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Compounds Contributing to Meat Flavour

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ABSTRACT

This communication reports the occurrence of five heterocyclic disulphides in the headspace volatiles from beef, three of which have not been reported previously in meat. Evidence is presented which indicates that two of these compounds contribute to the desirable aroma of cooked beef.

INTRODUCTION

Although more than one thousand volatile compounds have been identified from cooked meats, the identities of the key odour impact compounds responsible for desirable meat flavour have proved difficult to ascertain. Recent studies by Gasser & Grosch (1988) have established 2-methyl-3-furanthiol and bis(2-methyl-3-furyl) disulphide as important contributors to the odour of beef. A number of related disulphides have been identified amongst the volatile products of the Maillard reaction between sulphur-containing amino acids and reducing sugars, both by ourselves (Farmer & Mottram, 1990) and others (Misharina *et al.*, 1987; Werkhoff *et al.*, 1989, 1990). These compounds have been sought in the volatiles from beef muscles by both GC–MS and odour assessment.

MATERIALS AND METHODS

The volatile compounds from three cooked bovine muscles were examined: cardiac muscle (heart), *M. semimembranosus* (SM), and *psoas major* (PM).

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Heart meat is reputed to be particularly strong in flavour and it was anticipated that the key odour compounds might prove easier to detect in cooked heart than in meat from more conventional muscles. The muscles were minced and 60 g portions cooked in polyester/polypropylene bags in a boiling water bath. The headspace volatiles from each portion of freshly cooked material (held at 80°C) were swept on to a trap containing Tenax-GC with a stream of nitrogen for 1 h. The methods for collection of volatile compounds on to Tenax traps, analysis by GC–MS and GC–odour assessment, and the calculation of linear retention indices (LRI) have been described previously (Whitfield *et al.*, 1988). A CPWAX 52CB capillary column (50 m × 0·32 mm i.d., Chrompak UK Ltd, London) was used for both GC–MS and GC–odour assessment. For GC–MS, the contents of three traps per muscle type were desorbed on to the front of the column prior to analysis. Odour assessment of individual components was performed using a dilution technique, adapted from Gasser & Grosch (1988). The collected volatiles from six traps were desorbed into a glass capillary tube cooled with liquid N_2 and dissolved in 20 μl heptane/ethanol (5:2). Odour assessments were performed on the GC effluent from 1 μl of this sample and dilutions of 1/4, 1/16 and 1/64; the greatest dilution at which an odour could be detected was noted by two assessors and expressed as the flavour dilution factor (FD-factor), as described by Gasser & Grosch (1988).

Authentic 2-methyl-3-furanthiol and 2-furanmethanethiol (Aldrich Chemical Co.) were dissolved in diethylether and hexane respectively (1 mg ml^{-1}). These solutions, and a mixture of the two, were analysed by GC–MS. An aliquot of the combined solution was shaken with aqueous $CuSO_4$ (3 M), washed with distilled water and dried with Na_2SO_4 (anhyd.) before analysis.

RESULTS AND DISCUSSION

Five structurally related late-eluting disulphides (**I** to **V**) were detected among the volatiles from heart muscle (Fig. 1, Table 1). Compound **I** was also clearly identifiable in both SM and PM, in smaller quantities. Mass spectral evidence also existed for the occurrence of compounds **II** to **V** in SM and/or PM, albeit only in trace quantities. The presence of **I** in beef has been established by Gasser & Grosch (1988), while Werkhoff *et al.* (1990) recently commented that they have identified compound **V** in the headspace of beef as well as model systems. Compounds **II** to **IV** have not previously been reported in the volatiles from meat.

The identities of compounds **I** to **V** were indicated by interpretation of the mass spectral data. These compounds have all been detected in greater abundance in heated model systems containing cysteine and ribose;

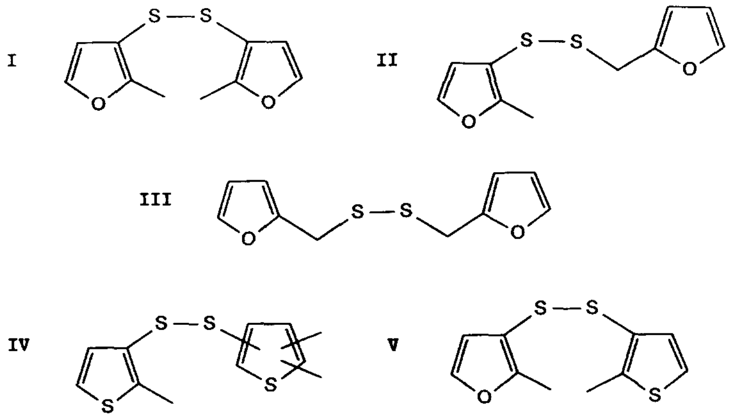

Fig. 1. Some disulphides identified in the volatiles from heated bovine muscles.

comparison with the mass spectra for compounds from these systems with the same LRI values aided tentative identification where the mass spectra from the SM and PM samples were weak. Confirmation of identity for compounds **I** and **III** was obtained by comparison with the mass spectra and LRI values for late-eluting compounds occurring as minor components in solutions of 2-methyl-3-furanthiol and 2-furanmethanethiol respectively, while a compound whose data matched that for compound **II** was also formed when these two solutions were mixed. These compounds are formed by oxidation of the monomeric thiols; treatment with $CuSO_4$ increased the yield of all three disulphides.

