6 Non-carbonated beverages

P.R. Ashurst

6.1 Introduction

Non-carbonated beverages represent an important segment of the market for soft drinks but they present some special technological issues for product developer and manufacturer alike. The principal groups of non-carbonated beverages are as follows:

- dilutable drinks
- ready-to-drink pre-packaged beverages
- fruit juices and nectars.

As indicated elsewhere in this volume, the technical issues relating to tea, coffee and milk-based drinks are not considered except insofar as they relate to the marketplace or where they are used in soft drinks as ingredients.

Soft drinks are low-pH beverages that are based mostly around fruit-derived ingredients or incorporate fruit flavours. They are an important source of hydration but are usually selected on the basis of pleasant taste and convenience of use. There are some soft drinks, of which cola-flavoured beverages are the most prominent, which do not rely primarily on fruit flavours. Some of these non-fruit-flavoured products are almost invariably produced only in a carbonated form, whereas others, such as peppermint, almost always appear only in dilutable and non-carbonated form.

The particular issues that must be addressed when non-carbonated beverages are to be produced relate mainly to the prevention of microbial spoilage and the deterioration of product taste and appearance as a result of oxidation, and to enhancement of flavour. Carbonated beverages use the presence of carbonation to boost flavour characteristics and provide palate stimulation.

Thus there are different considerations to be applied to formulation and packaging when non-carbonated beverages are produced.

6.2 Dilutable beverages

6.2.1 Overview

Dilutable beverages have been widely used for many years as a low-cost, convenient means of producing soft drinks on the consumers’ premises.
The product formulation is often broadly similar to that for a syrup produced by a carbonated beverage manufacturer who subsequently dilutes this intermediate with carbonated water before packing into the containers sold to consumers.

Dilutable products, on the other hand, offer the consumer a number of advantages, including the ability to use differing syrup:water ratios, the ability to produce variable volumes of end-product and the possibility of using different diluents such as water, alcoholic drinks or milk.

Although syrups in various forms have been around for many years, a particular milestone was the production and use of concentrated orange juice as a dilutable ‘syrup’ in the United Kingdom during the Second World War.

Some readers may recall that the product was a 60°Brix concentrated orange juice packed in 8 fluid ounce (200 ml) ‘medical flats’ – glass bottles with flat sides and rolled-on metal caps with cardboard inserts. The product was produced for and distributed by the UK government as a means of enhancing the nutritional intake of babies and young children, particularly in respect of their vitamin C needs.

Although this product was available following the war years, it spawned the development of other products such as whole fruit drinks, ‘squashes’ and cordials, which became and remain the mainstay of the United Kingdom and Commonwealth dilutables market.

6.2.2 Nomenclature

Dilutable products were given the particular product designations used above, and to ensure consistency between manufacturers, the United Kingdom introduced legislation in 1964 which defined, for the first time, specific compositional requirements for these products. These regulations, known as the 1964 Soft Drinks Regulations (Anon, 1964), were revoked some 31 years later when it was recognised that many factors rendered these compositional constraints unnecessary. In particular, this move coincided with a change of emphasis in legislation towards improved labelling and consumer choice. For example, the imposition of regulations in the United Kingdom requiring percentages of fruit ingredients to be declared (Anon, 1998) was one of a number of factors that facilitated such a change of emphasis.

An outline of the principal fruit component compositional requirements of the UK 1964 Soft Drinks Regulations compared with those of today is shown in Table 6.1.

In addition to reserved descriptions for these products, the 1964 regulations also defined minimum levels for carbohydrates and imposed various compositional constraints. It is perhaps noteworthy that at the time of writing, the only compositional constraint that is legally imposed in the United Kingdom is that for a quinine content (milligrams/litre) to enable a product to be described as ‘Indian Tonic Water’.
Despite the removal of compositional legislation, the descriptions of dilutable soft drinks in the United Kingdom are still widely used today. Consumers and enforcement authorities alike still have an expectation that a product described as a ‘squash’ will be a cloudy product containing a significant proportion of fruit juice. Similar expectations still apply to the other products mentioned above.

### 6.2.3 Ingredients

Other chapters of this volume deal in more detail with the ingredients of all soft drinks, and readers requiring more information should refer to them. However, it is appropriate here to make reference to special issues concerning ingredients insofar as they relate to dilutable soft drinks. The main ingredients of dilutable soft drinks are set out in Table 6.2.

#### 6.2.3.1 Fruit components

6.2.3.1.1 Concentrated juices. It will be evident from the section on nomenclature that the principal fruit components that are used in dilutable soft drinks are fruit juices (both clear and cloudy) and whole fruit preparations – the so-called comminutes.

