Food processing: The Advantages of Processed Foods

Food processing | Why do we process food? | 01 June 2010

1. Introduction and definitions

We all process foods everyday when preparing a meal for ourselves or our family and virtually all foods undergo some form of processing before they are ready to eat. Some foods are even dangerous if eaten without proper processing. The most basic definition of food processing is “a variety of operations by which raw foodstuffs are made suitable for consumption, cooking, or storage”. Food processing includes any action that changes or converts raw plant or animal materials into safe, edible and more enjoyable, palatable foodstuffs. In large-scale food manufacture, processing involves applying scientific and technological principles to preserve foods by slowing down or stopping the natural processes of decay. It also allows changes to the eating quality of foods to be made in a predictable and controlled way. Food processing also uses the creative potential of the processor to change basic raw materials into a range of tasty attractive foods that provide interesting variety in the diets of consumers. Without food processing it would not be possible to sustain the needs of modern urban populations, and the choice of foods would be limited by seasonality.

The term ‘processed foods’ is used by many with certain disdain, suggesting that processed foods are in some way inferior to their non-processed counterparts. However, it is important to remember that food processing has been used for centuries in order to preserve foods, or simply to make foods edible. In fact, processing spans the whole food chain from harvesting on the farm to different forms of culinary preparation in the home, and it greatly facilitates provision of safe food to populations around the globe.

Food processing can lead to improvements in, or damage to, the nutritional value of foods, sometimes both at the same time, and it can help to preserve nutrients that would otherwise be lost during storage. For instance, shock-freezing of vegetables shortly after harvesting slows the loss of sensitive nutrients. Raw beans are inedible and the simple process of heating (e.g. boiling) renders them edible by destroying or inactivating specific anti-nutritional factors they contain. The process of boiling vegetables does lead to losses of vitamin C but it can also release certain beneficial bioactive compounds such as beta-carotene in carrots, which would otherwise be less available during digestion because the heating breaks down the plant cell walls.

For centuries, ingredients have served useful functions in a variety of foods. Our ancestors used salt to preserve meats and fish, added herbs and spices to improve the flavour of foods, preserved fruit with sugar, and pickled vegetables in a vinegar solution. Today, consumers demand and enjoy a food supply that is nutritious, safe, convenient and varied. Food processing methods (e.g. food additives and advances in technology) help to make this possible. Food additives are added for a particular purpose whether it is to ensure food safety, to add nutritional value or to improve food quality. They play an important role in preserving the freshness, safety, taste, appearance and texture of foods. For example, antioxidants prevent fats and oils from becoming rancid whereas emulsifiers stop peanut butter from separating into solid and liquid fractions. Food additives keep bread free of mould for longer and allow fruit jams to "gel" so they can be spread onto bread.

2. History

Humans have been processing foods for centuries (see table 1). The oldest traditional techniques included sun-drying, the preservation of meat and fish with salt, or fruit with sugar (what we now call jamming). These all work on the premise that reduction of water availability in the product increases shelf-life. More recently, technological innovations in processing have transformed our food supply into the rich variety that is available in supermarkets today. In addition, food processing enables manufacturers to make nutritionally enhanced products (‘functional foods’) with added ingredients that provide specific health benefits beyond basic nutrition.

2.1 The canning story

Canning originated in the early 19th century as Napoleon’s troops faced a serious food shortage. In 1800, Napoleon Bonaparte offered an award of 12,000 francs to anyone who could devise a practical method for food preservation for armies on the march; he is widely reported as saying "An army marches on its stomach". After years of experiment, Nicolas Appert submitted his invention of sealing foods in glass jars and cooking them, and won the prize in 1810. The following year, Appert published L'Art de conserver les substances animales et végétales (or The Art of Preserving Animal and Vegetable Substances), which was the first cookbook of its kind on modern food preservation methods. Also in 1810, the Englishman Peter Durand applied the Appert process using various vessels made of glass, pottery, tin or other metals and obtained the first canning patent from King George III. This can be considered the origin of the modern can.

2.2 The history of freezing

The modern frozen food industry was started by Clarence Birdseye in America in 1925. He was a fur trader in Labrador, and noticed that fillets of fish left by the natives to freeze rapidly in arctic winters retained the taste and texture of fresh fish better than fish frozen in milder temperatures at other times of the year. The key to Birdseye’s discovery was the importance of the speed of freezing, and he pioneered industrial equipment to freeze foods rapidly. We know today that, coupled with appropriate treatment prior to freezing, this rapid freezing has the potential to ensure excellent preservation of nutritional value for a wide range of foods.

