CHAPTER 1

# Introduction

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## 1.1 Overview

Fruit juices and soft drinks are available in essentially the same form almost anywhere in the world. From polar bases to the tropics, and from the largest developed nations to small and less developed countries, soft drinks and fruit juices are available in bottles, cans, laminated paper packs, pouches, cups and almost every other form of packaging known.

This chapter outlines what soft drinks are, describes the various types of products available and sets the scene for later chapters, which deal with the more specialised aspects of the chemistry and technology of these products.

## 1.2 Soft drinks

What are soft drinks? There is no single definition available, but it is generally accepted that they are sweetened, water-based beverages, usually with a balancing acidity. They are flavoured by the use of natural or artificial materials, are frequently coloured, and often contain an amount of fruit juice, fruit pulp or other natural ingredients. The predominant ingredient is water – often ignored and frequently maligned – and it should be considered that the primary function of soft drinks is hydration. The sweetness and other characteristics enhance the enjoyment of consumption and make the products more appealing to consumers. They are, in some respects, secondary, and yet have importance in the provision of energy and some of the minor essential nutrients needed to meet daily requirements.

It is generally accepted that the description of soft drinks excludes tea, coffee, dairy-based beverages and, until recently, alcohol. However, in many countries, the production of 'soft' drinks containing alcohol is growing. Many see this as an undesirable trend because, traditionally, the taste of alcoholic beverages has

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been associated with adulthood. The blurring of the edges between the markets and tastes for alcoholic drinks and soft drinks appears to facilitate an easy transition for children and young people to the consumption of alcohol. It should be noted that, in many soft drinks, small amounts of alcohol (less than 0.5% alcohol by volume (ABV)) may be present as a consequence of alcohol being used as a solvent for many flavourings. Small amounts of alcohol may also be present in fruit juices.

There are two basic types of soft drinks: the so-called ready-to-drink (RTD) products that dominate the world market and the concentrated, or dilute-to-taste, products that are still important in some markets. These include syrups and so-called squashes and cordials.

Whether RTD or dilutable, soft drinks characteristically contain water, a sweetener (usually a carbohydrate, although artificial sweeteners are increasingly important), an acid (citric or malic and phosphoric in colas are the most common), flavouring, colouring and preservatives. There is a large range of additional ingredients that can be used for various effects.

### 1.2.1 Ready-to-drink products

This sector accounts for the largest volume of soft drinks production, and is divided into products that are carbonated – that is, they contain carbon dioxide – and those that are not. Carbonated RTD soft drinks dominate the world market, and detailed consumption trends are discussed in Chapter 2 of this volume.

The market for carbonated soft drinks is dominated by two giant brands of cola drinks that, together with their associated brand names, account for just over half the world's consumption of such products.

Non-carbonated RTD beverages have shown some considerable growth in recent years, mainly because of the availability of aseptic packaging forms. Non-carbonated drinks that rely on chemical preservation, or hot-pack/in-pack pasteurisation, often suffer from a number of potential problems, including rapid deterioration of flavour and colour.

### 1.2.2 Concentrated soft drinks

Concentrated soft drinks became very important during the Second World War, and in the early years following that conflict. Many were based on concentrated orange juice, which was widely available as a nutritional supplement in the United Kingdom, packed in flat-walled medicine bottles.

The main markets for concentrated soft drinks developed mainly in the United Kingdom and its former empire. The products became universally known as 'squashes' or 'cordials', and became enshrined as such in UK food legislation in the 1960s.

Another very important development was the production of citrus comminutes. These were produced by mixing together, in appropriate proportions, the juice, peel components and essential oils of citrus fruits, and comminuting the mixture in a suitable mill. The resulting product delivered a more intense flavour and cloud than could be obtained from juice alone, and allowed the creation of 'whole fruit drinks', which have dominated the concentrates market in the United Kingdom over the past 40–50 years.

### 1.2.3 Legislation

It is not the intention of this chapter to cover legislation affecting soft drinks in any detail – not least, because it varies from country to country, and there is often a continuous variation of legislation within countries.

Legislation is, however, important from an historical perspective. For example, in the United Kingdom, the Soft Drinks Regulations 1964 (as amended) codified the products according to the way in which the industry was then organised, and set into law definitions not only of 'soft drinks', but also of many different product types, such as crushes, squashes and cordials. These names subsequently became generic household names in the United Kingdom and in many parts of the English-speaking world.