Fruit juices and comminutes that are added to dilutables (and other non-carbonated drinks) may be either freshly pressed or in the form of a concentrated juice. It is self-evident that if a significant proportion of juice (25%, for example) is required in a dilutable drink the addition may be difficult unless a concentrated juice is used. In practice, most non-carbonated beverages use concentrated juices and comminutes to obtain the required level of fruit components.

The concentration of most fruit juices is conveniently measured in degrees Brix, although the strict interpretation of this measure refers to pure solutions of sucrose in water (e.g. 10°Brix is 10% w/w sucrose in water). For juices with a high proportion of sugars to acids, such as orange, pineapple and apple, this is
Table 6.2 Principal ingredients of dilutable soft drinks

<table>
<thead>
<tr>
<th>Nutritional</th>
<th>Non-nutritional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit components</td>
<td>Preservatives</td>
</tr>
<tr>
<td>Carbohydrate syrups</td>
<td>Colours</td>
</tr>
<tr>
<td>Acidulants</td>
<td>Emulsifiers and stabilisers</td>
</tr>
<tr>
<td>Other nutritional components, e.g.</td>
<td>Antioxidants</td>
</tr>
<tr>
<td>vitamins and minerals</td>
<td>Acidity regulators</td>
</tr>
<tr>
<td></td>
<td>Intense sweeteners</td>
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<tr>
<td></td>
<td>Flavourings</td>
</tr>
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<td></td>
<td>Clouding agents</td>
</tr>
</tbody>
</table>

a useful and convenient means of measuring concentration. In some instances a correction factor may be introduced to take account of the acidity (see Chapter 10). Brix measurement is simply related to refractive index and there is a slightly different relationship between the refractive index and concentration of citric or malic acids and that of simple sugars.

The observed Brix (and acidity) of a given freshly pressed juice will vary over a limited range depending on a number of plant variables such as seasonality, variety and location. However, concentrated juices are produced to an industry standard and so there will be slight variations in the degree of concentration required to achieve the standard of concentrated juice.

For example, frozen concentrated orange juice (FCOJ) – the industry standard material for orange – is traded as 65–66°Brix concentration. Oranges that are used may, on pressing, yield a juice of variable Brix – say, from around 10° to as much as 14 or 15°. Thus, the degree of concentration required to produce 65–66°Brix concentrate will be slightly different for a 10°Brix juice compared with a 13°Brix juice.

Most countries therefore adopt a ‘standard’ Brix for juices to facilitate the production of a comparable product when juices are reconstituted. In most European countries this standard is 11.2°Brix for orange juice. A similar approach will be adopted when calculating the amount of a concentrated juice required to deliver, say, 25% juice in a dilutable drink.

The typical concentrated juices and comminutes used by the industry for manufacturing dilutable drinks are shown in Table 6.3.

6.2.3.1.2 Comminutes. The process of comminution refers only to citrus products, where the oils that reside in the flavedo (coloured peel) have intense flavour characteristics. At its simplest, comminution involves taking a complete orange (or other citrus fruit) and making a pulp from it. This pulp will have a much more intense flavour than juice alone but because of the presence of much peel and albedo (pith) it would be unacceptable in taste to most consumers. Thus, the process of comminute production, developed in the immediate post-war years, is typically as set out in Figure 6.1.
The components of the citrus fruit are separated into the principal products: citrus oils, juice and residual peel and pith. After concentration of the juice, the oils and some peel and pith will be recombined with the concentrated juice. The whole mixture will then typically be finely milled and homogenised before being pasteurised.

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**Table 6.3** Typical concentrated juices and comminutes for manufacturing dilutable drinks

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Typical concentrate</th>
<th>Comminute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orange</td>
<td>Frozen concentrated juices 65–66°Brix</td>
<td>30–60°Brix (3 : 1–6 : 1)</td>
</tr>
<tr>
<td>Lemon</td>
<td>Frozen juice or sulphite-preserved 4 : 1 or 5 : 1 clear or cloudy product</td>
<td>25–40°Brix (4 : 1–6 : 1)</td>
</tr>
<tr>
<td>Lime</td>
<td>450 g per litre citric acid = 6:1–3:1</td>
<td>Not normally produced</td>
</tr>
<tr>
<td>Apple</td>
<td>69–70°Brix concentrate</td>
<td>Not available</td>
</tr>
</tbody>
</table>

**Figure 6.1** Simplified outline process for citrus comminute production.
Finished comminutes are often available at between about 35 and 60°Brix. When used for making whole fruit drinks they deliver, apart from a more intense fresh flavour, cloud and colour.

6.2.3.1.3 Other fruit components. Other fruit components that may be used in the manufacture of non-carbonated beverages, particularly dilutables, include pectins and aroma substances obtained during the concentration of fruit juices. These components do not normally count towards the fruit content of products as they are usually classified as types of permitted additives.

