
1 Creating and formulating flavours

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1.1 INTRODUCTION

There are many different approaches to flavour creation and no one approach has a monopoly on the truth. Any successful technique must simply recognise the fundamental structures of flavours and then proceed logically to the goal. Some flavourists rely totally on blotters (strips of filter paper that are used to assess the odour of a mixture by sniffing). Some never touch them and make everything up to taste. Some flavourists throw most of the ingredients in at the start and some prefer to build up the composition step by step. Arguments about the logic, or lack of logic, inherent in some of these creative approaches miss the point. I have known good flavourists who use techniques that seem to me to be impossibly complicated and impractical. What all successful flavourists have in common is the ability to imagine the interactions between a very complex blend of raw materials and to use intuition and creative originality to fashion a work of art. Many successful flavourists are trained as scientists, but some had no scientific training whatever. Scientific method alone, without the spark of creativity, would mean that a single flavour would be a lifetime's work.

1.1.1 A little history

The flavour industry originated in the latter half of the nineteenth century with essential oil distillation and botanical extraction as the main sources of raw materials, often with a strong link to the pharmaceutical industry. Simple chemicals were available by the turn of the century, and during the first half of the twentieth century the fledgling flavour industry was increasingly driven by chemical research. For the flavourist of those times (who was often a pharmacist or chemist-turned flavourist), the task of making flavours was purely creative. Very little was known of nature, other than the major components of essential oils and a very limited number of chemicals that had been isolated from food and successfully identified.

Most new chemicals that were synthesised had no possible value in flavours. The few that proved useful became the starting point for the synthesis of every possible related compound. Thus, the available raw materials were concentrated in a few obvious areas. Flavours created in this era were often not very close to the character of the real food, but some of them displayed real creativity and became accepted standards in their own right.

The advent of gas chromatography and mass spectroscopy marked a real turning point for the industry. For the first time it was possible to see, in some detail, the chemicals used by nature to flavour food. The advance was, understandably, treated with some caution. What had been a purely creative and artistic profession could possibly be reduced to analytical

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routine. The early analyses quickly dispelled all concerns. On reconstitution it was never possible to recognise anything more than a passing resemblance to the original target. Relieved flavourists quickly settled back to the old routine, but the more astute among them recognised a few diamonds in the mud.

Among the first useful results from the new analytical techniques were pyrazines and unsaturated aliphatic alcohols. Chemicals such as trimethylpyrazine gave a true-to-nature roasted note to nut and chocolate flavours. Earlier flavours had been forced to rely on old-fashioned phenolic compounds such as dimethyl resorcinol. Dimethyl resorcinol provided a hint of roasted character but, at the same time, drowned the flavour in an uncharacteristic rubbery phenolic soup. *cis*-3-Hexenol gave an authentic green note to a multitude of fruit flavours, which previously had to depend on methylheptine carbonate to achieve a modicum of freshness (although tinged with melons and violets).

Many of the failings of the early analytical techniques have now been overcome. Analyses are still not easy to interpret and different techniques can give very contradictory results, but they should form the starting point for the work of a good flavourist.

1.2 INTERPRETING ANALYSES

For virtually all flavours the nucleus is nature. We may or may not aim to reproduce nature accurately, but fully understanding nature is essential even for a caricature. Analysis is therefore the first step. Usually, several different types of analyses will be available (see Chapters 9 and 10 for details of the different flavour analyses available). Headspace analyses emphasise the more volatile components and are relatively true to the character of the food being analysed. The quantification of headspace analyses can usually be improved by applying vapour pressure correction factors. Early headspace analyses lacked detail and failed to capture less volatile components, but these shortcomings have now been largely overcome. Extract analyses are less accurate and contain more artefacts. They are often representative of a rather cooked character, but they do emphasise the less volatile components. Stir bar sorptive extraction is a good, nonintrusive, analytical technique and offers a wide-ranging analysis of liquids. Specialised analyses are often carried out to investigate the high-boiling components and also the sulfur and nitrogen compounds. The flavour of food will often vary depending on the plant variety as well as the growing or cooking conditions, and many analyses will quantify these differences. In consequence, the flavourist will often first have to correlate a wealth of information about the target food.

The correlated list can be daunting, often running into many hundreds of different chemicals. The quantification used by the flavourist should be derived from the best of the headspace and stir bar results, corrected for vapour pressure, with extract results pressed into service for the less volatile chemicals – an impossibly complex problem on the face of it. The ‘trick’ of being a successful flavourist hinges on the ability to imagine the smell of complex mixtures, but a mixture of several hundred ingredients is far too complex to imagine. The first priority is to simplify the problem.

Simplification can be carried out in three stages. The first stage is relatively easy. Many of the chemicals that have been found will be present well below their threshold levels and it might seem safe to ignore them all. Some caution is needed because synergistic and additive effects are common. The best approach at this stage is to build in a comfortable margin of error and retain any questionable chemicals.

The second stage of simplification is to eliminate those chemicals that are likely to be artefacts. Artefacts can be present in the original food, produced during the separation process prior to analysis or produced during the actual analysis. Again, in cases of doubt, retain rather than discard.

The final stage of simplification is to reject those notes in the target food that are genuinely present but are not desirable. Examples would be the trace by-products of fermentation and enzymatic browning in fresh fruits.

Even the simplified analysis will usually be of daunting complexity. At this stage it is beneficial to try to reconstitute the analysis by mixing the flavour components in the proportions identified by the various analyses and then smelling and/or tasting the mixture. The result is certain to be disappointing, but it will serve to clarify the key aroma characteristics of the target food. Sometimes it is feasible to recreate the conditions of the original analysis using the reconstitution.

Reanalysis will highlight the odd errors of identification, but it will invariably give a much improved quantitative base to start from.

A second reconstitution may now give a recognisable product, but not one that anybody would be remotely happy to buy. It is time to abandon the strictly scientific approach and move on to the more abstract creative approach.

1.3 FLAVOUR CHARACTERISTICS

Smelling and tasting the target food will give the flavourist a good idea of which aroma characteristics are important. Reconstituting the analysis will clarify this assessment even further and may well add a few unexpected notes. The aroma characteristics can be divided into two broad categories, primary and secondary characters.

1.3.1 Primary characters

Primary characters are essential to the recognition of the target food. They constitute the basic skeleton of the flavour. Good examples are 'violet' (α -ionone) in raspberries and 'clove' (eugenol) in bananas. It is impossible to create a realistic flavour without some contribution from these notes.

Secondary characters are not essential for recognition but contribute an optional descriptive characteristic. Good examples are 'leaf green' (*cis*-3-hexenol) in strawberries and 'dried' (2-methylbutyric acid) in apricots. In both cases it is perfectly possible to make good, authentic flavours without these notes. Their effect is simply to vary the type of flavour to green strawberries and dried apricots, respectively.

Strictly speaking, the primary characteristics can also be regarded, in some circumstances, as having secondary characteristics as well. A raspberry flavour with unnaturally emphasised α -ionone will smell distinctly violet. This is not a problem because the object of this exercise is, once again, simplification. It allows the flavourist to balance the primary characteristics in isolation and leave the secondary characteristics for later.

Flavours vary greatly in the complexity of their primary recognition characteristics. The simplest example, at first sight, is probably vanilla. On its own, the chemical vanillin smells recognisably of vanilla. For many vanilla flavours in common use worldwide, this is all the primary character needed. Where consumers are accustomed to a more complex flavour, such

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as the character of real vanilla beans, vanillin alone will not suffice to build a recognisable skeleton.

