

Table 1. Key odorants in chocolate and their probably origins

| Odorant | Probable source |
|--|-----------------------------|
| vanillin (24) | Vanilla or synthetic |
| 3-methylbutanal | Cocoa mass |
| 2-ethyl-3,5-dimethylpyrazine (20) | Cocoa mass |
| 5-methyl-2-hepten-4-one | Nut paste |
| 2-ethyl-3,6-dimethylpyrazine | Cocoa mass |
| 2,3-diethyl-5-methylpyrazine (21) | Cocoa mass |
| <i>trans</i> -2- <i>cis</i> -6-nonadienal | ? |
| <i>cis</i> -2-nonenal | Cocoa mass |
| 2- and 3-methylbutyric acids | Cocoa mass |
| methyl 2-methyl-3-furyl disulphide (23) | Cocoa mass |
| <i>trans</i> -2- <i>trans</i> -4-nonadienal | Cocoa mass |
| <i>trans</i> -2- <i>trans</i> -4-decadienal (19) | Cocoa mass? |
| <i>R</i> - δ -Decalactone (26) | Milk solids |
| 1-octen-3-one | Milk solids or thermolysis? |
| dimethyl trisulphide (22) | Cocoa mass or thermolysis? |
| <i>trans</i> -2-nonenal | Cocoa mass |
| phenylacetaldehyde (25) | Cocoa mass |
| <i>R</i> - δ -octalactone | Milk solids? |
| ethyl cinnamate | Cocoa mass |
| γ -decalactone | Milk solids? |

cation; sexual attraction between an animal and its food is unlikely to be a successful evolutionary strategy.

2. To find/identify food: At first sight, this is the “obvious” explanation. However, most of the high impact aroma chemicals are formed only when food is cooked; because the cooking of food is of very recent provenance in evolutionary terms, it is unlikely that we have evolved any physical features to respond to this. Some high impact materials are found in fruits, but again, the chemical may only be released when the fruit is actually being eaten; for example allyl disulfide and the other allium sulfides are only released only when the tissues of the garlic clove have been damaged, and a cow certainly doesn’t smell of roast beef.

“Why are we so sensitive to these aroma chemicals?”

3. To avoid toxins: There are three main sources of toxins: those present in the environment, those produced as an organism’s waste and those produced by the decomposition of food. It is this latter area that gives a clue that this may be the cause of the response to these high impact chemicals; the group of compounds to which we have the greatest sensitivity is mercaptans, and these are produced by the decay of cysteine and methionine in proteins. This

Figure 21. Chocolate’s savory side

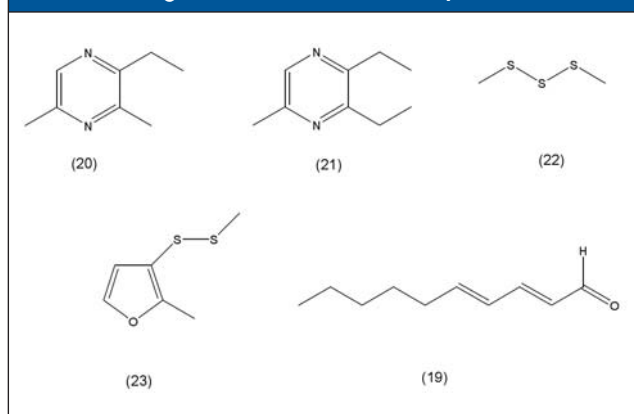


Figure 22. La dolce vita (the sweet side of chocolate)

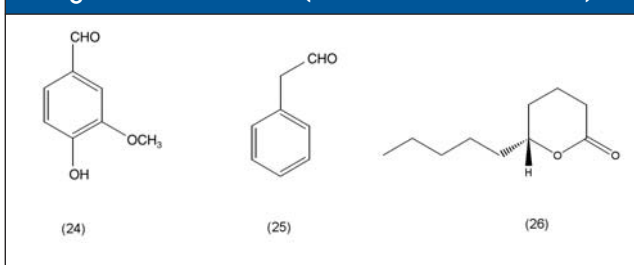


Table 2. Aroma chemicals in the wrong place at the wrong time

| AROMA CHEMICAL | AS A DESIRABLE NOTE | AS AN OFF-NOTE |
|--|---------------------|-------------------|
| <i>trans</i> -2- <i>trans</i> -4-decadienal (19) | chicken meats | cooked potatoes |
| 2-methoxy-4-vinylphenol (5) | coffee | orange juice |
| methional (27) | fried foods | orange juice |
| 2-methyl-3-furanthiol (12) | beef | orange juice |
| prenyl mercaptan (8) | coffee | beer |
| methional (27) | fried foods | alcohol-free beer |
| sotolone (28) | fenugreek | citrus drinks |