6.2.3.2 Carbohydrates
Carbohydrates still feature as important components of many non-carbonated beverages, and they are particularly important in the manufacture of dilutable drinks. Historically, the UK Soft Drinks Regulations of 1964 required dilutable drinks to have a minimum level of 22.5% w/v carbohydrates unless they were declared to be ‘low calorie’. The regulations assumed a five times dilution factor (1 part dilutable plus 4 parts water) and thus a minimum carbohydrates level of 4.5% w/v in finished drinks.

Today, manufacturers in most countries can choose how much carbohydrate (if any) to use, the information being passed to the consumer by the product label.

Sweeteners generally are dealt with in more detail in Chapter 4.

6.2.3.2.1 Sucrose. The preferred carbohydrate for most manufacturers is still sucrose, although its 2004 price within Europe is so artificially high that other alternatives are often sought and are increasingly used. Sucrose is readily available as a bulk dry solid or as a 67°Brix syrup and it is in this latter form that most manufacturers will use it.

6.2.3.2.2 Invert sugar. Invert sugar, sometimes referred to as partially inverted refiner’s syrup, is produced by acid or enzymic hydrolysis of the disaccharide sucrose into its 2004 component parts of fructose and dextrose (glucose). Invert syrups usually contain a mixture of sucrose, fructose and dextrose. The main advantage of such a syrup is the reduced likelihood of crystallisation and an increase in osmolality, which may be useful in reducing spoilage risk.

Because of the development of fructose-containing glucose syrups, invert sugars are little used now. Some product formulators maintain that the sweetness of invert syrup is marginally greater than that of sucrose at the same strength.

6.2.3.2.3 Glucose syrups. Glucose syrups are a group of industrial syrups manufactured from starch – usually corn starch (maize). The starch may be hydrolysed by either acid or enzymic hydrolysis or, more usually, a combination
of the two. Glucose syrups are normally referred to as having a dextrose equivalent (DE), which broadly relates to the percentage of dextrose in the mixture of carbohydrate produced on hydrolysis. In general, the DE also gives an indication of the sweetness of the syrup. Typical glucose syrups that are commercially available include 42DE and 63DE syrups. Products available from the hydrolysis of starch include pure dextrose, glucose syrups with a range of carbohydrate components and maltodextrins.

Glucose syrups are often used in energy drinks, where a high level of carbohydrate is required (e.g. 20% at drinking strength) but without the sickly sweetness that this strength of sucrose would bring. There can also be commercial advantages in using glucose syrups as the solids levels are usually around 80% w/w compared with the maximum of 67% w/w for sucrose syrup. One particular technical disadvantage is that glucose syrups are often extremely viscous and if allowed to cool to below 30°C can become very difficult to handle. The solids levels in glucose syrups are measured in degrees Baumé rather than degrees Brix and some examples of the relationship between degrees Baumé, degrees Brix and physical characteristics are shown in Table 6.4.

### 6.2.3.2.4 Modified glucose syrups
An important development in the production of alternative carbohydrate sources for beverage and other food uses has been the production of fructose-containing glucose syrups. One such product is known as high-fructose glucose syrup (HFGS). It is widely used in

<table>
<thead>
<tr>
<th>Table 6.4</th>
<th>Comparison of degrees Brix, degrees Baumé and physical characteristics of carbohydrate syrups</th>
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</thead>
<tbody>
<tr>
<td>Degrees Brix</td>
<td>Degrees Baumé</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>2.79</td>
</tr>
<tr>
<td>10</td>
<td>5.57</td>
</tr>
<tr>
<td>15</td>
<td>8.34</td>
</tr>
<tr>
<td>20</td>
<td>11.10</td>
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<tr>
<td>25</td>
<td>13.84</td>
</tr>
<tr>
<td>30</td>
<td>16.57</td>
</tr>
<tr>
<td>35</td>
<td>19.28</td>
</tr>
<tr>
<td>40</td>
<td>21.97</td>
</tr>
<tr>
<td>45</td>
<td>24.63</td>
</tr>
<tr>
<td>50</td>
<td>27.28</td>
</tr>
<tr>
<td>55</td>
<td>28.54</td>
</tr>
<tr>
<td>60</td>
<td>32.49</td>
</tr>
<tr>
<td>65</td>
<td>35.04</td>
</tr>
<tr>
<td>70</td>
<td>37.56</td>
</tr>
<tr>
<td>75</td>
<td>40.03</td>
</tr>
<tr>
<td>80</td>
<td>42.47</td>
</tr>
</tbody>
</table>
the United States and to a lesser extent in Europe, where the commercial advantages of use are less. In these products, starches (usually corn starch) are hydrolysed to dextrose syrup. A further enzymic modification then takes place whereby a proportion of the dextrose present is converted to fructose. Depending on the proportion converted, the resulting level of fructose can reach up to 100% or more of the dextrose level to give a product that is chemically similar to invert sugar syrup and has similar technical and organoleptic properties. Syrups with a lower proportion of dextrose converted to fructose have also been found to be a useful carbohydrate source for beverage manufacture. The approximate comparative sweetness values of various carbohydrate sweeteners are shown in Table 6.5.