Table 1. Chronological development of food processing techniques

Traditional processing	More modern processes (circa 1900 onwards)	Most modern techniques (post 1960)
Canning	Extrusion cooking	Freeze drying
Fermentation	Freezing and chilling	Infrared processing
Freezing	Pasteurisation	Irradiation
Oven drying	Sterilisation	Magnetic fields
Pickling	Ultra-High Temperature (UHT)	Microwave processing

Traditional processing	More modern processes (circa 1900 onwards)	Most modern techniques (post 1960)
Salting		Modified atmosphere packaging
Smoking		Ohmic heating
Sun drying		Pulsed electric fields
		Spray drying
		Ultra-sonification

3. Main benefits of processed foods

3.1 Palatability and sensory improvements

Virtually all foods undergo some form of processing before they are ready to eat. At its most simple, this could be peeling a banana or boiling a potato. However, with some products such as wheat, it requires quite elaborate processing before it becomes palatable. First there is grain harvesting, then removal of the husk, stalk, dirt and debris. The cleaned up grain is usually cooked or milled into flour and then it is often made into another product such as bread or pasta.

The organoleptic (sensory) quality of some foodstuffs benefits directly from processing techniques. For example, baked beans derive their creamy texture from the heat treatment during canning. Extruded and puffed products like breakfast cereals or crisps would be almost impossible to make without large scale modern food processing equipment.

3.2 Preserved and improved nutritional quality

Processing such as freezing preserves the nutrients that are naturally present in foods. Other processes, like cooking, can sometimes improve the nutritional value by making nutrients more available. For example, cooking and canning tomatoes to make tomato paste or sauce renders the bioactive compound lycopene more available to the body. When processed carefully, cocoa and chocolate processing preserves the levels of flavonoids like epicatechin and catechins, but their contents can be reduced with poor processing conditions. Lycopene and flavonoids have antioxidant properties which, according to some research, contribute to maintenance of heart health and may reduce the risk of certain cancers.

Researchers are currently investigating the manipulation of nutrient digestibility through food processing to create foods that have enhanced nutrient availability. For example, it appears that homogenisation of milk can reduce droplet size of fat, caseins and some whey proteins. This seems to result in a better digestibility than untreated milk. Early research suggests that manipulation of triacyglycerol (fork-like basic skeleton of fats) structures may also affect the digestibility of fats, thus altering their impact on cardiovascular disease risk post-ingestion.

3.3 Safety

Many processing techniques ensure the safety of foods by reducing the numbers of harmful bacteria that can cause illness (e.g. pasteurisation of milk). Drying, pickling and smoking reduce the water activity (i.e. water available for bacterial growth) and alter the pH of foods and thereby restrict the growth of pathogenic and spoilage micro-organisms and retard enzyme reactions. Other techniques such as canning, pasteurisation and Ultra-High Temperature (UHT) destroy bacteria through heat treatment.

Another benefit of processing is destruction of anti-nutritional factors. For example, cooking destroys protease inhibitors such as trypsin inhibitors found in peas, beans or potatoes. Trypsin inhibitors are small globular proteins which inhibit the action of the human digestive enzymes trypsin and chymotrypsin required to break down dietary proteins. If present in foods, they can reduce the nutritional value of the food and in high doses they have been shown to be toxic in animal studies, with some human evidence showing similar results. Prolonged boiling also destroys the harmful lectins present in legumes such as red kidney beans. Lectins make red blood cells clump together and if not degraded prior to consumption cause severe gastro-enteritis, nausea and vomiting.

3.4 Preservation, convenience and choice

Food processing enables extension of the shelf-life of foods (e.g. perishable foods such as meat, milk and products thereof). The application of modified atmosphere packaging means that fruit and vegetables can be stored at home for longer, thus meaning less frequent food shopping for fresh items and less spoilage loss. Sophisticated storage and packaging enable convenience for the consumer.

Food processing enables us to enjoy a varied diet that fits with the fast pace and pressures of our modern day society. People are increasingly travelling abroad for their holidays, thus they are exposed to a wider selection of flavours and styles of foods. Individuals are also changing the way they spend their time, and many choose not to cook foods from scratch. To meet consumer expectations, manufacturers are therefore producing sophisticated foods of restaurant quality, or from far-away countries to cook and enjoy in our own homes.

