

13.1 Introduction

The main ingredients in the soft drinks are water, sweeteners, acidulants, colorants, flavours and clouding agents.

13.2 Water

Water is the major component of soft drink. A carbonated soft drink usually contains 82–97% water. The quality of the water used in a beverage has a critical impact on the taste, appearance, physical and microbiological stability. The water used may come from the two main sources – water supply from local government agencies and privately owned wells. Although, the local government agencies or private well owners treat the water, but it may still have components that may affect the quality of the beverages in which it is used. These need to be eliminated or reduced to minimize their effects. Moreover, the water from different sources may differ considerably; so to maintain the uniform quality of the product the water has to be standardized in its quality [23].

13.2.1 Adverse factors from water

Possible adverse factors from water that could affect the quality of soft drinks are suspended matter, micro-organisms and source quality variation.

Suspended matter

The suspended colloidal matter and organic particles not only cause unpleasant appearance and turbidity but can also encourage the micro-organisms to grow. These serve as *hiding places* for micro-organisms.

Micro-organisms

One of the prime aims of treatment of source water is to eliminate pathogenic organisms. But soft drinks manufacturers cannot take any risk in this matter to use the water as such. So water must be disinfected to check the health risks.

Source quality variation

Sources of water (the surface and underground types) are often subjected to seasonal changes as well as unpredictable local events in the environment that affect the quality of raw water. Chemical composition of minor ingredients of the water is important. The alkalinity and pH of the raw water is determined by the amount of minerals dissolved. High pH neutralizes the acidity component of the beverage that affect the overall taste profile of the beverage. The minerals like iron, chloride, and sulphates at even very low concentration can impart off-taste to the beverage. The dissolved organic compounds such as trihalogens or residual pesticides may also be present, which are also hazardous to health. As the raw water from different sources differs considerably, there is a need for standard water specification to achieve consistent quality of soft drinks [23].

13.2.2 Water treatment

The soft drink manufacturers have to select an appropriate treatment to maintain quality of the product. The different treatments include lime decarbonization, ion exchange, reverse osmosis and nanofiltration for water with heavy salt loading. The consideration is to be given to economic viability, limitation of different treatments and extension of existing equipment in order to incorporate new treatment technology. Basic water treatment is presented in the Figure 13.1.

13.3 Sweeteners

The sensation of sweetness is transmitted to human brain through specific protein molecules called receptors. The function of sweeteners is to bind these receptors on the surface of the cells. These receptors then produce the signals corresponding to different ingredients present in the food perceived by human brain. Probably the sweetness is the most important feature of a soft drink. According to UK Soft Drinks Regulations, 1964 [24], a low-calorie soft drink should contain sugar to a minimum level of 45g/l, but these regulations have been revoked in the year 1995 [25].

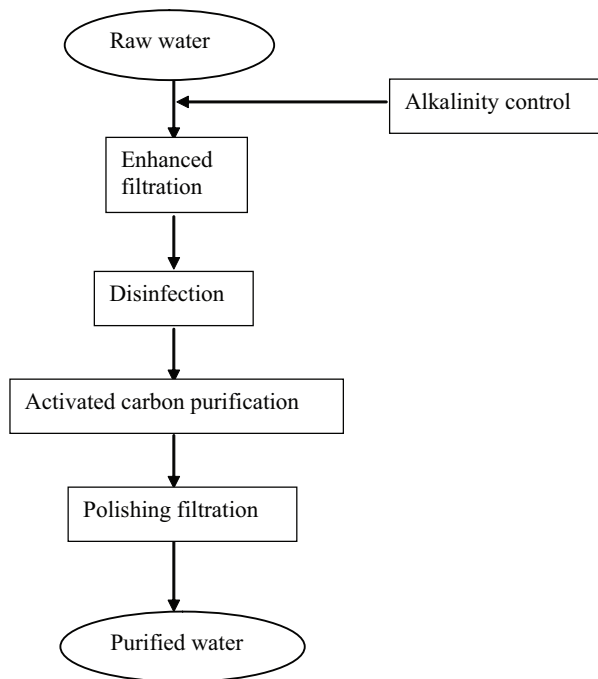


Figure 13.1 Purification of water

13.3.1 Classification

Sweeteners are classified as natural and synthetic. The *natural* ones are the most nutritive dietary sweeteners like sucrose, fructose, lactose and maltose. Sucrose is considered to be the major sweetener responsible for improving the acceptability of food from centuries [26]. Relative sweetness of natural sweeteners is presented in Table 13.1.

Table 13.1 Relative sweetness of natural sweeteners [27]

Sugar	Relative sweetness
Sucrose	1.0
Glucose	0.6
Fructose	2.0
Maltose	0.6
Lactose	0.25
Steviol glycosides	40–300

From Table 13.1 it can be observed that there is a difference in the degree of sweetness of various sweeteners, such as glucose and maltose are half as sweet as sucrose while fructose is twice as sweet as sucrose. The sweetness

of lactose is only one-fourth of that of sucrose. Relative sweetness of artificial sweeteners is presented in Table 13.2.