Strawberry is a more complex flavour, and a more complex mixture of notes is required to achieve a recognisable flavour. In this example, 'peach' (γ -decalactone), 'fruity' (ethyl butyrate), 'guava' (methyl cinnamate) and 'candy' (Furaneol[®]), blended in the correct proportions, would be the primary characters for the strawberry flavour skeleton.

Some of the primary characteristics will be simple and will be represented by just one chemical in the analysis. Others may be more complex and may be represented by several chemicals. An example is the 'peach' note in fruit flavours. Major contributors to this note in many fruit products are γ -decalactone and γ -dodecalactone. Both chemicals have a similar 'peach' odour, but the taste characteristics intensify (and the odour strength decreases) with increasing molecular weight. When several chemicals contribute, the balance between the different components may need to be adjusted from that indicated by the analysis. Fortunately, that task can often be deferred until the basic skeleton of the flavour has been devised. It is easy to introduce unnecessary complication at this stage. In our peach example, we will find numerous additional lactones of similar structure in an analysis and it is tempting to think of them as part of a very complex primary characteristic. In reality, the additional lactones are not essential for peach recognition and are secondary notes.

The flavourist is now ready to begin the real creative work. The objective is to achieve the best possible combination of what is now a reasonably limited number of chemicals to obtain a recognisable flavour skeleton. The analysis can be taken as a starting point, but it is no more than that. Even if the analysis is entirely quantitatively accurate, which is unlikely, it is still probably a long way from the optimum blend. It represents, at best, a specific example of the target food rather than one with every characteristic optimised – something that never quite occurs in nature. Ultimately, individual notes should be emphasised or reduced to make the flavour more attractive than the specific example of nature that has been analysed.

It is possible, at this point, to try to take a relatively scientific approach and blend the two most important components first. The next step would be to determine the best level for the third component, and so on. The problem with this approach is that the presence of the third component alters the ideal balance between the first two components. The scientific approach rapidly becomes unimaginably complex and impossibly time-consuming.

The best approach is to plunge in, taking the analysis as a starting point, and experiment with blends to understand the role of each of the primary characteristics. Speed is normally vital for commercial reasons, but it is also vital if the flavourist is to remain fresh and able to smell accurately. For that reason it is best just to use blotters at this stage and to experiment with large rather than cautious changes. If an addition is overdone, it can be blended back very quickly. If it is underdone, it is a slow process to carry on adding small quantities and there is a very real risk that the nose will fatigue to the chemical being added.

1.3.2 Secondary characteristics

Once the basic skeleton has been built, the flavourist has to concentrate on the more complex secondary characteristics. These can generally be worked on in groups. Green notes, for example, usually contain several subcategories and many different chemicals. Our strawberry flavour would almost certainly contain the common 'leaf green' character *cis*-3-hexenol, but it could also contain lesser quantities of 'fruity green' (*cis*-3-hexenyl acetate), 'apple green' (*trans*-2-hexenal), 'melon green' (melonal; 2,6-dimethyl-5-heptenal), 'unripe green'

(hexanal) and 'tropical green' (*cis*-3-hexenyl butyrate). Once again the empirical approach is used to optimise this blend.

Working through all the secondary characteristics will probably take some time. It is still best to use a blotter at this stage and to experiment with large rather than small changes. By now, the first stirrings of pride should be evident. It is time to taste the flavour. Tasting solutions should be simple and appropriate. If, for example, the target is a fruit and contains sugar and acid, then the taster should contain sugar and acid for the flavour to be appreciated accurately. Forget the end application at this stage.

Two problems are apparent. The first, and most obvious, is that the balance between the components will seem a little different in aqueous solution from the way it appeared on the blotter. This is something flavourists learn to allow for when using blotters and is usually only a problem for trainees. Blotters offer three great advantages to the flavourist. They allow a very quick evaluation of each flavour. They also allow the simple comparison of many variants. Blotters uniquely offer a panorama of different aspects of your flavour as they air off and the more volatile components evaporate. This is a big advantage because it allows you to smell 'through' the flavour as it evaporates. The odour approximates that experienced in a simple taster for a relatively short time, usually about 5–10 minutes after dipping.

The second problem is that some of the real taste (as opposed to odour) characteristics may be partially or even totally missing. For some flavours, such as roast beef, the taste element is obviously vital. Even when it is not so obviously important, for example in bananas, it is still surprisingly vital to the realism of the flavour. Correcting the taste imbalance is the next step in the flavour creation process.

1.3.3 Taste effects

Taste effects are normally confined to individual flavouring ingredients that are highly water soluble or have a high molecular weight. Research on taste has lagged far behind that on odour, so natural extracts are still widely used to confer subtle taste effects.

Maltol is a good example of a water-soluble taste effect ingredient. Maltol has a pleasant candyfloss odour, and a lingering sweet aftertaste, and is claimed to have flavour-enhancing properties (Labbe *et al.*, 2007). It forms an important part of the aroma of a number of flavours, but the use of maltol as a taste ingredient dwarfs its use as an odour ingredient. Ethyl maltol is stronger than maltol, has similar taste and odour characters, but is not found in nature. Furaneol is even stronger than ethyl maltol and is found widely in nature. The only drawback to the use of Furaneol is that it can be easily oxidised. Vanillin is another water-soluble ingredient frequently used for its sweet taste effect and vanilla odour. Vanillin is widely found in nature and can be integrated into many flavour types.

The taste effect of high-molecular-weight ingredients can be illustrated by the lactones in dairy flavours. The two most important lactones in all dairy flavours are δ -decalactone and δ -dodecalactone. δ -Decalactone provides an excellent creamy odour in dairy flavours. δ -Dodecalactone has a similar odour but has only about 10% of the odour strength of δ -decalactone. The two ingredients have similar costs, and if odour were the only consideration, it would not make any sense to use δ -dodecalactone. The higher molecular weight of δ -dodecalactone gives it a noticeable creamy, oily taste. If cost were no object, the best combined taste and odour results would be achieved by a mixture of ten parts of δ -dodecalactone and one part of δ -decalactone.

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Many high-boiling, nature-identical chemicals have been little used in flavours because of the historical emphasis on odour rather than taste. They can often play a very useful role in enhancing taste characteristics even though they have little or no effect on the odour of the flavour.

A wide range of natural botanical extracts have useful taste characteristics. Kola nut extract has a good astringent character, ginger extract has a hot character, Saint John's bread extract has an attractive fruity sweetness and gentian extract has a lingering bitterness. All of these extracts also possess noticeable odours, and care must be taken to blend in their odour when they are added to a flavour for their taste effect.

1.3.4 Complexity

Flavour formulations vary radically in complexity. The simplest flavour can be based on just one component. Many flavours, just like nature, contain hundreds of ingredients. Which is best?

Very simple flavours have been popular since the earliest days of the flavour industry. Vanillin, isoamyl acetate and benzaldehyde have been the most popular single-component examples. Very simple flavours may represent an attractive caricature, but they never taste like a real food. At the other extreme, very complex flavours often lack impact and can taste flat and characterless. Complex flavours can be deliberate (the result of slavishly following every detail of an analysis) or accidental (the result of lazy blending of flavours and intermediates).

If a natural character is desired, then the optimum level of complexity is often the minimum number of components required to prevent the taster from perceiving the individual characters. This level of complexity can vary from perhaps as few as 15 components in simple fruit flavours to up to 100 in the most complex flavour of cooked food. There are, however, some important exceptions to this rule.

The key problem with complex flavours is that a mixture of two chemicals usually smells weaker than the sum of its parts. The perceived intensity of flavour chemicals has a logarithmic rather than a linear relationship with concentration. At low concentrations, near the threshold, the logarithmic relationship does not hold because the chemical is not perceived at all until it reaches the threshold level. At high concentrations the relationship also does not hold because the nose fatigues to the stimulus. The lower extremes of the concentration scale explain synergistic effects, which otherwise appear to contradict the rule that a mixture smells weaker than the sum of its parts (see Keller and Vosshall, 2004, for more information on measuring odour psychophysics).

