TOMATO FRUIT FLAVOUR

T.R. Gormley

Introduction

With rising standards of living consumers are becoming more aware of the food they eat and often criticise certain aspects of quality, such as flavour. This trend will continue and producers, wholesalers and retailers will have to become more flavour conscious in relation to the food they are selling. The complaint is often heard that today commercially produced tomatoes are not as good as the ones from the back garden. There may be some truth in this since tomatoes produced in the back garden usually receive individual attention from the home gardener. In commercial production it is not possible to give this individual attention and yields are much higher. However, if growing conditions and nutrition are good, high quality well flavoured fruit can be produced. Research is in progress at Kinsealy on factors influencing fruit flavour and at least one supermarket chain considers good flavour as one of the most important attributes of the tomatoes they sell. These examples show that flavour is not the neglected child that many people point the finger at and every effort is being made to include good flavour as an essential quality factor in addition to other attributes.

What is flavour?

Flavour is an aspect of quality that can be sensed and is comprised of taste and aroma\(^1\). Taste has four dimensions and is sensed by the tongue (Table 1). Aroma has many more dimensions than taste and is due to volatile materials which are released from the food and are sensed by receptors at the back of the nose and throat (Table 1).

In the case of tomatoes, taste rather than aroma seems to be the important aspect of flavour. Freshly harvested tomatoes have a characteristic aroma, much of which seems to come from the calyx\(^2\). However, this is lost shortly after harvesting and the tomato does not have much aroma. It is the chemical compounds remaining in the tomato, i.e. sugars, acids, salts, etc., that give the tomato its characteristic flavour as sensed by the consumer. The dimensions of taste (Table 1) which refer specifically to tomatoes are sweet, sour and salt while bitterness is not very important. It is worthwhile stressing that most people confuse the terms sour and bitter. The correct description of a sharp tasting acidic tomato is that it is sour; bitterness refers to another dimension altogether which is not normally found in tomatoes.

Dennison et al\(^3\) have stated that the sugar and acid contents of tomato fruit are two of the primary factors determining flavour. The total amount of each and the ratio of sugar to acid is very important. If the ratio (percent sugar divided by percent acid) is too low the fruit are sour and have an insipid flavour. An unnaturally
Table 1 - Dimensions of taste and aroma

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Chemical compounds responsible for flavour sensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>Sweet: Sugars</td>
</tr>
<tr>
<td></td>
<td>Sour: Acids</td>
</tr>
<tr>
<td></td>
<td>Salt: Potassium and other salts</td>
</tr>
<tr>
<td></td>
<td>Bitter: Quinine sulphate</td>
</tr>
<tr>
<td>Aroma</td>
<td>Many dimensions</td>
</tr>
<tr>
<td></td>
<td>Small amounts of a large number of volatile compounds</td>
</tr>
</tbody>
</table>

Sweet flavour is produced if the ratio is too high. Tomato fruit with a low level of sugar and a low acid content could have the same sugar/acid ratio as fruit with a high sugar and acid content(4). On the basis of the sugar/acid ratio both samples should have the same flavour. However, in reality the sample containing the high levels would probably be better flavoured since the absolute amounts of acid and sugar are likely to have an affect. For this reason the potassium content may be a better index of tomato fruit flavour than the sugar/acid ratio.

SC of tomato juice and potassium content

Since estimating the potassium content of a tomato involves expressing the juice and measuring the potassium content on a flame photometer it was decided to use the simpler conductivity measurement. In this test one part of centrifuged juice is diluted with nine parts of distilled water and the SC of the solution measured. The SC (umhos/10) and potassium content of 430 samples (a number of varieties over five seasons) were measured and the results plotted graphically (Fig. 1). A high correlation was obtained (0.94) which agrees with work by Davies and Winsor(5) and suggests that SC measurement on the juice can be used to predict the fruit K content within practical limits.

Fig. 1. Relationship between the conductivity and potassium content of expressed tomato juice
Potassium and tomato flavour

Taste panel tests at Kinsealy have shown that there is a good correlation between fruit potassium content and good flavour. Tests were carried out using 10 tasters and 6 samples and each panelist was asked to rank the samples from best to worst. The potassium content of portions of the fruit tasted by the panel was measured and ranked in order of magnitude. The results (Table 2) show that the panel and potassium rankings are in reasonable agreement. It should be stressed that the differences in potassium content of the samples were small making it more difficult for tasters to distinguish between them. It is likely that with larger differences between samples, e.g. contents of 2000 ppm to 4500 ppm at 500 ppm incremental levels the panel ranking would agree perfectly with that for potassium. It was decided, therefore, to carry out further taste panel tests to see how readily panelists could distinguish between samples with widely different potassium contents. For this purpose a large number of paired comparisons were made. Each panelist was given two samples of tomato fruit with a difference of at least 500 ppm in potassium content between them and was asked which he or she preferred. The results (Table 3) show a highly significant \( (P \approx 0.001) \) preference (71\%) for the sample with the higher potassium content. The cultivar Eurocross BB was used exclusively in this test but in future seasons other cultivars will be tasted in a similar manner.

