THE INGREDIENT WAREHOUSE

High Impact Aroma Chemicals

Flavour Reference Guide

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FLAVOUR REFERENCE GUIDE

THE INGREDIENT WAREHOUSE have developed the concept of a flavour guide to further illustrate its large range of specialty high impact aroma chemicals (one of the largest in Australasia) and to highlight possible application areas to various flavourists.

Under each section of the guide are various suggested molecules which could be used to create the flavour type that you desire.

Contents

For sample enquiries and other placement please contact a member of our customer service team by emailing sales@theingredientwarehouse.com.au or alternatively by telephone on the number attached with this guide.

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Green, Grassy

For this, the group of molecules to firstly concentrate on are the 'hexenyl' compounds, these are produced by all green tissues as a consequence of the peroxide defence mechanism, this is where linoleic acid acts as an attractant and captures peroxy radicals and is in turn cleaved.

A popular molecule which is often associated with Fresh Green grassy notes is 2-Isobutyl thiazole (odour threshold 3 ppb). This particularly interesting molecule is released by the tomato vine and has both tomato and a more general green (geranium, string bean) character, especially on particular dilutions.

The most obvious and the first High Impact Aroma Chemical is cis-3-Hexenal 1, which is the first cleavage product of linoleic acid.

This then will rearrange to the stable aroma chemicals trans-2-hexenal (leaf aldehyde) or is reduced to cis-3-hexenol (leaf alcohol).

These compounds are used widely and have odour thresholds of 17 and 70 ppb respectively, because of this they just register as high impact chemicals, although the most interesting part of these are their flavour.

Description	FEMA No.	CAS No.
Acetaldehyde PG Acetal	4099	12/3/90
Acetaldehyde Dipropyl Acetate	None	105-82-8
Allyl Thiopropionate	3329	41820-22-8
Sec-Butyl3-Methbut-2-Ene Thiote	None	34322-09-3
2,5-Dimethylpyrazine	3272	123-32-0
3-(2-Furyl) Acrolein	2494	623-30-3
2-Heptenoic Acid	None	18999-28-5
Trans-2-Hexen-1-ol	2562	2305-21-7
Cis-3-Hexenol	2563	928-96-1
Cis-3-Hexenyl Isobutyrate	3929	41519-23-7
Hexel Hexanoate	2572	6378-65-0
2-Methyl-2-Pentenal	3194	623-36-9
3-(Methylthio) Hexanal	3877	38433-74-8
3,5-Octadien-2-One	4008	30086-02-3
Phenylacetaldehyde Dimethyl Acetal	2876	101-48-4

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Herbaceous

There are many molecules which can be used for this application as it is a wide-ranging group. This can be clearly shown below in our product list.

Of particular interest are the thioesters, which are typified by sec-butyl 3 methyl but-2enethionate are commonly found in galbanum oil, and the key odourants of coriander are long-chain unsaturated aldehydes. An example of this is trans-2-dodecanal.

Description	FEMA No.	CAS No.
Natural P-Mentha-8-Thiol-3-One	3177	38462-22-5
8-(Acetylthio) Menthone	3809	94293-57-9
Acetaldehyde Dipropyl Acetal	None	105-82-8
Sec-Butyl3-Methbut-2-Ene Thioate	None	34322-09-3
Sec-Butyl Thioisovalerate	None	2432-91-9
Decanal Dimethyl Acetal	2363	7779-41-1
Guaiacyl Phenylacetate	2535	4112-89-4
Cis-3-Hexenol	2563	928-96-1
P-Mentha-8-Thiol-3-One	3177	38462-22-5
3-Mercapto-3-Methylbutyl Formate	3855	50746-10-6
Nat P-Mentha-8-Thiol-3-One (1% In PG)	3177	38462-22-5
3-Propylidenepththalide	3952	17369-59-4
Sulfox Aceate	3809	94293-57-9

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Spicy

Spicy can also mean both strongly flavoured and hot. For Spicy, an excellent example is the fenugreek lactone or sotolone, which has an intense and very persistent curry fragrance – its persistence includes an interesting tendency to linger on the skin if you have accidental contact with it.

For hot requirements, we have capsaicin; whilst its effect is as a sensation via the trigeminal system, the intensity of its effect on the tongue (or any other part of the body it has contact with) is intense enough to consider to be a high impact chemical.

