

Flavour volatiles of tetraploid banana fruit.

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INTRODUCTION

International trade in dessert bananas is dominated by various triploid cultivars described according to genome classification (1) as *Musa* AAA. Formerly, the cultivar «Gros Michel» was the most highly favoured, but owing to its lack of resistance to Panama disease, it has largely been replaced by various cultivars of the Cavendish group, of which cv. «Valery» is now the most widely grown. Previous investigations on the volatile constituents of bananas have been made on triploid clones, for example on cvs. «Gros Michel» (2), «Poyo» (3) and «Valery» (4). The large number of compounds present in banana volatiles have been catalogued (5), and the subject generally reviewed (6,7). The components present are similar in all the main AAA cultivars which have been studied and once the fruits are ripe to normal eating standards esters comprise much the largest group: indeed it has been reported that esters compose 70 % of the total volatiles (3). Esters also make the principal contribution to the characteristic banana aroma, pentyl esters being responsible for the «banana-like» note and butyl esters for the «fruity» note (8), while phenyl esters contribute to the ethereal note in the aroma. Pentyl and hexyl alcohols, aldehydes and ketones contribute to the «green» note, important in unripe and partially ripe fruits. Synthesis of banana volatiles and their changes during ripening in AAA clones has recently been reviewed (7).

During recent decades, the Banana Breeding Research Scheme (B.B.R.S.), Jamaica, has had a substantial programme aimed at producing a completely new range of dessert bananas, which are tetraploids (AAAA) derived genetically from triploid cv. «Gros Michel» or its dwarf mutant cv. «Highgate» as the female parent and various wild or hybrid seeded diploids (AA) as male parents (1, 9). Fruit from the tetraploid clones differ widely in their consumer acceptability, the best being closely comparable to the currently

preferred Cavendish clone, «Valery», and preferred to «Gros Michel», while others were of much lower acceptability, either from lack of typical banana flavour, or from the presence of undesirable flavours (10, 11).

The present paper discusses the flavour volatiles of selected tetraploid clones of different levels of acceptability, in comparison with the established triploid clone, «Valery».

MATERIALS AND METHODS

All experimental fruit was provided by the Banana Breeding Research Scheme, Jamaica. Full details of provenance, transportation, handling and ripening procedures, and of the coding system used have been given in earlier publications (10, 11).

Ten tetraploid clones were selected for flavour - chemical investigation on the basis of taste-panel results out of the thirty-one studied, as representing different levels of organoleptic acceptability. The triploid clone «Valery» was included as a standard of comparison. Tetraploids A, A2, E, C and D2 were of good to average acceptability on the basis of the preference tests, and also achieved above-average scores for «banana flavour» and below-average scores for «green or woody» off-flavours in Scored Descriptive Analysis (SDA) tests. Clones D and J were of low acceptability in ranking trials: assessors' comments indicated that clone D lacked flavour and clone J lacked flavour and was also inclined to exhibit off-flavours. Clones G2 and J2 were chosen as clones of below-average acceptability for which SDA data were available. Clone T was included as a clone of average acceptability but which nevertheless scored below-average for «banana flavour» and above-average for «green or woody» off-flavours (10, 11).

Headspace analysis was chosen as the method most likely to give a realistic indication of the proportions of volatile constituents in the fruit as they are perceived when it is eaten (12). The main disadvantage of this method is variability

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lity arising from minor differences in injection technique : the operator must standardise all aspects of the operation so as to obtain reproducible traces. Some problems were encountered with varying retention times of the individual volatile constituents on both isothermal and temperature-programmed runs, but, as they were found to be constant on any one day, the variations probably arose from some cause such as minor changes in flow rate. Once the typical chromatographic trace patterns had been established and the major peaks identified, these variations could be ignored although they can be seen when different traces are compared.