6.2.3.2.5 Fructose syrup. In addition to the glucose/fructose syrups mentioned above, a fructose syrup has been produced using inulin as a source. Inulin is the fructose analogue of starch, and the chicory root is the standard source for commercial hydrolysis. Fructose syrups are usually too expensive for routine use in beverage production but they have been employed where a particular claim is to be made for fructose. They have also been used for the adulteration of fruit juices as they are chemically difficult to detect. Detection is possible at the sub-molecular level by techniques such as stable isotope ratio measurement. Fructose is also manufactured using sucrose as a starting material.

6.2.3.3 Intense sweeteners
More details about intense (or artificial) sweeteners appear in Chapter 4, but no chapter dealing with beverage manufacture would be complete without mentioning these important ingredients. A comparative picture is shown in Table 6.6.

6.2.3.3.1 Saccharin. Intense sweeteners have been widely used for many years. The oldest, saccharin, was used as a sugar substitute during the Second

<table>
<thead>
<tr>
<th>Carbohydrate</th>
<th>Approx sweetness compared with sucrose</th>
<th>Typical form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>1.00</td>
<td>67°Brix syrup or solid</td>
</tr>
<tr>
<td>Invert sugar</td>
<td>1.00–1.1</td>
<td>Syrup</td>
</tr>
<tr>
<td>Glucose syrup</td>
<td>0.4–0.8</td>
<td>Syrup</td>
</tr>
<tr>
<td>High-fructose glucose syrup</td>
<td>1.0–1.1</td>
<td>Syrup</td>
</tr>
<tr>
<td>Glucose/fructose syrups</td>
<td>0.8–0.9</td>
<td>Syrup</td>
</tr>
<tr>
<td>Fructose syrup</td>
<td>1.05–1.1</td>
<td>Syrup</td>
</tr>
</tbody>
</table>
World War and for many years was used together with sucrose as a mainstay of beverage sweeteners. Saccharin, by experiment, has a sweetness factor compared with sucrose of 450 for the soluble form (sodium saccharin dihydrate) and around 550 for the much less water-soluble imide form. Despite commercial advantages saccharin is little used now because of its bitter aftertaste.

6.2.3.3.2 Aspartame. Aspartame is a widely used intense sweetener that has excellent taste characteristics. It is a peptide made from two amino acids, phenylalanine and aspartic acid, but will in an acidic beverage medium slowly hydrolyse to its components. The fact that aspartame is a source of phenylalanine is of concern to consumers with certain complaints, and suitable label declarations are now required by law. Technically, this slow hydrolysis brings about loss of sweetness.

6.2.3.3.3 Acesulfame. Acesulfame K has similar taste characteristics to aspartame but without the disadvantages of hydrolysis causing loss of sweetness. The product has found wide use in beverages.

6.2.3.3.4 Cyclamic acid. Cyclamic acids in the form of cyclamate salts were in wide use in the 1965–75 period but because of a sudden scare that they could be a cause of certain cancers were removed from the marketplace. Cyclamates were re-permitted on a limited basis in Europe in around 1995 but have found little commercial use since then.

6.2.3.3.5 Neohesperidin dihydrochalcone. Neohesperidin dihydrochalcone (NeoHDC) is a sweetener of natural origin that has been chemically modified. It has found little use in the beverage or food industries.

6.2.3.3.6 Sucralose. Sucralose is the most recently permitted artificial sweetener. It is a chemically modified sugar but has a very high sweetness factor, comparable with that of saccharin, but without the unpleasant aftertaste.
The sweetness profile of sucralose is claimed to be excellent and it has already found some use in the beverage and food industries.

6.2.3.4 Other ingredients

6.2.3.4.1 Acidulants. The preferred acidulant for dilutable (and other) soft drinks is citric acid, which is readily available both as a crystalline solid (citric acid anhydrous) and as a 50% w/w solution in bulk. Other acidulants that are used in specific products include malic acid, lactic acid and tartaric acid. Phosphoric acid, until recently permitted only in cola drinks, is now available for use in the United Kingdom but has so far found little, if any, use in dilutable products. Acids other than citric are usually employed only where a slightly different taste profile is needed. Ascorbic acid is usually employed as an antioxidant rather than as a direct acidulant.

6.2.3.4.2 Preservatives. Despite the requirement that most dilutable drinks should be pasteurised (see Section 6.4), the use of chemical preservatives in these products is, in most situations, almost essential. The main reason for this is that dilutable products are used over a period of time during which the container will remain part full or ullaged. The storage period will vary from user to user and may be as short as a few hours from first opening to several weeks or even months. During this time the consumer expects a product to remain free from fermentation, mould growth or other microbial development and to retain an acceptable taste. Preservatives permitted in the United Kingdom include benzoic acid, sorbic acid and sulphur dioxide (in limited situations). Dimethyl dicarbonate (velcorin) is permitted but little used in dilutables.