In the Western world, our foods are predominantly based on five staple crops – rice, wheat, maize, oats and potatoes. The array of characteristics we are used to in our foods are derived from these five simple staples combined with modern food processing techniques. Therefore, it can be said that today we have become accustomed to a diversity of foods, made from a narrow range of plant species, to provide our nutrition. This transformation of staple foods into processed foods would not be possible without modern food technology.

3.5 Reducing health inequalities and concerns

It is recognised that people living on a low income have a less varied diet and this is reflected in poorer nutrient intake and poorer nutritional status. Processing such as fortification of certain products like flour, bread and breakfast cereals has reduced the number of people in Europe with a low nutrient status. In addition, preservation of nutrients through processes such as freezing enables those without access to such a wide range of foods to gain better nutrition from the narrower range of foods available to them.

Chronic diseases such as heart disease, obesity and diabetes can be managed, in part, through dietary strategies. In response to this, manufacturers have applied food processing techniques to offer consumers the choice of low fat or fat-free versions of many foods and meals. Perhaps the simplest example of this is the production of semi-skimmed milk (also known as ‘low fat’ or ‘half-fat’) where the fat is removed from the product during processing – the cream is skimmed off the top of the milk following a centrifugation step. Fat can also be reduced in foods by the addition of water or other ingredients to replace some of the fat and reduce the energy density. Reduced fat margarines are a good example here. The addition of water does lead to a more perishable product though, and consequently reduced fat products may have additional stabilisers and preservatives present to restore their original shelf-life and stability. In addition to low fat products, food processing now enables production of low salt, low sugar and high fibre versions of many foods, enabling consumers to make food choices suitable for their individual health requirements.

4. Different processing methods

4.1 Traditional

4.1.1 Heating

The temperature of the food is raised to a level which inhibits the growth of bacteria, inactivates enzymes or even destroys viable bacteria. Traditional wet cooking methods include blanching, boiling, steaming and pressure cooking. Dry cooking methods include baking, frying and roasting. In newer techniques, heat is applied by electro-magnetic radiation such as microwaves.

Ultra-High Temperature (UHT) techniques are used widely across the food industry. This involves heating the food to ≥135 °C for at least 1 second followed by rapid cooling in order to destroy all microorganisms.

Pasteurisation is when the food is heated to at least 72 °C for at least 15 seconds to kill most food-borne pathogens, then cooled rapidly to 5 °C.

4.1.2 Cooling

The temperature of the food is reduced to slow deterioration of the food either through bacterial growth retardation or inactivation of enzymes with deteriorative effects. Traditional cooling methods include refrigeration where temperatures are around 5 °C, and freezing, where temperatures are reduced to below -18 °C (even down to -196 °C in commercial deep freezers). The lower the temperature, the longer foods can be stored safely. However, severe temperature changes over prolonged time periods can lead to nutrient losses and breakdown of integral food structures such that the nature and nutritional value of that food is significantly reduced.

4.1.3 Drying

In drying, the water content of plant foods is reduced to the level where biological reactions (like enzyme activity and microbial growth) are inhibited and the likelihood of food spoilage is thus lowered. Drying may be in the form of freeze-drying (e.g. herbs and coffee), spray-drying (e.g. milk powder), sun-drying (e.g. tomatoes, apricots) or tunnel-drying (e.g. vegetable pieces).

4.1.4 Salting

The addition of salt to foods has been used for centuries as a method of food preservation. This method works on the premise that the salt reduces the water activity of the food being preserved, which prevents growth of spoilage organisms. Depending on the type of food, similar effects may be achieved with sugar. It is also possible to slow or halt growth and kill certain micro-organisms by altering the pH of the food (e.g. the addition of acids such as vinegar in pickling).

There are different ways in which salt is added to foods, but normally the term salting refers to preservation of food with dry salt. Salting is mainly used for preservation of meat and fish. The salt may be added as such or be rubbed into meat. Salt fish (dried and salted cod) and salt-cured meat such as Italian prosciutto crudo are examples of salted foods. Other food processing methods in which salt plays a role are brining and pickling.

In brining the food is put in brine, water saturated, or nearly saturated with salt, a method which has been a common way to preserve meat, fish and vegetables. Today, brining of foods is a less pertinent preservation method, but it is still used for ripening of cheeses such as feta and halloumi.