The above regulations were probably among the most proscriptive compositional statutes that existed for any food products in the United Kingdom, and for beverages anywhere in the world. As well as defining soft drinks, they laid down the requirement for minimum levels of sugars in certain product types, the maximum levels of saccharin (the only artificial sweetener then permitted) and the minimum levels of comminuted fruit and fruit juices that defined the best-known product categories. These regulations were eventually revoked in 1995.

The current trend is to move away from compositional legislation, to a much freer approach in which carbohydrates and other nutritional components can be used at will, and additives are taken from 'positive' lists of functional components. Other ingredients are frequently controlled by negative usage (i.e. they must not be present, or must not exceed closely defined limits).

This move to remove controls on formulations is now backed by informed labelling that contains increasing amounts of information for the consumer. This approach is now used widely throughout the world, with only relatively minor variations from country to country.

At the time of writing, the relevant European Union regulations (EU 1169/2011) require that a food which includes fruit juices and soft drinks must be labelled, and that labels must contain the following information:

1 the name of the food;
2 the list of ingredients;
3 any ingredient or processing aid listed in Annex II (of the regulations), or derived from a substance or product listed in Annex II causing allergies or intolerances that is used in the manufacture or preparation of the food and is still present in the finished product, even if in an altered form;
4 the quantity of certain ingredients or categories of ingredients (see below);
5 the net quantity of the food;

6. the date of minimum durability or the use-by date;
7. any special storage conditions and or conditions of use;
8. the name or business name and address of the food business referred to in Article 8(1);
9. the country of origin or place of provenance, where provided for in Article 26;
10. instructions for use where it would be difficult to make use of the food without such information;
11. In beverages containing more than 1.2% of alcohol by volume of alcohol, the actual alcoholic strength by volume;
12. a nutritional declaration.

It will be apparent that not all of the above will apply to fruit juices and soft drinks, but the declaration of the quantity of key ingredients (fruit or fruit juice in soft drinks) became law through earlier quantitative ingredient declaration regulations in Europe. Where artificial sweeteners and carbohydrates are used together, an appropriate statement is necessary. A warning about the product being a source of phenylalanine must be incorporated when aspartame is used as a sweetener.

Other additional regulations may also apply, and the above information should only be considered as a general guide. There is a wealth of additional information on this topic available on the internet. Readers requiring more specific information should consult appropriate authorities.

Because, in most countries, legislation is a rapidly changing sphere, it is essential for those formulating, producing and marketing soft drinks to update themselves regularly as regards the legislation of consumer countries, and to ensure label compliance.

### 1.2.4 Product types

#### 1.2.4.1 Ready-to-drink products

Historically, soft drinks were refreshing beverages that copied or extended fruit juices. Fruit juices typically have around 10–12% naturally occurring sugars, mostly with a pleasant balancing acidity that varies from about 1% down to 0.1%. It is, therefore, not surprising that soft drinks were typically formulated to contain around 10–11% sugar content, with about 0.3–0.5% of added acid (usually citric acid). The simplest form of beverage contained such a mix of these basic nutritional components in water, with flavouring, colouring and chemical preservatives added as necessary.

With the addition of carbon dioxide to render the product ‘sparkling’, ‘effervescent’ or ‘fizzy’, the manufacturer had a lemonade or similar product. With the addition of fruit juice to a level of 5–10%, a pleasing effect of both taste and appearance could be achieved. Such products were typically described as ‘fruit juice drinks’, ‘fruit drinks’ or ‘crushes’ (a reserved description in the old UK regulations). Various other additions could be made, including vitamins and minerals, clouding agents and foaming agents, and plant extracts.

RTD beverages are mostly carbonated (i.e. contain carbon dioxide). This, as well as giving sensory characteristics, provides some antimicrobial effect, especially against yeasts and moulds. Carbon dioxide is effective against yeasts, because it tends to suppress the production of more $CO_2$ as a by-product of the fermentation of sucrose to ethanol. In addition, it deprives moulds of the oxygen that most require for growth. Good hygiene standards are the norm in most soft drink-bottling operations today, and it is possible to produce carbonated drinks without chemical preservatives, by flash-pasteurising the syrup before it is mixed with carbonated water. The risk of microbiological spoilage is then low but, where large containers are used, the risk is increased because of the potential for subsequent contamination as product is removed and the container ullaged.