Traces of components that, tasted individually, would be well below their threshold level can thus have significant positive effects in mixtures. At the other extreme, it is unwise to use so much of any single ingredient that the taster will quickly become fatigued. A mixture of two or more chemicals with complementary odours can often give better results.

1.3.5 Flavour balance

Evaluating the flavour in tasters may also involve quite a number of modifications to improve the overall balance of the flavour. Once you have something you are basically happy with, it is a good idea to try out variations of concentration of the flavour in the taster. This is a little known, but extremely critical, way of evaluating a new flavour.

Most flavours in nature are not particularly sensitive to changes in concentration. If you add twice as many apricots to a yoghurt, apart from the added acidity and sweetness, the yoghurt just tastes twice as strongly of apricots. The flavour does not become unbalanced. Most flavours created by humans do not fare nearly so well. It is possible to draw an analogy with jigsaw puzzles. An ingredient that does not have a counterpart in nature, in the flavour being created, can be seen as a large misshapen piece in the jigsaw puzzle. Not only is that specific piece out of place, but it also forces many of the other components out of balance. It may be possible, with enough effort, to get this flavour to taste right in a specific application and at a specific dose rate. The flaws will immediately become obvious if the application or the dose rate is varied because the apparent strengths of the different components will not change in unison.

A prime example of an 'alien' unbalancing ingredient is ethyl methyl phenyl glycidate (strawberry aldehyde). This chemical is seductively attractive to flavourists because it smells more like strawberries than any other ingredient they have. It is very hard to turn your back on something that seems likely to give your flavour such a great start. It is not found anywhere in nature and it is certainly not found in strawberries. As we saw earlier, the natural character recognition skeleton of strawberry is a combination of 'peach', 'fruit', 'guava' and 'candy' primary characteristics. Ethyl methyl phenyl glycidate has a very complex odour, with a little of each of these notes. 'Peach' and 'guava' dominate and the chemical also has a strong 'jammy' character. It follows that if ethyl methyl phenyl glycidate is used in a strawberry flavour, it is impossible to build up the rest of the character recognition skeleton in the correct balance and it is also impossible to avoid some degree of 'jammy' character.

This phenomenon is a powerful argument for using only those ingredients that are found in nature in the target flavour. This is undoubtedly the ideal, but as long as the odour character of a potential raw material is close to that of a naturally occurring ingredient, it is often possible to use it effectively. This sort of substitution would be very desirable if the naturally occurring ingredient were prohibitively expensive, impossible to make or very unstable.

Tasting the flavour at double the optimum dose rate will make unbalanced components horribly obvious. Once those problems are corrected, the flavour should, at last, be something that is ready to show to other people. As with everything else involved in flavour creation, opinions vary radically about when and how to solicit opinions from other flavourists, non-flavourists and sensory panels. One thing is certain – I do not know of a single instance of a really successful flavourist who works in complete isolation.

1.3.6 Unfinished work

An old saying cautions that you should 'never show fools or children unfinished work'. Like many old sayings, it has an uncomfortable kernel of truth. It certainly highlights a real dilemma for the aspiring flavourist.

Successful flavourists must be able to memorise and recognise a formidable range of raw materials. They must also have the ability to imagine the effect of complex mixtures and the creative spark to use these talents to make original flavours. A further essential requirement for this formidable being is an abundant helping of self-confidence. By self-confidence I certainly do not mean arrogance. Input from others is vital and it should never be treated with contempt. Self-confidence is essential to keep the flavourist sane in the face of well-meaning, but often contradictory, suggestions and criticism.

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Help for a trainee during the early stages of the creation of a new flavour is really the preserve of a mentor who is deeply involved in the project. There are always many different possible approaches to any problem, and it may not be obvious to other flavourists in which direction the trainee is trying to go. Their advice in the early stages of a project is likely to be wildly contradictory. Advice once the flavour has taken shape can be sought from a wide variety of sources.

Other flavourists can be very helpful in a number of ways. They can give quick, and often accurate, assessments based solely on blotters. They will often have original ideas of raw materials to try out. Some will work and some will not, but the extra source of ideas is invaluable. Other flavourists can often pick out mistakes that the originator has missed or, more frequently, has become too saturated with the flavour to notice. It is important to recognise that the advising flavourist is often making an impromptu suggestion based on a quick evaluation. However good the flavourists, their suggestions are not necessarily gold dust.

Sensory panels, especially expert panels, can be a valuable source of guidance on matches, hedonic ratings of new flavours and profiling. Panels are especially helpful in matching work. No flavourist is ever completely satisfied with a match of another flavour and a panel provides a reality check. Preference mapping, linked to profiling, can provide real insight into the best way to optimise a flavour for a specific consumer group. Simple sensory panels should be avoided as they all tend to lead in the direction of a bland, uninteresting flavour that offends nobody but, equally, excites nobody (see Chapter 11 for more detail on sensory testing methodologies).

Other, noncreative, staff can also be a useful source of criticism. It is often helpful to involve applications and sales staff. It is, after all, very difficult for sales staff to sell something that has not first been sold to them. Sensory panels and noncreative staff can rarely comment on blotters or simple tasters. The flavour must first be applied to a realistic end product.

1.4 APPLICATIONS

All flavours are used in end products that impose some requirements on the finished flavour because of interactions with the finished food. These interactions can be broadly grouped into four categories – ingredients, processing, storage and consumption.

1.4.1 Ingredient factors

The most important factor is the fat content of the finished product. Flavour chemicals vary in polarity and consequently in fat solubility. Taste thresholds in fat are much higher than in water. The partition of different components in a flavour may vary, and this can alter the balance of the perceived aroma. It is often possible to adjust the formulation, and the methods described in Chapter 10 have been used to measure aroma release and then rebalance flavours in foods with different fat contents (Shojaei *et al.*, 2006). However, an alternative approach is to avoid drastic differences in the polarities of the flavour components. In all foods containing fat, added flavour will slowly partition between the fat and the aqueous phases on storage. This effect can be partly avoided by adding separate flavours to the fat and the aqueous

phases, but this is a laborious approach and will rarely be sufficiently accurate to avoid subsequent partition effects. Care must be taken in application trials to store the finished food sufficiently long before tasting to allow the partition of the flavour to be substantially completed.

The lipophilic gum base in chewing gum has an effect similar to that of fat, but the problems are aggravated because the flavour is gradually extracted by chewing. If there are differences in the polarities of the flavour components, the chewing gum will appear to taste mainly of the most polar components at the start of chewing. Eventually only the nonpolar chemicals will be extracted. A completely fat-soluble flavour may be necessary for some applications. At the other extreme, entirely water-soluble flavours are essential for clear soft drinks. In both cases it is difficult to produce a balanced profile within a restricted range of polarity. In these examples it is sometimes helpful to depart from the essentially nature-based approach we have used so far. All flavourists should keep a reference record of the characteristics of all the raw materials they have encountered. This database can usually be used to find a chemical with a similar odour character to a problem raw material but with different physical or chemical properties.

Natural extracts and oils often contain chemicals with widely differing polarities. They can be processed by distillation, solvent extraction and chromatography to reduce these differences. The most common example of this type of process is the deterpenisation of lemon oil. Lemon oil contains about 90% of terpene hydrocarbons, which are nonpolar, low boiling and susceptible to oxidation, and contribute little to the overall flavour character. The oil also contains about 6% of oxygenated chemicals, which are polar, relatively high boiling and less susceptible to oxidation, and provide most of the flavour character.

