

Flavor focus

Meaty Aromas

Characteristic structural unit of sulfur-containing compounds with a basic meat flavor

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A characteristic structural unit of meaty aromas was proposed for the first time in our previous study on the basis of summarizing the olfactory properties of 29 kinds of sulfur-containing flavors with known FEMA numbers. We herein conclude that organic compounds with such a structural unit, as shown in F-1, should have a basic meat flavor.¹

Included in this class are 2-methyl-3-furylthiols, α - and β -disulfides, 3-mercapto-2-butanol, α -mercapto ketones, 1,4-dithianes, and 3-oxo-tetrahydrothiophenes. A series of 1,3-oxathiolanes, which contained the above characteristic structural unit, were synthesized starting with mercaptoethanol and ketones with toluenesulfonic acid as catalysts in our lab.²⁻⁵ The results of sensory evaluation for these compounds indicated that all of them had a meaty odor.⁶

The compounds with the characteristic structural unit reported in the literature, most of which do not yet possess FEMA numbers, were classified further into six subclasses, as shown in F-2. They all have a basic meat flavor, which proved our presumption.

Sulfur-Containing Compounds With Various Characteristic Structural Units

Compounds with one S-C-C-O structural unit: 3-Mercapto-2-butanol (FEMA# 3502), a typical compound in this class, is used widely due to its meaty and roasted aroma.¹ 2-Methyl-3-tetrahydrofuranthiol (FEMA# 3787), furfurylthiol (FEMA# 2493), furfuryl thio-acetate (FEMA# 3162) and furfuryl thio-propionate possess a meaty and roasted aroma as well.¹ The other compounds containing one S-C-C-O structural unit are listed in T-1.

We can conclude from T-1 that the compounds with one S-C-C-O structural unit have a meaty aroma, which is consistent with our presumption.

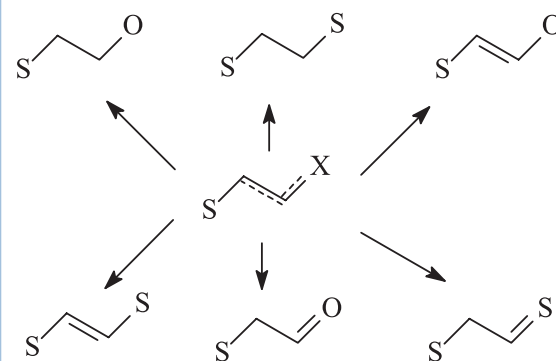
Compounds with one S-C-C-S structural unit:

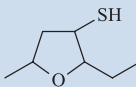
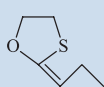
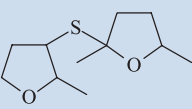
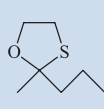
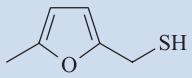
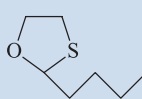
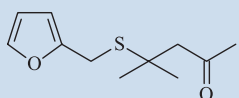
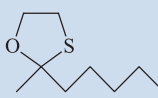
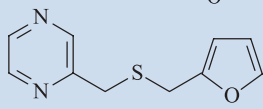
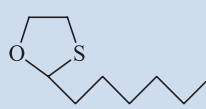
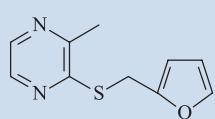
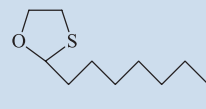
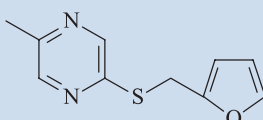
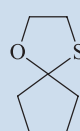
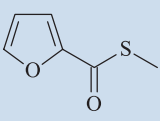
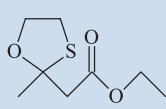

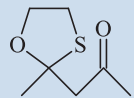
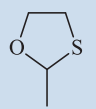
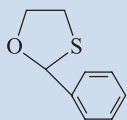
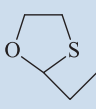
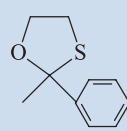

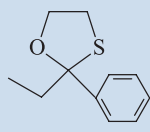
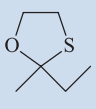
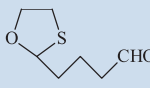
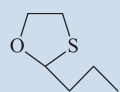
In addition to the compounds discussed in our previous study — 1,2-ethanedithiol (FEMA# 3484), 2,3-butanedithiol (FEMA# 3477) and 1,4-dithiane (FEMA# 3831), for example — other compounds containing one S-C-C-S structural unit are listed in T-2.