TABLE 1
Some Compounds Identified in the Headspace Volatiles from Three Cooked Beef Muscles

No.	*Compound identity*	*LRI*	*Heart*	*SM*	*PM*
I	Bis(2-methyl-3-furyl) disulphide	2 107	+ +	+	+
II	2-Furfuryl 2-methyl-3-furyl disulphide	2 345	+ +	tr	tr
III	Bis(2-furfuryl) disulphide	2 517	+	tr	tr
IV	Dimethylfuryl 2-methyl-3-furyl disulphide (t)	2 385	+	tr	nd
V	2-Methyl-3-furyl 2-methyl-3-thienyl disulphide (t)	2 387	tr	tr	tr

+, + + = detected (as very small or small components of GC–MS chromatogram).
tr = trace.
nd = not detected.
t = tentative.

TABLE 2
Some Late-Eluting Meat-Like Odours Detected in the Headspace Volatiles from Cooked Beef Muscles

Odour description	*LRI*	*FD-factor*[a]	
		Heart	*SM*
Oxo, roasted, toast, mealy, meaty	2 113	32	16
Roasted, meaty, roasted meat	2 351	64	8

[a] FD-factor = maximum dilution at which odour is detectable (averaged for two assessors).

The monomeric 2-furanmethanethiol (LRI = 1406) was readily identifiable by GC–MS in all three muscles, although the levels in heart were highest, while 2-methyl-3-furanthiol (LRI = 1285) was detectable in trace quantities in only a few analyses.

Preliminary studies of the volatiles from cooked heart and SM by GC–odour assessment showed the presence of two late-eluting aromas which were described as ‘meaty’ and were detectable at high dilution (Table 2). The LRI values of these aromas corresponded to two of the disulphides reported (**I** and **II**). Of these, bis(2-methyl-3-furyl) disulphide (**I**) has been identified as an important odour constituent of beef by Gasser & Grosch (1988) and is known to have a very low odour threshold of 2 parts in 10^{14} in water (Buttery *et al.*, 1984).

In contrast, the contribution to cooked beef aroma made by 2-furfuryl 2-methyl-3-furyl disulphide (**II**) has not been reported previously. It is notable that **II** contributed to the aroma of SM even though it was present at very low levels such that it could barely be detected by GC–MS. In order to assess the odour qualities of this compound, GC–odour assessments were performed on the products formed from 2-methyl-3-furanthiol and 2-furanmethanethiol; their odour descriptions are listed in Table 3 and comparison with the aromas detected in the cooked beef muscles (Table 2) shows good agreement for those at LRI *c.* 2110 and 2350. GC–odour

TABLE 3
Odour Descriptions and LRI Values for Compounds Formed from a Mixture of 2-Methyl-3-Furanthiol and 2-Furanmethanethiol

Compound	*LRI*	*Odour description*
Bis(2-methyl-3-furyl) disulphide	2 106	Meaty, oxo, roasted, burnt
2-Furfuryl 2-methyl-3-furyl disulphide	2 342	Meaty, roasted, burnt
Bis(2-furfuryl) disulphide	2 515	Roasted, burnt

assessments were performed at a series of dilutions to determine the lowest level at which these compounds were detectable; the aromas of all three disulphides were detected down to the low pg levels, suggesting that the odour threshold of **II** may be as low as that of **I**.

These results suggest that, in addition to bis(2-methyl-3-furyl) disulphide (**I**), 2-furfuryl 2-methyl-3-furyl disulphide (**II**) is an important odour impact compound in cooked beef. The higher levels of the reported compounds in heart than in SM or PM may offer an explanation for the reputedly strong flavour of cooked heart. Both of these compounds contain the 2-methyl-3-furylthio- moiety; it is possible that, depending on the prevalence of different thiols generated during cooking, various disulphides containing this grouping could be formed, all perhaps contributing to meat aroma to a greater or lesser extent. This may explain the range of flavour and aroma intensities experienced in cooked beef.

REFERENCES

Buttery, R. G., Haddon, W. F., Seifert, R. M. & Turnbaugh, J. G. (1984). Thiamin odor and bis(2-methyl-3-furyl) disulphide. *J. Agric. Food Chem.*, **32**, 674–6.

Farmer, L. J. & Mottram, D. S. (1990). Recent studies on the formation of meat aroma compounds. In *Flavour Science and Technology*, ed. Y. Bessiero & A. F. Thomas. John Wiley and Sons, Chichester, pp. 113–16.

Gasser, U. & Grosch, W. (1988). Identification of volatile flavour compounds with high aroma values from cooked beef. *Z. Lebensm. Unters.-Forsch.*, **186**, 489–94.

Misharina, T. A., Vitt, S. V. & Golovnya, R. V. (1987). Chromatography–mass spectrometric study of the volatile constituents of model systems with meat odor. *Biotekhnologiya*, **3**, 210–15.

Werkhoff, P., Emberger, R., Guntert, M. & Kopsel, M. (1989). Isolation and characterization of volatile sulfur-containing meat flavor components in model systems. In *Thermal Generation of Aromas*, ed. T. H. Parliment, R. J. McGorrin & C.-T. Ho. American Chemical Society, Washington, DC, pp. 460–78.

Werkhoff, P., Bruning, J., Emberger, R., Guntert, M., Kopsel, M., Kuhn, W. & Surburg, H. (1990). Isolation and characterization of volatile sulfur-containing meat flavor components in model systems. *J. Agric. Food Chem.*, **38**, 777–91.

Whitfield, F. B., Mottram, D. S., Brock, S., Puckey, D. J. & Salter, L. J. (1988). Effect of phospholipid on the formation of volatile heterocyclic compounds in heated aqueous solutions of amino acids and ribose. *J. Sci. Food Agric.*, **42**, 261–72.