Table 13.2 Relative sweetness of artificial sweeteners [27]

Sweetener	Relative sweetness*
Saccharine	300–500
Acesulfame-K	150–300
Cyclamate	30
Sucralose	600
Aspartame	150–200
Neotame	7000–13000
Alitame	2000
Talin	2500

*With reference to sucrose

The synthetic sweeteners because of their intense sweetness are called high potency sweeteners (HPS) e.g. certain proteins, terpenoid glycosides like saccharin, cyclamates, aspartame and acesulfame-K. The need for HPS sweeteners arises due to health reasons for persons who cannot have sugar in their meal. Further, the economic reasons also add for the development of HPS. According to American Dietetic Association, the consumer can safely enjoy both nutritive and non-nutritive sweeteners within the context of a diet consistent with the dietary guidelines for Americans. The International Food Information Council has also expressed same opinion.

Major limitations of genetic production of natural HPS in commercialization are limited production and high cost. The genetically modified HPS are thaumatin and brazzein, extracted and purified from the plants. The degree of sweetness of natural HPS is presented in Table 13.3.

Table 13.3 The degree of sweetness of HPS [27]

Sweetener	Degree of sweetness*	Chemical nature
Thaumatococcus	1000	Protein
Brazzein	2000	Protein
Stevioside	300	Triterpene-Glycoside
Glycyrrhizinic acid	300	Triterpene-Glycoside
Mogrosin	250	Triterpene-Glycoside

* With reference to sucrose

13.3.2 Sweeteners in the industry

These are broadly of three types – carbohydrate sweeteners, intense sweeteners and mixed sweeteners.

Carbohydrate sweeteners include

- Mono and disaccharides – glucose, fructose, sucrose, raw sugar, brown sugar, invert sugar, lactose, maltose, corn syrups, caramel sugar, caramel.
- Sugar alcohols – sorbitol, mannitol, xylitol, isomalt, maltitol, lactose and starch hydrolysates.
Intense sweeteners comprise of
- Natural sweeteners – stevioside, thaumatin, dihydrochalcone, miraculin
- Major artificial sweeteners – saccharin, cyclamate, acesulfame-K, and aspartame
- Other sweeteners – synthetic peptide sweeteners, sucralose, L-sugar

Carbohydrate sweeteners

The profile of the use of sweeteners in soft drinks has changed significantly over the last 10–15 years. Carbohydrate sweeteners are widely being used in juices and soft drinks and represent the largest share of the global sweetener market. Currently these account for the 81% of sweetener usage [28]. A number of carbohydrate sweeteners are used in soft drinks to provide different attributes, including sweetness, mouth feel, stability and colour. Some of the carbohydrate-based sweeteners, which are used in soft drinks, are described below.

Sucrose

It is regarded as the ‘gold’ standard for a sweet taste. It is a disaccharide with molecular weight of 342.31. It is available in crystalline form and is manufactured from cane or beet. During manufacturing, juice extracted from the cane or beet is subjected to purification steps including precipitation, absorption, crystallization and evaporation, which remove non-sugars and progressively concentrate the sucrose solution.

Glucose syrups / high fructose corn syrups

Glucose syrups, also known as corn syrups, are defined by the European Commission (EC) as “a refined, concentrated aqueous solution of D(+)-glucose, maltose and other polymers of D-glucose obtained by the controlled partial hydrolysis of the starch” [29].

These are manufactured either by acid or enzymatic hydrolyses of starch. In acid hydrolysis, hydrochloric acid is used because sulphuric acid causes

haze in syrups due to insoluble sulphates. Corn, potato, wheat or cassava, all can be used as the source of starch in the manufacturing process. The method of acid hydrolysis is non-specific, but if conditions are tightly controlled, it is possible to make products with a reasonably good carbohydrate profile. The degree of hydrolysis is defined by 'DE' value or 'dextrose equivalent'. It is the total reducing sugar content of the syrup, compared to D(+)-glucose on a dry matter basis. Starch with no hydrolysis has a DE of 0, whereas glucose or dextrose, which is the product of starch hydrolysis, has a DE of 100. Glucose syrups with DE values in the range of 42–63 are used in soft drinks industry [3].

Enzymatic method involves the use of glucose isomerase, which converts glucose to fructose, and provides greater degree of control over the sugar profile of the resulting syrup. High fructose corn syrup with fructose levels of 42% provides the same sweetness as sucrose. This can be further refined to obtain 55% fructose syrup. In soft drinks, glucose syrups are used to provide sweetness and mouth-feel to the products and occasionally, specific physiological properties in sports and energy drinks.

Fructose

Fructose is unique among known sugars in being sweeter than sucrose. Fructose has a clean, sweet taste and functions as a synergist with many bulk and intense sweeteners. It is very soluble and also relatively hygroscopic, compared to sucrose [30]. Chemically, it is very active and readily takes part in Maillard reactions, which may cause browning in some products.

Fructose can be used as a sugar substitute in crystalline or syrup form. It is found naturally in many fruits and also in honey, but commercially it is manufactured using sucrose as a starting material. Initially, sucrose is hydrolysed to give a mixture of glucose and fructose; these are separated using chromatography and the fructose is then crystallized.