Pickling often implies salting or brining in combination with fermentation or adding of vinegar and is mainly used for preservation of vegetables (e.g. sauerkraut, cucumbers, peppers, onions and olives) and fish (e.g. herring).

Curing is a common name for food processing methods, mainly used for fish and meat, in which combinations of salt and sugar and also sometimes nitrates or nitrite (which prevents the growth of the harmful bacteria Clostridium botulinum and gives the meat an appealing pink colour) are added to food. In curing the food is sometimes also smoked.

4.1.5 Fermentation

In fermentation, specific yeasts or bacteria are used to give a food its desired flavour and texture, but it is also a way of altering the biochemical characteristics of foods and thereby prevent growth of spoilage micro-organisms.

Yeast fermentation is used in processes such as the baking of bread and the production of alcoholic beverages. Likewise, soy sauce is a result of yeast fermentation.

In aerobic conditions, i.e. when oxygen is available, the yeast converts sugars and other carbohydrates to carbon dioxide and water. This is what makes dough leaven; the yeast produces carbon dioxide, which forms gas bubbles in the dough and makes it expand. When baked, the spongy structure is fixated by the heat and the bread gets its soft texture. The yeast is killed off by the heat.

In the production of beer, wine and other alcoholic beverages the role of the yeast is to form alcohol and partly also to carbonate the beverage. Under anaerobic (oxygen-free) conditions, yeast transforms sugar or other carbohydrates to alcohol (ethanol) and carbon dioxide. If the carbon dioxide is not eliminated, it will make the beverage fizzy. In the manufacture of alcoholic beverages it is common to add specific yeast cultures, but in certain production processes the beverage undergoes spontaneous fermentation, meaning that the fermentation is driven by yeast and other micro-organisms naturally occurring on the grapes or in the production environment. In baking, ethanol is formed as a by- product. The fermentation process alters from being aerobic to anaerobic along the leavening as the oxygen is consumed by the yeast. However, the alcohol evaporates during baking and thus, bread does not contain any alcohol. Fermentation is of great importance for the taste of beer, wine etc. as the yeast, besides ethanol and carbon dioxide, produces a number of other compounds, that give these beverages their specific aromatic characteristics.

Another type of fermentation used in food production is driven by lactic acid producing bacteria naturally occurring in the foods or added in the production process. The bacteria use lactose (milk sugar) or other carbohydrates as substrate for production of lactic acid. As the lactic acid content increases, the pH decreases and this may impact on the characteristics of the food as certain proteins are sensitive to acidity. For example, an acidic environment coagulates casein, a protein present in milk, which makes the milk thicken and gives yoghurt and other soured dairy products their particular consistency. Not all soured dairy products are fermented; lactic acid as such may also be added to the milk. Among other food products, which are fermented with lactic acid producing bacteria, are sauerkraut, pickles, sourdough bread and meat products such as salami.

As mentioned above, fermentation enhances the durability and the safety of foods. Both alcohol and acidity as well as the presence of harmless (or beneficial) micro-organisms prevents growth of degrading and harmful bacteria, fungi etc. Alcohol is a widely used disinfectant and plays the same role when present in beverages; it may kill and prevent micro-organisms from multiplying. Acidic environments are also inhibitory to microbial growth. In both cases, the efficacy depends on the levels of alcohol and acid. Harmless micro-organisms in food also impact on the amounts of unwanted germs and their proliferation rate as the competition for substrates (nutrients) increases with the number of micro-organisms present.

In addition to the taste and texture, durability and safety of foods, fermentation may enhance the nutritional value of foods. Micro-organisms do produce amino acids, fatty acids and certain vitamins which are absorbed and made use of as we eat the foods. The microbial activity may also reduce the content of antinutrients, substances present in certain foods (e.g. pulses, cereals, vegetables), which interfere with the absorption of nutrients. Reducing the content of such components enhances absorption of nutrients from the food and thereby increases its nutritional value. One example is sourdough, which contains lactic acid bacteria with the ability to eliminate phytate. Phytate is an antinutrient present in wholegrain flour, which, through its capacity to form complexes with minerals, may prevent absorption in the intestine of essential nutrients such as calcium, iron, zinc and magnesium. The bioavailability of minerals is thus higher in sourdough bread than in bread leavened by yeast only.