The level of lemon oil that would be required to impart an acceptable flavour level to lemonade would result in a level of terpene hydrocarbons in the drink well in excess of their limit of solubility. The oxygenated chemicals would be readily soluble at this level, so a clear drink could be obtained by removing the hydrocarbons from the oil. Chromatography and solvent extraction are obvious possibilities. Distillation also works because of the difference between the boiling points of the terpene hydrocarbons and most of the oxygenated chemicals. Some loss of the true lemon character is inevitable owing to processing and the small, but significant, flavour contribution made by the hydrocarbons. This is more than justified by the gain in stability to oxidation. Solvent extraction generally gives better results than distillation because this method retains the most volatile aliphatic chemicals, which are responsible for the fresh, juicy character of many citrus oils, especially orange oil. Solvent extraction is discussed in more detail later in this chapter. Distillation, if it is used to produce a terpeneless oil, unfortunately also removes the high-boiling antioxidants that are present in cold-pressed citrus oils.

Major components of a flavour may themselves cause problems in a finished food. These problems are often changes in texture or in the stability of emulsions. The solvents are the most likely culprits, and in many instances a change of solvent will provide a cure. Where flavour dose rates are very high, particularly in chewing gum, individual flavour chemicals may also be responsible. When this happens, the flavour can often be modified, but sometimes the only possible solution is to modify the formulation of the application. This may also be an issue if the flavour necessarily contains large quantities of a food additive, for example, an acid. This could happen, for instance, in a natural flavour containing significant quantities of concentrated fruit juices.

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Carbohydrates in a finished food may have a binding effect under certain conditions, but this is not a frequent problem. The most obvious example is the loss of flavour in bread on storage because of flavour binding to the helices in starch molecules.

Flavour binding by proteins is a more serious problem. Most protein molecules are folded in such a way that the nonpolar amino acid side chains are on the inside and the polar groups are on the outside. Flavour chemicals can interact with the nonpolar interior regions of the protein and cause it to unfold. They can be bound into the protein by absorption at the protein surface or inclusion in the nonpolar interior. Protein flavour binding is most evident in processes involving heat and is most pronounced with carbonyl flavour chemicals. Chemical interactions and partitioning effects make it essential to wait at least 24 hours before tasting some applications.

1.4.2 Processing factors

Minor effects from processing include those from filtration, aeration and freezing, but by far the most important factor is heat. This may cause chemical changes in the flavour, but the main problem is the loss of volatiles. This may have the effect of reducing the fresh top note of a flavour. If the key recognition chemicals have widely different boiling points, heat could render the flavour unrecognisable. The choice of solvent can reduce this problem. In some instances, volatile chemicals may be replaced by higher boiling analogues. It is usually possible to change the balance of the flavour to allow for differential losses, but this solution gives a flavour that is suitable for only a limited range of applications. In processes involving considerable heat, such as bakery and extrusion, the best solution is multiple encapsulation. In this process a spray-dried flavour is coated with a high-melting-point fat. This process protects the flavour until the fat melts. Chapter 6 introduces the key concepts required to encapsulate flavours effectively.

1.4.3 Storage factors

Some wines and cheeses improve with age, but they are the exceptions rather than the rule. Flavour stability in an application should ideally at least match the shelf-life of the food itself.

When a flavour is added to food, some chemical changes, such as the hydrolysis of acetals, occur quite quickly. There are frequently subtle differences in flavour character after only one day. In the longer term, oxidation is responsible for most of the changes in flavour during storage. When most flavour chemicals oxidise, the effect is simply perceived as loss of flavour because the flavour chemical has a much stronger odour than its oxidation products. When some incidental components, such as the hydrocarbons in a lemon flavour, oxidise, the effect is often perceived as an off-note. Substitution of flavour components with more stable alternatives and the use of antioxidants usually reduce the problem to manageable proportions.

Migration of flavour chemicals into or through food packaging materials can sometimes occur. It may lead to a detectable loss of flavour or cross-contamination problems. A change in packaging material is the best cure, but, if this is not possible, it may be practical to reformulate the flavour without the problem of chemicals. This may change the profile of the flavour.

Tea bags present a very specific packaging problem because of the size of the holes in the tea bags. Liquid flavour can be spread directly onto tea leaves, but this leaves the flavour very prone to oxidation and evaporative losses. Spray-dried flavours need to be agglomerated to prevent them from falling through the holes in the tea bags. Tea dust can be included in the agglomerated flavour to give it a similar appearance to the tea in the bags. Tea used in tea bags is generally of small particle size, and care needs to be taken to ensure that the size of the agglomerated flavour particles matches that of the tea.

1.4.4 Consumption factors

Many of the processing problems can resurface when the food is consumed. This is particularly common when a powder flavour is used in a dry convenience food. The final factor that may influence the formulation of the flavour is the temperature at which the finished food is consumed. At temperatures below room temperature, as in the case of ice cream, the intensity of the whole flavour is reduced. The intensity of the most volatile chemicals is reduced relatively more than the rest of the flavour, and they may need to be increased. Caution should be exercised because the food can warm up in the mouth. Foods that are consumed hot are more difficult to flavour. The high temperature increases the intensity of the flavour, particularly the more volatile chemicals. At the same time it may cause a relatively greater loss of the same components.

1.5 FLAVOUR FORMS

Liquid and powder flavours can be split into a number of major types, each of which poses some specific problems for the flavourist.

1.5.1 Water-soluble liquid flavours

These are by far the most common types of flavours. The flavour chemicals and natural components are dissolved in a simple solvent, most commonly propylene glycol, triacetin or ethanol, with the possible addition of water.

If the flavour contains significant amounts of solids, such as vanillin or maltol, then the quantities added must remain well within their limit of solubility. Storage conditions can be much harsher in real life than in a laboratory, and a large safety margin should be built in. The same consideration should be applied to the nonsolid components of the flavour, but problems are not as common in this area.

Propylene glycol is usually the solvent of choice. It is stable, virtually characterless in use, and confers some stability in applications involving heat processes. The drawbacks of propylene glycol are that it is not a strong solvent, that it is not natural, that the levels of use are restricted in some countries, and that it forms acetals and ketals quite readily with carbonyl flavour chemicals. Acetal and ketal formation can be inhibited by the addition of water to the flavour, but this makes an already weak solvent even weaker. Acetals and ketals can actually be useful in some applications because they may protect the parent carbonyl from oxidation during storage of the flavour. They will later break down to release the parent carbonyl in many applications in the presence of water. The most serious problem deriving from acetal and ketal formation is that many acetals and ketals are only poorly soluble in

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propylene glycol. This can result in the puzzling phenomenon of an initially clear flavour, gradually phase separating and forming two layers.

Ethanol is also widely used, especially where there are no duty handicaps (many countries impose high taxes on ethanol). It is relatively stable, has a mild but pleasant character in use, is readily available in a natural form, and can be diluted significantly with water. The drawbacks are relative instability in applications involving heat processes, religious restrictions in some countries, flammability and the formation of acetals and ketals. The last factor is less important because ethanol is a strong solvent and can still remain effective if sufficient water has been added to inhibit acetal and ketal formation.

Triacetin is not a solvent of choice for most applications. It is not very water soluble, and when it does dissolve, it decomposes to glycerol and acetic acid. Triacetin has a slight bitter taste and acetic acid has a noticeable 'vinegar' odour. Triacetin can be the solvent of choice when water solubility is not critical (as in many confectionery applications), when propylene glycol is restricted, when the components of the flavour will not dissolve readily in ethanol or propylene glycol and, most importantly, when propylene glycol has an undesirable effect on the texture of the finished food.