It has some interesting physiological properties. It is a monosaccharide with energy content of 4 kcal/g. Due to its increased sweetness, it can be used at lower levels than sucrose. It is slowly absorbed and metabolized in the body, independent of insulin production and does not cause rapid rise in blood glucose after ingestion. It is therefore, suitable for diabetics and also for use in drinks intended to act as a slower, more sustainable energy source. It is a low glycemic index sugar when compared to glucose and has been seen to have an increased satiety value [31]. Mineral absorption (iron and calcium) has also shown to be positively affected by the incorporation of fructose into the diet [32].

L-Sugars

L-sugars are simple six-carbon low calorie sugar (hexoses, monosaccharides), which are true sugar-flavour sweeteners and bulking agents. These taste like sucrose, but human body does not seem to metabolise. The L-sugars such as L-glucose, L-fructose and L-galactose were patented as low calorie sweeteners [33]. L-sugars provide a clean sweet taste while furnishing the bulk, texture, browning and other properties so necessary for effective formulation of food products.

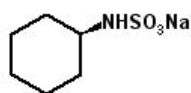
L- and D-sugars differ in their structure but they have similar physical characteristics, such as melting point, solubility, viscosity, texture, hygroscopicity, density, colour and appearance. Chemical properties of both forms in symmetrical environments are likewise identical. For e.g., thermal and pH stabilities in various aqueous solutions were identical for the glucose and fructose enantiomers. Unlike all currently available low calorie sweeteners, the L-sugars brown upon baking. Therefore, L-sugars are expected to yield food products similar to those using D-sugars, but without the calories. The taste profile of L-sugars was found to be same as that of D-sugars and no cooling effect or aftertaste was reported. The sugars are tested for toxicity and other side effects before approval from US FDA.

Intense sweeteners

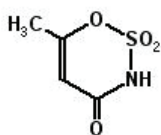
Mostly, these are synthetic sweeteners (Figure 13.2). Properties and applications of important synthetic sweeteners in foods are presented in the following sections.

Saccharin (o-sulfobenzoic acidimide).

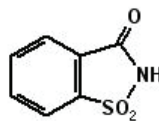
Saccharin is the oldest among synthetic sweeteners. The commercial manufacture of saccharin begins in early 1900 when millions of diabetic patients all over the world were waiting for the substitute of sugar. Saccharin is free from problems like tooth decay and also safe to use for diabetic patients. It is a white crystalline product, which gives a metallic after-taste when used at higher concentration [34]. The products used as masking agent for saccharin's bitter taste are fructose, gluconates, tartarates, ribonucleotides [35], sugars, sugar alcohols and other intense sweeteners. Saccharin is widely used throughout the world; however, according to a clinical research, high dose of it may cause cancer [36].



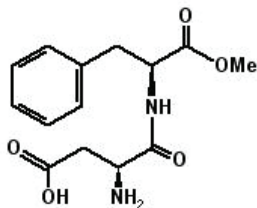
Cyclamate



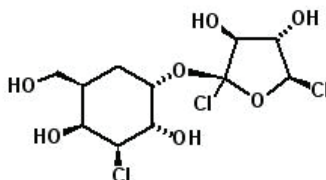
Acesulfame · K



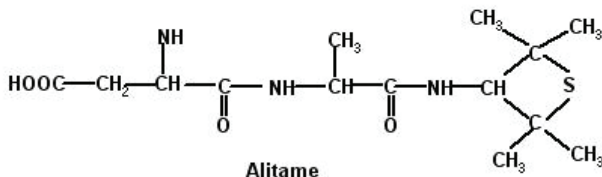
Saccharine



Aspartame



Sucralose



Alitame

Figure 13.2 Intense sweeteners

Acesulfame- K

Clauss and Jensen [37] accidentally discovered a compound, Potassium salt of 6-methyl-1,2,3-oxathiazine-4 (3H)-one-2, 2-dioxide. Initially, used in dry food mixes now is used in carbonated as well as in non-carbonated drinks as well.. The sweetness varies from 100 to 200 times of sucrose, depending upon concentration and application can withstand high cooking temperatures. Basically acesulfame-K is a white crystalline powder. The specific gravity of pure crystalline acesulfame-K is 1.83 g/cm³ [38]. The sweet taste of acesulfame-K is perceived quickly and does not persist longer. In aqueous solution with higher acesulfame-K, bitterness can be detected sometimes [39]. It is not found to be reactive with other soft drink ingredients; however, the addition of potassium ion in the presence of acesulfame-K should be taken into account.

Cyclamate

Cyclamate derived from sulphamic acid of cyclohexylamine (cyclamic acid). It is approximately 35 times sweeter than sucrose, compared to other sweeteners. Moreover, this is banned in some countries as it is suspected to be carcinogenic. Cyclamate has improved sweetness in the presence of other sweeteners like acesulfame-K, aspartame, saccharin and sucralose [40]. Most of the people reported to metabolise less than 10% cyclamate. However, 47% of population can metabolise 20–85% cyclamate into cyclohexylamine [41, 42].