Description	FEMA No.	CAS No.
Allyl 3,5,5-Trimethylhexanoate	None	71500-37-3
Methylmethylthiofuran (10% In Tac)	3949	63012-97-5
Natural 2-Methoxy-4-Vinylphenol (1% In PG)	2675	7786-61-0
3-(Acetylthio)Hexyl Acetate	3816	136954-25-1
Butyl Cinnamate	2192	538-65-8
Sec-Butyl3-Methbut-2-Ene Thiote	None	34322-09-3
Sec-Butyl Thioisovalerate	None	2432-91-9
Cinnamyl Isobutyrate	2297	103-59-3
Cinnamyl Isovalerate	2302	140-27-2
Cinnamyl Propionate	2301	103-56-0
Ethyl Cinnamate	2430	103-36-6
3-(2-Furyl) Acrolein	2494	623-30-3
3-Mercapto-3-Methylbutanol	3854	34300-94-2
2-Methoxy-4-Methylphenol (Creosol)	2671	93-51-6
2-Methoxy-4-Vinylphenol	2675	7786-61-0
2-Methoxy-4-Vinylphenol (10% In PG)	2675	7786-61-0
2-Methoxy-4-Vinylphenol (50% In Tec)	2675	7786-61-0
Methyl Cinnamate	2698	103-26-4
2-Methyl-3(2-Furyl) Acrolein	2704	874-66-8
Methyl Phenyl Acetate	2733	101-41-7
3-(Methylthio)-1-Hexyl Acetate	3789	51755-85-2
Natural-2-Methoxy-4-Vinylphenol	2675	7786-61-0
Natural Methyl Cinnamate	2698	103-26-4
3-Propylidenephthalide	2952	17369-59-4
Theaspiran	3774	36431-72-8
Thymol Methyl Ether	3436	1076-56-8
Wine Lactone	4140	182699-77-0

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Fruity, Ester Like

For fruity flavour notes, esters are obviously chemicals here, although many have low odour thresholds (example: Ethyl Butyrate 1 ppb, Ethyl Isobutyrate 0.1 ppb, Ethyl 2 Methyl butyrate 0.1 ppb, Ethyl Hexanoate 1-3 ppb).

However, there are many other interesting materials which offer a variety of fruity notes, one of which is the infamous p-1-menthen-8-thiol, also well known as Grapefruit mercaptan. This has the particularly low threshold of ~10-5 ppb, and very interestingly it retains its character even at low levels.

At actively high concentrations, the molecule quite simple has a sulphurous odour, which is common to mercaptans, and this requires dilution to at least 0.001% before the fresh grapefruit juice character can be identified.

Description	FEMA No.	CAS No.
N-butyl acetate	2174	123-86-4
Acetaldehyde Diisoamyl Acetal	4024	13002-09-0
Butyl Benzoate	None	136-60-7
Ethyl Thioacetate	3282	625-60-5
Ethyl Valerate	2462	539-82-2
4-(P-Hydroxyphenyl)-2-Butanone	2588	5471-51-2
Natural Isoamyl Decanoate	None	2306-91-4

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Blackcurrant

Blackcurrant is a particularly complicated flavour. However, it is also frequently used in a number of applications.

When considering the key contributors to blackcurrant flavour profile, 2-methoxy-4-methyl-4-butanethiol is an obvious one; interestingly it is also an important contributor as a fruity flavour to olive oil.

Two other materials which are also important to mention for alternative notes of blackcurrant are p-methacholine, which is main odour-active ingredient of Buchu leaf oil (Betulina and Crenulata), and 4-mercapto-4-methyl-2-pentanone, which is also known as Cat Ketone.

Description	FEMA No.	CAS No.
Methoxymethylbutanethiol (1% In PG)	3785	94087-83-9
Methylmercaptopentanone (1% In Ethanol)	3997	19872-52-7
Natural P-Mentha-8-Thiol-3-One	3177	38462-22-5
8-(Acetalthio) Menthone	3809	94293-57-9
P-Mentha-8-Thiol-3-One	3177	38462-22-5
Methoxy Methyl butanethiol	3785	94087-83-9
4-Methyl-4-Mercaptopentan-2-One (1% In PG)	3997	19872-52-7
Natural 4-Methyl-4-Mercaptopentan-2-One (1% In PG)	3997	38462-22-5
Sulfox Acetate	3809	94293-57-9

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Nutty

Nuttiness is often associated with pyrazines; although it is part of the character of virtually all pyrazines, it is particularly associated with the stronger pyrazines such as methyldihydrocyclopentapyrazine (Maple lactone pyrazine) and 5,6,7,8-tetrahydroquinoxaline.

2-Acetylpyrazine is very reminiscent of popcorn; whilst its odour threshold is rather high at 62 ppb, it has a particularly persistent character which identifies it as a high impacter. Some pyrazines are present in the raw nut, whereas others are formed in roasted nuts by the Maillard reaction between amino-acids and sugars. This also generates furans, such as 5-Methylfurfural. This also has an almond, marzipan aroma.

Description	FEMA No.	CAS No.
2-Ethyl 4,5-Dimethyl Oxazole	3672	53833-30-0
Acetal	2002	105-57-7
2-Acetoxy-3-Butanone	3526	4906-24-5
2-Acetyl-3-Ethylpyrazine	3250	32974-92-8
2-Acetyl-5-Methylfuran	3609	1193-79-9
2-Acetyl-3-Methylpyrazine	3964	23787-80-6
2-Acetylpyrazine	3126	22047-25-2
2-Acetylthiazole	3328	24295-03-2
Cocoa Pyrazine Base (10% In PG)	None	None
2,6-Dimethylpyrazine	3273	108-50-9
2,3-Diethyl-5-Methylpyrazine	3336	18138-04-0
2,3-Diethylpyrazine	3136	15707-24-1
2,4-Dimethyl-5-Acethylthiazole	3267	38205-60-6
Dimethyl Dihydrocyclopentapyrazine	None	38917-6192
2,3-Dimethylpyrazine	3271	5910-89-4
2,5-Dimethylpyrazine	3272	123-32-0
2,4-Dimethylthiazole	None	541-58-2
4,5-Dimethylthiazole	3274	3581-91-7
2-Ethyl-3(5/6)-Dimethylpyrazine	3149	27043-05-6
3-Ethyl-2-Methylpyrazine	3155	15707-23-0
2-Ethyl-3, (5 Or 6)-Dimethylpyrazine		13925-07-0
2-Ethyl-4-Methylthiazole	3680	15679-12-6
Fusel Fraction 7:50	None	None
Furfuryl Thiocetate	3162	13678-68-7

