PRECURSORS OF FLAVOUR IN COOKED BEEF

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Background

The desirable aroma and flavour of cooked beef arise as a result of chemical reactions which occur during cooking. Research over the last fifteen years has concentrated on identifying which of the many volatile compounds formed from these reactions are responsible for the characteristic aroma of cooked beef (for example, Gasser and Grosch, 1988; Gasser et al., 1994; Farmer and Patterson, 1991). An understanding of the routes of formation of these compounds (Mottram, 1991), suggests that the natural components of raw meat, which react during cooking to give beef flavour, include reducing sugars, ribonucleotides, amino acids, thiamine, lipids and fatty acids. To study the effect of some of these compounds on normal flavour formation in cooked beef, various researchers have added selected precursors into homogenised raw meat (Mottram and Madruga, 1994; Farmer et al., 1996; Hudson and Loxley, 1983). These studies have shown that inosine monophosphate and reducing sugars can alter the volatile compounds formed and/or the sensory quality of beef, lamb and pork.

Objectives

Investigations at Belfast have aimed to discover which of the possible precursors of beef flavour is most important for the formation of the aroma and flavour of cooked beef. The overall odour has been studied using sensory methods, while individual odours have been analysed by gas chromatography (GC)-odour assessment and GC-mass spectrometry (MS).

Methods

Individual solutions of ribose (RIB), ribose-5-phosphate (R5P), glucose (GLU), glucose-6-phosphate (G6P), inosine 5'-monophosphate (IMP), fructose (FRU) and thiamine (THI) were prepared at various concentrations. Aliquots were homogenised with raw minced beef (*M. semimembranosus*; 10ml $100g^{-1}$). Control (CON) meat was prepared by adding distilled water in place of the above solutions. The treated meat was held in covered beakers at 4°C for 18 h, before use for sensory analysis or volatile collection. Samples (20g) were cooked in an oven at 120°C for 25 mins.

<u>Sensory evaluation.</u> Treated meat has been compared with control samples either by sensory profiling or paired comparison methods. Sensory profiling (9 panellists) was used to compare the odour of cooked meat from six equimolar treatments (2 mmoles each substance added to 100g meat). The panellists discussed and agreed more than twenty words to describe meat aroma. Assessments were made at three stages; an 'initial' assessment was conducted immediately on receiving the sample some descriptors were assessed again at 'after 40s' after serving, and all terms were scored again 'after mashing' the meat with a fork. Paired comparisons were conducted to compare control meat with that containing added precursors at 2x or 4x the natural concentration. Panellists (30) were asked "Which sample has more meaty odour?" "roasted odour" and "off-odour".

<u>Analysis of volatile aroma compounds.</u> Freshly cooked beef samples were held at 60°C and the volatiles collected by dynamic headspace collection for 30 mins. The collected volatile compounds were separated on a fused silica capillary column (CPWAX-52CB, Chrompak UK Ltd, London) using a Carlo Erba 5300 gas chromatograph connected to a Kratos MS25 RFA mass spectrometer, as described previously (Farmer et al., 1998).

Results and Discussion

<u>Effect of equimolar concentrations of five precursors.</u> Sensory analyses shows that the addition of 2mmoles $100g^{-1}$ of some precursors to raw beef causes a significant and detectable change in the odour quality of the cooked meat (Figure 1). The addition of ribose and ribose-5-phosphate considerably increases the intensity of 'roasted' odour detected by panellists and, after mashing the sample, ribose also increases 'meaty' odour (Farmer et al., 1998). There is also a tendency for ribose to decrease scores for certain odours which may be regarded as undesirable (not shown). In contrast, the addition of glucose, glucose-6-phosphate or IMP to raw beef has little effect on the odour.

