MEAT FLAVOUR GENERATION IN MAILLARD COMPLEX MODEL SYSTEMS


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Abstract

Meat flavour generation in Maillard complex model systems was studied. Mixtures of 3 amino acids and 2 sugars were studied at 3 concentration levels and 3 reaction times using a statistical factorial design. The selected systems tried to mimic the flavour composition in real food products containing both meat and tomato cooked together. Samples were compared by their thiol composition and sensorial profile. The used meat flavour generation marker was 2-methyl-3-furanthiol (MFT). It was observed that MFT formation was well correlated with cysteine and xylose as starting material as well as with the meaty sensory attribute. Synergetic effects seem to occur between glutamic acid and cysteine. In the presence of glutamic acid the sensorial profile changed from burnt, roasted meat to boiled meat, bouillon-like. Also the reaction kinetics of MFT generation changed in the presence of glutamic acid. We strongly believe that to study model systems with increased complexity will give results which can more reliably be translated to real food products.

Introduction

The formation of thiols, related to meat flavour, during the Maillard reaction has been known for decades (1). Besides thiamine, sulphur containing amino acids, such as cysteine, are known to be indispensable reaction precursors. In the presence of ribose or its less expensive isomer xylose, they participate in the Maillard reaction and Strecker degradation to form sulphur-containing compounds characteristic of meat odour (Figure 1). A number of which have been identified and reported in literature. Up-to-date, most studies focused on simple model systems, using only one sugar and one amino acid. Often those results are difficult to translate into real food products. The complex composition of real food products is expected to have a big impact on the reaction kinetics of the generated flavour compounds as well as on the final sensory profile (2). Farmer et al. (3) reported that the cysteine/ribose/lecithin reaction mixture had a much more pronounced “meaty, beefy” odour than a reaction mixture containing cysteine and ribose only. The aim of the present study was to better understand the impact of the system composition on the kinetics of known meat flavour generation markers. Also, to verify if the sensorial profile changed as a result. The selected systems’ composition tried to mimic meat flavour generation in real food products containing both meat and tomato cooked together.

Experimental

Meat flavour related complex model systems (more than one sugar and one amino acid) were studied using a statistical experimental design. Time and concentration
were the variable parameters, whereas pH and temperature were kept constant at 6 and 100°C, respectively, as shown in Table 1. The type of reactants was also a variable parameter, however in order to provide a minimum of meat flavour generation all systems had a minimum level of xylose and cysteine present. The studied systems were heated at 100°C in pyrophosphate buffer solution (50 mL, 0.2M, pH 6). D-Glucose (D-Glc), D-Xylose (D-Xyl), L-Cysteine (L-Cys), L-Glutamic acid (L-Glu), L-Glycine (L-Gly), 2-methyl-3-furanthiol (MFT), furfurylthiol (FFT) and bis(2-methyl-3-furanyl) disulfide (MFT-MFT) were purchased from Aldrich (Zwijndrecht, The Netherlands) and the respective stable-isotope labelled internal standard (labelling degree >98%) MFT* ([2H3] 2-methyl-3-furanthiol) and MFT*-MFT* ([2H6] bis(2-methyl-3-furanyl)disulphide) from AromaLAB AG (Munich, Germany). Prior to analysis by SPME GC-MS, 1% dithiothreitol (DTT) was added, enough to enable reducing conditions (reducing potential: -330 mM). Under these conditions the measured thiols were prevented from oxidation and/or liberated from already established sulphide bounds. Sensorial evaluation was done with an expert panel of 10 panellists. Common Flavour Language references were used. A standardised communication tool for sensory purposes developed by Unilever, International Flavour & Fragrances, Firmenich and Symrise.

Table 1. Complex model systems composition (%) heated at 100°C, pH 6.