Table 2 - Relationship between potassium content of tomato fruit and taste panel response

<table>
<thead>
<tr>
<th>Fruit potassium content (ppm)</th>
<th>Taste panel response (mean rank for 10 tasters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4450 (1)</td>
<td>1 (best)</td>
</tr>
<tr>
<td>4250 (2.5)</td>
<td>2</td>
</tr>
<tr>
<td>4250 (2.5)</td>
<td>3</td>
</tr>
<tr>
<td>3850 (6)</td>
<td>4</td>
</tr>
<tr>
<td>3950 (6)</td>
<td>5</td>
</tr>
<tr>
<td>4150 (4)</td>
<td>6 (worst)</td>
</tr>
</tbody>
</table>

that the differences in potassium content of the samples were small making it more difficult for tasters to distinguish between them. It is likely that with larger differences between samples, e.g. contents of 2000 ppm to 4500 ppm at 500 ppm incremental levels the panel ranking would agree perfectly with that for potassium. It was decided, therefore, to carry out further taste panel tests to see how readily panelists could distinguish between samples with widely different potassium contents. For this purpose a large number of paired comparisons were made. Each panelist was given two samples of tomato fruit with a difference of at least 500 ppm in potassium content between them and was asked which he or she preferred. The results (Table 3) show a highly significant \( (P \approx 0.001) \) preference (71\%) for the sample with the higher potassium content. The cultivar Eurocross BB was used exclusively in this test but in future seasons other cultivars will be tasted in a similar manner.

Table 3 - Paired comparison taste panels on tomato fruit\(^1\) (1972)

<table>
<thead>
<tr>
<th>No. of comparisons</th>
<th>No. of tasters selecting sample with high potassium</th>
<th>No. of tasters selecting sample with low potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td>123</td>
<td>87</td>
<td>36</td>
</tr>
</tbody>
</table>

\(^1\) each pair of samples compared differed by at least 500 ppm in potassium content
The part the potassium ion itself plays in giving good flavour is difficult to assess. It may be that it contributes greatly to good flavour; on the other hand a high fruit potassium may be just an index of good plant growth and management with accompanying high levels of acid and sugar in the fruit which are responsible for the good flavour. In the fruit sap the potassium ion usually exists as a salt of an organic acid. Correlation coefficients for potassium x % soluble solids, potassium x acidity, potassium x sugar/acid ratio obtained at Kinsealy on samples tested from various trials involving nutrition, feeding methods and soil type over two seasons are given in Table 4. The results show a high correlation between fruit potassium and acidity which agrees with findings of Davies and Winsor (6). Correlation coefficients between potassium content and % soluble solids were also reasonably high indicating that high levels of potassium may also be associated with high sugar content in the fruit. These data indicate, therefore, that potassium is a good index of tomato fruit flavour irrespective of whether the potassium ion is directly responsible for flavour or not. The close relationship between the potassium content of the fruit and the grading results (5), is another good reason for measuring the amount present in the fruit.

<table>
<thead>
<tr>
<th>Season</th>
<th>Cultivar</th>
<th>K x acidity</th>
<th>K x % SS</th>
<th>K x % SS/acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>Extase</td>
<td>0.91</td>
<td>0.89</td>
<td>-0.36</td>
</tr>
<tr>
<td>1971</td>
<td>Selsey</td>
<td>0.85</td>
<td>0.72</td>
<td>-0.66</td>
</tr>
<tr>
<td>1972</td>
<td>Eurocross BB</td>
<td>0.96</td>
<td>0.85</td>
<td>-0.33</td>
</tr>
</tbody>
</table>

Potassium content of Irish tomatoes

The potassium content of 380 samples of tomato fruit from experimental plots have been tested at Kinsealy over the last few years. The results (Fig. 2) show that spring crop tomatoes had a higher potassium content than fruit from autumn crops. This finding is probably related to the better light conditions in spring and early summer and suggests that fruit from spring crops is better flavoured.

Results for mean potassium levels in commercial samples tested from 1969–72 are given in Table 5. Levels were low in 1972 compared to other years and this may have been due to poor light conditions during the growing season. The criticism could be raised that the figure obtained in 1972 was more representative because of the larger number of fruit sources involved, than that for 1969 and 1970 and this might partly explain the lower potassium content of fruit in 1972.
This was not the case, however, since even the highest potassium levels obtained in 1972 were only about equal to the mean values obtained in 1969 and 1970.

The effects of nutrition and cultural techniques on the potassium content of tomato fruit is dealt with in another paper (7).

Table 5 - Mean potassium levels (ppm) in commercial samples of tomato fruit (1969-72)

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of commercial sources</th>
<th>No. of samples</th>
<th>K (ppm)</th>
<th>No. of commercial sources</th>
<th>No. of samples</th>
<th>K (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>4</td>
<td>45</td>
<td>3500</td>
<td>3</td>
<td>22</td>
<td>3340</td>
</tr>
<tr>
<td>1970</td>
<td>5</td>
<td>36</td>
<td>3395</td>
<td>3</td>
<td>18</td>
<td>3200</td>
</tr>
<tr>
<td>1971</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1972</td>
<td>77</td>
<td>178</td>
<td>2630</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Quality image

It would be useful to have a quality image based on potassium levels for Irish tomatoes in addition to appearance factors such as shape, size, colour and absence of defects. This in effect would be a guarantee of flavour. To establish such a quality image, minimum potassium levels for consignments of fruit would have to be guaranteed. This should be feasible provided nutrition and growing programmes are strictly adhered to. This type of scheme could easily be tested on a small scale by a producer group. If a good flavour image could be established it is likely that a premium price would subsequently be paid for fruit with a high potassium content.

In order to establish minimum potassium levels in the fruit further taste testing must be done. In addition many more commercial samples should be tested in order to see what potassium levels are being obtained in practice. Methods of sampling consignments of fruit must be evolved in order to find out how many samples should be tested to obtain an overall picture of the lot. If this type of scheme could be operated it should give the Irish producer an advantage on the markets of Europe.

Acknowledgements

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References