Sucralose

This is trichloro-galacto sucrose which is formed by chlorination of sucrose. It is safe to use as it does not contribute calorie and does not cause dental caries. It was approved to be used as tabletop sweetener during 1998 [27].

Aspartame

The trade names are NutraSweet, Equal, Sugar-Free, Egal, or Canderl. L-aspartic acid and L-phenylalanine are the two natural amino acids present in aspartame. It is the most popular sweetening ingredient now days, which was discovered in 1965 [43]. Earlier, it was synthesized by chemical method but now by enzymatic method (formation of peptide bond between its constituent amino acids). Currently, Japan's Ajinomoto Company is the largest manufacturer of aspartame. It is slightly soluble in water (about 1.0% at 25°C) and is sparingly soluble in alcohol [44]. The solubility increases at elevated temperatures and in acidic conditions. The taste of aspartame is similar to sucrose sweetness.

Neotame and Alitame

These two are closely related to aspartame. Neotame (N-[N-3, 3-dimethylbutyl]-L- α -aspartyl]-L-phenylalanine-methyl ester) differs from aspartame in structure, having neohexyl group in addition to the methyl ester group. It has been reported as a flavour enhancer and it is found to be 8000 times sweeter than sucrose, therefore, used at a very low concentration in soft drinks e.g. 6ppm in cola. The products containing neotame can be processed by high-temperature short-time (HTST) approach. Alitame (L- α -aspartyl-N-(2,2,4,4-tetramethyl -3-thietanyl)-D-alanine) is a peptide sweetener. The aspartic acid component of alitame is metabolized, contributing 4kcal/gram to diet, but it produces negligible energy as a sweetener. It is a white, crystalline, non-hygroscopic and water-soluble

powder. It is partially metabolised and is excreted as unchanged alitame and mixture of its metabolites [45].

Blends of synthetic sweeteners

The blend of synthetic sweeteners shows synergy. They reduce the total quantity of sweetener to achieve a predominated level of sweet taste. The use of a blend is to improve the shelf life of the product and blended sweeteners pose no health safety risk. They provide a balanced profile of sweetness without pronounced after taste [27].

Mixed sweeteners

Food technologists have found that the use of combination of more than one sweetener in a single system is more economical and characteristically feasible, e.g. saccharin and cyclamate, aspartame, saccharin / aspartame mixtures in soft drinks industry. The aim behind the combining of sweeteners is to imitate the taste and stability of their sugar sweetened counterpart, to create new taste by using sweeteners as flavours in the industry, to increase the safety level and to regulate the cost [46]. A variety of nutritive as well as non-nutritive sweeteners have been discovered, and many of these occupy a place in the commercial market [26]. Sweetener combinations for applications are presented in Table 13.4.

However, the analysis of their organoleptic and functional characters shows that none of these currently known sweeteners can match the taste and functionality of sucrose. The differences are observed in the following parameters

1. Taste properties such as sweetness lag, e.g., Aspartame [44], undesirable lingering after taste, e.g., Stevioside having menthol after taste [47]
2. Lack in bulking properties
3. Problems of stability during food processing
4. Competitive prices, e.g., high cost of Aspartame

Table 13.4 Sweeteners combinations [35, 48]

Sweetener	Amount (mg) ^(a)
Acesulfame-K	50–60
Acesulfame-K + Aspartame	30 +3
Aspartame	40–50
Sodium saccharin	30–40

Sodium cyclamate	150–200
Sodium cyclamate + Sodium saccharin	80 + 8
Aspartame + Sodium saccharin + Sodium cyclamate	10 + 4 + 30
Aspartame + Sodium saccharin	5 + 15

^(a) Effective amount required to provide the sweetness equivalency of two teaspoons;

These limitations can be overcome partially in some selected applications e.g., introduction of polydextrose combined with sugar substitutes can now help avoid the bulking problems. In Canada, aspartame is the only sweetener approved for this application. Beverages contain 50–95 mg of aspartame per 100 ml depending on the brand and flavour. Aspartame-based beverages lose sweetness depending on the storage time, temperature and pH. A study shows that about 50% of initial aspartame remains in cola beverages stored at 30°C for 24 weeks and in cola syrups pH 2.4, 75% of initial aspartame remains after about 2 weeks of storage at 30°C [49].

The use of aspartame in combination with saccharine at a ratio 1:1 and stored at 20°C, shows significantly better sweetness stability than the beverages sweetened with aspartame alone and stored at the same conditions [50]. Addition of small amount of aspartame (0.0007%) can improve the acceptance of saccharine sweetened beverages significantly [51]. Combination of Acesulfame-K and aspartame enhanced the sweetness by about 35%, while combination of Acesulfame-K and cyclamate yields excellent taste quality and exceptional storage stability. Neohesperidin dihydrochalcone (NHDC) when used in combination with saccharine, has a synergistic effect and gives improved taste perceptions [52]. In Japan, combination of fructose and stevioside has been successfully used and has good acceptance in reduced calorie soft drinks [53]. While Hoppe [54] discussed the effect of various mixtures of sucrose, saccharine and cyclamate on sweetness perception in aqueous solutions, and also the benefits of the consumers that can be derived from the use of combination sweeteners in soft drinks.