4.1.6 Food additives

Food additives are substances that are added to foods to serve specific technical purposes, and are grouped depending on the function they perform when added to foods, e.g. preservatives, antioxidants, stabilisers, anti-caking agents, or packaging gases. Only substances that are not normally consumed as a food in itself and that are not normally used as a characteristic ingredient of food, qualify as additives.

With the increase in use of food processing in our food chain since the 19th century, the number of additives in use has increased. Additives may be natural, nature identical or artificial. All food additives in processed foods must be approved by the national regulatory body charged with food safety in each country. Strict limits are placed on the amount and types of additives in foods and any additive must be included in the ingredients listing on a food package. In Europe, approved additives are given the prefix 'E' for Europe, e.g. E330 is the acidulant citric acid. Citric acid was first isolated in 1784 by the Swedish chemist Carl Wilhelm Scheele, who crystallized it from lemon juice.

4.2 The advantages of new technologies

Many of the traditional methods of preservation cause inevitable losses in nutrient levels and can adversely affect the nature and quality of the produce following processing. The newer technologies often referred to as 'minimal processes', aim to produce safe foods that are of higher nutritional quality with better organoleptic and keeping qualities. Every new process undergoes lengthy testing to ensure the effects on nutritional value are fully evaluated.

4.2.1 Microwaving

Microwave processing is heating by radiation as opposed to the more traditional convection or conduction techniques. Microwaves are transmitted efficiently in water but not by plastics or glass, and are reflected by metals. It is oscillation of the water molecules in food which leads to the heating of that food. Since the water is usually distributed unevenly in a food, occasional stirring is required for proper heating and safe food handling. Microwaving food is a fast method of heating which requires little addition of water and thus leads to less nutrient losses than other forms of cooking.

4.2.2 Modified atmosphere preparation (MAP)/storage/packaging

MAP may be defined as 'the enclosure of food products in gas-barrier materials in which the gaseous environment has been changed'. It refers to controlled alterations of the atmosphere in which foods are prepared, packaged or stored, which together inhibit the growth of bacteria. Usually oxygen, carbon dioxide and nitrogen are the gases employed. MAP can be vacuum packaging or the introduction of a gas during packing. Most recently, MAP has evolved into active packaging where the atmosphere continuously changes during the shelf-life of the product. For example, oxygen absorbers or carbon dioxide emitting films may be used. Reduction of oxygen levels and increase in carbon dioxide levels both lead to microbial growth inhibition.

Meat, fish and cheese are examples of so-called non-respiring products that need very low gas permeability films to maintain the initial gas mixture inside the package. On the other hand, interaction of the packaging material with the product is important for respiring products such as fruits and vegetables. It is possible to adapt the gas permeability of the packaging film to the products' respiration, so that equilibrium of the gas mixture will establish in the package and the shelf-life of the product will increase.

4.2.3 Irradiation

Processing by ionising radiation is a particular kind of energy transfer with the portion of energy transferred per treatment being high enough to cause ionisation. It is used to control and disrupt biological processes in order to extend the shelf-life of fresh products, and it can be applied to sterilise packaging materials. Beneficial biological effects of irradiation include sprouting inhibition, ripening delay and insect disinfestations. Microbiologically, irradiation suppresses pathogenic and other spoilage-causing microorganisms. The major advantage of irradiation is that it passes through the food, kills microorganisms but because it does not heat the food it has a marginal effect on the nutritional composition. Proteins and carbohydrates may be broken down to some degree but their nutritional value is little affected.

In European food law (1999/2/EC and 1999/3/EC), the treatment with ionising radiation of a specific food item may only be authorised if:

- there is a reasonable technological need
- it presents no health hazard
- it is of benefit to the consumers or
- it is not used as a substitute for hygiene and health practices or for good manufacturing or agricultural practice.

To comply with the European law, any food irradiated as such or containing irradiated food ingredients has to state this clearly on the label.

4.2.4 Ohmic heating

This is a thermal process in which heat is internally generated by the passage of alternating electrical currents through the food which acts as electrical resistance. Ohmic heating is also known as 'resistance heating', or 'direct resistance' heating. It is not reliant on transfer of energy by water particles so it is an important development for the efficient heating of low water, low particulate foods. It is a high-temperature short-time (HTST) method, thus decreasing the possibility of high-temperature over-processing and its likely associated loss of nutrients. Another advantage of Ohmic heating is that it keeps delicately structured foods such as strawberries intact.