Characteristic structural unit of sulfur-containing compounds with a meat flavor F-1



Six subclasses of sulfur-containing compounds with a meat flavor; X = S or O F-2



Molecular structure	Odor characteristics (FEMA#)	Molecular structure	Odor characteristics (FEMA#)
	Meat, roasted meat flavor ⁷		Roasted meat, green-leaf ⁶
	Beef flavor ⁷		Onion, roasted meat ⁶
	Meaty ⁸		Onion, garlic, spicy, roasted meat ⁶
	Roasted meat flavor ⁹		Celery, roasted meat, onion, garlic ⁶
	Cooked meat, coffee, chocolate ¹⁰		Strawberry, roasted meat, sulfury ⁶
	Cooked meat, coffee (3189) ¹⁰		Celery, roast chicken ⁶
	Cooked meat, coffee (3189) ¹⁰		Garlic, onion, meaty ⁶
	Meaty, seafood flavor (3311) ¹¹		Apple, strawberry, bacon nuance ⁶
	Onion, garlic, roasted meat ⁶		Medicinal, roasted meat ⁶
	Onion, garlic, roasted meat ⁶		Roasted meat, almond nuance ⁶
	Onion, garlic, roasted meat ⁶		Almond, walnut, pine nut, roasted meat ⁶
	Onion, garlic, roasted meat ⁶		Almond, roasted meat, sulfury ⁶
	Onion, garlic, roasted meat ⁶		Roasted meat ⁶
	Roasted meat, onion, garlic, spicy ⁶		

As shown in T-2, all these compounds have a basic meaty odor, which is also in line with our presumption.

Compounds with one S-C=C-O structural unit:

Almost all of 3-furyl sulfides have a meaty aroma, 12 of which have been discussed in our previous study.¹ Some of them, such as 2-methyl-3-furanthiol (FEMA# 3188), 2-methyl-3-methylthiofuran (FEMA# 3949) and di(2-methyl-3-furan)disulfide (FEMA# 3259), are the most important meaty flavors.¹ Other compounds containing an S-C=C-O structural unit are listed in T-3.

The data in T-3 indicate that these compounds all have a meaty aroma, which, again, is consistent with our presumption.

Compounds with one S-C=C-S structural unit:

All 3-thiophene sulfides containing such a structural unit have a meaty aroma. We have previously discussed 2-methyl-3-methylthio thiophene and methyl 2-methyl-3-thienyl disulfide, neither of which are yet approved for use in flavors.¹ Other compounds containing one S-C=C-S structural unit are listed in T-4.

As shown in T-4, the compounds with an S-C=C-S structural unit have a meaty aroma, which again confirmed our presumption.

Compounds with one S-C-C=O structural unit:

1-Mercapto-2-acetone (FEMA# 3856), 3-mercapto-2-butanone (FEMA# 3298), 3-mercapto-2-pentanone (FEMA# 3300), 3-tetrahydrothienone (FEMA# 3260) and 2-methyl-3-tetrahydrothienone (FEMA# 3512), which are contained in this subclass, were discussed in our previous study.¹ Other compounds containing one S-C-C=O structural unit are listed in T-5.

All of the compounds in T-5 have a meaty aroma, which proved our presumption one more time.