13.3.3 Current trends of sweeteners

The fructose is nearly two times sweeter than sucrose while glucose is only half as sweet as sucrose. The sugar produced during hydrolysis of cane sugar is sweeter than sucrose but less sweet than high fructose syrup. “High Fructose Syrup” is nowadays used to reduce the total sugar in beverages. This is done to get predetermined degree of sweetness. Another advantage is that it helps in regulating post prandial blood sugar level in diabetic persons. The development of low calorie beverages with reference to use of multi-sweet is to combat increasing incidence of obesity. Further, the sensory properties

of beverages sweetened with multi-sweet compared well with conventional sweeteners. The demand in low calorie sweeteners is to highlight the decline in consumption of sugar, changes in consumer's habits and interest in health foods with increase in consumer sophistication. The concentrations of aspartame and sodium saccharin in mixed sweetener for soft drinks and syrup is presented in Table 13.5.

Table 13.5 Concentration of saccharin and aspartame in soft drinks and syrups

Flavour	Aspartame (mg per 100 ml) [55]	Sodium saccharin (mg per 100 ml) [48]
Soft drinks		
Cola	57.7	31–42
Orange	92.6	37–38
Lemon-Lime	50.1	26–42
Syrups		
Cola	347.6	–
Orange	401.0	–
Lemon-Lime	234.2	–

13.4 Acidulants

The acid component is useful in modifying the sweetness of sugar. The acidulants stimulates the flow of saliva in the mouth due to their thirst-quenching properties. The acids act as mild preservatives as they reduce the pH level of the product [3]. The common acidulants for beverage industry are presented in Table 13.6.

Table 13.6 Commonly used acidulants in beverage industry

Acidulants	Molecular weight	Melting point (°C)
Citric acid	192.1	152–154
Tartaric acid	150.1	171–174
Phosphoric acid	98.0	42–43
Lactic acid	90.1	18
Malic acid	134.1	98–102
Fumaric acid	116.1	299–300
Acetic acid	60.0	16–18

13.4.1 Citric acid

Citric acid is the most widely used acidulant. It has a fruity character blended with fruit flavours. For example unripe lemon contains 5–8% citric acid,

associated with malic acid in apple, apricot, blueberries, cherries, gooseberries, peaches, plum and pears; with isocitric acid in blackberries and with tartaric acid in grapes. Citric acid is a white crystalline solid and is available in powder form as the monohydrate [3].

13.4.2 Tartaric acid

Tartaric acid is present in the form of acid or potassium salt. It occurs naturally in grapes. This acid can be obtained in four forms – dextro, laevo, meso-tartaric acid and mixed- isomer equilibrium. The acid is produced by means of fermentation process. It is a white crystalline solid and imparts a strong and tart taste [3].

13.4.3 Phosphoric acid

It occurs usually in the form of phosphates in some fruits e.g. lime and grapes. It is exclusively used in cola-flavoured carbonated beverages. Phosphoric acid bears a sharp flavour as compared to other flavours like citric acid or tartaric acid; therefore, it tends to blend better with non-fruit drinks. It is a colourless crystalline solid [3]. It is highly water-soluble and available in solution concentration of 75, 80 and 90%. It is highly corrosive so recommended to use in rubber-lined steel/food grade stainless steel.

13.4.4 Lactic acid

Lactic acid is used to a greater extent in the food industry but not commonly used in beverages. This acid has a mild taste as compared to other acids and is mainly used in soft drinks as a flavour modifier rather than an acid. A lactic acid bacterium produces lactic acid through fermentation [3].

13.4.5 Acetic acid

It is widely used in soft drinks industry except in non-fruit beverages. It is a colourless crystalline solid with melting point of 16°C and bears a suffocating and pungent aroma. The acetic acid in terms of its dissociation constant is found to be strongest among all other acidulants [3].

13.4.6 Malic acid

Malic acid is the primary acid present in apple and the secondary acid present in citrus fruit rather than citric acid. It imparts a smoother fruity flavour than any other acid. Malic acid is a crystalline white solid with a melting point of

100°C. It is water soluble and less hygroscopic as compared to others, so as to provide a good storage shelf-life. It is widely used in low-calorie drinks, e.g. cider (apple wine). It enhances the colour and flavour in carbonated and non-carbonated fruit-flavoured drinks [3].

13.4.7 Fumaric acid

Fumaric acid is used at a lower level, as two parts of it are just equivalent to three parts of citric acid. The main drawback in its use is that the solubility of fumaric acid is lower than that of citric acid. It is not allowed for use in soft drinks directly by UK or EU legislation whereas it is permitted under Annexure IV of directive 95/2/EC (98/72/EC). It also has a tendency to stabilize the suspended matter in both flash-pasteurized and frozen fruit concentrates [3].

13.4.8 Ascorbic acid

Ascorbic acid is not only used as an acidulant but it also behaves as a stabilizer. It has anti-oxidant property (provides shelf-life stability of flavours) by shielding the ingredients used in flavours against oxidation. It also acts as a browning inhibitor [3].