Chewing gum is the most important example. Propylene glycol hardens chewing gum, but triacetin acts as a plasticiser. Water is not added to triacetin-based flavours because it would hydrolyse the triacetin.

Other solvents may be useful in specific cases. Triethyl citrate is similar in many respects to triacetin. It is poorly water soluble, but is odourless and confers heat stability. The major difficulty with triethyl citrate is the bitter aftertaste, which severely restricts the level of use. Diacetin is also similar to triacetin but is generally less effective. Glycerol is a very weak solvent but can be used effectively in conjunction with ethanol in natural extracts to confer some heat stability. Lactic acid is not generally a very effective solvent but can be useful, in mixtures, for some problematic raw materials, especially maltol. Benzyl alcohol has a faint floral character and is a good solvent but is prone to oxidation to benzaldehyde. Benzyl benzoate is stable and relatively odourless. It can be used in solvent mixtures, especially for oil-soluble flavours, but has an unpleasant flavour at high levels. Many of these lesser solvents are not universally recognised as solvents. They may be permitted as flavouring ingredients, but care must be taken of the level of use.

1.5.2 Clear water-soluble liquid flavours

This category is very similar except for the requirement that the end product, usually a beverage, should be crystal clear. Most flavour raw materials are entirely water soluble at their normal level of use. The exceptions are limited to a few chemicals that need to be used at relatively high levels (usually esters), chemicals that can form insoluble polymers on storage and terpene hydrocarbons. Terpene hydrocarbons are found in many natural essential oils. They have limited use as flavouring ingredients (there are exceptions, such as myrcene), and they are prone to oxidation.

The hydrocarbons can be removed from essential oils by distillation, chromatography or solvent extraction. The most effective method is solvent extraction (often called 'washing') because it causes least change in the character of the original oil. The most effective solvent is a mixture of ethanol and water, but propylene glycol can also be used. The extraction is carried out by dissolving the oil (for example, orange oil) in ethanol, adding water to throw out the hydrocarbons (commonly called 'terpenes'), chilling the mixture and allowing it to stand for 2 days. The terpenes float to the top of the mixture, which can then be drawn off

and filtered. A little extra alcohol is added as the final stage to prevent the flavour becoming cloudy if it is stored in the cold.

The process can be speeded up by the use of a coalescer, a metal mesh that coalesces the oil droplets. Propylene glycol 'washings' are difficult to make because of the viscosity of the solvent and the small amount of water that can be added. The use of a coalescer is virtually essential to make propylene glycol-based 'washings'.

A surprising, but effective, alternative way to produce clear beverages is through the use of low-payload, small particle size emulsions. The flavour must contain only very limited amounts of terpene hydrocarbons for the process to work. This method is widely used for cola flavours.

1.5.3 Oil-soluble liquid flavours

Oil-soluble flavours are needed where the end product is an oil or a fat. They are also used where the end product cannot tolerate water. Both ethanol and propylene glycol contain small amounts of water, so these solvents cannot be used in water-sensitive products such as chocolate. Natural or synthetic (medium-chain triglyceride) vegetable oils can be used as solvents. The problems are susceptibility to oxidation (for the natural oils) and poor solvent power. Many of the chemicals that are important for taste effects are highly polar and poorly soluble in oils.

Some of the minor solvents discussed earlier, such as benzyl benzoate and triethyl citrate, can be particularly effective in oil-soluble flavours. They all have some drawbacks and may be more effective when used as mixtures. If this does not work, one possible solution is to dispense with traditional solvents altogether and use the major components of the flavour to dissolve the solids. This is not always possible without adding excess quantities of weak-tasting esters such as ethyl acetate. When it can be done, the resulting flavour may be highly concentrated and very difficult to dose accurately in an industrial environment.

Essential oils can be effective 'solvents' for some oil-based flavours. This is especially true of citrus flavours. The natural oil gives a realistic, complex background and added flavour ingredients give powerful specific character.

1.5.4 Emulsion-based flavours

Emulsions, based for example on orange oil, are often used to give cloud to a beverage, but they can also be a cheap and effective way of delivering a flavour where cloud is not an issue. The water-soluble components, such as vanillin, can be dissolved in the gum solution (typically gum arabic or modified starch is used as emulsifiers), and the remaining components can be mixed together to form an oil phase, which is then emulsified. Potential problems include the clumping or separation of the oil phase, the hydrolysis of susceptible flavour ingredients and the microbiological stability of the emulsion over an extended period, especially once the container has been opened. Ideally, for these applications, the oil phase should constitute around 5% and certainly not more than 10% of the emulsion.

1.5.5 Dispersed flavours

Dispersions are a similar, cheap and cheerful, way of delivering flavours in powder form. If all the ingredients are solids, they may be mixed together and diluted with a carrier such

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as lactose. If some of the ingredients are liquids, they are mixed together and spread on the carrier before the solids are mixed in. This method works if all the ingredients are relatively high boiling and not susceptible to oxidation. Even so, it produces flavours with a relatively short shelf-life and it is difficult to mix the flavours so that they are entirely homogeneous.

1.5.6 Spray-dried flavours

Spray-drying is the method of choice for powder flavours (see Chapter 6 for the mechanisms of flavour encapsulation). The flavour is typically emulsified in an aqueous gum solution, and then dried by spraying into a hot chamber. This method is preferable to dry mixing because the resulting flavour is stronger and much more stable to evaporation and oxidation.

Spray-drying works so well because the sprayed droplets form a semipermeable shell very quickly, long before most of the water has evaporated. The semipermeable shell allows water to pass, continuing the drying process, but is relatively impermeable to most flavour components. This is true of even the smallest flavour molecules, such as ethyl acetate and acetaldehyde. Only a small proportion of the ethyl acetate or acetaldehyde added to a flavour survives spray-drying, but, without the effect of the semipermeable shell, logic would dictate that the loss on drying would be virtually 100%.

Flavourists are not expected to be experts in the area of spray-drying and the many variants of this technique, but they should know enough to get the best out of the process. The first issue is the way the flavour is added to the emulsion. The criteria are much the same as those for liquid emulsions, except that there is no need for the emulsion to be stable in the long term. The ingredients of the flavour should be split into water-soluble and oil-soluble keys. The water-soluble components should be dissolved in the gum solution. The oil-soluble components should be emulsified in the resulting mixture. This emulsion does not need to be stable for longer than it takes to dry the batch, but it should be emulsified to a reasonably small and uniform particle size. Poor emulsification will result in more surface oil, flavour loss and susceptibility to oxidation. Some solvents should not be used in the formulation of the keys. Ethanol will increase the flavour loss, and propylene glycol (in more than trace amounts) will make the powdered flavour hygroscopic. Triacetin works well in most instances. The maximum loading of the oil phase is around 30% of the dry weight, but drying losses increase steeply after 20%, as does the amount of surface oil. For cost-effectiveness, 20% is a good maximum to aim for.

The second issue is the composition of the gum solution. Gum acacia is the most widely used material, although some modified starches can give equally good results. Gum acacia varies widely in quality and care should be taken to buy 100% pure gum from a reputable source. The cheap gum that has been cut back with filler is always of poor value. The flavourist should be free to control the proportion of pure gum used. It is a waste of money to use 100% gum acacia as the carrier. In spray-dried flavours, 30% is the absolute maximum quantity of gum needed for even the most challenging applications. In many cases as little as 10% is all that is needed to form the semipermeable film during drying. The filler, usually maltodextrin, is important because a high dextrose equivalence is needed to make the shell of the spray-dried particle less permeable to oxygen. One unintentional advantage of using reduced levels of gum acacia is that the viscosity of the emulsion is lower. This allows the solid content of the emulsion to be increased, while still keeping to a viscosity level that can be handled readily. Higher solids mean more throughput and less energy costs.