4.2.5 Ultra-high pressure

High pressure technology subjects foods to pressures of 100 – 1000 Megapascal usually for 5 – 20 minutes. It has a number of key attributes including micro-organism inactivation, modification of biopolymers such as gel formation and quality retention such as colour, flavour and nutrients. This is because of its unique ability to directly affect non-covalent bonds (such as hydrogen, ionic and hydrophobic bonds) whilst leaving covalent bonds intact, and both without employing heat. As a consequence, it offers the possibility of retaining vitamins, pigments and flavour components while inactivating microorganisms or enzymes that could otherwise negatively affect food functionality through food spoilage.

4.2.6 Light pulses

This method uses intermittent flashes of white light (20% UV, 50% visible and 30% infra-red) with an intensity claimed to be 20,000 times that of the sun at the earth's surface. One to twenty flashes per second are typical pulse rates which lead to significant surface reductions in micro-organisms when used on meat, fish and bakery products. This technique is ideal for surface decontamination of packaging materials and works best on smooth, dust-free surfaces.

4.2.7 Pulsed electric fields (PEF)

This process involves applying repeated short pulses of a high-voltage electric field (10 – 50kV/cm) to a pumpable fluid flowing between two electrodes. It does not use electricity to generate heat, but instead it inactivates micro-organisms by disrupting the walls and membranes of cells exposed to the high-voltage pulses. PEF is mostly used in refrigerated or ambient products and because it is applied for just one second or less, it does not result in heating of the product. It is for this reason that it has nutritional advantages over more traditional thermal processes which degrade heat-sensitive nutrients.

5. Effects of processing on nutritional quality

Food processing can lead to improvements in, or damage to, the nutritional value of foods. Simple food preparation processes in the domestic kitchen lead to inevitable damage to the cells of plant foods, leading to leaching of essential vitamins and minerals. However, if we are careful in the way we process foods, and choose a variety of processed foods, they can play an important role in a nutritious and balanced diet. Unlike the domestic environment, food manufacturers have access to commercial scale, fast processing methods which cause minimal nutrient losses, and they utilise processes which actually help to release positive nutrients (like lycopene in the cooking of tomatoes) or eradicate compounds of concern (like lectins in legumes).

5.1 Vitamins and minerals

There are 13 vitamins, required by the body in small amounts, but nonetheless essential. Four are fat soluble (A, D, E, and K) and the remaining nine are water soluble (C, B group vitamins). No single food contains all the vitamins so a balanced and varied diet is necessary for an adequate intake. Processing affects different vitamins in different ways. For example, the water soluble vitamins tend to be more sensitive to processing and are often partially lost during boiling and heat treatment. However, newer 'non-thermal' processes such as Ohmic heating or ultra-high pressure treatment can help to retain vitamins because they subject the food to lower temperatures (if any) and the processes occur for a very short time. In some situations, processed foods actually contain more vitamins than fresh products. For example, frozen vegetables picked and frozen within hours retain more vitamin C than their fresh counterparts because more vitamin C is lost over time during chilled storage compared to frozen storage.

Minerals are inorganic elements which our body needs in small amounts, usually obtained sufficiently by consuming a conventional mixed diet. Food processing can have important beneficial effects on the availability of minerals from foods. For example, phytates in wholegrain cereals inhibit iron and zinc absorption but during fermentation, enzymes are released which degrade the phytates and increase the iron and zinc availability in the dough.

A variety of foods are now enriched with vitamins and minerals as a public health measure. Ready-to-eat breakfast cereals often have added iron and this has become one of the primary sources of iron in the diet of young women because their intakes of red meat have dropped (red meat having naturally high levels of easily absorbable iron). Iron deficiency is one of the biggest nutrient deficiency concerns in Europe, affecting up to 30% of young women. Breakfast cereals and flours in some countries are fortified with folic acid as a means of increasing the folate status in women of child-bearing age. This stems from the recognition that low folate status during pregnancy is associated with increased risk of neural tube defects (e.g. spina bifida) in unborn children.

5.2 Carbohydrates and fibre

For mono- and oligosaccharides, little degradation occurs at temperatures right up to those used in UHT processing but there are several reactions that may affect nutritional quality. For example, some sugars could change their molecular structure during heating, which may affect digestibility. This could be advantageous in reducing the presence of indigestible oligosaccharides (like stachyose or raffinose present in legumes and some other foods) that cause flatulence if over-consumed.

