QUENCHING METHOD, MOISTURE CONTENT, AND AROMA STABILITY OF ROAST AND GROUND COFFEE

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Abstract

Roasted coffee beans with different moisture content were ground and packaged under nitrogen and under normal atmosphere. The evolution of characteristic odorants was followed by means of headspace solid-phase microextraction coupled to gas chromatography–mass spectrometry. Under atmospheric storage conditions, decrease of dimethyl sulphide, 3-mercapto-3-methylbutyl formate, and N-methylpyrrole was accelerated in the coffee with highest water content. Storage under nitrogen atmosphere during 83 days at 37°C resulted in a considerable faster degradation of dimethyl sulphide, 3-mercapto-3-methylbutyl formate, N-methylpyrrole, 2-furfurylthiol, 2- and 3-methylbutanal, 2,3-butanedione, and 2,3-pentanedione with increasing moisture content. With both storage conditions, a large increase of dimethyl trisulphide concentration was observed; the increase being more pronounced in coffees with higher moisture content. This is a sign of faster thiol oxidation in roast and ground coffees with increased moisture content. The decrease in aroma stability is mainly attributed to a plasticising effect of water, which decreases the glass transition temperature of ground coffee and by this increases the mobility of reactants.

Introduction

Aroma stability of roasted coffee is very limited. It is supposed that aroma staling of coffee is mainly a result of degradation of important odorants such as methanethiol, 2-furfurylthiol, and Strecker aldehydes, rather than an effect of newly formed off-odorants (1, 2). Loss of aroma compounds is particularly fast if storage takes place under normal atmospheric conditions, and roast and ground coffee is especially susceptible to oxidation because of its increased surface and the short diffusion distance for the action of oxygen. Single sealed portions of roast and ground coffee increased in popularity recently and have gained high market share. High storage stability is expected in these coffees, particularly if grinding, degassing and packaging takes place under protective atmosphere. However, manufacturers tend to increase moisture content to the maximum allowed (5 g / 100 g wb) although there is still little knowledge about the consequences of an increased water content on aroma deterioration in roast and ground coffee under protective atmosphere.

Experimental

Raw material, roasting, grinding, and storage conditions. Batches (45 kg) of Colombian Coffea arabica with initial water content of 10 g/ 100 g wb were roasted
with a semi-fluidizing bed roaster CR-1250 from G. W. Barth Ltd. (Freiberg/Neckar, Germany). The coffees were roasted to an equal degree of roast, and roasting times were around 13.5 min. The roaster layout with separate roasting and cooling zones allowed the application of different quenching methods, i.e. air quenching, water quenching in the roasting zone, and water quenching in the cooling zone. By water quenching in the roasting zone only, it was possible to produce a water-quenched coffee without increasing its moisture content. The application of water in the cooling zone, however, resulted in an increased moisture content in the final product. Using the quenching methods mentioned above, four batches of coffee with identical degree of roast and differing water contents were produced (Table 1). Roasted coffees were packaged under nitrogen in polyethylene valve bags in portions of 1 kg as soon as the quenching process was completed. Colour and moisture content of the roasted coffees were determined as previously described (3).

### Table 1. Roasting trials with different quenching methods and resulting water contents.

<table>
<thead>
<tr>
<th>Batch</th>
<th>Quenching method</th>
<th>Water used in RZ(^a) [L]</th>
<th>Water used in CZ(^b) [L]</th>
<th>Moisture roasted coffee [g/100 g wb]</th>
<th>Colour [L(^*)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>air</td>
<td>0</td>
<td>0</td>
<td>1.3</td>
<td>21.2</td>
</tr>
<tr>
<td>Q2</td>
<td>water (RZ) &amp; air</td>
<td>5</td>
<td>0</td>
<td>1.4</td>
<td>21.2</td>
</tr>
<tr>
<td>Q3</td>
<td>air &amp; water (CZ)</td>
<td>0</td>
<td>6</td>
<td>3.2</td>
<td>21.2</td>
</tr>
<tr>
<td>Q4</td>
<td>air &amp; water (CZ)</td>
<td>0</td>
<td>8</td>
<td>6.5</td>
<td>21.5</td>
</tr>
</tbody>
</table>

\(^a\) roasting zone  
\(^b\) cooling zone

After 24 h of equilibration time under nitrogen atmosphere at room temperature, the roasted coffee beans were ground and packaged. To prevent the contact of coffee with oxygen, the full operation was carried out under protective atmosphere. For this purpose, a disk mill (Bühler-Miag 4000, Bühler Ltd., Milano, Italy) was placed in a glove box with controlled nitrogen atmosphere (<1% O\(_2\)). Coffee beans were ground at level 3, then transferred to 100 g polyethylene valve bags, which were then heat sealed. The packaged coffee was stored at 37 °C during 83 days. In addition, open storage at normal atmosphere and 25 °C in the absence of light during 40 days was carried out.