Sulphur dioxide remains a key preservative in dilutables containing fruit components, where it is permitted (at least in the United Kingdom) at a rate of 250 mg/l. This preservative, which is a gas in solution in the product, will diffuse into the product headspace and help to minimize microbial development.

It is normal to use additionally a mixture of both benzoic and sorbic acids, added as their sodium and potassium salts respectively. Current UK preservative regulations permit a maximum level of 300 mg/l of sorbic acid and 150 mg/l of benzoic acid, both at drinking strength. For this reason it is normal to suggest on the product label a dilution ratio, which can then be used as a factor in calculating the amount of these preservatives to be used. An example is set out in Table 6.7.

In most dilutables, these levels would be more than adequate to deliver enough preservation after pasteurisation, and a typical preservative mix for a dilutable containing up to 25% fruit juice might be as follows:

<table>
<thead>
<tr>
<th>Preservative</th>
<th>Concentration</th>
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<tbody>
<tr>
<td>Sulphur dioxide</td>
<td>150 ppm</td>
</tr>
<tr>
<td>Benzoic acid</td>
<td>500 ppm</td>
</tr>
<tr>
<td>Sorbic acid</td>
<td>800 ppm</td>
</tr>
</tbody>
</table>
The actual additions would be sodium metabisulphite (solution or solid) and aqueous solutions of sodium benzoate or potassium sorbate. Convenient conversions for these materials are shown in Table 6.8.

Because of the limited solubility of benzoic and sorbic acids in water, great care must be exercised during the manufacturing process of dilutables to ensure that acidification does not result in precipitation and loss of the preservatives.

There is a small but growing market for high-value dilutables that are declared to be free from preservatives. These products must be adequately processed using in-bottle pasteurisation and the label clearly marked with the need for time-limited storage in refrigerated conditions.

6.2.3.4.3 Flavourings. Flavourings are widely used in dilutable soft drinks to boost or substitute those occurring naturally. There are other publications that deal with this topic in more detail, but, in brief, it is necessary to ensure that appropriate beverage flavours are selected to produce adequate solubility. Most manufacturers of dilutables will use either natural or nature-identical flavours.

6.2.3.4.4 Colourings. Most dilutable beverages are formulated with added colourings, although, depending on the fruit preparation used, many products
will have a significant level of colour delivered by the fruit components. In the United Kingdom, artificial colours are now little used in dilutable beverages except for lime juice cordial, which is usually marketed as a clear product with a synthetic lime-green colour that is difficult to achieve by means of natural ingredients.

The available natural colourings offer a limited range of yellow through orange to red/purple colours for products. The most common natural colours used in dilutables include β-carotene, apocarotenal, curcumin and anthocyanins.

To obtain maximum colour stability a careful balance must be achieved between sulphur dioxide and ascorbic acid contents to avoid bleaching the colours.

6.2.3.4.5 Remaining additives. Various other additives are employed in dilutable soft drinks manufacture including antioxidants, acidity regulators, emulsifiers and stabilisers. Stabilisers are particularly important for ensuring physicochemical stability of the product to avoid unsightly oil ring formation or undue sedimentation of fruit components. Cloudy agents are often used to boost the turbidity of natural fruit components. These ingredients can also be made to incorporate citrus oils and colourings by creating an oil-in-water emulsion using a mixture of permitted emulsifiers and final emulsification of cloud to a low particle size (<10 μm).

6.2.3.4.6 Compound ingredients. Compound ingredients were widely used at one time for the manufacture of dilutables. They are still available today but are much less widely used. This probably reflects a number of factors such as the disappearance of many small soft drinks manufacturing companies and the need for precise fruit component content. A compound would typically contain all the components to make a dilutable except for the water and carbohydrate. Thus, a manufacturer would purchase, for example, a 10-fold orange squash compound. By adding the required amounts of sugar and water the manufacturer would make 10 times the volume of compound (i.e. 25 l of 10-fold compound would make 250 l of orange squash) into a product that would contain the legal minimum fruit content.

6.2.4 Manufacturing operations

The manufacture of dilutables is essentially a very simple process, with the required ingredients being mixed in order in a large vessel. After checking the final volume for process variables the mixture is then flash pasteurised and filled into the required containers.

The process is diagrammatically summarised in Figure 6.2.
6.2.4.1 Ingredients
Addition of the ingredients in the correct order is essential to avoid production problems. The normal order starts with the presence of around 30–50% of final product volume of process water to which preservatives other than sulphur dioxide are first added. This volume should be as large as possible to allow the addition of carbohydrates and fruit components, which follow in that order. At this point, the volume should be approaching 90% of final volume to allow the dilution of preservatives. Acidulant is then added, followed by colourings, flavourings and all other components.