Extensive research is currently underway to investigate the effects of processing on the solubility and digestibility of certain fibres and starches such as resistant starch. Low digestibility may be advantageous as it has been shown that slow-release carbohydrates may reduce the rise in blood sugar and insulin levels that occur after a meal. Excessive blood glucose and insulin levels have been associated with the development of insulin resistance, potentially a precursor for Type II Diabetes. Extrusion cooking has been shown to increase the ‘solubility’ of fibre. Soluble fibres such as β-glucan may lower serum cholesterol levels, thus being advantageous in reducing cardiovascular disease risk.

5.3 Fats and proteins

Most fats are reasonably stable during processing. However, unsaturated fatty acids are prone to oxidation and rancidity during storage. The application of modified atmosphere packaging, antioxidants and aseptic packaging can lead to significantly increased storage times, thus alleviating these concerns.

Proteins are generally denatured at high temperatures, which can lead to detrimental effects on food structure. However, this can be advantageous nutritionally because it can mean increased protein digestibility. Exciting new research also shows that newer methods of food processing like high pressure, electric field application or irradiation could have an impact on food allergens. Destruction of anti-nutritional proteins such as avidin in raw eggs is advantageous during processing because it enables the absorption of otherwise bound nutrients. Avidin strongly binds to biotin in raw eggs and in doing so blocks the absorption of this B vitamin, but the bond is released when avidin is denatured through heating.

6. Why are processed foods so important for modern society?

Nowadays it is difficult to eat a diet based only on fresh, unprocessed foods. The major portion of our family's food needs comes from processed food products that add variety to our diets and convenience to our busy lives. Processed foods enable consumers to shop less frequently and to stock a wide range of foods on which to base varied and nutritious meals.

Many processed foods are just as nutritious or in some cases even more nutritious than fresh or home-cooked foods depending on the manner in which they are processed. For example, the folate and thiamine levels in beans survive the canning process better than the lengthy soaking and cooking necessary if home-prepared from dried beans. Frozen vegetables are usually processed within hours of harvest. There is little nutrient loss in the freezing process so frozen vegetables retain their high vitamin and mineral content. In contrast, fresh vegetables are picked and transported to the market. It can take days or even weeks before they reach the dinner table, and vitamins are gradually lost over time no matter how carefully the vegetables are transported and stored. Canned fish are a good source of calcium because the fish is often canned without being boned and the processing makes the small bones softer and more edible.

The inclusion of a wide range of foods, be it fresh, frozen, canned or otherwise processed enables consumers to reach their recommended daily intakes. For example, canned fruits, fruit juices and smoothies, and frozen vegetables all count towards the popular '5 portions of fruits and vegetables a day' target. The key for consumers is balance and variety – no one food provides enough nutrients to survive, and each method of processing affects nutrients differently.

7. Fast facts about food processing

- Humans have been processing foods – preserving them for future use and to ensure their safety – for centuries.
- Food processing provides the means to extend shelf-life of otherwise perishable foods, thus increasing choice and reducing the dependency on seasonality.
- Storage losses in fresh foods are generally greater than those associated with food processing, and food processing can improve the nutritional value of certain foods.
- The addition of nutrients to foods and drinks is used globally as a public health measure and is a cost-effective means of ensuring nutritional quality of the food supply.
- Canned, fresh and frozen fruits and vegetables all provide nutrients needed for a healthy diet. Exclusively consuming fresh fruits and vegetables ignores the nutritional benefits provided by processed foods, which include both manufactured foods as well as foods processed in the home.

References and further reading

Henry CJK & Chapman C. (2002). The nutrition handbook for food processors. Woodhead Publishing Ltd.

International Food Information Council (2009). From farm to fork: Questions and answers about modern food production.

MacEvilly C & Peltola K (2003). The effect of agronomy, storage, processing and cooking on bioactive substances in food. In Plants, Diet and Health Ed. Gail Goldberg. Blackwell Science Publishing.

Mills EN, et al. (2009). Impact of food processing on the structural and allergenic properties of food allergens. Molecular Nutrition & Food Research 53(8):963-969.

BNF (1999). Nutrition and Food Processing. British Nutrition Foundation Briefing Paper.

Paschke A (2009). Aspects of food processing and its effect on allergen structure. Molecular Nutrition & Food Research 53(8):959-962.