13.5 Colours

Colourants are used in food items to enhance aesthetic appeal and also to promote sales. Colour provides a means of presenting a beverage to the consumer. The colours used in soft drinks are both natural and synthetic ones. The natural colorants are anthocyanins, betanins and carotenes. The natural colours are derived from plant sources like beetroot, cabbage and paprika, which are easily available and acceptable also. Natural carotene is used as colorant emulsion in soft drinks [10]. The carotenoids useful for soft drinks are carotene, annatto, carotenal, carotenic acid and canthaxanthin. Major ones are the synthetic colours such as tartrazine, sunset yellow, chocolate brown, caramel, amaranth and carmosine, etc. The reasons for the popularity of synthetic colours are low price, high effectiveness and excellent stability. The market for natural colours is expected to grow twice as that of synthetic colours due to improved technological performance of natural colours. The daily-consumed synthetic colours are Amaranth, Erythrosine and Allura Red [56].

13.5.1 Natural colours

Nowadays consumers are more aware of their diet and health. This can be achieved by means of concept of functional foods, where the natural colours/

pigments have recently been recognized for their health benefits. The increase in demand for natural colours as consumers increases their awareness of food ingredients. The other factors includes improved stability to oxidation, pH, heat and light, colour shades extension, increased intensity and brightness, oil soluble pigments in water dispersible forms, application of oil-soluble colour pigments in fat based media, replacement of ingredients unfriendly to consumers, development of new pigment resources. Some of the natural colours used in soft drinks along with sources and their shades are provided in Table 13.7.

Table 13.7 Sources and shades of natural colours^(a)

Pigment	Sources	Shade	E-No
Anthocyanin	Grape Skins, Elderberry, Red Cabbage, Hibiscus	Red-purple-blue, pH dependent	E163
Beetroot Red	Red beetroots	Pink to red	E162
Carmine	Cochineal insect	Strawberry red, orange/red hues	E120 E160
Annatto	Seeds of annatto shrub	Orange	E160
β -Carotene	Carrots, Algae, Palm synthesized	Yellow to orange	E160
Paprika	Red pepper	Orange to red	E160
Lutein	Aztec marigold	Yellow	E161
Curcumin	Turmeric	Yellow	E 100
Chlorophylls	Green-leafed plants	Green	E140,141

^(a)EU DIRECTIVE 94/36/EC; The Commission of the European Committee, 1999; E-Under consideration by EEC for 'E' prefix.

13.5.2 Synthetic colours

Synthetic colourants can be classified as water-soluble and fat-soluble colourants based on their solubility. The water-soluble colourants are Amaranth (E123, FD&C red no.2), Brilliant Blue FCF (E133, FD&C blue no.1), Ponceau 4R (E124, FD&C red no.7), Sunset Yellow FCF (E110, FD&C yellow no.6) and Tartrazine (E102, FD&C yellow no.5). The synthetic colours have been added legally into foods since 1880. The use of food colouring is carefully controlled under various legislations like EEC (European Economic Committee) and FDA (Food and Drug Administration of the USA). The permitted synthetic colours for soft drinks are presented in Table 13.8.

Table 13.8 Synthetic colours – soft drinks

Colour	Shade	E-No.
Quinine yellow	Greenish yellow	E-104
Tartrazine	Lemon yellow	E-102
Sunset Yellow	Orange shade	E-110
Carmosine	Bluish red	E-122
Ponceau 4R	Bright red	E-124
Patent blue FCF	Bright blue	E-131
Indigotine	Dark bluish red	E-132
Brilliant blue FCF	Greenish blue	E-133

13.5.3 Global food colours market

Global food market is estimated to exceed US\$1,201.23 million. The rate of growth of natural colours is expected to be 4–6% per year whereas the growth rate for synthetic colours is expected to be only 2% per year. In figures, the market is split as 28% share for natural colours, 41% for synthetic colours, 20% for nature- identical colours and 11% for caramel. The natural-identical products are synthetic colours having the same structure as found in nature and the colours include β -carotene and apo-carotenal. These are only sparingly soluble in vegetable oils and fats and insoluble in water. Hence, water-dispersible suspensions and fat-soluble preparations are used in beverages. The studies show that for each 100 litres of finished beverage, 10–50 g of carotene is used.[57].

13.6 Flavours

Flavours are the substances that impart the distinct characteristic sensory properties of the beverage. Flavours share fifty percent of a soft drink's raw material cost and can be of great significance in the beverage formulation design. All the ingredients of soft drinks, such as sweetener and acidulant, contribute to the taste of a beverage, but flavours are the one, which gives the overall distinctive properties of taste and smell. A drink is made by water, sugar and acid, but the characteristic part of any soft drink is its flavour. Flavours can be broadly classified as water-soluble and water in-soluble ones. Water-soluble flavours are easily dissolvable and dispersible and relatively small amount of flavour is required, whereas non water-soluble flavours forms a neck-ring in the beverages and can be seen as tiny suspended particles, giving an unsightly appearance. To overcome this problem, these are formulated as flavour emulsions [23].

13.6.1 Classification

Most flavours are of plant origin so are termed as *natural flavours* and those which do not have any existing counterpart in nature, and are synthesized are termed as *artificial flavours*. The mostly used flavours are made of whole aromatic plants such as mint, thyme and oregano. These are commonly called spices, which play a considerable role in beverage industry.