**Aroma analysis.** Dimethyl sulphide, dimethyl trisulphide, 3-mercapto-3-methylbutyl formate, 2-furfurylthiol, 2-methylbutanal, 3-methylbutanal, hexanal, 2,3-butanedione, 2,3-pentanediol, N-methylpyrrole, and 2,3,5-trimethylpyrazine were sampled with headspace solid-phase microextraction (HS-SPME), analysed by GC-MS, and quantified by stable isotope dilution assay as described (3).

### Results

**Open storage of roast and ground coffee.** Storage under normal atmospheric conditions leads to a very fast degradation of aroma compounds and the emergence of stale notes within a few days of storage (1, 4, 5). The evolution of some high volatile aroma compounds during open storage is displayed in Figure 1. While no differences with moisture content were observed for 2,3-butanedione, 2-furfurylthiol (not shown), 2- and 3-methylbutanal (not shown), 2,3-pentanediol (not shown), and 2,3,5-trimethylpyrazine (not shown); 3-mercapto-3-methylbutyl formate, dimethyl sulphide, and N-methylpyrrole (not shown) degraded faster in the coffee with highest
moisture content. Dimethyl trisulphide exhibited a large increase with increasing moisture content. A similar behaviour was observed in an earlier study on roasted coffee beans with different moisture contents (6), and the assumption was made that the fast increase in coffees with high moisture content was related to a faster oxidation of thiols.

**Figure 1.** Alteration of selected aroma compounds during open storage of roast and ground coffee: air quenched (Q1, 1.3 g H₂O/100 g wb, ■), water quenched in roasting zone (Q2, 1.4 g H₂O/100 g wb, ○), water quenched in cooling zone (Q3, 3.2 g H₂O/100 g wb, ▲), water quenched in cooling zone (Q4, 6.5 g H₂O/100 g wb ▼).

Storage of roast and ground coffee under nitrogen atmosphere. Roast and ground coffee sealed in valve bags with an oxygen concentration lower than 1% was stored at 37 °C during 83 days. The increased storage temperature was chosen to shorten storage time. The impact of temperature on roast and ground coffee shelf-life was investigated by Cardelli and Labuza (7). The authors found a decrease in shelf-life of about 20% by increasing the storage temperature by 10 °C. The retention of aroma compounds after storage is displayed in Figure 2. Due to the better storage conditions, changes in the aroma profiles were slower, and differences in degradation rates with different moisture content were clearly visible. Dimethyl sulphide, 2-furfurylthiol, 3-mercapto-3-methylbutyl formate, 2- and 3-methylbutanal, 2,3-butanedione, 2,3-pentanedione, and N-methylpyrrole exhibited considerable faster degradation with increased water content. Similar to the open stored samples, the increase of dimethyl trisulphide was more important with increasing moisture content. The concentration of 2,3,5-trimethylpyrazine remained practically constant during storage. The amount of hexanal, which is a secondary product of lipid oxidation, was more than doubled after 83 d of storage, but no differences with moisture content were observed. This is in agreement with data on water activities of roast and ground coffee at a moisture content between 2 and 5 g/100 g wb, which were specified as being between 0.1 and 0.5 (8, 9). According to Labuza (10), lipid oxidation is only slightly enhanced at these two water activity
values. The faster degradation reactions of odorants in coffees with high moisture content may be explained by the plasticizing effect of water, which reduces the glass transition temperature in amorphous solid systems (11). It was shown that a reduced glass transition temperature led to increased reaction rates in low moisture systems (11-14).

![Graph showing percent retention of aroma compounds](image)

**Figure 2.** Percent retention (relative to \( t = 0 \) d) of aroma compounds during storage under nitrogen atmosphere at 37 °C. Air quenched (Q1, 1.3 g H\(_2\)O/100 g wb, □), water quenched in roasting zone (Q2, 1.4 g H\(_2\)O/100 g wb, △), water quenched in cooling zone (Q3, 3.2 g H\(_2\)O/100 g wb, □), water quenched in cooling zone (Q4, 6.5 g H\(_2\)O/100 g wb, □). 3-MMBF: 3-mercapto-3-methylbutyl formate.

**References**