The third issue is the processing conditions. They should ideally be set for each flavour. The emulsion should not be warm because this will damage the flavour. The inlet temperature must be adjusted so that particles hitting the sides of the drier do not stick. In general, the best results are obtained with the highest inlet temperatures and the highest throughput. The outlet temperature should be reduced as much as possible, but not so much that the spray-dried particles contain significant moisture when they leave the drier.

1.6 PRODUCTION ISSUES

One of the most difficult challenges facing flavour companies is the link (or lack of it) between the creative flavourists and the production staff. It is possible to sidestep the issue by introducing a complete department to sort out problems, but it is obviously much better not to have them in the first place.

More thought should be given during the training of flavourists to the possibility of a spell in production. QC training is often included, but nothing beats getting your hands dirty and learning about the practical issues first hand.

The first issue is the total number of raw materials available for use. A sensible number can be reached by adding to the number of GRAS (generally recognised as safe; see Chapter 2 for information on the legal status of flavours) and European raw materials (around 3500), the number of sensible variations of natural products (around 500) and the legal variations (natural, organic, kosher, etc.) (around 1500). A sensible maximum is 6000. Not many companies can boast such a small list, but the cost, quality and service problems associated with large raw material lists are formidable.

The total number of flavour formulations is also often quoted by production as a key problem metric, but it is only a problem if the operations function is so inefficient that it is necessary to keep stock of finished flavours. Very few flavours are now sold off-the-shelf and the tailor-made flavour is becoming the standard. It makes much more practical sense, and it is much more cost-effective, to concentrate on controlling the number of raw materials.

The second real issue is the number of raw materials in any individual formulation. It is simply not possible to justify more than 100 ingredients in a flavour. Depending on the type of flavour, the optimum number of ingredients can vary between 15 and 100 but in most cases the best effect is obtained using between 15 and 50 ingredients. The cost of compounding and the service problems associated with very complex flavours are both serious issues.

Accurate compounding in a production environment is very different from the situation in a laboratory. The use of solutions should be tailored to production needs and kept to a minimum necessary for accurate weighing. Old solutions should be discarded. The use of a single key ingredient may be helpful in some instances to separate out all the very low-volume items. Outside this restricted context, the use of keys and the blending of flavours in general are real headaches for production. They are also, frankly, indicative of lazy work on the part of the flavourist concerned.

The correct compounding order may be obvious to the flavourist, but it must be specified in a formulation to assist production. Other important notes are the need to filter (which can often be avoided by better selection of raw materials or more careful formulation) and full details of any processes. The originating flavourist should always be involved in the quality control testing of the first batch in case there are problems scaling up the flavour.

1.7 REGULATORY AFFAIRS

Flavourists should receive extensive training on regulatory issues, not simply the widely varied global flavour regulations but also the implications for finished foods and labelling (see Chapter 2 for further information on the safety and legislation of flavours). With the current time scales for projects, it is not practical to expect that a final regulatory check should be anything more than a safety net. A generally conservative approach should be taken, and wherever possible GRAS ingredients should be used. The regulations in Europe and the US are increasingly well harmonised, so this restriction is usually practical. For any country, the IOFI (International Organisation of the Flavour Industry) guidelines represent the minimum standard, irrespective of the lack of local regulations. Natural certification of raw materials should not be accepted without critical evaluation. Natural standards vary by country and common sense should be applied.

1.8 A TYPICAL FLAVOUR

Raspberry flavour is a good learning tool. It is relatively simple, but not so simple that it does not contain a multitude of useful lessons. To illustrate the process of flavour creation, we will work on an imaginary, but typical, customer project. The task at hand is to create a nature-identical flavour, with a profile, that the customer has described as true to nature, fresh and red. The end use is hard candy.

Let us imagine that the flavourist has two analyses to work from. One derived from the analysis of an extract from the fruit and the other derived from the analysis of the headspace over the fruit. In these two, hypothetical analyses, 362 different chemicals have been identified, 271 in the extract analysis and 203 in the headspace analysis. In both cases the quantification is expressed as a percentage of the total volatiles. The headspace analysis is also quantified with an added vapour pressure correction. Table 1.1 gives the quantification of those chemicals from the analyses that we will consider using to create a simple flavour.

The first step is to decide which chemicals in either analysis represent primary characteristics. In the case of raspberries, the violet note is clearly essential. The analyses contain both α -ionone and β -ionone. α -Ionone has a clean 'violet' note and β -ionone has a 'violet' note in addition to a strong 'cedar' note. To keep things simple there is an obvious temptation

Table 1.1 Flavour components identified in analyses of raspberry flavour.

Cost (in order of appearance)	Extract (%)	Headspace (%)	Vapour pressure adjusted (%)
α -ionone	4.00	0.70	8.000
β -ionone	1.80	0.50	9.500
4-Hydroxyphenylbutan-2-one	0.50	—	—
Damascenone	0.05	0.02	0.150
Dimethyl sulfide	0.02	1.50	0.001
Acetyl methyl carbinol	0.50	0.20	0.002
Ethyl acetate	5.00	9.80	0.040
<i>cis</i> -3-Hexenol	8.00	0.60	0.030
<i>cis</i> -3-Hexenyl acetate	0.02	0.04	0.010
δ -Decalactone	0.60	—	—

to ignore the complications of β -ionone and work with α -ionone alone. This simplification might work, but it is probably unwise. The 'cedar' note of β -ionone generates a 'pippy' or 'seedy' effect in raspberry flavours. This note is hardly a primary characteristic, but it is normally attractive. If β -ionone is ignored at this stage, then a later correction to add a 'seedy' note will necessitate a rebalancing of the 'violet' character.

The next step is to establish an estimate of the correct concentration of the 70/30 mixture (these proportions are derived from the extract analysis) of α -ionone and β -ionone using a simple taster. A good starting level would be 0.25 ppm (part per million or milligram/kilogram). The most common dilution of flavours in beverages is 0.05% rtd (ready to drink). This is equivalent to 0.035% α -ionone and 0.015% of β -ionone in the flavour.

The other primary characteristic is not quite so easy to identify. The flavour of α -ionone alone is simply 'floral, violet'. The missing character should confer a specifically 'berry' note. The only feasible candidate in the analyses is 4-hydroxyphenylbutan-2-one. This chemical has a distinct 'berry' aroma, even a specific hint of raspberries. Again trial and error can be used to establish a good balance between these two chemicals. A good starting level would be around 2% in the flavour, but later in the process this will prove to be too high (once other ingredients with somewhat similar characteristics have been added) and the final level is 1%.

At this stage we already have a recognisable raspberry skeleton. We can move on to the optional, secondary components. The customer wants a true-to-nature character, but also describes the target as 'red' and 'fresh'. Neither of these descriptors is very specific, so the flavourist has to try to guess the customer's wishes. This dilemma is very common and illustrates the need to work with customers to establish specific descriptors.

'Red' can reasonably be taken to mean red raspberries rather than black (so no musk character), ripe rather than unripe (so ripe, 'fruit' notes and restricted 'green' notes). 'Fresh' can be taken to mean an absence of 'jammy' or 'cooked' notes. It might also indicate high 'green' notes, which certainly confer freshness. A more moderate level of 'green' notes is probably a good idea because 'red' was also specified. High levels of 'green' notes, especially 'raw, green' notes, give an unripe effect.

