside the home in increasing numbers. Economic prosperity increased, food was readily available, and the variety of foodstuffs increased. The common life-threatening and disabling infectious and deficiency diseases were a thing of the past. The dominance of the consumer was emerging, and the food processors spurred on by the expanding supermarket chains, were driven to address the life-style and convenience demands of these consumers. The chronic conditions of heart disease, cancers and diabetes emerged as the major causes of morbidity and mortality. Nutritional and epidemiological research implicated diet as a major factor in the aetiology of these diseases, and a number of foodstuffs and diet components were suggested as causative. These included over-consumption of fat, in particular saturated fat, over-consumption of refined carbohydrate, and under-consumption of dietary fibre[44–47]. Although the mechanisms of action of these diet components in the aetiology of these diseases was, and remains, unclear, dietary guidelines recommended changes to correct these perceived imbalances[48,49]. In response to consumer demand, the food processors produced a range of new products. These included food with increased polyunsaturated fats, and low and reduced fat foods, reduced sugar foods, and foods with high fibre levels. At the end of the century, attention is being increasingly focused on food which can confer specific health benefits, so-called functional foods, whose further development may help the population to attain even greater health in the twenty-first century[41].

Plus la change....

'A population beset by a range of diseases, apparently caused or exacerbated by dietary factors, but whose aetiologies are poorly understood. Consumers concerned about the safety of the food they eat.'

Although the diseases and the public anxieties may have changed, these statements held true for the UK in both 1900 and 1999. The population in 1900 was smitten by deficiency and infectious diseases; by 1999, it was afflicted by chronic diseases, by cancers, heart disease and diabetes and attendant conditions. In 1900, the population was concerned about the effects of adulteration, and the use of potentially harmful additives.

By 1999, the concerns were manifold, additives were still an issue, added to which were concerns about issues such as the use of genetically modified food species, the presence of chemical residues from farming or processing, the possible presence of pathogens and allergens, and the ethical and environmental implications of a food-chain which linked ever more efficient production with increasingly centralised and standardised processing systems. Despite these parallels, there have been enormous improvements in the general health, well-being and life expectancy of the majority of the population, and developments in food processing have contributed substantially to these improvements.

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