MODELLING THE ODOUR OF COOKED BEEF *IN VITRO* USING DIFFERENT FATTY ACIDS

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Background

After tenderness, flavour is the most important characteristic of meat quality perceived by the consumer. The development of cooked meat aroma and flavour is a very complex process in which different components react to produce intermediates or final flavour volatiles. The process is not fully understood although Maillard reactions between reducing sugars and amino compounds play a central role. Phospholipids have been shown to be important key ingredients in beef flavour formation and lipid degradation products have been found to dominate the volatile extracts (Mottram *et al.*, 1982; Mottram and Edwards, 1983). These components in lean muscle are considered to be mainly responsible for the basic meaty flavour. Phospholipids are very unsaturated compounds containing the largest amounts of n-3 and n-6 fatty acids in the muscle lipids, represented by linolenate and linoleate and their longer chain products. Due to their polyunsaturated structure, they easily undergo oxidation during the cooking procedure giving a large range of volatile products, some of which react with Maillard products. These volatiles can be studied using aqueous model systems (Salter *et al.*, 1988).

Objectives

To assess sensory perceptions of meat odour created *in vitro* by cooking different mixtures of fatty acids.

Methods

Six different mixtures were created from combinations of fatty acids, C18:1, C18:2 and C18:3 with or without a mixture of L-cysteine and D(-)ribose. For each model system, 0.5 mmol of each compound was placed in 100ml capacity screw capped *Duran* borosilicate glass bottles with 20ml of pyrophosphate buffer 0.2M at pH 5.5. The reaction mixtures were heated at 140°C under pressure for 30 minutes and allowed to cool. Reaction mixtures were diluted 1/100 and 10ml were transferred into 50ml capacity narrow mouth *Volac* amber bottles with glass stoppers for odour assessment. They were presented as a triangular test to a 10-member trained taste panel following the pattern of Table 1 as an example. This pattern was changed in every session. Panellists assessed the smell at room temperature in individual booths with red light to mask colour differences. They were asked to identify the odd sample and to describe the difference. All combinations studied were carried out in duplicate on different days. Chemicals were purchased from Sigma.

Table 1. *Example of the order of presentation of odour samples to each panellist during a triangular test.*

Panellist	1	2	3	4	5	6	7	8	9	10
	ABB	AAB	ABA	BAA	BBA	BAB	ABB	AAB	ABA	BAA

Results and discussion

Results in Table 2 show that the odours associated with each fatty acid alone were distinctively different from those when cysteine and ribose were also included. The panellists more easily separated the different fatty acids when C18:3 was present. It seems that C18:3 produces more distinctive compounds than the other fatty acids. Its extra double bond would produce (*E,E*)-2,4-heptadienal and (*E,E*)-2,4-hexadienal instead of the higher molecular weight (*E,E*)-2,4-decadienal and (*E,E*)-2,4-nonadienal produced by C18:2, an n-6 fatty acid. These products can form 2-alkylthiophenes and 2-alkyl-(2*H*)-thiapyrans by reacting with hydrogen sulphide and sulphur compounds are considered characteristic of meat flavour. The number of comments that panellists gave in their positive answers during the triangular tests is shown in Table 3. 'Meaty' comments appeared only when cysteine and ribose were involved. The presence of sugars and amino acids in the muscle has been shown to be essential in the formation of meat aroma (Mottram, 1998). They are involved in Maillard reactions which lead to the formation of aldehydes, pyrazines and other heterocyclic sulphur compounds (Vernin and Parkanyi, 1982), so important in meat flavour. Alkyl-3-thiazolines and 3-thiazoles have been isolated from cooked beef (Elmore *et al.*, 1997). It has been suggested that these compounds would be produced from the interaction of Maillard reaction products with aldehydes derived from lipid degradation and more readily in pressure-cooked meat than in grilled meat (Mottram, 1998), similar to the method used in this work. Pyrazines are produced through the Strecker degradation of amino acids by dicarbonyl compounds and have been ascribed a roast-burnt note. As a result of this, 'Burnt' was only used as a descriptor in cysteine and ribose combinations alone. 'Fishy' was described only when C18:3 was involved. Miejboom and Stroink (1972) described a fishy off-flavour associated with 2-*trans*, 4-*cis*, 7-*cis*-decatrienal derived from the oxidation of n-3 PUFA in fish oils and also formed to a lesser extend by the autoxidation of oils containing linolenic acid, which could explain why mixtures were considered 'fishy' only when C18:3 was used. 'Oily' comments were only related to the presence of C18:2 and C18:3. These fatty acids can be considered the key to flavour development since they are the precursor fatty acids for the formation of the n-6 and n-3 series. Feeding can modify the content of C18:3 in the muscle in relation to C18:2 and also alter the longer-chain PUFA (Enser *et al.*, 1998) which can affect meat flavour. Grass-fed steers were considered as 'grassy' and 'oily' while grain-fed steers were characterised as 'fatty' by Melton *et al.* (1982). Although interactions with sugars and amino acids can occur in the muscle, when fatty acids were cooked with cysteine or ribose very few 'oily' comments were found. All 'linseed' comments except one (21) were associated with