A good choice for the red 'fruit' note is the 'damson' character of damascenone. This chemical is found widely in nature and is, justifiably, a favourite with flavourists. The 'damson' character of damascenone adds richness and a deep 'fruity' character to our fledgling raspberry flavour. Taking the extract analysis as a guide (damascenone is fairly high boiling), the levels of the ionones used in the flavour indicate a level of 0.0004% of damascenone in the flavour. This seems very low indeed. To obtain the correct character we must increase the level in the flavour to 0.04%. Dimethyl sulfide is also an excellent ripe 'fruit' note in dilution, although at high levels it has a 'cabbage' character and can make the flavour seem cooked and 'jammy'. The addition of dimethyl sulfide also improves our flavour dramatically, but 0.01% is the most we can add before the character becomes slightly 'jammy'. This is, however, far more than the level indicated by the vapour pressure-corrected headspace analysis.

The 'buttery' note of acetyl methyl carbinol will also, surprisingly, add to the 'ripe', 'red' character. The concentration that would be required in the flavour, on the basis of the amount found in the extract analysis, relative to α -ionone, is around 0.005%. This level works well and provides the required note.

The final 'fruity', 'red' note is ethyl acetate. The headspace analysis indicates a very low level, but the extract analysis (which would be expected to give a low result) indicates a level broadly similar to that of α -ionone. Increasing that level a little to 0.10% in the flavour gives an attractive result.

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The most obvious green note is *cis*-3-hexenol, but this chemical has a ‘leaf, green’ character, similar to fresh-cut grass. Like damascenone, *cis*-3-hexenol is found very widely in nature and is often the first choice when a ‘fresh’ character is desired. We could add a low level of *cis*-3-hexenol, but we would run the risk of introducing an ‘unripe’ note. A much better choice for this flavour would be *cis*-3-hexenyl acetate, which has a softer ‘fruity, green’ character and very little unripe note. The analyses would indicate a low level of *cis*-3-hexenyl acetate, but a higher level is necessary because we are not adding any *cis*-3-hexenol. In practice, the ideal level is 0.02% in the flavour.

This flavour will smell reasonable but taste very thin. Only two components of the flavour so far have a significant taste effect – damascenone and 4-hydroxyphenylbutan-2-one. The flavour has a degree of ‘berry’ depth of taste, but needs added ‘sweet’ character. The addition of 2% of maltol (not found in the analysis) will help to solve this problem, but is obviously not the ideal solution. Maltol has a ‘candyfloss’ aroma and imparts a lingering sweet aftertaste. It adds depth, but is too a simple character. One other addition that will help to add depth is δ -decalactone. This chemical has a ‘creamy’ character and trial, and error establishes an ideal concentration in the flavour of 0.05%. This level is higher than that indicated by the extract analysis.

The flavour we have developed thus far is much too simple and will taste like an obvious mixture of separate notes. The addition of a small amount of jasmine absolute (0.02%) will add complexity and traces of desirable ‘berry’ (from benzyl acetate), ‘lavender’ (from linalool), ‘animalic’ (from indole) and ‘jasmine’ (from methyl jasmonate) notes.

The final stage in the creation of our very simple raspberry flavour is to make allowances for the processes involved in making hard candy. The only factor is heat, so the most volatile components must be increased to allow for the losses in processing. Ethyl acetate should be increased to 0.20%, dimethyl sulfide to 0.02%, acetyl methyl carbinol to 0.009% and *cis*-3-hexenyl acetate to 0.03%.

In real life, the process of developing this flavour would be much more complicated, but this simple example serves to illustrate the principles involved. The composition of the final flavour is compared to the two analyses in Table 1.2.

The analyses help, but they are a long way from the quantification of the finished flavour. This example illustrates the high level of creative input, even when analyses are taken as the starting point.

Table 1.2 Comparison of raspberry flavour analysis (from Table 1.1) with formulation of a raspberry flavour suitable for hard candies.

Cost (in order of appearance)	Extract (%)	VP adjusted (%)	Flavour (%)
α -Ionone	4.00	8.000	0.035
β -Ionone	1.80	9.500	0.015
4-Hydroxyphenylbutan-2-one	0.50	—	1.000
Damascenone	0.05	0.150	0.040
Dimethyl sulfide	0.02	0.001	0.020
Acetyl methyl carbinol	0.50	0.002	0.009
Ethyl acetate	5.00	0.040	0.200
<i>cis</i> -3-Hexenol	8.00	0.030	—
<i>cis</i> -3-Hexenyl acetate	0.02	0.010	0.030
Maltol	—	—	2.000
δ -Decalactone	0.60	—	0.050
Jasmine absolute	—	—	0.020

1.9 COMMERCIAL CONSIDERATIONS

1.9.1 International tastes

We are all accustomed to rapidly increasing globalisation, and with it the assumption that one product can be sold in all markets. There are cases where, with sufficient advertising, this is manifestly true. In most cases, however, the assumption does not hold. Regional tastes for most of the key flavour types still override global stereotypes. The regional tastes are often derived from historical familiarity and may fade in time, but, for now, they are very important. The main regional preferences for the most important flavour categories are summarised as follows:

Beef: Roast beef is the preferred profile in the UK. Grilled beef reigns supreme in the US, and in much of Asia boiled beef is the main profile.

Cheese: Cheddar is far and away the most important type of cheese in terms of flavour sales. Blue cheese and Parmesan are very small categories compared with Cheddar. Cheddar can be broken down into two main types by region: sharp and mild. Sharp Cheddar is best defined (ironically) by aged US or Canadian Cheddar cheese and represents the target profile in Europe. The taste preferences of US consumers are very different. In this region a mild, creamy, buttery character is preferred.

Cherry: In Europe the hawthorn note of Morello cherries is preferred, but in the US benzaldehyde is the prominent character.

Chocolate: Milk chocolate predominates in most markets outside Europe and the milk component often has a cooked character. Some popular milk chocolates also have an added signature note such as cinnamon or almond. Dark chocolate is popular in Europe and can have pronounced burnt and bitter characteristics in this market.

Lemon: In the UK especially, but also in much of Continental Europe, a high citral level is liked. The European taste also likes an exaggerated level of jasmine character. In the US, lemon is milder and more floral, and in much of the rest of the world citral is the defining note, sadly, sometimes accompanied by the waxy character of oxidised oil.

Mango: As with most other tropical fruits the situation is the exact reverse of berry flavours. The genuine character, with its strong terpene, skin note is preferred in Asia and Latin America. In Europe and the US a pale imitation flavour is preferred, with much reduced skin and sulfur notes and an emphasis on melon and peach.

Milk: Fresh milk and dairy flavours are optimum in the US and Europe. In Asia a boiled, condensed milk note is preferred, and in Latin America the even more caramelised 'dulche de leche' is ideal.

Orange: In Europe there is the strange contradiction that the flavour of processed juice is liked, presumably for nostalgic reasons, together with the pungent, fresh note of acetaldehyde. An exaggerated hint of violet is also liked in many orange flavours for confectionery. Fresh juice character is popular in the US and, for the rest of the world, cold-pressed orange peel oil is the most popular character.

Raspberry: In the US a strong violet character is preferred, but in Europe this note is muted and balanced by fresh and green characters. In Asia real raspberries are a rarity and an old-fashioned candy character is preferred.

Strawberry: At first sight, strawberry would seem to be easily standardised. Not so. It is one of the most difficult flavours to fit into its many regional variations. In the US, strawberry is generally sweet and slightly jammy. Green notes are not liked. In most of Europe the preferred character is fresh and distinctly green. Within Europe, the French taste is

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for a pronounced jasmine note and the Spanish taste is for strawberry jam. In Asia the preferences are more abstract and old-fashioned because of relative unfamiliarity with the real fruit.