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Nutty - continued

Description	FEMA No.	CAS No.
3-(2-Furyl) Acrolein	2494	623-30-3
2-Isopropenylpyrazine (1% In PG)	3296	38713-41-6
2-Isopropenylpyrazine	3296	38713-41-6
2-Isopropyl-4-Methylthiazole	3555	15679-13-7
2-Methyl-3(5/6) (Furfurylthio) Pyrazine	3189	65530-53-2
2-Methoxy-3-Methylpyrazine		2847-30-5
2-Methoxy-3 (5/6)-Isopropyl Pyrazine	None	25773-40-4
2-Methoxy-3(5/6)-Methyl Pyrazine	3183	68378-13-2

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Caramel

Caramelisation does occur with the heating of sugars and carbohydrates. This is the typical Maillard reaction sequence. This then in turn generates furans with characteristic caramel odours.

Hydroxydimethylfuranone has a sweet, fairy floss aroma and a low odour threshold of 0.04 ppb. 2-Methyltetrahydrofuran-3-one (coffee furanone) is to some extent less odorous but has a very pleasant, sweet caramel character.

Description	FEMA No.	CAS No.
Acetoin (Acetyl Methyl Carbinol)	2008	513-86-0
2-Acetoxy-3-Butanone	3526	4906-24-5
Acetoxy Dimethyl Furanone	3797	4166-20-5
2-Acetyl-3-Methylpyrazine	3964	23787-80-6
2-Acetypyrazine	3126	22047-25-2
Butyl Butyryl lactate	2190	7492-70-8
2,5-Dimethyl-3(2h)-Furanone	4101	14400-67-0
2,3-Dimethylpyrazine	3271	5910-89-4
Ethyl Trans-2-Butenoate	3486	10544-63-5
Furfural	2489	98-01-1
Furfuryl Alcohol	2491	98-00-0
Furfuryl Pentanoate	3397	36701-01-6
2-Furyl Methyl Ketone	3163	1192-62-7
3,4-Hexanedione	3168	4437-51-8
4-Hydroxy-2,5-Dimethyl-3(2h) Furanone	3174	3658-77-3
2-Methoxy-3(5/6)-Methyl Pyrazine	3183	68378-13-2
Methyl Cyclopentenolone Hydrate	2700	80-71-7
2-Methyltetrahydrofuran-3-One	3373	3188-00-9
2-Methylfuran	4179	534-22-5
5-Methylfurfural	2702	620-02-0
2-Methoxy-3-Methylpyrazine		2847-30-5
Acetoin	2008	513-86-0
Nat 2,5-Dimethyl-3(2h)-Furanone	4101	14400-67-0
Natural Hydroxy Dimethyl Furanone	3174	3658-77-3
Nat Hydroxy Dimethyl Furanone (10% In PG)	3174	3658-77-3
Nat Hydroxy Dimethyl Furanone (15% In PG)	3174	3658-77-3
Natural Trimethylpyrazine	3244	14667-55-1
2,3-Pentanedione (Acetyl Propionyl)	2841	600-14-6
Tetrahydrofurfuryl Acetate	3055	637-64-9

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Vegetable

This is probably the largest category. One of the most important chemical compounds is dimethyl sulphide (DMS, methyl sulphide, odour threshold ~3 ppb). When pure, this has a very clean, crisp sweetcorn like odour. Some materials on the market lack this note and have unpleasant, sulphurous, rotten cabbage odours; GCMS on such material has often shown the presence of dimethyl disulphide and methyl ethyl sulphide. Other obvious powerful compounds for vegetable notes are 3-methylthiopropanal (methional, odour threshold 0.2 ppb) and its homologue 3-methoxypyrazine, the bell pepper, main character impact compound found in green or bell peppers, with its very low odour threshold of 0.002 ppb.