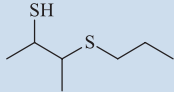
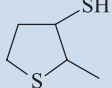
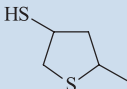
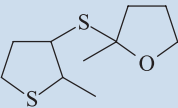

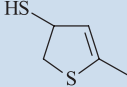

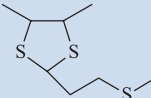

Compounds with one S-C-C=S structural unit:

4-Methyl-4-(3'-furyl)-2-thiopentanone (F-3) was described as having a roasted meaty aroma in literature, but as far as we know, no compounds with such an S-C-C=S structural unit were reported having a meaty aroma.⁹ Whether the sensory properties of compounds in this subclass conform to our presumption requires further study.

Compounds with multiple characteristic structural units: Many sulfur-containing flavor compounds contain multiple characteristic structural units, including difurfuryl disulfide (FEMA# 3146), di(2-methyl-3-furyl)disulfide (FEMA# 3259), di(2,5-dimethyl-3-furyl)disulfide (FEMA# 3476), di(2-methyl-3-furyl)tetrasulfide (FEMA# 3260), 2,5-dimethyl-3-thiofuroyl furan (FEMA# 3481), 2,5-dihydroxy-1,4-dithiane (FEMA# 3826), 2,5-dimethyl-2,5-dihydroxy-1,4-dithiane (FEMA# 3450), α -methyl- β -hydroxy propyl α' -methyl- β' -mercapto propyl sulfide (FEMA# 3509), spiro [2,4-dithia-1-methyl- 8-oxabicyclo [3,3,0] octane-3,3'-(1'-oxa-2'-methyl) cyclopentane] and spiro [2,4-dithia-6-methyl-7-oxa bicyclo[3,3,0] octane-3,3'-(1'-oxa-2'-methyl) cyclopentane] (FEMA# 3270).¹ Other compounds with multiple characteristic structural units are listed in T-6.

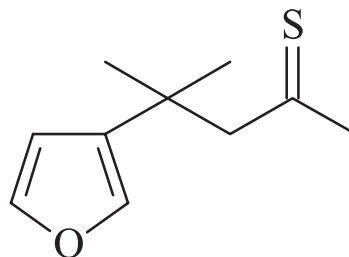
Odor characteristics of compounds with one S-C-C-S structural unit

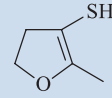
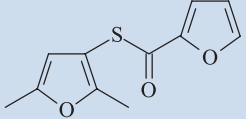
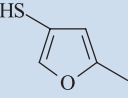
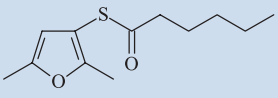
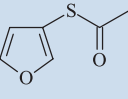
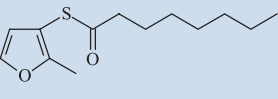
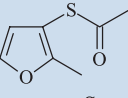
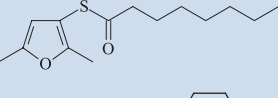
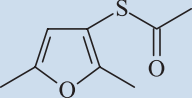
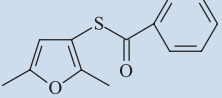
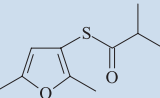
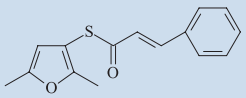
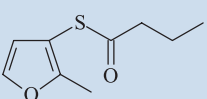
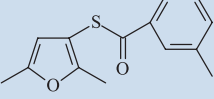
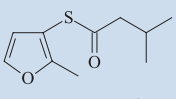
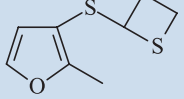
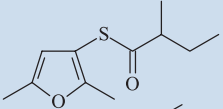
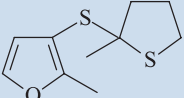
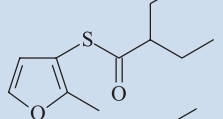
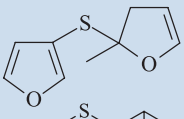
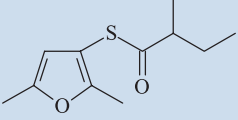
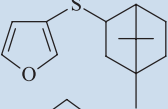
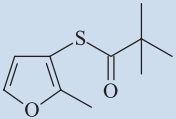
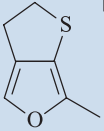
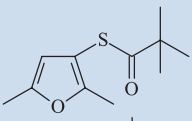
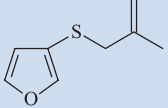
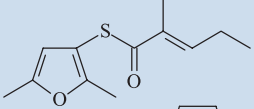
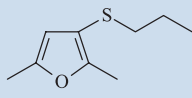
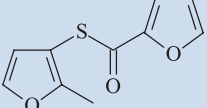
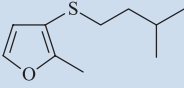
T-2