It was reported (13) that headspace vapours above sliced fruit reached equilibrium after 30 minutes and were qualitatively identical to those above the whole, unpeeled fruit. In the present study it was observed that the headspace vapours above fruit slices became increasingly rich in alcohols after the first few minutes, and that the perceived odour changed from that of freshly cut banana, correlating with observations made in the sensory evaluation studies where it was necessary to work with sliced rather than whole fruit, when some assessors complained that an artificial or «chemical» flavour was detectable if the slices were not absolutely fresh. These observations suggest that significant changes take place after peeling and slicing and that the flavour of slices that have been kept for some time is not precisely that of freshly cut fruit, as has previously been reported elsewhere (14). However, it was found that reproducible traces could be obtained with adequate concentrations of volatiles after 10 minutes incubation and this shorter period was thus adopted.

Individual banana fingers were selected on the third day of panel testing i.e. when fully ripe (11), peeled and cut into 5 mm transverse slices. Five slices from different fingers of the same clone were then immediately transferred to a 250 ml Erlenmeyer flask which was closed with a ground glass joint connected to a screw-cap adaptor fitted with a silicone rubber septum. The flasks were incubated in a waterbath at 18°C for 10 min and 5 ml samples of headspace vapour withdrawn by syringe. This technique has been criticised, as absorption of volatiles on the silicone rubber may occur (15), but was adopted here as a basically simple, comparative system was required.

Gas-liquid chromatographic analysis was carried out using a Pye 104 chromatograph fitted with a flame ionisation detector and a 3 m x 6 mm glass column packed with acid-washed Chromosorb W coated with 5 % UCON 50-HB-2000. The column was operated at a temperature of 85°C for isothermal runs and between 85 and 135°C, increasing by 5°C per minute, for programmed runs. Injector temperature was 150°C and detector 200°C. The carrier gas was nitrogen, at a flow rate of 50 ml/min. Peaks were identified by comparison with reference compounds, synthetic mixtures of standards dissolved in water also being sampled by the headspace technique and injected onto the same column under identical conditions.

RESULTS

Typical isothermal traces obtained for «Valery» and tetraploid clones A, C and J are shown in Figures 1 to 4, in which the principal volatiles are indicated by the code numbers given in Table 1. Traces for all ten tetraploid clones, both isothermal and programmed, are available (10). The pattern of peaks obtained from «Valery» fruit generally resembled that previously reported (8), the main differences being lower proportions of certain alcohols and a somewhat lower proportion of acetaldehyde and 2-pentanone. These differences are probably the result of the shorter period of time adopted between slicing the fruit and sampling the headspace, as discussed above.

All tetraploid fruit, even from clones of high acceptability, produced lower total amounts of volatiles than did «Valery» fruit. However, the differences were much smaller than that found (8) between «Valery» and «Gros Michel», where «Valery» fruit produced almost ten times as much total volatiles as «Gros Michel».

Fruit from clones A, E, C, A2 and B2 (good to average acceptability) produced a pattern of volatile constituents in which the total concentration was only a little less than that of «Valery» fruit and the level of 3-methyl butyl butyrate was high. Clone T produced a similar chromatographic trace but, while it had been considered of average acceptability, unlike the other acceptable clones examined for volatiles, it was given a low score for «banana flavour». This discrepancy may be related to its near ideal texture score. The effect of texture on overall acceptability has been discussed elsewhere (10, 11).

The tetraploid clones D, J, G2 and J2, which had low acceptability and, where tested by SDA, low «banana flavour» scores, showed a common pattern, in which the total concentration of volatiles was lower and the relative amounts of 3-methyl butyl acetate, 1-pentyl acetate and 3-methyl butyl butyrate, lower still. The relative amounts of 2-pentanone and 1-butanol were higher than were found in the more acceptable clones.

TABLE 1 - Key to GLC peaks.

1 and 2	Acetaldehyde, methyl acetate.
3	Ethyl alcohol, ethyl acetate.
4	2-pentanone.
5	2-methyl propyl acetate.
6	2-methyl propyl alcohol.
7	1-butyl acetate.
8	1-butyl alcohol.
9	3-methyl butyl acetate.
10	3-methyl butyl alcohol.
11	1-pentyl acetate.
12	1-butyl butyrate.
13	1-pentyl propionate.
14	1-hexyl acetate.
15	3-methyl butyl butyrate.
16	1-hexyl alcohol.
17	1-pentyl butyrate.