The last ingredients to be added are cloud emulsions. Sulphur dioxide should ideally be added after the final make-up water to avoid loss to atmosphere of the gaseous preservative.

6.2.4.2 Mixing
A stainless steel mixing vessel, fabricated from 316 grade stainless steel with some form of cover that allows access for ingredient addition, is an ideal unit for mixing dilutables. The vessel is normally fitted with a stirrer, the power and design of which take account of whether sugar is to be added as a crystalline solid (and thus dissolved) or added as a syrup. Either a top-mounted propeller stirrer or a side-entry unit will mix components adequately, especially if the inside surface of the vessel is fitted with fixed baffles. The use of a stirrer that creates a sufficient vortex to draw in air should be avoided.
High-shear stirrers can be a useful way of mixing components, but they often draw in air and can destroy added emulsions. Mixing can also be done through an external circulating loop with an in-line pump or emulsifying mixer. All systems should ideally be connected to a clean-in-place (c.i.p.) system.

6.2.4.3 Pasteurisation

6.2.4.3.1 Flash pasteurisation. For a normally preserved dilutable soft drink the typical conditions for flash pasteurisation are 85–90°C for 30–60 s. The actual conditions should be determined by reference to the quality of ingredients used, although pasteurisation must never be used as a means of employing sub-standard components. Products containing particulate such as fruit cells should be pasteurised in a plate pasteuriser with 3–4 mm spacing or in a tubular pasteuriser. Great care must be taken to avoid microbial contamination downstream of the pasteuriser. Pasteurised product should be stored in a very clean (or even aseptic) bulk buffer tank prior to filling.

6.2.4.3.2 In-pack pasteurisation. In-pack pasteurisation is normally reserved for dilutable products that are made without preservatives. Unless there are particular circumstances that demand a preservative-free product (e.g. manufacture of a certified organic product), preservatives should always be used in dilutables because of the way the drinks are used and stored. A dilutable without preservatives is very vulnerable to microbial contamination, which can lead to fermentation and possibly bottle bursting. Dilutables without preservative must be labelled to encourage refrigerated storage and short shelf life.

In-pack pasteurisation normally demands very large and expensive tunnel pasteurisers which have several stages. Bottles are introduced into a pre-heating stage, typically around 40°C, to reduce thermal shock, and then into the pasteurisation zone, which will normally be at 70°C, for some 20 min. Following this are two hydro-cooling zones. The first of these reduces product temperature to around 40°C; the second, to ambient temperature. Recovery of heat is essential to an economically viable operation.

Final product temperature should ideally be below 20°C to avoid the phenomenon of ‘stack burn’ where packed and palletised product that is not adequately cooled will effectively be ‘slow cooked’. This can result in excessive browning and the development of a cooked taste.

6.2.4.4 Homogenisation

Some manufacturers homogenise all cloudy dilutable products to obtain maximum physical stability for the product, but others achieve the same result by careful ingredient selection. If homogenisation is to be used, a piston-type unit is preferred with an operating pressure range of around 50–100 bar. As with all beverage manufacturing plant, effective cleaning is essential.
6.2.5 Filling and packaging

Gravity fillers are normally employed for dilutable products, and filling speeds tend to be fairly slow as container sizes are relatively large. For most dilutables the smallest container is usually 0.7 l with sizes up to 3 or 5 l being common.

Most manufacturers now use polyethylene terephthalate (PET) bottles, which provide a good degree of protection from oxygen ingress but without the weight disadvantages of glass packs. For PET bottles, closures are normally moulded polyethylene (LDPE or HDPE), whereas manufacturers packing in glass will normally use roll-on pilfer proof (ROPP) caps made of aluminium.

6.2.6 Product range

The dilutables of the 1960s were fairly limited in range – orange squash, whole orange drink, lemon squash, lemon barley water, lime juice cordial and blackcurrant cordial being a typical product spectrum. Seasonal products that were added to the range included ginger and peppermint cordials.

Over the past 20 years, the UK market for dilutables has developed and grown to include high-value products that have become a niche market. The range of dilutable products available today is much wider and includes products such as elderflower cordial, summer berry fruits, lime and lemongrass, to name but a few.

6.3 Ready-to-drink non-carbonated products

6.3.1 Overview

There has always been a market for ready-to-drink (RTD) non-carbonated products, but it has been a difficult market to develop because consumers need persuading away from making their own RTD products using dilutables.

The market has often been seen as one of low-quality products with an overriding convenience factor, but over the last 25 years packaging developments and increasingly affluent consumers have encouraged the development of this market. Early products in the market were packed in pre-formed plastic cups, pouches or early TetraPaks, but today there is a wide variety of packing options available.