Molecular structure	Odor characteristics (FEMA#)
	Roasted meat ⁷
	Meaty ^{7,12,13}
	Meaty ^{12,13}
	Beef flavor ⁷
	Sweet, meat, roasted meat ^{7,10,12}
	Roasted meat ^{7,10,12}
	Roasted meat ^{13,14}
	Meaty, HVP-like, meat extract-like aroma and taste ¹⁵
	Roasted, grilled meat (3718) ^{7,14,16}

Roasted meat aroma

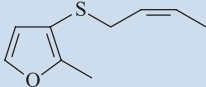
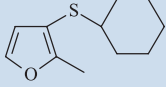
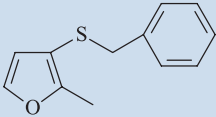
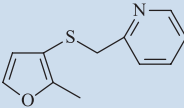
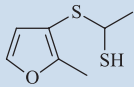
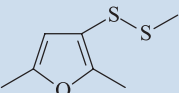
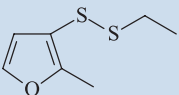
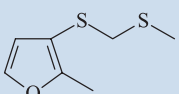
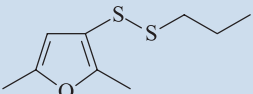
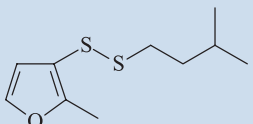
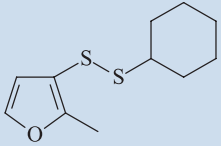
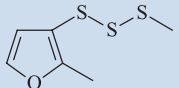
F-3



Molecular structure	Odor characteristics (FEMA#)	Molecular structure	Odor characteristics (FEMA#)
	Meat, roasted meat ^{7,12,14}		Meaty (3481) ¹⁸
	Green, meaty, roasted meat ^{7,12}		Meaty ¹⁸
	Meat flavor ⁷		Meaty ¹⁸
	Meat flavor (3973) ^{7,17}		Meaty, brothy, nutty ¹⁸
	Roasted meat flavor (4034) ¹⁸		Cooked chicken, roasted meat ¹⁸
	Meaty, nutty ¹⁸		Meaty, sweet ¹⁸
	Sweet, roasted meat flavor ¹⁹		Roasted meat, meaty ¹⁸
	Meaty ¹⁸		Sulfury, cabbage, meaty, rubbery ¹⁹
	Meaty, roasted aroma and taste ¹⁸		Sulfury, roasted, meaty ²⁰
	Meaty ¹⁸		Beef flavor ⁹
	Sweet, nutty, meaty ^{7,18}		Meat-like flavor ⁹
	Roasted meat, sweet ¹⁸		Cooked meat, grilled, smoky ^{8,21}
	Sweet, meaty ¹⁸		Pork, beef broth flavor, meaty, nutty ^{9,22}
	Meaty ¹⁸		Meat, roasted meat, roast beef flavor ^{7,18}
	HVP-like, meaty ^{7,18}		Sweet, baked bread, meaty, roast beef flavor ^{7,23}



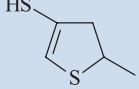
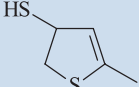
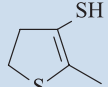
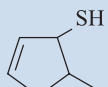
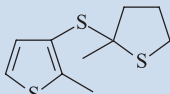
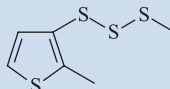
Odor characteristics of compounds with one S-C=C-O structural unit (continued)