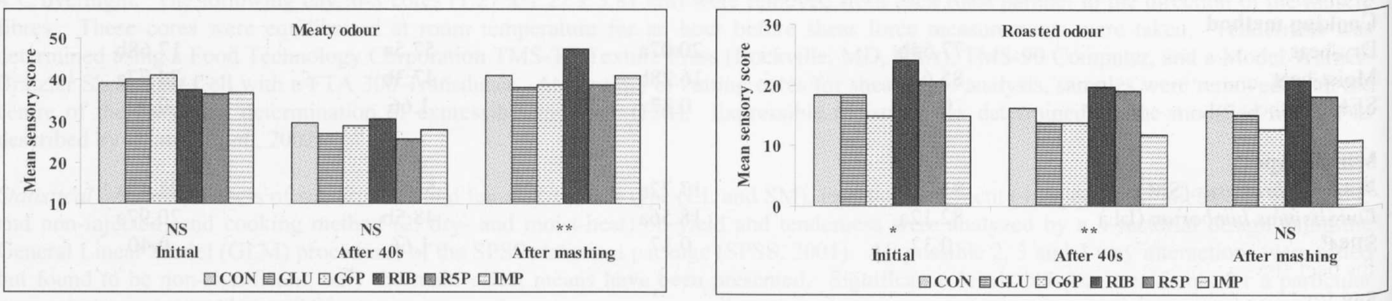

Figure 1 Sensory scores for 'meaty' and 'roasted' odours detected in cooked beef, with and without added precursors

The effect of these precursors on the volatile compounds explains some of the sensory effects. The quantities of the sulphur-containing furans, believed to be key odour impact compounds for the meaty and roasted character of beef (Gasser and Grosch, 1988), increased with the addition of ribose and ribose-5-phosphate (Figure 2). In addition, dimethyltrisulphide (from the Maillard reaction) was increased and hexanal (a lipid oxidation product) was decreased by both ribose and ribose-5-phosphate. This agrees with previous findings, that some aldehydes were decreased in the presence of ribose (Farmer et al., 1996). Methional, benzeneacetaldehyde and 2-acetyl-2-thiazoline were increased by ribose-5-phosphate. This work demonstrates that, at the concentration of sugars added, ribose and ribose-5-phosphate are the most reactive reducing sugars for the formation some of the key odour and flavour compounds in beef.

<u>Effect of small additional quantities of added precursors.</u> The above work compares the effects of equimolar additions of precursors to raw meat. However, the quantities of the various precursors in meat differ considerably. Consequently, studies have also been

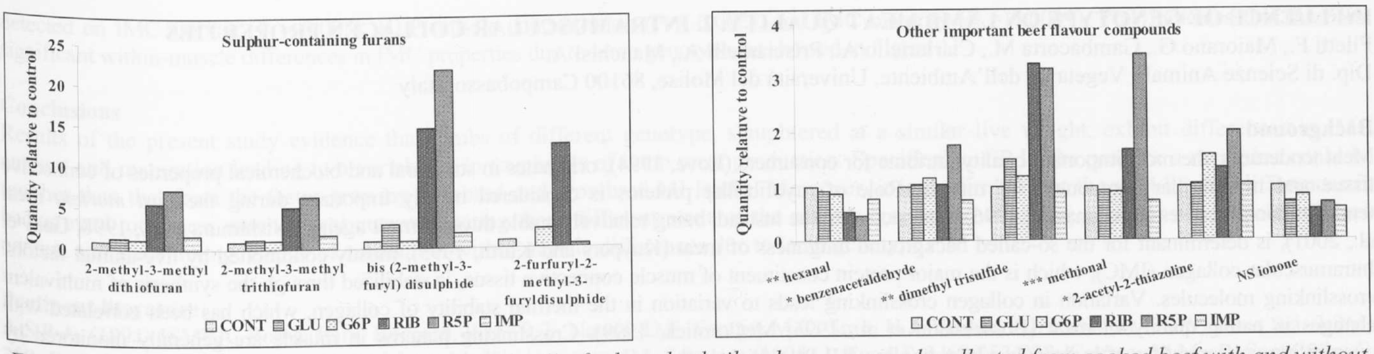

Figure 2 Relative quantities (compared with control = 1) of selected volatile odour compounds collected from cooked beef with and without the addition of selected precursors

conducted on additions of individual precursors, in comparable quantity with the natural concentration. It would be expected that small increases in those precursors whose concentrations were limiting for flavour formation would have a noticeable effect on the odour.