Description	FEMA No.	CAS No.
Methyl-2-Methyl-3-Furyldisulphide	3573	65505-17-1
3-(Acetylthio) Hexyl Acetate	3816	136954-25-1
2,3-Diethyl-5-Methylpyrazine	3336	18138-04-0
Ethyl 3-(Furylthio) Propionate	3674	94278-27-0
Ethyl Trans-2-Hexenoate	3675	27829-72-7
3-Mercapto-3-Methylbutanol	3854	34300-94-2
3-Mercaptohexyl Butyrate	3852	136954-21-7
3-Mercaptohexyl Hexanoate	3853	136954-22-8
Methyl Furfuryl Disulphide	3362	57500-00-2
Methyl (2-Methyl) Thiobutyrate	3708	42075-45-6
Methyl 3-Methylthiopropionate	2720	13532-18-8
Methyl Sulphide 'A' Grade	2746	75-18-3
Methyl Sulphide 'A Plus'	2746	75-18-3
DMS 10% In Dipropylene Glycol	2746	75-18-3
3-(Methylthio) Butanal	3374	16630-52-7
4-(Methylthio)-2-Butanone	3375	34047-39-7
3-(Methylthio)-1-Hexanol	3438	51755-66-9
2-Methylthio-3(5/6)-Methylpyrazine	3208	67952-65-2
3-(Methylthio) Propanol (Methionol)	3415	505-10-2
3-(Methylthio)Propionaldehyde	2747	3268-49-3
4-Methyl-5-Vinylthiazole	3313	1759-28-0
Methyl Thiopropionate	4172	5925-75-7
Natural Methyl Sulphide Extra	2746	75-18-3
Natural Methyl Furfuryl Disulphide	3362	57500-00-2
1-Octen-3-OL	2805	3391-86-4
1-Penten-3-OL	3584	616-25-1
2,4,5-Trimethylthiazole	3325	13623-11-5

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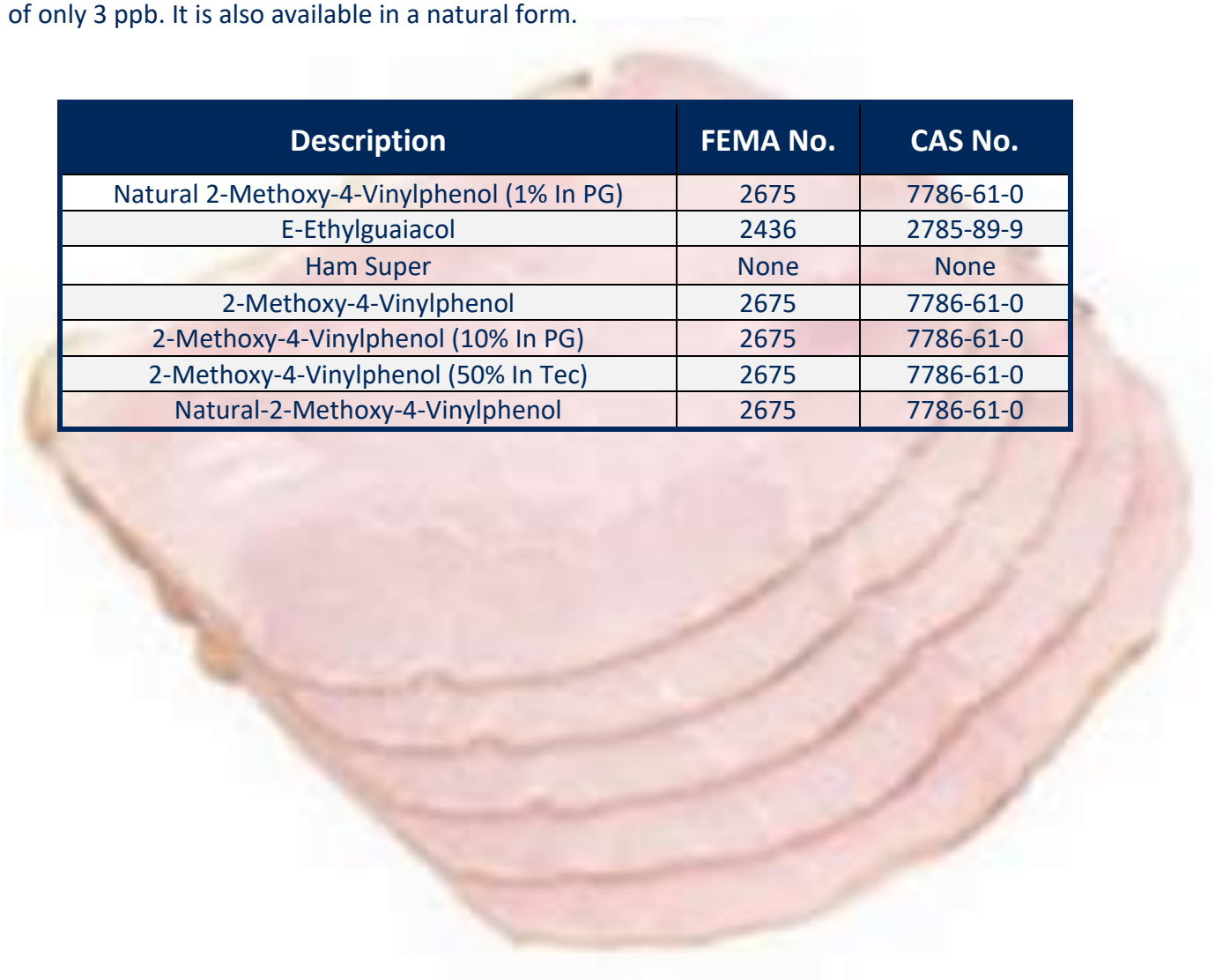
Woody, Smoky

Particular Guaiacols are very important in this particular flavour area. 4-Ethyl- and 4-methylguaiacols have rather characteristic, phenolic, medicinal odours with threshold of 90 and 50 ppb respectively, but more important is 4-vinylguaiacol (2-methoxy-4-vinylphenol, MVP).