T-3

Molecular structure	Odor characteristics (FEMA#)
	Rubbery, sulfury, meaty flavor ²²
	Meat, roast beef flavor ⁷
	Sweet, pot roast, meaty aroma flavor ²²
	Meaty, beef flavor ⁹
	Roasted, brothy, spicy, onion, garlic, vegetable, meat, gravy, roast beef ¹⁸
	Sweet, roasted meat flavor ²⁴
	Sweet, roasted, liver-like, pot roast, beef flavor ²⁴
	Wheaty, green, sulfury, sweet, meaty flavor ²²
	Sweet, roasted, meat, HVP-like flavor ²⁴
	Meat, liver, chicken fat, sweet, nutty, roasted flavor ²⁴
	Meaty, liver, sweet, nutty flavor ²⁴
	Meaty ¹⁹

Odor characteristics of compounds with one S-C=C-S structural unit

T-4

Molecular structure	Odor characteristics (FEMA#)
	Fatty, onion, coffee, boiled meat flavor ¹³
	Meat, roasted meat flavor ^{7,12}
	Meat flavor ^{7,12,13}
	Roasted meat ¹³
	Meaty ^{7,12,13}
	Sweet, roasted meat ¹³
	Oniony, cabbage, roast meat ²⁰
	Meaty, roasted ¹⁹

The data in T-6 indicates the compounds in this subclass all have a meaty aroma, thus making our presumption more believable.


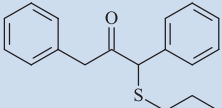

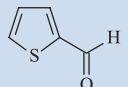
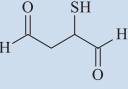
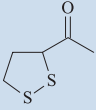
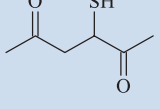
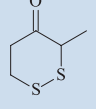
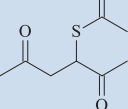
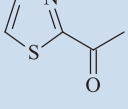
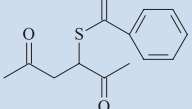
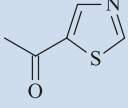
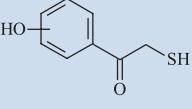
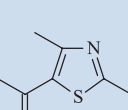
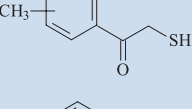
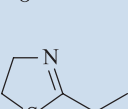
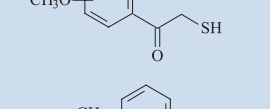
Conclusions

The compounds containing one or more characteristic structural units depicted in F-2 very nearly feature a meaty aroma, which proved our presumption very well. This presumption can be used to direct the development of new meaty aromas, and avoid aimlessness in screening aromas. In addition, it is helpful in selecting materials for more efficient formulation of meaty flavors. The study of compounds with an S-C-C=S structural unit is still in progress.