The effects on the odour quality of beef of twice and four times the natural concentrations of precursors (reported in the literature) have been studied (Farmer et al., 1996). These data suggested that relatively small increases in ribose, glucose phosphate or IMP, would give an increase in meaty and roasted odours in cooked beef. However, the literature values for the concentrations of ribose in beef were variable and there was no information on the quantity of ribose phosphate. The development of an HPLC method (Aliani and Farmer, 2002), has allowed us to determine accurately the quantities of ribose and ribose phosphates in beef for the first time (Table 1). Although the beef analysed was a different muscle *(L. dorsi)* to that used for the sensory experiments, these data suggest that the quantities of ribose in beef muscle may be 10 fold lower than those previously reported in the literature, while the quantities of ribose phosphate are lower still. In addition, fructose and fructose phosphate were also present (Table 1).

Table 1 Concentrations of precursors in raw beef (mg $100g^{-1}$)

	Liter-ature	Range-reported means	Recent data [c]	Range–individ. animals
Ribose	300 [a]	126-524	26	12-29
Ribose phosphate	no info.		9	0-29
Glucose	70 [a]	40-106	148	93-203
Glucose phosphate	150 [a]	36-250	80	17-248
Fructose			31	10-52
Fructose phosphate			39	7-55
IMP	85 [a]	6-300		
Thiamine	0.13 [b]			

a (Farmer et al. 1998), b in cooked beef (USDA,), c (Aliani and Farmer, 2002)

Further experiments have now compared the role of low concentrations of ribose, fructose and also thiamine for aroma formation (Table 2). The addition of 4x the natural concentration of ribose has shown a consistent but non-significant trend towards increased 'meaty' and 'roasted' odours. In contrast, the addition of fructose, at 4x the actual concentration, had no effect. This agrees with results obtained for glucose (Farmer et al., 1996); 6-carbon sugars would be expected to be less reactive than 5-carbon sugars.

The addition of thiamine at 4x its natural concentration causes no increase in 'meaty' or 'roasted' odours, suggesting that the very low concentrations of thiamine in beef play little role in meat flavour formation. Many of the furanthiols and disulphides important for the flavour of cooked beef can, in model systems, be formed from either the Maillard reaction, or from the breakdown of thiamine (Mottram, 1991). Grosch and co-workers (1993) showed that, in a model system with cysteine, thiamine forms more of these furanthiols than ribose, even though the concentration of ribose used was 200x that of thiamine. However, the addition of thiamine and cysteine to beef extracts did not demonstrate the same effect. These authors concluded that the formation of these compounds from thiamine required higher phosphate concentrations than were available in the beef extracts.

Table 2 Effect of added precursors on panellist answers to paired comparison tests on 'meaty' 'roasted' and 'off' odours

	Conc. added (4x)	'Meaty' odour	'Roasted' odour	'Off' odour
CON vs RIB	127 [a]	10:20	11:19	13:17
CON vs FRU	126 [a]	15:15	14:16	16:14
CON vs THI	0.52	19:11	14:16	14:16

a 4x natural concentrations of ribose and ribose phosphates (32 and 30 mg $100g^{-1}$) determined in beef used for sensory analysis; b 21 of 30 panellists must select same treatment for significance (P<0.05)

A direct comparison between the effects of ribose, ribose-5-phosphate, and other precursors will be conducted in order to compare their roles in aroma formation.

Conclusions

Studies involving the addition of precursors to raw beef before cooking have indicated that the quantities of certain flavour precursors in beef muscle affect the final flavour quality of the cooked beef. At equimolar concentrations, ribose gives the greatest increase in 'roasted' and 'meaty' odours and those volatile compounds responsible for them. However, studies conducted to determine which precursors are critical for beef flavour formation have demonstrated that various sugar containing components of beef may contribute, but that thiamine, glucose and fructose are not important. Further studies are ongoing to compare the relative importance of these flavour precursors.

Pertinent literature

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