This has a spicy, clove-like smokiness particularly associated with smoked ham, and a low odour threshold of only 3 ppb. It is also available in a natural form.



Description	FEMA No.	CAS No.
Natural 2-Methoxy-4-Vinylphenol (1% In PG)	2675	7786-61-0
E-Ethylguaiacol	2436	2785-89-9
Ham Super	None	None
2-Methoxy-4-Vinylphenol	2675	7786-61-0
2-Methoxy-4-Vinylphenol (10% In PG)	2675	7786-61-0
2-Methoxy-4-Vinylphenol (50% In Tec)	2675	7786-61-0
Natural-2-Methoxy-4-Vinylphenol	2675	7786-61-0

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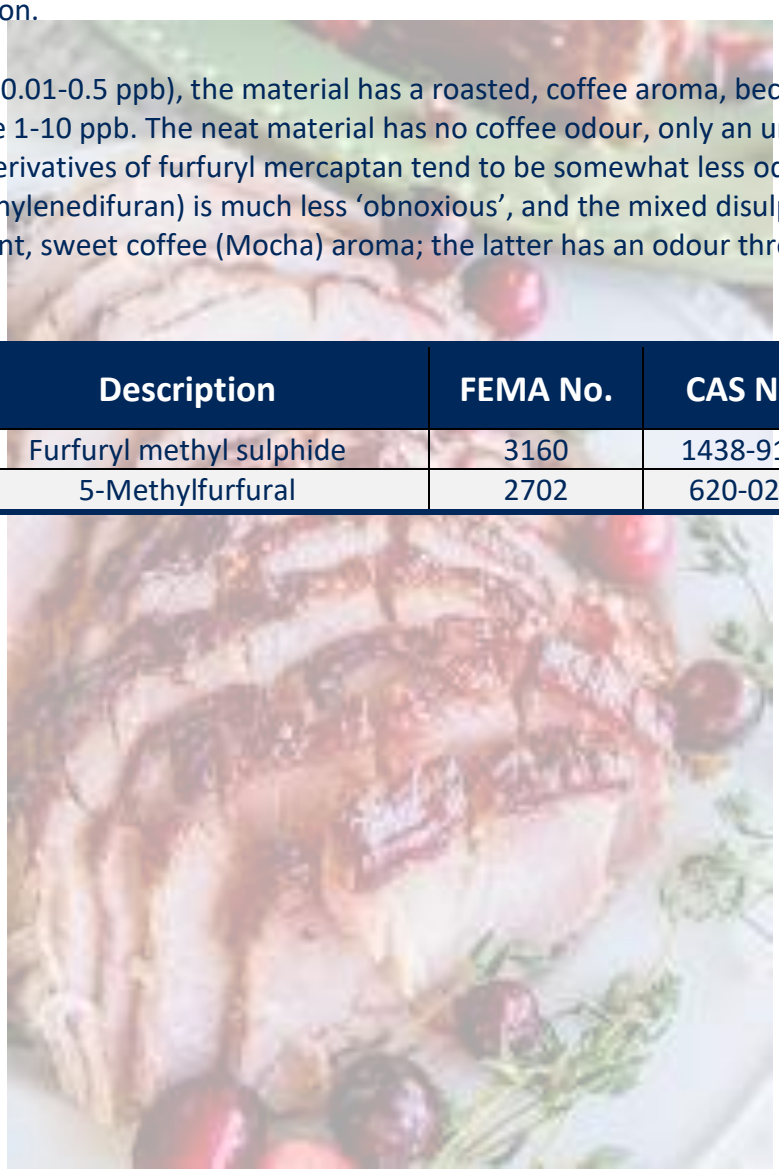
Roasted, Burnt

This area is clearly associated with cooked food; in this and the following sectors, the high impact chemicals are those produced in the Maillard Reaction. These are secondary products formed from reaction of primary Maillard products such as Strecker aldehydes with sulphur sources such as crysteine. Shieberle has used the term ‘advanced’ or ‘extended’ Maillard products for such materials.

For roasted and burnt notes, derivatives of furfuryl mercaptan are most important. The mercaptan itself, with an odour threshold of 0.005 ppb, was the first high impact aroma chemical to be identified. It exhibits one of the classic phenomena associated with high impact chemicals, the change in the nature of the odour with concentration.

At low concentrations (0.01-0.5 ppb), the material has a roasted, coffee aroma, becoming burnt and sulphurous in the range 1-10 ppb. The neat material has no coffee odour, only an unpleasant oily smell resembling gasoline. Derivatives of furfuryl mercaptan tend to be somewhat less odorous; the disulphide(dithiodimethylenedifuran) is much less ‘obnoxious’, and the mixed disulphide furfuryl methyl disulphide has a pleasant, sweet coffee (Mocha) aroma; the latter has an odour threshold of 0.04 ppb.

Description	FEMA No.	CAS No.
Furfuryl methyl sulphide	3160	1438-91-1
5-Methylfurfural	2702	620-02-0



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Meaty, Beefy

The first molecule that springs to mind when looking at this area is 2-methylfuran-3-thiol and its derivatives.