<table>
<thead>
<tr>
<th>Sample</th>
<th>D-Xyl</th>
<th>D-Glc</th>
<th>L-Cys</th>
<th>L-Gly</th>
<th>L-Glu</th>
<th>Time (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>0</td>
<td>0.05</td>
<td>1.5</td>
<td>1.5</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>0.05</td>
<td>3.6</td>
<td>0.75</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>0.05</td>
<td>3.6</td>
<td>0.05</td>
<td>1.5</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>0</td>
<td>0.75</td>
<td>1.5</td>
<td>1.5</td>
<td>1.75</td>
</tr>
<tr>
<td>E</td>
<td>0.05</td>
<td>3.6</td>
<td>0.05</td>
<td>0</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
<td>3.6</td>
<td>0.05</td>
<td>1.5</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>G</td>
<td>0.05</td>
<td>0</td>
<td>0.75</td>
<td>0</td>
<td>0</td>
<td>1.75</td>
</tr>
<tr>
<td>H</td>
<td>3</td>
<td>0</td>
<td>0.75</td>
<td>1.5</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>
Results and Discussion

The use of cysteine in combination with a pentose is responsible for the formation of very potent sulphur-containing meat flavour compounds, such as 2-methyl-3-furanthiol (MFT), 2-furfurylthiol (FFT) and bis(2-methyl-3-furanyl) disulphide (MFT-MFT), as described in Figure 1. In aqueous solution it was observed that these compounds show considerable instability. MFT, in particular, was highly dependent on the reaction time and cysteine content. Similar results have been observed by Seeventer and co-workers (4). The signal intensity greatly increased with cysteine concentration, stabilising above cysteine concentration of 0.5% (results not shown). This led us to the hypothesis that the presence of cysteine, prevented MFT from oxidation and/or promoted its liberation from previously formed disulfide bonds by reducing them. As a result, MFT quantification was performed under reducing conditions by addition of dithiothreitol, which has similar reducing potential as cysteine. The measured concentration of MFT was therefore the total potential amount, even if some may have already been in the dimmer form.

The results showed that MFT formation increased when both cysteine and xylose increased simultaneously (Figure 2). This is in line with the reaction mechanism presented in Figure 1. However, the reaction kinetics of MFT generation seemed to be influenced by the increasing complexity of the system. For the same initial concentration of xylose and cysteine, the addition of glutamic acid reduced, by approximately half, the time required to generate the same amount of MFT (Figure 2, sample D vs sample H). Synergetic effects seem to occur between cysteine and glutamic acid. An extra experiment where system H is measured after 1.75 hours of reaction, with and without glycine, should be performed to support this conclusion. In line with the high levels of MFT, samples D & H were also the ones perceived as the meatiest as shown in Figure 3. However, in the presence of glutamic acid (sample D) the sensorial profile changed from burnt, roasted meat to boiled meat, bouillon-like.

Figure 2. Complex model systems in an aqueous pyrophosphate buffer solution (0.2M, pH 6) heated at 100°C. 2-Methyl-3-furanthiol (MFT); L-Cysteine (Cys); L-Glutamic acid (Glu); D-Xylose (Xyl).
Figure 3. Sensorial evaluation of meat flavour complex model system samples. Samples A, B, C, D, E, F, G, H composition described in Table 1. An expert panel of 10 panellists and the Common Flavour Language references were used.

Synergetic effects seem to occur between glutamic acid and cysteine, with impact on the sensory profile. In home cooking, such as stewing of meat, tomato is often used. Tomato is known to be a rich source of glutamic acid. This kitchen practice gives the meat a more cooked note instead of a roasted note, which is in line with the obtained results. However, as mentioned above many other meaty compounds apart from MFT are also formed. Further validation of the present results would be necessary to verify if samples having highest MFT level are always the meatiest.

Conclusions

Some evidence has been given that studies in complex model systems give results which can more reliably be translated into real food products. The analytical data were well aligned with the sensorial evaluation. The samples rich in MFT were also the ones perceived as most meaty in the sensory evaluation. The alignment between analytical and sensorial results supported the hypothesis that providing reducing conditions, MFT could be used as a meat flavour reaction marker, to compare samples with different cysteine content. The increase in complexity, mainly in terms of amino acid content influenced the reaction kinetics. Synergetic effects seem to occur between glutamic acid and cysteine with an important impact on the sensory profile. Future work is still required to better understand the underlying reaction mechanism.

References