6.3.2 Formulations

RTD non-carbonated drinks are usually made by formulations and processes that are identical to the manufacture of dilutables except that the dilution takes place at the manufacturer’s rather than the consumer’s premises. However, because many non-carbonated drinks often sell in low-price markets, many of
the formulations used contain little if any fruit components, although, as mentioned above, a market has now developed for higher-unit-value products in more expensive packaging forms.

### 6.3.3 Special problems

There are particular problems in the manufacture of non-carbonated RTD beverages that are not aseptically packed. These relate to microbial contamination. Products that have no carbon dioxide in their headspace are particularly vulnerable to contamination by moulds and certain types of bacterial infection. For many years it was possible to control such potential contamination by the use of low levels of sulphur dioxide (50 ppm). Changes in European Preservative Regulations now make the use of this preservative in RTD formulations (but not dilutables) illegal unless it is ‘carried over’ from a fruit component, when up to 20 ppm SO₂ may be present. Even at this level, the gaseous preservative is rapidly lost and is quickly ineffective.

To avoid such microbial problems manufacturers must either employ aseptic packing lines, which are very capital-intensive, or use flash pasteurisation and scrupulous downstream hygiene and close control over formulations.

One significant difference in these RTD products is that levels of preservatives will normally be raised to close to the permitted maximum to gain maximum benefit.

A further potential problem with non-carbonated RTD products is that they invariably contain atmospheric air in their headspace as there is no carbon dioxide to displace it. This often leads to undesirable oxygen levels in the product with resulting flavour and colour deterioration in a short time period.

Accordingly, it will often be necessary to adjust the product formulation to incorporate appropriate levels of antioxidants, such as ascorbic acid, and to use flavour and colour preparations that are stable to oxidation.

### 6.3.4 Manufacturing and packing

The normal manufacturing and packing sequences for both aseptic and non-aseptic products are shown in Figure 6.3.

Various alternative configurations can be used, and in particular some manufacturers employ non-aseptic form–fill–seal operations which usually produce either in-line cup packs or cartons such as TetraPak or Combibloc packs.

### 6.3.5 Packaging types

Many non-carbonated RTD products that are not pure fruit juices or nectars are packed in either pre-formed or form–fill–seal plastic packages, although an
increasing number are now packed in PET bottles. Flexible pouches have also been used by a number of manufacturers.

Depending on the shelf life required, the use of some form of barrier in the packaging is highly desirable or even essential. Much of the packaging used today will be based on a rigid or semi-rigid container employing polystyrene as a major component. The incorporation, often in the form of laminated structure, of a barrier plastic can significantly enhance the product shelf life by reducing the rate of oxygen transfer. Some flexibility can be introduced into containers by incorporating polyethylene into the laminate.

The increased use of PET bottles for packing non-carbonated RTD drinks probably reflects the availability and convenience of this form of packing coupled with the low oxygen transfer rate.

6.4 Fruit juices and nectars

This chapter will not provide the background to the production of fruit juices and nectars, as that is dealt with elsewhere in this volume. However, fruit juices and nectars represent the largest volume of non-carbonated beverages that are sold in almost every marketplace. It is therefore appropriate that some aspects of these products, particularly those relating to processing and packaging, are mentioned here.
6.4.1 Processing

Fruit juices and nectars are highly susceptible to fermentation and other forms of microbial spoilage and with few exceptions it is essential that some form of pasteurisation is employed when these products are packaged. The exceptions that are seen usually relate to freshly squeezed orange (or other) juices that are processed directly from fresh fruit and packaged immediately. These products have a very short shelf life, usually a few days, and are maintained by storage at temperatures between 0 and 5°C.

There is also a market for reconstituted fruit juice made from concentrate and not further processed but maintained, during its short shelf life, by refrigeration. For all other fruit juice and nectar products either frozen storage or in-pack pasteurisation will be used, although some manufacturers who employ a hot fill process.

6.4.1.1 Flash pasteurisation

Typical flash pasteurisation operations for fruit juices and nectars will employ a plate pasteuriser with heat recovery and final product cooling. Typical flash pasteurisation conditions will use temperatures between 85 and 95°C with holding times varying between 15 and 60 s. Selection of the appropriate conditions will depend on the product, including the level of microbial load pre-pasteurising. If enzyme deactivation is required as well as microbial removal then a temperature between 90 and 95°C will normally be used. At these temperatures, holding times are normally reduced to around 15 s.

Juices containing cells, particulate material or products that are particularly viscous, such as some of the tropical juices, may be pasteurised in tubular units or plate pasteurisers with wide (3–5 mm) spacing.