Carbon dioxide levels vary widely, and are usually expressed as 'volumes of $CO_2$ gas' (i.e. the volume of carbon dioxide contained in solution in one volume of product). Lightly carbonated products will contain around 2.0–3.0 volumes of the gas, while moderate carbonation usually refers to about 3.5–4.0 volumes, and high carbonation levels are around 4.5–5.0 volumes. Large bottles that are likely to become partially full will be relatively highly carbonated, while mixer drinks contain among the highest carbonation levels, because the resultant mixture (e.g. gin and tonic) needs to have a satisfactory residual level of dissolved carbon dioxide.

RTD beverages are also produced in non-carbonated forms. The most popular current form of these is distributed in aseptic card/foil laminate packs, such as Tetra Pak or Combibloc. These drinks are typically unpreserved, and come in volumes of 200–330 ml.

An alternative form of non-carbonated beverage comes in form-fill-seal plastic containers, which are typically square or round section cups, with a foil or plastic laminate lid. Such products are difficult to produce to a quality that will satisfactorily compete with the shelf life of aseptic foil/laminate packs. Form-fill-seal containers leave their contents vulnerable to oxidative degradation, are especially at risk of mould spoilage, and require the use of preservatives. The packs are now increasingly produced in aseptic conditions and are free from preservatives.

Some manufacturers produce RTD products at drinking strength, but this is wasteful of plant and requires large-volume production tanks. The usual approach is to manufacture a syrup or concentrated form of the beverage, which is then diluted with water and carbonated as required. Alternatively, the syrup, which can be flash-pasteurised, can be dosed into bottles which are then topped up with water. This is known as the 'post-mix' method. Where the alternative ('pre-mix') method is employed, syrup and water are mixed in the correct proportions in special equipment, prior to bottle filling.

### 1.2.4.2 Dilutables

As indicated in Section 1.2.2, some markets are substantial consumers of concentrated soft drinks. These products are purchased in concentrate form by the consumer, who then adds water (which can be carbonated if required) to achieve the desired taste.

In the United Kingdom and many parts of the English-speaking world, these products are referred to generically as 'squashes' or 'cordials'. Chapter 6 of this volume covers this topic in detail.

Most concentrated beverages contain fruit juice or 'whole fruit', a term that refers to a comminuted form of citrus that includes components of juice, essential oils, peel (flavedo) and pith (albedo). Concentrated soft drinks are usually flash-pasteurised and chemically preserved, where permitted. Their dilutable form means that they are often held in partially filled bottles for significant lengths of time (often many weeks, or even months). They are thus extremely vulnerable to spoilage by micro-organisms.

Some manufacturers do produce unpreserved concentrates, but such products are invariably pasteurised in the bottle, and carry a warning that the contents should be refrigerated after opening and consumed within a short time-span (typically two weeks).

Concentrates are normally produced at their packed strength, flash-pasteurised and transferred immediately to their final packaging.

### 1.2.5 Development trends

Probably the most significant trend in soft drinks manufacture in recent years has been towards the use of non-calorific artificial sweeteners. The best known of these – saccharin – was used in soft drinks during and after the Second World War, when sugar was in short supply. Saccharin, in its soluble form, is about 450 times sweeter than sugar and can be a significant cost-reducer, but its sweetness is marred by a bitter taste to which many consumers are sensitive.

In more recent years, other artificial sweeteners have been developed, and it is now possible to produce soft drinks with almost all the characteristics of the sugar taste. Such products are almost free of any energy (calorific) content, and lack much of the cariogenic property for which many have criticised sugar-containing beverages. Increasingly, however, the acidity of soft drinks is considered equally, if not more, damaging for dental health.

Almost all soft drinks are now available in 'low calorie', 'diet' or 'light' formulations. These products have a low energy content, and may be cheaper to manufacture than the corresponding sugar-containing products. The issue of sugar consumption and its potential contribution to obesity and diabetes is increasingly under scrutiny. Considerable effort is being made by pressure groups to encourage manufacturers to reduce the sugar content of all products – and particularly, soft drinks.

Another, and perhaps more obvious, development area is the constant search for new flavours and unusual ingredients. There is currently a great interest in the use of various botanical extracts, such as guarana and ginseng, because of their implied qualities, but it is noteworthy that one of the oldest, and certainly the most successful, flavours – cola – was originally formulated with, and still contains, a natural vegetable extract of cola nut.