Acknowledgements

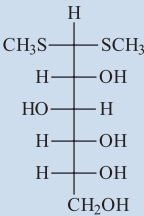
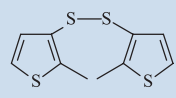
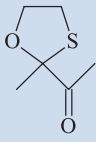
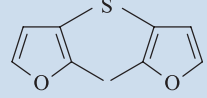
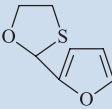
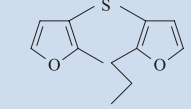
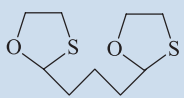
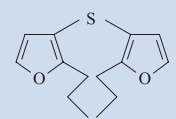
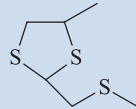
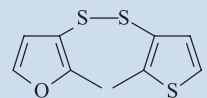
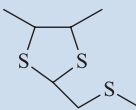
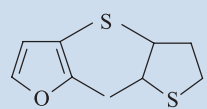
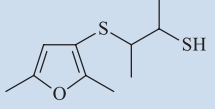
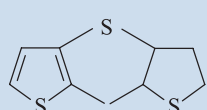
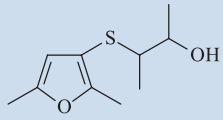
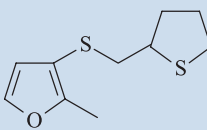
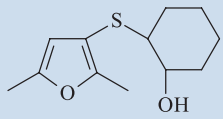
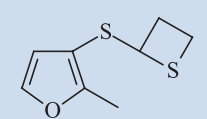
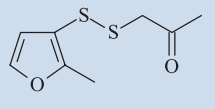
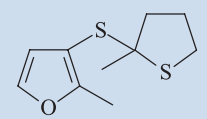
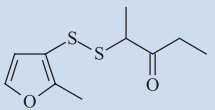
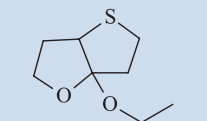
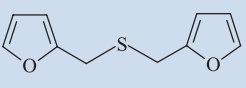
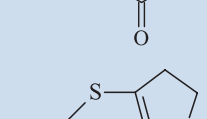
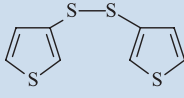
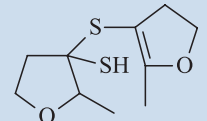
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Molecular structure	Odor characteristics (FEMA#)	Molecular structure	Odor characteristics (FEMA#)
	Meat flavor ⁷		Meat, onion flavor ⁹
	Meat flavor ⁷		Spicy, meaty, nutty ^{13,14}
	Roasted meat ⁷		Meaty, onion, shiitake, liver ¹³
	Roasted meat ⁷		Bloody, sulfury, meaty ⁸
	Roasted meat ⁷		Beef flavor (3328) ¹⁶
	Roasted meat ⁷		Roasted meat flavor ¹⁶
	Meat flavor ⁷		Musty, nutty, earthy, coffee, meaty ^{16,25}
	Meat flavor ⁷		Roasted beef flavor ¹⁶
	Meat flavor ⁷		

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Molecular structure	Odor characteristics (FEMA#)	Molecular structure	Odor characteristics (FEMA#)
	Meat flavor ⁷		Sulfurous, metallic, rubbery, slightly meaty ¹³
	Chicken, boiled mushroom aroma ⁶		Roasted meat ⁷
	Boiled meat, coffee aroma ⁶		Roasted meat ⁷
	Roasted meat, dried mushroom aroma ⁶		Roasted meat ⁷
	Meaty, onion, roasted, HVP-like ¹⁵		Onion, garlic, meaty, metallic, fatty ^{8,13,14}
	Sweet, meaty, HVP-like ¹⁵		Nutty, mushroom, bread, meaty, grilled liver ²⁰
	Beef broth, bacon, meat, nutty flavor ^{7,9}		Mushroom, meaty, roasted meat ²⁰
	Meat, nutty flavor ⁷		Sulfury, leek, chives, garlic, onion, slight meat ²⁰
	Meat, nutty flavor ⁷		Sulfury, rubbery, oniony, slight meat ²⁰
	Roasted meat, pork, onion ¹⁹		Sulfury, meaty, peanut, peas ²⁰
	Meaty ¹⁹		Potato, sulfury, meaty, cabbage ¹⁹
	Beef, chicken flavor (3238) ²¹		Meat-like ⁷
	Roasted meat ⁷		

Molecular structure	Odor characteristics (FEMA#)	Molecular structure	Odor characteristics (FEMA#)
	Meat-like ⁷		Meat, beef flavor ⁷
	Meat-like ⁷		Meat, beef flavor ⁷
	Green, meat, roasted meat, maggi-like ^{7,12}		Meat, beef flavor ⁷
	Meaty, maggi-like ^{12,13}		Meat, beef flavor ⁷
	Roasted meat ¹⁶		Meat flavor ⁷
	Roasted meat ¹⁶		Roasted meat flavor ⁹
	Meaty ¹²		Sweet, meat flavor ⁹
	Meat flavor ⁷		

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