Flavours are broadly classified as natural flavourings, nature identical flavourings and artificial flavourings [23].

Natural flavourings

The natural flavourings are obtained by physical process (including drying and solvent extraction) or by an enzymatic or microbiological process from material of vegetable or animal origin.

Nature identical flavourings

Nature identical flavourings are prepared using chemical processes. These are chemically identical to a substance present in natural product intended for human consumption.

Artificial flavouring substances

Artificial flavourings are also chemically synthesised and these substances have not been identified in natural products, whether processed or not.

Industrial application of flavourings

The flavourings that are most common in use in the beverage industry are of two types – water-miscible and water-dispersible. Water-miscible flavourings as the name suggest forms a clear solution with water at the rate of 0.1%.

Flavouring substances are dispersed in a suitable carrier solvent system (ethyl alcohol / propylene glycol), which tend to exhibit variation in sensory profile due to blending and allowing them to settle, as the component may react before their stabilization. Water-dispersible flavourings are water-insoluble ones, having non-polar oil phase. These flavourings are used as emulsions (Figure 13.3), which facilitate the oil-based flavouring substances to be incorporated into beverage system. These emulsions serve dual purpose of an oil phase, that is, it provides flavour and cloud effects [3].

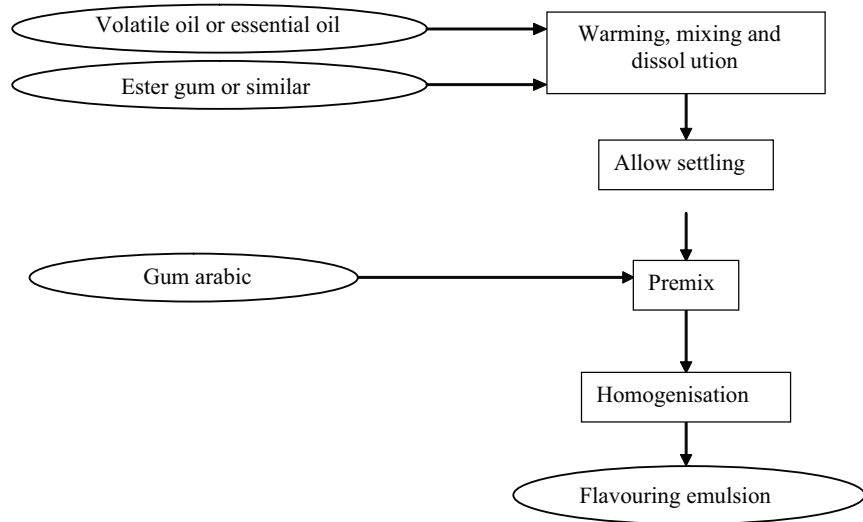


Figure 13.3 Preparation of flavouring emulsions

Aqueous phase contains hydrocolloids; gum Arabic is used primarily and its admixture with other gums are also used. Oil phase, usually contains essential oil or volatile (e.g., citrus oil) based with 'weighting agent' such as ester gum, sucrose acetate iso-butyrate, beeswax and brominated vegetable oil (restricted use, not permitted in selected countries).

13.6.2 Methods of isolation

Flavours can be isolated using different methods viz., distillation (e.g. steam distillation, hydro distillation, simultaneous distillation and solvent extraction), solvent extraction and mechanical pressing.

Distillation

Distillation is used for isolation of volatile aromatic flavouring compounds. In the process of distillation water or steam is used to separate flavouring compounds from their plant source. By virtue of their different condensation temperatures, they can be distilled in different fractions. A large part of flavourant is occupied by these compounds, which are extensively used in soft drinks [23].

Extraction

Flavours are extracted from the plant source by using organic solvents. The solvent is then removed and flavourant is retained in its pure concentrated

form, e.g. vanilla flavour is prepared by curing beans of the vanilla plant, which results in a flavourant known as *vanillin*. Vanillin is extensively used in soft drinks such as colas and cream soda formulations. Similarly, oleoresins of spices (e.g., ginger) and various fruit flavours are produced and used in soft drinks [23].

Mechanical pressing

By mechanical pressing of plant source material, the essential oil as well as other flavourant compounds can be prepared; e.g. citrus processing where peel oils are collected and subjected to cold pressing. The resultant product is termed, as *cold pressed oils* and very often used in beverages. These may be further processed by extraction or distillation processes.

The active ingredients present in these essential oil are volatile substances such as Terpenes, aromatic or aliphatic esters/alcohols. As these are water insoluble components, these have to be incorporated as emulsion in carbonated soft drinks [23].

13.5.3 Flavours in soft drinks:

1. Citrus flavours;
2. Orange flavours
3. Lime
4. Grapefruit
5. Cranberry
6. Strawberry
7. Cherry
8. Pomegranate
9. Pineapple flavours
10. Coconut and winter fruits.

In carbonates, new flavours include mango tango, apple splash, fanta, raspberry and cranberry, Britvic 55.