The third major area for development is that of soft drinks containing ingredients that enable some special nutritional or physiological claim to be made for the product. This will usually be an energy claim because soft drinks are an ideal vehicle for delivering carbohydrates, some in specially formulated mixtures, in a readily and rapidly assimilable form. Of the other nutrients that can be included, fruit juice, vitamins and minerals are the most common, but some products contain significant levels of protein or even fibre (as non-metabolisable carbohydrate).

### 1.2.6 Nutrition

The nutritional value of soft drinks is currently under scrutiny in many countries, because of their sugar content and its possible impact on health. That said, the value of soft drinks must not be understated, because they are an important vehicle for hydration. Soft drinks, depending on their formulation, may be absorbed more readily than water (because of their osmolality), can replace lost salts and energy quickly, and are rapidly thirst-quenching. Their balance of sweetness and acidity, coupled with pleasant flavours, makes them attractive to all ages of consumers. Products are specially formulated to meet the tastes, nutritional needs and physiological constraints of the whole population, from babies to geriatrics.

The claims that are legally permitted for soft drinks vary from country to country but, for the most part, are limited to nutritional claims concerning energy, proteins, vitamins and/or minerals. Any form of medicinal claim (i.e. curative or symptomatic relief) will almost always be excluded by corresponding medicines legislation. There is, nevertheless, a growing trend to include natural extracts in many soft drinks (e.g. ginseng or ginkgo), and then rely on the general understanding and folklore that surrounds such ingredients to impart the special values that have been attributed to them.

There are three main areas of particular nutritional significance for soft drinks. The first is energy. Some soft drinks are formulated to deliver a rapidly assimilated energy boost to the consumer. All carbohydrates are important sources of energy, but soft drinks generally contain soluble sugars, which are easy to administer. However, because high levels of sugars are often intensely sweet and even sickly, and leave a cloying sensation in the mouth, energy drinks are often formulated around glucose syrup. For a given solid carbohydrate content, this raw material is much less sweet than sucrose. Selection of the method of hydrolysis used for the corn starch as the starting point allows glucose syrup to be tailored, to some extent, to include mixed carbohydrates – that is, mono-, di-, tri-and oligosaccharides. Such blends are the basis of some very effective products which are used by athletes and those recovering from illness.

The second area of nutritional significance is that of so-called isotonic drinks, which are of equivalent osmolality to body fluids. They promote extremely rapid uptake of body salts and water, and are thus very important products for participants in sports, as well as others requiring almost instant hydration.

Third, soft drinks have been widely formulated to low-calorie forms, and these are now available for those who wish to enjoy such beverages and yet minimise their calorific intake.

Other nutritional benefits that are claimed by some producers include the delivery of essential vitamins and minerals, especially to children.

On the negative side, soft drinks have acquired a reputation for being an agent in the development of dental caries, as well as contributing to obesity and diabetes. The issue of dental caries is claimed to arise when sugar residues remain in the mouth, or when (especially) young children have an acidic drink almost constantly in their mouths. It is perhaps now accepted that the dental caries problem is related more to the misuse, or even abuse, of soft drinks, than to the effects of normal consumption of such products as part of a balanced diet.

### 1.2.7 New product trends

New product development is a constant activity for most soft drinks producers. For the most part, there are few really new products. Alternative flavours and different forms of packaging are widespread, and no doubt will continue to be so.

The development of specialised energy drinks or isotonic beverages is, perhaps, an example of a truly new product area. As new raw materials become available (for example, soluble whey protein), whole ranges of products are likely to be spawned.

A recent trend has been to incorporate alcohol into soft drinks. Depending on the level of addition, such products can no longer be classified as soft drinks when their alcohol content exceeds 1.2% ABV.

As indicated above, another area of interest is the reintroduction of botanical extracts into soft drinks. It is sometimes overlooked that one of the earliest widely available soft drinks was based on an extract of cola nut.

Packaging developments are likely to offer some exciting new opportunities in the future, and soft drinks are likely to remain at the forefront of product innovation in many countries.

## 1.3 Fruit juices

What is a fruit juice? Various definitions have been suggested, but the one used in the UK Fruit Juice and Fruit Nectars Regulations of 2013 is helpful, as it provides various specifications. These regulations implement EU Directive 2012/12/EU, amending directive 2001/112/EC. Specifications are provided in schedules for fruit juice within the United Kingdom as follows:

**1** Fruit juice (schedule 2);
**2** Fruit juice from concentrate (schedule 3);
**3** Concentrated fruit juice (schedule 4);
**4** Water extracted fruit juice;
**5** Dehydrated and powdered fruit juices.