This is because the thiol, its disulphide, mixed disulphide and thioether, have at some time all been found in beef; for some circumstances, the odour threshold of the disulphide has been reported as being 2 x 10-5 ppb.

2-methylfuran-3-thiol has primarily a chemical odour, but this will later become meatier on dilution.

With the disulphide, it has a more clearly recognisable character, a traditional mature/aged beef aroma, a more flame grilled steak odour/flavour.

The thioether is actually quite different in many ways. It has a more of a roasted odour profile.

Other notable mercaptans to mention which have beef character are 3-Mercapto-2-butanone and 3-mercapto-2-pentanone. These are commonly found in 'beef' Maillard reactions.

Description	FEMA No.	CAS No.
Bis (2-Methyl-3-Furyl) Disulphide	3259	28588-75-2
3-Methyl-2-Butaneithiol	3304	2084-18-6
Methylmethylthiofuran (10% In Tac)	3949	63012-97-5
Tetrahydro-2-Methylfuran-3-Thiol	3787	57124-87-5
Beef	None	None
3-Mercaptobutanone (10% In Tac)	3298	40789-98-8
Meat Reaction B1000	None	None
Pyrazine Ethanethiol	3230	35250-53-4

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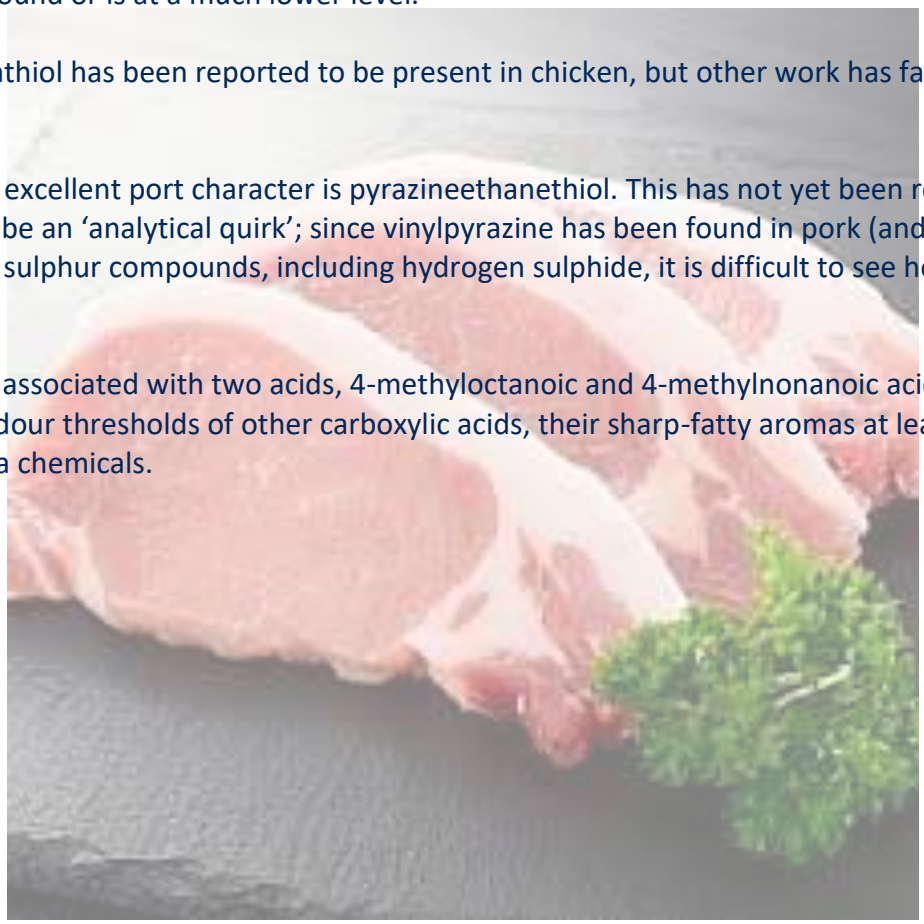
Pork, Lamb, Chicken

While 2-methyl-3-furanthiol is important in other meats as well as beef, in particular pork, other high impact chemicals also do occur. Mercaptopropanone dimer has an intense chicken broth like odour and the unsaturated aldehyde trans-2-trans-4-decadienal is very reminiscent of chicken fat; the latter has been listed in the observation that whereas 2-methyl-3-furanthiol has been found in chicken, its intensely beefy disulphide is not found or is at a much lower level.

2,5-Dimethylfuranthiol has been reported to be present in chicken, but other work has failed to confirm this.

A compound with excellent port character is pyrazineethanethiol. This has not yet been reported in nature, but his again may be an 'analytical quirk'; since vinylpyrazine has been found in pork (and other meats), and pork is rich in sulphur compounds, including hydrogen sulphide, it is difficult to see how it can't be formed.

Lamb character is associated with two acids, 4-methyloctanoic and 4-methylnonanoic acid; whilst these have the higher odour thresholds of other carboxylic acids, their sharp-fatty aromas at least group them as high impact aroma chemicals.