For aseptic packaging operations, flash pasteurisers are often linked integrally with the aseptic packaging unit, either directly or via an aseptic buffer tank. When flash pasteurisation is used, care should be taken to minimise product recirculation when the pasteuriser is in divert mode. Excessive recirculation can lead to thermal damage to the product, resulting in unpleasant cooked flavours and product browning.

6.4.1.2 In-pack pasteurisation

In-pack pasteurisation is often regarded as a foolproof operation, although product integrity will ultimately rely on the seal provided by the pack closure.

In-pack pasteurisation can be achieved at very low cost by simply immersing bottled product, with closures tightly applied, in tanks of heated water. A pre-heat tank at around 40°C should be employed to minimise thermal shock to the containers, and the main pasteurising tank will be held at around 70°C. A single
container into which is inserted a remote temperature probe should be used to ensure that the whole contents of the bottles reach pasteurising temperature.

The normal means of achieving in-pack pasteurisation is to use a tunnel pasteuriser. These are large, capital-intensive pieces of plant and require significant floor space and provision of services. Most units work by using water sprays in a pre-heating zone, pasteurising zone and cooling zone(s). Some form of heat recovery is almost essential if a tunnel pasteuriser is to work economically.

After containers leave the pasteuriser they should be air-dried and then labelled. Typical pasteurising conditions will be 70–75 °C for up to 20 min.

6.4.1.3 Hot filling
Hot filling provides a further means of ensuring the microbial integrity of fruit juices and nectars. The bulk product is heated to the required temperature then filled into containers and the closure applied. If glass bottles are used, they should be pre-heated, for example, by a warm water spray, before filling to minimize thermal shock. Following filling, containers are usually rotated through 360° to ensure contact between hot liquid and the whole inside of the container and cap.

Depending on the fill temperature, which is usually around 70–80°C, the filled containers will be held for the required time before being placed in a hydro-cooler. Containers should be cooled to below 25°C before being stacked. This will avoid further low-temperature ‘cooking’ of product inside a stack of containers. Labelling is carried out after air-drying the containers.

6.4.1.4 High-pressure pasteurisation
Claims have been made for the successful high-pressure pasteurisation of fruit juice in containers. The equipment required is expensive and the process is carried out as a batch operation, which tends to be both slow and ineffective. It may, in future, provide a very interesting means of low-temperature pasteurising of fresh juices, thus retaining all the flavour characteristics of the product.

6.4.2 Packaging

6.4.2.1 Boxes
Most fruit juices for retail sale are now in cartons, a high proportion of which will be aseptic packs. Cartons are formed, filled and sealed in a single operation, which will either be clean or aseptic depending on the product and shelf life sought. Typical packs include TetraPaks, Combibloc and Elopak.

The long-shelf-life packs for aseptic products are often made of a board, foil, plastic (polyethylene) laminate which gives protection from oxygen ingress and
light as well as mechanical strength and an excellent surface for printed material. Cardboard packs for short-shelf-life products are often a simpler laminate excluding foil.

6.4.2.2 Bottles
The selection of a container for fruit juices will often be based on a combination of the technical, cost and marketing needs. Many outlets for fruit juices require relatively small unit packs and these will invariably be glass bottles. In the United Kingdom, most fruit juice in bottles is limited to these small units (e.g. 200 ml), whereas many European markets prefer larger (up to 1 l) glass bottles with wide necks.

Glass bottles will normally be pasteurised using either the hot fill method or in-pack pasteurisation.

There is some limited use of plastic bottles for juice packing – mostly related to short-shelf-life products sold from the chill cabinet. Plastics are now available to support aseptic filling or even hot fill operations, but they have found limited support for the sale of fruit juices.

6.4.2.3 Cans
The sale of fruit juice in cans to either the retail or industrial markets has largely died out with the availability of other forms of packaging and storage. Some juices from developing country suppliers (e.g. mango juice) are still supplied in cans containing around 5 kg. This reflects the technology and packaging available in the supply country.

6.4.2.4 Bulk packs
Juice for industrial use has, over many years, been packed in a wide variety of drums. Typical drums are open-head steel containers with the juice packed inside several plastic bags. This package is the usual container for frozen juices and typically contains around 200 l.

Plastic drums have also been widely used over many years without the need for plastic liners, but they are less suitable for freezing as the plastic has a tendency to become brittle and may rupture. Plastic drums usually contain 200–250 l, although larger containers have been very successfully used – especially for chemically preserved juices. The Israeli manufactured ‘Rotoplas’ container was probably the best-known example. This container typically held around 1300 l.

Aseptic bulk packing has now become a well-established means of packing concentrated or RTD juice. Containers are available from as little as a 5 l bag-in-a-box to be dispensed from a bar up to a 1 000 l bin in a 1 m³ pallet box.
Finally, the transportation of fruit juice in temperature-controlled bulk road tankers of up to 25 000 l is well established as is intercontinental transfer by shipping tankers.

**Further reading**


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