An additional description refers to fruit nectars. The Schedules referred to above give more precise definitions of fruit juice.

Working from the above definitions, there are thus two principal juice product types, and it is these that dominate today's markets.

The majority of fruit juice as supplied to the consumer is made by reconstituting concentrated juice with water to a composition similar to that of the original state. However, since records are not usually kept of the exact quality of the original juice, such reconstitution normally relates to an agreed trade standard. Reconstituted juices are often packed in aseptic long-life containers, such as Tetra Pak or Combibloc.

In many countries, there is a growing market for fresh 'single-strength' juice, made by squeezing fruit, subjecting it to limited processing, and packaging and selling it within a cold chain distribution system. Such juice is usually referred to as 'not from concentrate', or direct juice, and it will have a shelf life that varies from 1–2 weeks to 2–3 months.

### 1.3.1 Processing technology

It is not intended to give a detailed description here of juice processing. The subject is covered in Chapter 3 of this volume, and in other volumes such as *Fruit Processing* (Arthey and Ashurst, 2001) or *Production and Packaging of Non-Carbonated Fruit Juices and Fruit Beverages* (Ashurst, 1995), which may help the reader who wishes to obtain more detail.

In general terms, fruits are collected, sorted and washed, and then subjected to a type of mechanical compression appropriate for the fruit concerned. Although there are general fruit presses that can be used for more than one fruit type, fruits such as citrus, pineapple and stone fruits are usually processed in specially designed equipment.

Some fruit types (e.g. pome fruits, such as apples and pears) require mechanical treatment (milling), coupled with a biochemical process (involving enzymes) to break down the cellular structure and obtain the best yields. It is possible to achieve almost total liquefaction by means of an appropriate enzyme cocktail.

Additionally, a diffusion or water extraction process can be used to obtain best yields from certain fruits.

If juice is to be sold as 'not from concentrate', it is usually screened and pasteurised immediately after pressing – an operation with two main objectives.

The first is to control the growth of spoilage micro-organisms that live on the fruit surface (mainly yeasts and moulds). The second is to destroy the pectolytic enzymes that occur naturally in fruit and would otherwise break down the cloudy nature of the juice. If, however, a clear juice is required (e.g. apple or raspberry), enzymes can be added to accelerate this natural process.

Juice for concentration is normally subjected to screening to remove cellular debris, and then fed to a one- or multi-stage evaporation process to remove most of the water and other volatile material. Evaporators today are highly efficient processing units. Up to nine stages are used, sometimes with thermal recompression to obtain maximum efficiency. Increasingly, evaporators also recover the volatile aromatic substances that are partly responsible for giving fruit juices their sensory characteristics. The re-addition of such volatiles is widely practised at the point when concentrates are reconstituted into single-strength juices, and the issue of whether this should be obligatory has been clarified. European Council Directive 2001/112/EC (the Fruit Juices Directive) makes the addition of such volatiles at reconstitution obligatory. The UK 2013 Regulations (which are based on this Directive) state that reconstituted fruit juice is the product 'obtained by replacing, in concentrated fruit juice, water extracted from that juice by concentration, and by restoring the flavours'.

After concentration, juices are normally held in storage until they are reconstituted. Some concentrated juices, particularly orange, require freezing at below −10°C for effective preservation. Others, particularly apple, can be held at around 10–15°C without risk of deterioration. The degree of concentration plays an important part in determining storage conditions. In the above examples, orange juice is normally concentrated to about 65° Brix and apple to 70° Brix.

An alternative method of storage is to hold juices under aseptic conditions, in drums or other containers. No particular temperature constraints then apply for microbial stability, but there is a substantially increased risk of colour browning and taste deterioration if juices are held aseptically at temperatures above about 10°C.

Some juices are held in sulphited conditions (e.g. 1500–2000 ppm sulphur dioxide), but this is suitable only for juices destined for uses other than reconstitution as fruit juice.

### 1.3.2 Adulteration

The adulteration of fruit juices has been widespread at times. As with any commodity, juice manufacturers, blenders, and those using juices as ingredients, can secure considerable financial benefit from adulterating fruit juice. It should be emphasised that food safety issues are not normally an issue in fruit juice adulteration. The issue is simply the fact that traders and consumers are being defrauded; an adulterated fruit juice sold as pure fruit juice is not as it has been labelled.