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Rancid, Cheesy

Cheese like flavour/fragrance, desirable or otherwise, is often associated with acids, but these have quite high odour thresholds, e.g., valeric acid, which has a particular nauseating sweaty cheesiness at high concentration, but also the mercifully high odour threshold of 3000 ppb.

However, such is the character of these that the impact is greater than the odour threshold might imply. Unsaturated acids such as trans-2-hexenoic acid have more powerful, acrid odours; several trans-2-enoic acids (trans-2-hept, oct- and non-enoic acid) were included on the GRAS 19 list.

Simple thioesters such as methyl thiobutyrate and methyl (2-methyl) thiobutyrate also have an intense cheesy-sweet-fruity odour.

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Fatty

Possibly not the most desirable category at first glance, importantly though as fattiness is a keynote in many food products in terms of both flavour and 'mouth-feel'.

The first and most obvious group of Aroma Chemicals are Aldehydes, which have very fatty notes and in particular trans-2-nonenal and trans-4-decadienal; the latter is more characteristic of chicken fat and has an odour threshold of 0.07 ppb.

A particularly interesting material is 12-methyltridecanal. With this molecule, you have the potential to create a boiled or stewed beef flavour, which are characteristically very different from roasted or fried beef.

Description	FEMA No.	CAS No.
Ethyl Butyldeltavalerolactone	None	67770-79-0
Nonanoic Acid	2784	112-05-0
2-Acetylpyridine	3251	1122-62-9
Ally Octanoate (Allyl Caprpylate)	2037	4320-97-1
Trans-2-Trans-4-Decadienal	3135	25152-84-5
Decanoic Acid (Capric Acid)	2364	334-48-5
Trans-2-Decanal	2366	3913-81-3
2,3-Epoxydecanal	None	102369-06-2
2,3-Epoxyheptanal	None	58936-30-4
2,4-Decadienal		2363-88-4
4,5-Epoxy-(E)-2-Decanal	4037	134454-31-2
Heptanal (Aldehydec7, Heptaldehyde)	2540	111-71-7
trans-2-HEPTENAL	3165	18829-55-5
Heptanoic Acid	3348	111-14-8
Hexanal	2557	66-25-1
Hexanoic Acid	2559	142-62-1
Trans-2-Hexenoic Acid	3169	13419-69-7
3-Methylbutyraldehyde	2692	590-86-3
Methyl 2-Hexenoate	2709	13894-63-8
4-Methylnonanoic Acid	3574	45019-28-1
4-Methyloctanoic Acid	3575	54947-74-9
1,9-Nonanedithiol	3513	3489-28-9
Trans-2-Nonenal	3213	18829-56-6
Natural Decanoic Acid (Capric)	2364	334-48-5
Natural Hexanoic Acid (Caproic)	2559	142-62-1

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Fatty – continued

Description	FEMA No.	CAS No.
Natural Isoamyl Laurate	2077	6309-51-9
Natural Lauric Acid	2614	143-07-7
1,8-Octanedithiol	3514	1191-62-4
Trans-2-Octenal	3215	2548-87-0
Octyl Isobutyrate	2808	109-15-9
Pyrazine Ethanethiol	3230	35250-53-4

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Mushroom, Earthy

For a mushroom note, there is no better High Impact Aroma chemical to first consider than 1-octen-3-ol. This has an odour threshold of only 1 ppb and is very characteristic of mushroom.

But there are also other compounds which are commonly overlooked. The first is 1-octen-3-one, which interestingly has a threshold some 200 times lower at only 0.05 ppb.

With this compound, it has a very fresh, wild mushroom aroma.

In relation to 'Earthiness', some of the more interesting pyrazines would be applicable, especially 2-methyl-3-methoxypyrazine.

Description	FEMA No.	CAS No.
1-Octen-3-ol		3391-86-4
3-Octanone		106-68-3
2-Methoxy-3-methylpyrazine		2847-30-5
2-Methoxy-3(5/6)-Methyl Pyrazine	3183	68378-13-2

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Truffle

The black truffle is perhaps the most select member of the fungal food's family. Whilst it contains familiar volatiles such as 1-octen-3-ol, the key character impact material is bis(methylthio)methane (2,4-dithiapentane, truffle sulphide).

This has the very powerful earthy-alliaceous aroma associated with truffle; also present is tris(methylthiomethane) (3-methylthio-2,4-dithiapentane, methylidynetris (methyl sulphide), 'manxane'), with an aroma more reminiscent of the white truffle.

Also recently identified in white truffle is the isomer of 2,4,6-trihiheptane.

Description	FEMA No.	CAS No.
Bis (Methylthio) Methane	3878	1618-26-4
Tris (Methylthiomethane)	None	5418-86-0

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Garlic

The major component of garlic oil is ally disulphide, with the mercaptan and higher sulphides such as the trisulphide and mixed disulphides, such as allyl propyl disulphide, are also present.

Allyl methyl disulphide is particularly strong and has been detected at unexpectedly high concentrations in research with the breath of various garlic eaters.