Vanilla: Alcoholic genuine vanilla extract, with rum and fruity overtones, defines the US taste. In France the taste veers towards a creamy hawthorn note, similar to the rare Tahitian natural vanilla extract. In Germany a hint of balsam is appreciated, and in much of northern Europe, a simple vanillin taste is preferred. The UK preference is for a distinctly buttery note.

1.9.2 Abstract flavours

Most flavours have an obvious natural target. The flavour may be realistic or have a degree of abstraction, especially for children's products. Many flavours, such as lemon-lime, are blends of recognisable natural targets. Very few flavours are basically abstract. The most important examples are cola and tutti-frutti.

Cola flavours are all quite complex blends. The main characters are distilled lime oil, cassia oil, nutmeg oil and vanilla extract. In some instances, the caramel colour also contributes a characteristic flavour. The flavour ages very quickly in the bottling syrup because of the high level of phosphoric acid. Matching cola flavours is especially difficult because of the noticeable change in flavour in the syrup and the need to age the syrup before evaluation.

Tutti-frutti flavours, in contrast, are quite widely varied. The main characters are banana, orange, pineapple, vanilla and berries. They can be classified into two broad types – those based on banana and those based on berries. The banana family is usually built around isoamyl acetate and the berry family is usually built around α -ionone.

There are other interesting, but less commercially important, abstract flavours. Root beer was originally based on sassafras oil, vanilla and methyl salicylate, as well as a host of minor ingredients. Sassafras oil has not been used for many years (because it contains safrole over which there are safety concerns) and the substitutes vary in effectiveness. Sarsaparilla and dandelion and burdock are similar products. Cream soda flavours were similarly modified in line with regulatory requirements and now consist of vanillin with lactone-based hay and cream notes. Cachou flavours are intensely perfumed and are often based on combinations of violet, rose and musk.

Another, accidental, category of abstract flavours is the group of the best of the flavours from the early years of the industry. They were often not exactly recognisable, but were triumphs of artistry over paucity of raw materials and became standards in their own right. Blackcurrant and cherry flavours are good examples. Early blackcurrant flavours were based on one simple raw material, buchu leaf oil. This raw material reproduced nothing more than the 'catty' character of blackcurrants and it was unpleasantly harsh and minty. Creativity improved this simple base by adding a mixture of ingredients, most importantly vanillin and α -ionone. The harshness was covered and the pleasant abstract confection is still the basis of many blackcurrant-flavoured foods today. The character is not close to blackcurrants, but it is an instantly recognisable standard.

Early cherry flavours relied on benzaldehyde in a similar way and were not particularly attractive. Creativity gradually improved on this ingredient and evolved a complex flavour with anisaldehyde and para-methoxy acetophenone as the main additions. This flavour type is exceptionally attractive. It is not close to any known variety of cherry, but it is still immensely popular.

1.9.3 Matching

No project is less welcome to the typical flavourist than one that requires matching. The very idea of matching someone else's work is profoundly unattractive. Improving on someone else's work is quite another matter and represents a real challenge, but simple matching is boring.

Behind the flavourist's manifest hostility is not just the simple lack of challenge and novelty; there is also the commercial fact that matching work represents by far the least rewarding use of creative time. Most matching projects are obtained by novice sales staff as a way of gaining entry to the account. Most successful matches are simply used to pressure the existing supplier to reduce prices. Very few product managers will risk changing the flavour of a successful consumer product to save a few cents, especially when it must involve expensive consumer trials. Some very successful flavour companies will generally not accept matching projects, and it is not evident that their customer standing has suffered as a result.

Despite all the objections, there are occasionally good reasons to carry out matching work. The customers may have become genuinely hostile to their current supplier and wish to change at any price. The need to carry out matching may also derive from a reduction in the number of suppliers in a core supplier programme. The customer may wish to duplicate a competitor's existing consumer product, although this type of project is more often directed towards beating the existing product.

Matching generally starts with an analysis. Normally, it will be a direct analysis of the existing flavour, if the customer is serious. In some cases it will be a consumer product. Once the analysis has been completed, it should be reconstituted and reanalysed (in consumer product if necessary) to pick up errors in identification and quantification. This corrected analysis represents the starting point for the flavourist. The target flavour will often contain natural extracts and essential oils, so the first job is to allocate all the components derived from natural sources correctly. This is usually a matter of experience and the analyst should also be able to provide some guidance. The trickiest part is usually trying to determine which processes (solvent extraction, concentration, etc.) have been applied to the natural raw materials. Trial and error, as well as quite a few reanalyses, overcome this hurdle. The major chemical components should be identified and quantified from the analysis. It is often helpful to carry out liquid chromatography of the main chemicals to improve the accuracy of the quantification.

One issue that is often forgotten is the need to get the solvents in liquid flavours identified and quantified correctly. Flavourists sometimes assume that they will not be important in the end product. That is not always true, but incorrect solvent balance always hinders rapid evaluation of matches on blotters.

All that remains are the trace components. Unfortunately, this is often where most of the problems lie. Traces of sulfur chemicals, for example, can be very difficult to pick up on analysis, but can be a vital part of the flavour.

Matches are often carried out under severe time pressure and it is easy to become stale and run out of ideas. Involving other flavourists is a must and can be especially helpful in generating ideas about the identity of missing trace components. It is also useful to have available a bank of analyses of flavours from the same competitor. In many companies the same ideas are trotted out with surprising regularity.

Sensory panel work is essential to validate the accuracy of the final match. It may also help persuade the customer to accept the change. Caution should be exercised about blindly

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accepting routine panel results. If a very close match is required, an expert panel may be needed.

1.9.4 Customers

A flavour is, sadly, nothing, if it is not sold. Part of the tremendous ‘buzz’ of being a successful flavourist is the feeling of having created something really good. The other part of the ‘buzz’ is seeing your product on the supermarket shelves, enjoyed by thousands, or perhaps millions, of people.

The best flavourists do not divorce themselves from customer involvement and the art of selling. Most successful flavourists reach the inescapable conclusion that they are the best judge of the market and the best flavour for a specific project. This conclusion has some basis in fact, but the sad truth is that customer involvement is usually the key to success. Customers usually do know their own market best and especially their own brands. They should be encouraged to guide the creative process and take a genuinely active part in the overall profile of the finished flavour. One additional advantage of this approach is that the customers buy into the process and regard the resultant flavour as ‘theirs’, not without some justification.

The only barrier to this approach is the communication problem. If the project has passed through intermediaries (sales, marketing, etc.) then communication is very difficult, however thoroughly the project information has been gathered. The use of intermediaries also wastes a considerable amount of time that could otherwise be put to good creative use. The only practical solution is direct contact between the flavourist and the application specialists in the customer’s laboratories. Descriptive terms need to be defined and understood and simple examples (such as *cis*-3-hexenol for ‘leaf green’) can help a great deal.

Knowledge of the customer’s application processes is also needed, and the involvement of an application specialist from the flavour company is often vital. Problems are often caused by the interactions between the flavour and the application ingredients and processes. In many cases a small change to the customer’s formulation or process can save the day.

Sensory evaluation can play a useful part if it is used in the right context. This is particularly true when expert panels are used to divine the precise flavour profiles preferred by a target market segment. This is usually a specialised area where the flavour company probably has more depth of knowledge than the customer.

Most projects go through a number of iterations before they are concluded successfully, and it is vital in this process to remember that ‘the customer is always right’.

1.10 SUMMARY

Flavour creation is still more of an art than a science. Science provides a vital understanding of nature and a broad palette of raw materials. Science may also provide insights into the preferences of a target group of consumers and some understanding of the mechanisms of taste and smell, but science cannot yet replace the intuitive, creative skills of a good flavourist. Readers requiring more information on the art of flavour creation can find more information in *Flavor Creation* (Wright, 2004).

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