Although adulteration is becoming increasingly sophisticated, it is normally seen as falling into one of three types:

**1** over-dilution of juices with water;
**2** use of cheaper solid ingredients (particularly sugars);
**3** blending of cheaper with more expensive juices.

The issue of too much water being added to juices has largely been addressed through the application of a minimum solids content (measured in degrees Brix). European Union and many other countries now have in place a minimum Brix value for various juices. These minima are backed either by legal statute or industry code of practice. They normally apply to juices prepared by adding water to concentrate, rather than to 'not from concentrate' products.

The second category of adulteration is perhaps the most common. For example, apple juice will normally contain around 11% by weight of solids. At least 90% of these solids are carbohydrates – sucrose, dextrose and fructose predominating. Considerably cheaper sources of carbohydrates can be found, and the simple addition of a mixture of carbohydrates, in roughly the same proportions as those found naturally in apple juice, can be used to 'stretch' apple juice by a considerable proportion. In more sophisticated forms of adulteration, the added components can be made to carry a similar 'signature' to the juice.

In the third category, a cheaper juice can be used to adulterate a more expensive one. For example, elderberry juice can be used to extend strawberry or raspberry juice.

The detection of adulteration and its quantification have spawned some elegant scientific techniques – some borrowed from other fields, and some developed specifically for use in fruit juice work.

Detection of over-dilution and the presence of sugars of other origin, is now carried out largely by measuring key isotope ratios (such as carbon 13 : 12 ratios, deuterium/hydrogen ratios and oxygen 18 : 16 ratios) and comparing them with both those found naturally in fruit and agreed international standards. An important part of the fight against adulteration has been the development of databases that examine fruit of different origins and season.

Another elegant method of detecting sugar addition in particular has been the use of high performance liquid chromatography (HPLC), to determine the presence of oligosaccharides that are characteristic of the added sugars, but not the fruit. The use of enzymic methods for determining the presence of specific components (e.g. d-malic acid, which does not occur naturally) is also helpful.

The analytical detection and measurement of fruit juice adulterants is a rapidly developing field, and the interested reader is directed to works dealing specifically with the subject, such as *Food Authentication* (Ashurst and Dennis, 1996) and *The Analytical Methods of Food Authentication* (Ashurst and Dennis, 1997).

Finally, the addition of cheaper juices to more expensive ones can usually be detected and measured using techniques appropriate for the likely components. For example, the addition of elderberry to strawberry juice can readily be detected by examining the anthocyanins present, using HPLC, and comparing them with standards.

### 1.3.3 Other processes

A number of other processes have become commonplace in the manufacture of fruit juices. For example, if oranges of the varieties Navel or Navellina are processed, the juice becomes unpleasantly bitter, because of the biochemical development of a glycoside, limonin. This substance can be partially or totally removed by the use of appropriate ion-exchange resins to yield a juice of acceptable taste.

There has also been a range of developments leading to the removal of acidity, colour and minerals from clear juices such as apple. The product of such a combination of processes can be a clear, colourless carbohydrate syrup that can be used in a variety of food processes. There seems little doubt that the legal status of such a product is not fruit juice – yet it is often, optimistically, so called.

Enzyme and finishing treatments are widely used in the processing of fruit juices to obtain products of particular specification.

Another contentious issue is the further processing of fruit pulp, especially citrus pulp. The addition of water to such a pulp can give an extract containing around 5% solids, which can be concentrated to around 65% and used to dilute more expensive pure juice. These products are normally described as pulp-wash extracts. Note, however, that 'in-line' pulp-wash extract arises in normal citrus processing, and is becoming an acceptable component, at levels of addition not exceeding 5% of the juice.

By-products of the juice industry are important, but are not dealt with here. The interested reader is referred to *Fruit Processing* (Arthey and Ashurst, 2001).

### 1.3.4 Nutrition

Fruit juice is important in human nutrition, far beyond its use as a refreshing source of liquid. Many fruits contain a variety of minor ingredients – particularly vitamins and minerals – as well as carbohydrates, which are the predominant solid component. Although fruit contains small amounts of proteins and fats, these are not important ingredients of juices.

Nutrients frequently consumed in sub-optimal concentrations by humans are proteins, calcium, iron, vitamin A, thiamin (vitamin B1), riboflavin (vitamin B2) and ascorbic acid (vitamin C). Some of these nutrients occur in higher concentrations in fruit juices than in other foods. There have been claims that ascorbic acid of natural origin is nutritionally superior to that of synthetic origin.