Figure 23. The high impact aroma chemicals of roast beef, coffee and chocolate

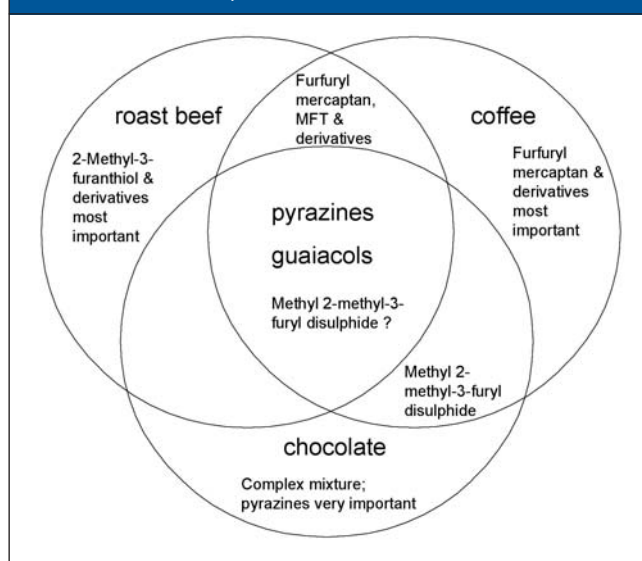


Figure 25. The good, the bad and the ugly

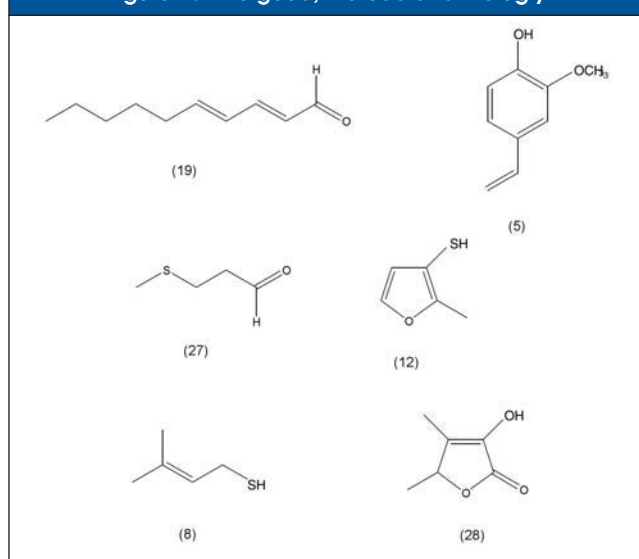


Figure 26. Future high impact aroma chemicals

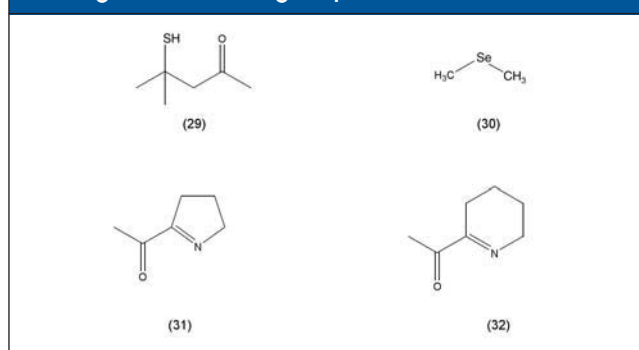
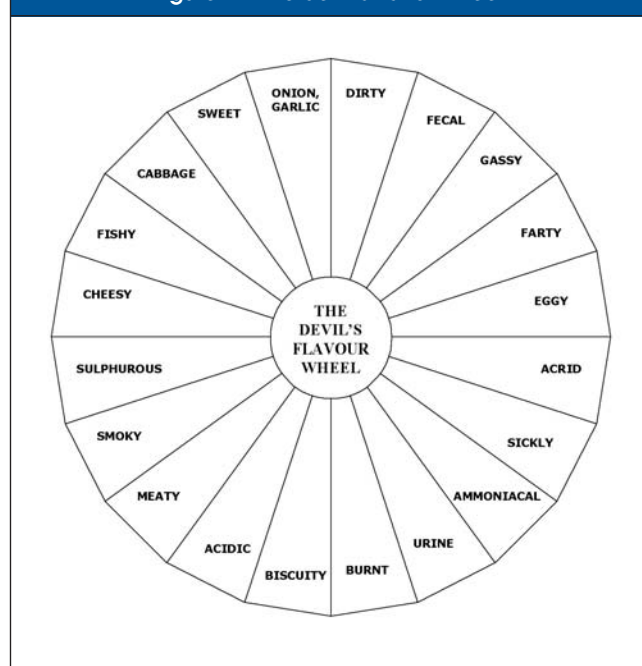