C18:3, which is the major component of linseed oil (60%). C18:1 when cooked alone had a weak odour or was described as odourless compared to the rest of the fatty acids, probably due to the less unsaturated molecule being more resistant to oxidation. Consequently, it would yield a lower number of volatiles in relation to C18:3 which was considered to produce a stronger odour than the other fatty acids. On the other hand, C18:1 produced a strong odour, comparable with the other two fatty acids, when combined with cysteine and ribose. These results agree with the hypothesis that the particular role of fatty acids in the development of the aroma of cooked meat depends upon flavour moderation and control (Mottram, 1998).

Conclusions

It is possible to reproduce meaty aromas that are recognisable by a taste panel by cooking mixtures containing fatty acids *in vitro*. The presence of a sugar and a sulphur amino acid is necessary for a desirable meaty aroma together with fatty acids. C18:2 and C18:3 also contribute to an 'oily' odour whereas C18:3 can produce 'fishy' and 'linseed' notes.

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Table 2. *Number of correct answers in triangle tests of cooked mixtures of fatty acids (C18:1, C18:2, C18:3), amino acid (cysteine,c) and sugar (ribose, r) using a trained panel during two sessions.*

	18:1 *vs* 18:1+c+r	18:2 *vs* 18:2+c+r	18:3 *vs* 18:3+c+r	18:1 *vs* 18:2	18:2 *vs* 18:3	18:3 *vs* 18:1	18:1+c+r *vs* 18:2+c+r	18:2+c+r *vs* 18:3+c+r	18:3+c+r *vs* 18:1+c+r
1st	8/10 **	9/10 ***	10/10 ***	6/9 *	8/9 ***	8/9 ***	6/10 ns	7/10*	7/10 *
2nd	8/8 ***	8/8 ***	7/8 **	7/10 *	8/10 **	10/10 ***	5/10 ns	8/10 **	7/10 *

ns = no significant; * = p<0.05; **=p<0.01; ***=p<0.001

Table 3. *Number of unsolicited comments of positive identifications in triangular tests for each cooked mixture by the total of panellists.*

	18:1	18:2	18:3	18:1+c+r	18:2+c+r	18:3+c+r
Meaty	0	0	0	20	13	15
Burnt	0	0	0	1	2	1
Oily	0	16	31	0	1	3
Fishy	0	0	7	0	0	1
Linseed	0	1	21	0	0	0
No odour	14	2	0	0	0	0
Weak odour	7	9	3	0	5	4
Strong odour	0	1	6	9	8	11

'Meaty' includes meaty, beefy, corned beef, pork.
'Oily' includes vegetable oil, greasy, grassy, oily, cooking oil, sunflower oil, linseed oil, rapeseed oil.
'Fishy' includes fishy, cod liver oil. 'Linseed' includes linseed oil, putty. 'Weak odour' includes weak, bland, mild, faint.