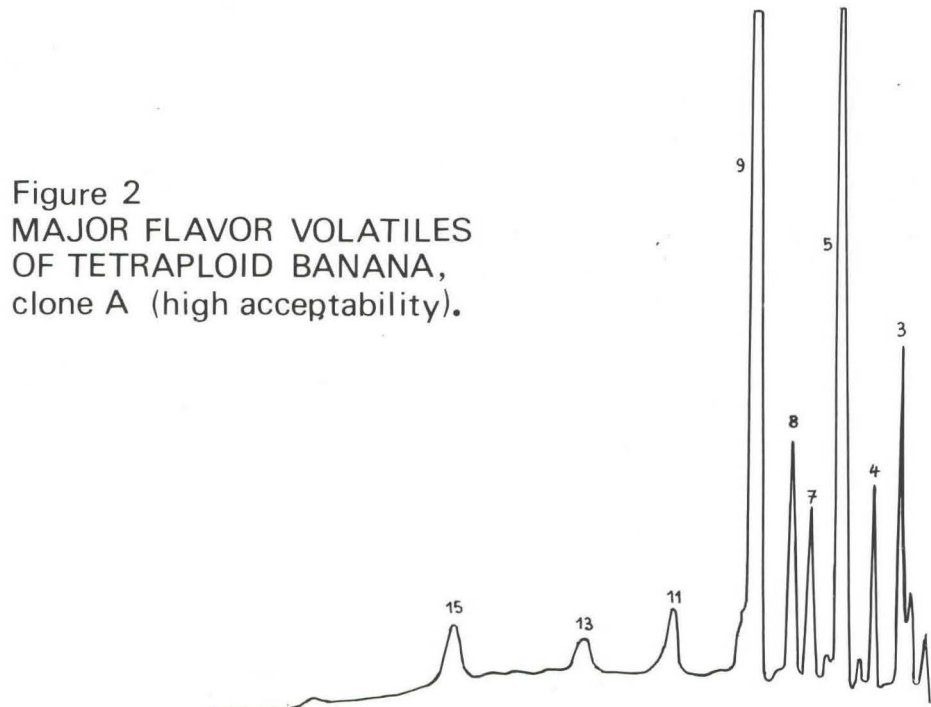
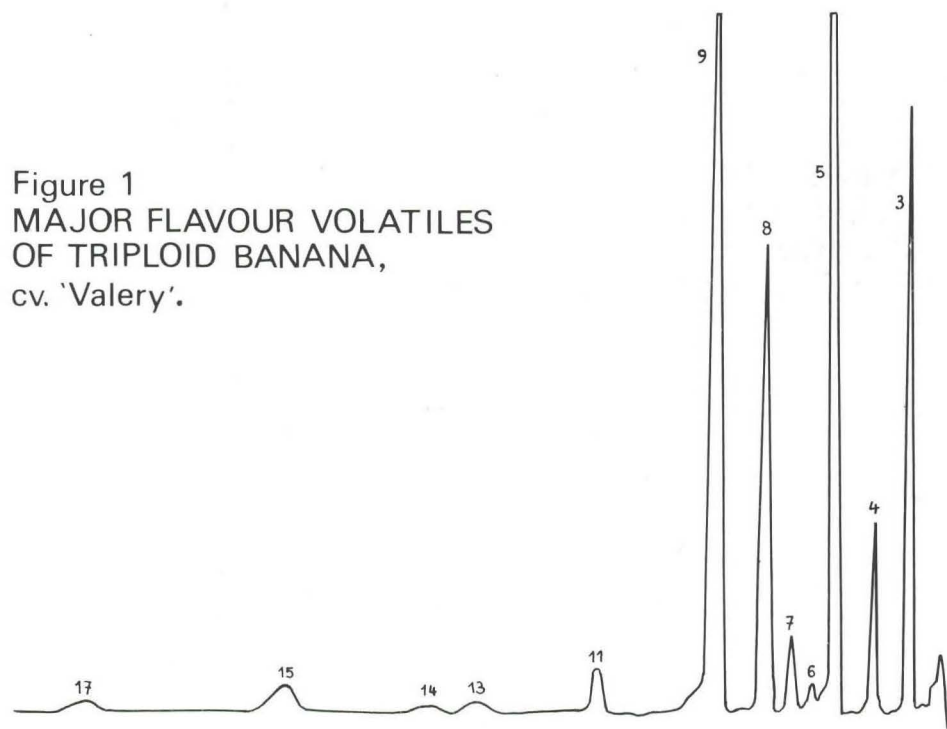


Figure 3
MAJOR FLAVOUR VOLATILES
OF TETRAPLOID BANANA,
clone C (average acceptability).