Figure 24. The devil's flavor wheel



may be the origin of our response to the simple materials, such as hydrogen sulfide, methyl mercaptan and simple alkyl thiols; the cause of the enhanced response to mercaptans, such as 2-methyl-3-furanthiol and p-menthene-8-thiol, may simply be that these materials happen to trigger the receptors more easily. This is a coincidental response and not a specific "design". To use an analogy from pharmaceutical chemistry, morphine happens to fit our endorphin receptors in the brain with great efficacy, but it is not suggested that we have evolved to develop morphine addiction. Evolution is conservative; a study on mouse olfactory receptor (OR) genes found that while humans have only

two-thirds of the OR genes of mice, they occupied a similar receptor space — hence, we retain the ability to recognize a broad range of aroma chemicals.¹⁵ Furthermore, a large number of the OR genes were described as “fish-like”.

These phylogenetic links indicate that our response to these molecules appears to have a very “primitive” origin, and we have yet to meet an individual with specific anosmia to these materials. The ability to respond to chemicals in our surroundings is the primary sense. We now differentiate taste and smell, but to the simplest organisms it is as one. Even the simplest and most primitive organisms, the prokaryotic bacteria and archaea, have this sense, and this leads us to a fascinating possibility; there is much evidence that life evolved in a sulfur-rich environment, where a sulfur compound would be a nutrient or a toxin, depending on concentration. Does our love for roast beef, coffee and chocolate have its ultimate origins in the days when the only course on the menu was the primordial soup?

Address correspondence to David Rowe, Oxford Chemicals Ltd., North Gare, Seaton Carew, Hartlepool, TS25 2DT, UK.

References

1. D. J. Rowe, *Perfumer & Flavorist*, 2000, 25 (5), 1.
2. D.J.Rowe, in “*Advances in Flavours and Fragrances: From the Sensation to the Synthesis*”, Ed. K.A.D. Swift, Royal Society of Chemistry, Cambridge, UK, 2002, p. 202.
3. P. Schieberle and T. Hoffmann, in “*Advances in Flavours and Fragrances: From the Sensation to the Synthesis*”, Ed. K.A.D. Swift, Royal Society of Chemistry, Cambridge, UK, 2002, p. 163.
4. T. Hoffmann, M. Czerny, S. Calligaria and P. Schieberle, *J. Agric. Food Chem.*, 2001, 49, 2382.
5. M. Czerny, F. Mayer, and W. Grosch, *J. Agric. Food Chem.*, 1999, 47, 695.
6. R. Kerscher and W. Grosch, *J. Agric. Food Chem.*, 1998, 46, 1954.
7. P. Schnermann and P. Schieberle, *J. Agric. Food Chem.*, 1997, 45, 867.
8. K. Jensen, M.A. Petersen, L. Poll, P.R. Brockhoff, *J. Agric. Food Chem.*, 1999, 47, 1145.
9. Y. Bezman, R. L. Rouseff, and M. Naim, *J. Agric. Food Chem.*, 2001, 49, 5425.
10. T. Konige, B. Gutsche, M. Hartl, R. Hubscher, P. Schreier, and W. Schwab, *J. Agric. Food Chem.*, 1999, 47, 3288.
11. P. Perpete and S. Collin, *J. Agric. Food Chem.*, 1999, 47, 2374.
12. A. Buettner and P. Schieberle, *J. Agric. Food Chem.*, 1999, 47, 5189.
13. E. Block, X.-J. Cai, P. C. Uden, X. Zhang, B. D. Quimby and J. J. Sullivan, *Pure & Appl. Chem.*, 1996, 68, 937.
14. S. Mahatheeranont, S. Keawsa-ard and K. Dumri, *J. Agric. Food Chem.*, 2001, 49, 773.
15. X. Zhang and S. Firestein, *Nat. Neurosci.*, 2002, 5, 124. ■