Day by day, the demand for flavours is increasing. The current trend in flavourings is demand for popular flavours, flavour blends, nutraceutical flavours, sport drink flavours and fortified beverage flavours.

13.7 Clouding agents

Clouding agents should impart the following attributes to the finished carbonated beverage: (1) products should remain stable for at least three

months without ‘ringing’, ‘creaming’ or ‘sedimentation’. (2) The clouding agents should not adversely interfere with the colour, taste or odour of the finished beverage. (3) The clouding agents must satisfy the legal requirements of the country in which the drink is consumed. Some of the examples of clouding agents are pectin, gelatin, glyceryl acetate, brominated vegetable oils, sucrose acetate, dibenzoate and tribenzoate etc. The functionalities and characteristics of two important clouding agents, viz. ‘Pectin’ and ‘Gelatin’, are discussed in the following sections.

13.7.1 Pectin

Pectin (Figure 13.4) is found to be a commonly used polysaccharide and it has a complex structure. The majority of the structure consists of homopolymeric partially methylated poly- α -(1 \rightarrow 4)-D-galacturonic acid residues, but there are substantial ‘hairy’ non-gelling areas of alternating α -(1 \rightarrow 2)-L-rhamnosyl- α -(1 \rightarrow 4)-D-galacturonosyl sections, containing branch-points with mostly neutral side chains (1-20 residues) of mainly L-arabinose and D-galactose (rhamnogalacturonan I).

Pectin may also contain rhamnogalacturonan II side chains containing other residues such as D-xylose, L-fucose, D-glucuronic acid, D-apiose, 3-deoxy-D-*manno*-2-octulosonic acid (Kdo) and 3-deoxy-D-*lyxo*-2-heptulosonic acid (DHA) attached to poly- α -(1 \rightarrow 4)-D-galacturonic acid regions. D-galacturonic acid residues form most of the molecules in blocks. The molecule does not adopt a straight conformation in solution, but is curved with a large amount of flexibility. The ‘hairy’ regions of pectin are even more flexible and may have pendant arabinogalactans. The carboxylate groups tend to expand the structure of pectins as a result of their charge. Methylation of these carboxylic acid groups forms their methyl esters which are more hydrophobic, and hence have a different effect on the structure of the surrounding water.

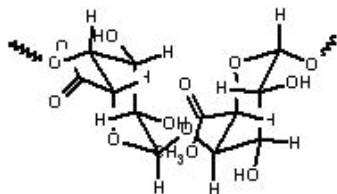


Figure 13.4 Pectin

The properties of pectins depend on the degree of esterification, which is normally about 70%. Low methoxyl-pectins (< 40% esterified) gel formed due to calcium di-cation, bridging between adjacent two-fold helical chains forming ‘egg-box’ junction zone structures, and a minimum of 14–20 residues

can cooperate. Gel strength increases with increasing Ca^{2+} concentration but reduces with temperature and acidity increase ($\text{pH} < 3$). If the methoxyl esterified content is greater than 50%, calcium ions show some interaction but do not form gel. The controlled removal of methoxyl groups converting high methoxyl pectins to low-methoxyl pectins is possible using pectin methylesterases. High methoxyl-pectins ($> 43\%$ esterified, usually $\sim 67\%$) gel by the formation of hydrogen-bonding and hydrophobic interactions in the presence of acids ($\text{pH} \sim 3.0$, to reduce electrostatic repulsions) and sugars. Low methoxy-pectins ($\sim 35\%$ esterified), in the absence of added cations, gel by the formation of cooperative 'zipped' associations at low temperatures ($\sim 10^\circ\text{C}$) to form transparent gel. The rheological properties of low methoxy-pectins are highly dependent on the salt cation, salt concentration and pH [58].

Pectins are mainly used as gelling agents, but can also act as thickener, water binder and stabilizer. Low methoxyl pectins ($< 50\%$ esterified) form thermoreversible gels in the presence of calcium ions and at low pH (3–4.5), whereas high methoxyl pectins rapidly form thermally irreversible gels in the presence of sufficient (65% by weight) sugars such as sucrose and at low pH (< 3.5); the lower the methoxyl content, the slower the set.

13.7.2 Gelatin

Gelatin [59] is a substantially pure protein food ingredient, obtained by the thermal denaturation of collagen. It possesses fruit juice's clarifying properties. In 'fining' applications, gelatin reacts with polyphenols (tannins) and proteins in fruit juices forming a precipitate, which settles leaving a supernatant, which is stable to further, give cloud formation with storage time. Traditionally, low bloom strength gelatins are used but it has been shown that high bloom strengths are equally effective. But, practically low bloom strength gelatin is used as it is cheaper and easier to mix into the bulk of the cold juice before gelation can occur.

The haze-forming activity of a polypeptide depends greatly on its proline content. Haze-forming polyphenols have at least two binding groups, each of which has at least two hydroxy groups on an aromatic ring. The protein/polyphenol ratio has a strong influence on the amount of haze formed; the largest amount occurs when the numbers of polyphenol binding ends and protein binding sites are nearly equal. This has important consequences for turbidimetric methods used to measure haze-active proteins and polyphenols in beverages. The ratio also influences the effectiveness of a number of stabilization procedures [58].