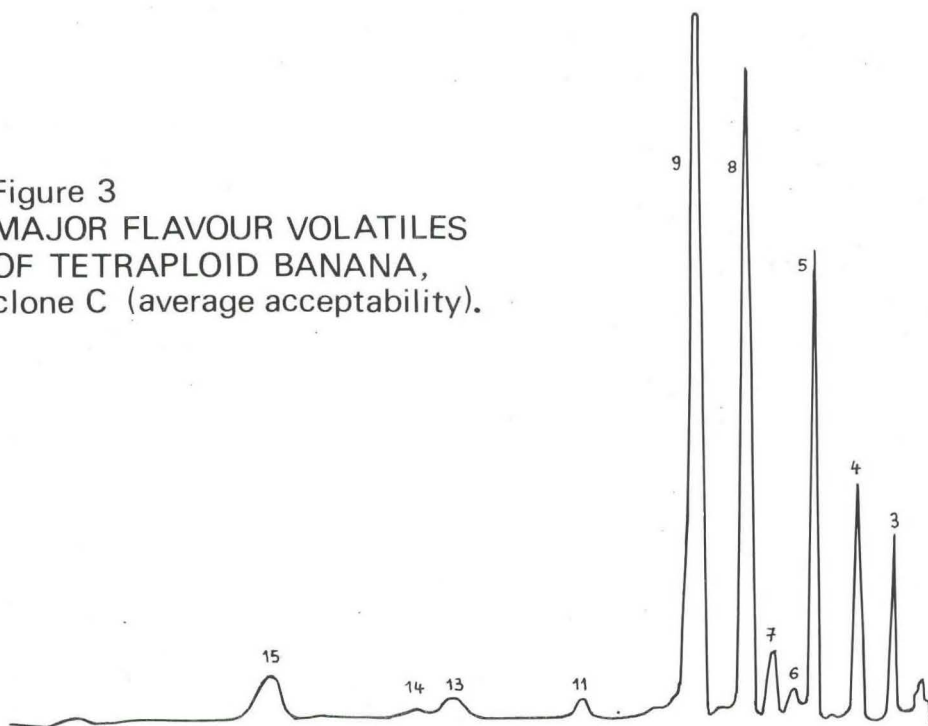
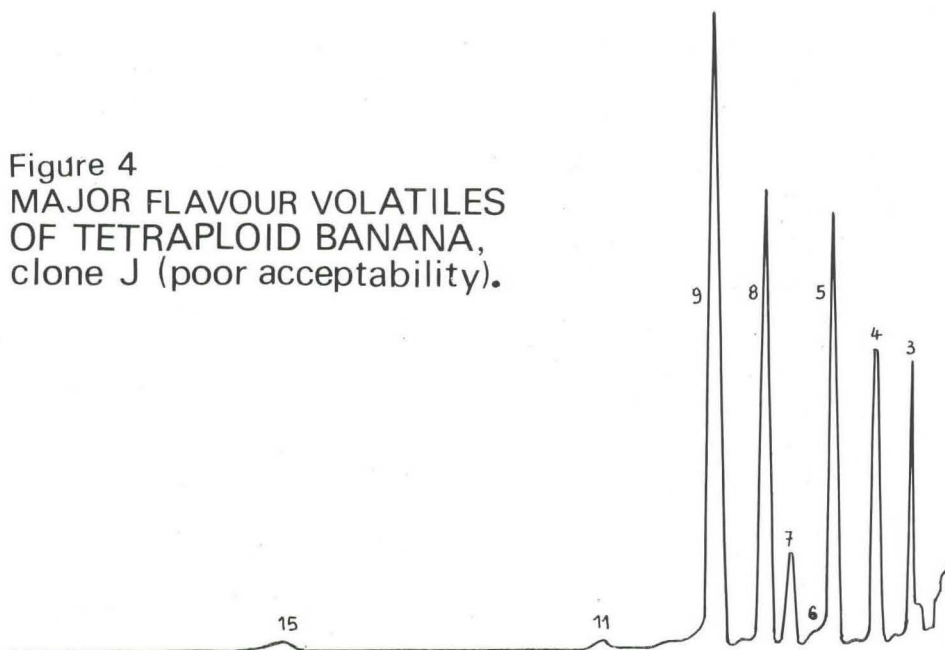