Description	FEMA No.	CAS No.
Allyl Disulphide	2028	2179-57-9
Allyl Mercaptan	2035	870-23-5
Allyl Methyl Disulphide	3127	2179-58-0
Allyl Methyl Sulphide	None	10152-76-8
Allyl Methyl Trisulphide	3253	34135-85-8
Allyl Propyl Disulphide	4073	2179-59-1
Allyl Propyl Sulphide	None	27817-67-0
Allyl Propyl Trisulphide	None	33922-73-5
Allyl Sulphide (Diallyl Sulphide)	2042	592-88-1
Allyl Thiopropionate	3329	41820-22-8
Diallyl Polysulphide	3533	72869-75-1
Dimethyl Tetrasulphide	None	5756-24-1
Dipropyl Sulphide	None	111-47-7
Dipropyl Trisulphide	3276	6028-61-1
Dipropyl Trisulphide Extra	3276	6028-61-1
Ethyl Propyl Trisulphide	4042	31499-70-4
Ethyl Methyl Trisulphide	3861	31499-71-5
Ethyl Trisulphide	4029	3600-24-6
Garlic Oil Extender	None	None
Methyl Propyl Trisulphide	3308	17619-36-2
Propyl Disulphide	3228	629-19-6

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Onion

As with previous group garlic, onion is very high in sulphur compounds, but mostly these are saturated compounds, such as the methyl and propyl sulphides, methyl propyl sulphide, methyl propyl disulphide, methyl propyl trisulphide, propyl disulphide and dipropyl sulphide.

These have less harsh, 'sweeter' notes compared to the allyl compounds.
Recently two new highly odorous mercaptans were identified in onion6, 3-mercapto-2-methylpentan-1-ol, an onion- and leek-like material with an odour threshold of 0.15 ppb, and 3-mercapto-2-methylpentanal, more pungent and meatier, with an odour threshold of 0.95 ppb.

Description	FEMA No.	CAS No.
Allyl Mercaptan	2035	870-23-5
Allyl Methyl Disulphide	3127	2179-58-0
Allyl Methyl Sulphide	None	10152-76-8
Allyl Methyl Trisulphide	3253	34135-85-8
Allyl Propyl Disulphide	4073	2179-59-1
Allyl Propyl Sulphide	None	27817-67-0
Allyl Propyl Trisulphide	None	33922-73-5
Allyl Thiopropionate	3329	41820-22-8
Butyl Mercaptan	3478	109-79-5
Diallyl Polysulphide	3533	72869-75-1
Diallyl Trisulphide 35-40%	3265	2050-87-5
Diethyl Disulphide	4093	110-81-6
Dimethyl Disulphide	3536	624-92-0
Dimethyl Trisulphide	3275	3658-80-8
Dipropyl Sulphide	None	111-47-7
Dipropyl Trisulphide	3276	6028-61-1
Dipropyl Trisulphide Extra	3276	6028-61-1
Ethyl Propyl Disulphide	4041	30453-31-7
Ethyl Propyl Trisulphide	4042	31499-70-4
Ethyl Methyl Trisulphide	3861	31499-71-5
Ethyl Trisulphide	4029	3600-24-6
Methyl 2-Thiofuroate	3311	13679-61-3
Methyl Propyl Disulphide	3201	2179-60-4
Methyl Propyl Trisulphide	3308	17619-36-2
Onion Oil Extender	None	None
1-Propenyl Propyl Disulphide	3227	5905-46-4
1 Propenyl Propyl Disulphide (1% In TAC)	3227	5905-46-4
Propyl Disulphide	3228	629-19-6

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Tropical

This is a very important area for high impact aroma chemicals. Analysis of passionfruit has displayed the presence of many powerful sulphur compounds.

A large number of these were included in FEMA's GRAS 18 list. Probably the best known is tropathiane, 2-methyl-4-propyl-1, 3-oxathiane, (odour threshold ~3 ppb): 3-mercapto-1-hexanol and a number of acylated derivatives were also included in FEMA's GRAS 18 list, as also were thioesters such as the thiohexanoate.

Description	FEMA No.	CAS No.
3-Mercaptohexan-1-Ol	3850	51755-83-0
3-(Acetylthio) Hexyl Acetate	3816	13654-25-1
Allyl Hexanoate	2032	123-68-2
Allyl Propionate	2040	2408-20-0
N-Amyl Butyrate	2059	540-181-1
Butyl Valerate	2217	591-68-4
Ethyl 3-Hydroxyhexanoate	3545	2305-25-1
Ethyl 3-Methylthiopropionate	3343	13327-56-5
Ethyl Trans-2-Octenoate	3643	7367-82-0
1-P-Menthene-8-Thiol	3700	71159-90-5
Isoamyl Isovalerate	2085	659-70-1
Isobutyl Isobutyrate	2189	97-85-8
Isopropyl 2-Methylbutyrate	3699	66576-71-4
2-Isopropyl-4-Methylthiazole	3555	15679-13-7
3-Mercaptohexyl Acetate	3851	136954-20-6
3-Mercaptohexyl Butyrate	3852	136954-21-7
3-Mercaptohexyl Hexanoate	3853	136954-22-8
3-Mercaptobutanone (10% In TAC)	3298	40789-98-8
Tropathiane	3578	67715-80-4
Propyl Isobutyrate	2936	644-49-5
Tetrahydrofurfuryl Butyrate	3057	2217-33-6

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