It has been established that the above phenomenon is caused by the presence of certain flavonoid compounds in fruit juice that influence blood circulation, increasing the permeability and elasticity of capillaries. This action is known as vitamin P activity, but the flavonoids showing this property are not classified as vitamins, because there are several substances that demonstrate this activity, and no serious deficiency diseases occur if they are not consumed. There are indications that these flavonoids have a useful protective action – in particular against some respiratory diseases – but they are readily decomposed in the body, and it is impossible to maintain an effective concentration in the blood.

Apart from the more obvious benefits of fruit juice, such as being a source of potassium, it contains other substances that have or are claimed to have useful pharmacological activity. For example, limonin and other related limonoid substances present in citrus fruit are believed by some to have a role in inhibiting certain forms of cancer. Sorbitol, which occurs in many fruit juices, has a laxative effect.

Several components with antioxidant activity are found in fruit juices. These include ascorbic acid, tocopherols (vitamin E), beta-carotene and flavonoids. Beta-carotene has antioxidant activity, which can quench the singlet oxygen that can induce pre-cancerous cellular changes.

Whatever the nutritional interest, it should be noted that changes occur during storage, particularly to the minor components of juices, and particularly under adverse conditions (e.g. light, increasing temperature, time).

## 1.4 Packaging

Later chapters in this volume deal specifically with packaging. However, it is perhaps useful to look briefly at the trends in packaging that are important in the whole area of beverage development.

Traditionally, most beverages were packed in glass. Glass has many attractive features – not least that it is an excellent protective medium – but its overriding disadvantages are its weight and its brittleness. Despite this, high volumes of soft drinks and juices are still packaged in glass, some of it multi-trip packaging.

The development of the board-polymer-aluminium package used to form in-line boxes, which are packed aseptically, has been perhaps the outstanding packaging development for beverages. The pack provides an almost ideal combination of protection, minimal weight and economic size.

Another important packaging development area is plastic. Various plastics have been, and continue to be, used: for example, high- and low-density polyethylene (HDPE, LDPE), polyvinyl chloride (PVC), polystyrene (PS) and various barrier plastics. These can be formed into bottles of conventional shape, or fed into machines producing form-fill-seal packages, typically cups.

By far the most important plastic is polyethylene terephthalate (PET). Bottles of this material are formed in a two-stage process. So-called pre-forms are made by injection moulding and, in a second process, are then stretch-blow-moulded to produce a bottle. PET has properties surprisingly like those of glass, but it does not have the same disadvantages of weight and brittleness. Processing systems that pack small PET containers aseptically are now in regular use.

Developments are yet to feature in fruit juice packaging. PET can be laminated with other plastics, such as nylon and ethylene vinyl alcohol (EVOH), to give extremely good barrier properties, and polyethylene naphthalate (PEN) may enable production of a plastic bottle that can be pasteurised at high temperatures, although aseptic processing and packaging is often preferred.

## 1.5 Summary

Soft drinks and fruit juices are widely consumed in ever-increasing quantities, and are very important commodities in the trade of most countries. This volume sets out to introduce the reader with a good general science background to the more detailed aspects of these products, and it is hoped by this means to provide a useful reference work that will be widely used by those wishing to learn more about these products.

## References and further reading

Arthey, D. and Ashurst, P.R. (eds, 2001). *Fruit Processing*, 2nd edition. Aspen Publishers Inc., Gaithersburg, MD.

Ashurst, P.R. (ed, 1995). *Production and Packaging of Non-carbonated Fruit Juices and Fruit Beverages*, 2nd edition. Blackie Academic & Professional, Chapman & Hall, London.

Ashurst, P.R. and Dennis, M.J. (eds, 1996). *Food Authentication*. Blackie Academic & Professional, Chapman & Hall, London.

Ashurst, P.R. and Dennis, M.J. (eds, 1997). *The Analytical Methods of Food Authentication*. Blackie Academic & Professional, Chapman & Hall, London.

European Communities Council Directive 2001/112/EC.

EU Regulation 1169/2011.

UK Fruit Juices and Fruit Nectars Regulations 2013, Statutory Instrument 2013 No. 2775, HMSO, London.

UK Soft Drinks Regulations 1964 (as amended), Statutory Instrument No. 760, HMSO, London.