Figure 4
MAJOR FLAVOUR VOLATILES
OF TETRAPLOID BANANA,
clone J (poor acceptability).



It was observed (10) in all the tetraploid clones studied that the ratio of 1-pentyl propionate to 1-pentyl acetate was closer to unity than was observed in «Valery». «Gros Michel» fruit also appeared to yield more 1-pentyl propionate, relative to 1-pentyl acetate, than did «Valery» fruit (12), which is of interest in view of the contribution of «Gros Michel» to the ancestry of the tetraploids. Neither 1-pentyl butyrate nor 1-hexyl acetate were found in any quantity in the volatiles of the fruit of any tetraploid clone investigated, although small amounts of 1-pentyl butyrate were detected in the samples of «Valery» fruit.

DISCUSSION

The traces obtained indicate that there are certain features in a typical headspace pattern which are characteristic of «good banana» flavour, which can be related to the acceptability of the clone by the general consumer, although, as discussed elsewhere (10,11), this may be influenced by textural considerations. This type of headspace pattern was reported for the Cavendish clone «Valery» when this clone was first investigated (13, 16) and was also found in the fruits of many of the acceptable tetraploid clones investigated here. The non-Cavendish «Gros Michel», the triploid parent of the tetraploids, has also been investigated in the past (13, 17), and it is interesting to note that the published chromatograms of the volatiles of its fruit bore certain resemblances to those obtained from the volatiles of tetraploid fruit. Nevertheless, the latter more closely resembled the typical «Valery» chromatogram when the tetraploid clone was an acceptable one. Compared with the Cavendish clones, the published chromatograms of «Gros Michel» fruit volatiles show relatively high concentrations of 1-butanol and 1-pentyl propionate and much lower concentrations of 1-pentyl acetate and 3-methyl butyl butyrate. The total concentration of volatiles also appear to be lower. Most of the tetraploid clones examined in this study had the relatively high level of 1-pentyl propionate typical of «Gros Michel», but the highly acceptable tetraploid clones contained relatively less 1-butanol and more 1-pentyl acetate and 3-methyl butyl butyrate than did «Gros Michel».

In the few ranking trials (11) for which whole fruit of «Gros Michel» or its dwarf form «Highgate» were available, they were ranked only average among the triploid and tetraploid fruit tested. This suggests that as far as flavour is concerned, the best tetraploids are superior to their triploid parent. It is unfortunate that no «Gros Michel» or «Highgate» fruit was available to be included in the present studies to confirm the typical pattern of volatiles of this clone. This might in turn confirm the hypothesis that the pattern of volatile constituents exhibited by the most acceptable tetraploids indicates that these fruit are indeed superior to «Gros Michel», although they have inherited some of their ancestor's characteristics.

Confirming earlier work (8), these investigation show that a simple analysis of the major flavour volatiles by gas/liquid chromatography, which can be conducted on very small samples (minimally, a single bunch), can give a useful initial indication as to whether a particular clone is likely to be acceptable : this should be a useful method for preliminary screening in any future dessert banana breeding programme. Such an early screening program using simple gas chromatographic techniques, could be of immediate practical use in selecting out unacceptable clones for early elimination from trials, and for early identification of highly favoured clones, for rapid multiplication. It would also lead to the accumulation of a body of information on the genetic potential of the parents used in the breeding scheme, which in turn could assist in the selection of such parent clones as well as their potentially successful progeny. Sensory evaluation trials would still be needed in the longer term, but these require larger quantities of fruit, and could be confined to the more promising clones.

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