STUDIES ON THE QUALITY AND FLAVOUR OF TEA
3—GAS CHROMATOGRAPHIC ANALYSES OF THE AROMA COMPLEX

Tei Yamanishi*, R. L. Wickremasinghe & K. P. W. C. Perera

Gas chromatographic analyses of high and low-grown tea showed that the former contained more linalool, linalool oxides, geraniol and cis-jasmone than the latter.

The results of an investigation of the low-boiling volatile compounds by gas chromatography (Wickremasinghe & Swain 1965), indicated that there were quantitative differences in some of these components, especially the methyl butyraldehydes. At the present time more than eighty compounds have been identified in the aroma concentrate (Yamanishi 1966), but the relative significance in tea flavour of these components is imperfectly understood. Information of fundamental value could possibly be obtained by studying the variations of the relative concentrations of already identified compounds in flavoury, high-grown and non-flavoury low-grown teas. If these studies are successful, it may be possible to modify conditions of manufacture to bring out the desired characteristic, or perhaps artificially add the required chemical compounds to semi-or fully-processed tea.

Samples of tea manufactured at St Coombs, Talawakele, and at St Joachim, Ratnapura, were compared for their content of volatile compounds. It was unfortunate that no pronounced flavour was produced at St Coombs at the time that the samples were manufactured, but marked differences were apparent in the two sets of samples, especially in regard to the relative concentrations of linalool and its oxides, geraniol, cis-jasmone, iso-pentanol, cis-3-hexenol and phenylethanol. The analyses were carried out initially at St Coombs and completed in the first-named author's laboratories in Tokyo.

Materials

1 — BOPF, manufactured at St Coombs on 18th January 1968—Good quality, but no flavour

2 — BOPF, manufactured at St Coombs on 25th January 1968—similar to No. 1

3 — BOP, manufactured at St Coombs on 26th January 1968—Better than Nos. 1 or 2, slight flavour

4 — BOPF, manufactured at St Joachim in November 1967.

Methods

1 — Aroma concentrates of the black teas were prepared by steam distillation, followed by extraction of the volatile compounds in the distillate with ether. The other extract was then concentrated by removal of the ether at as low a temperature as possible.

* Dr Tei Yamanishi, Professor of Food Technology and Nutrition at Ochanomizu University, Tokyo, spent one month at the Tea Research Institute of Ceylon as an expert adviser under the auspices of the Asia Productivity Organization.

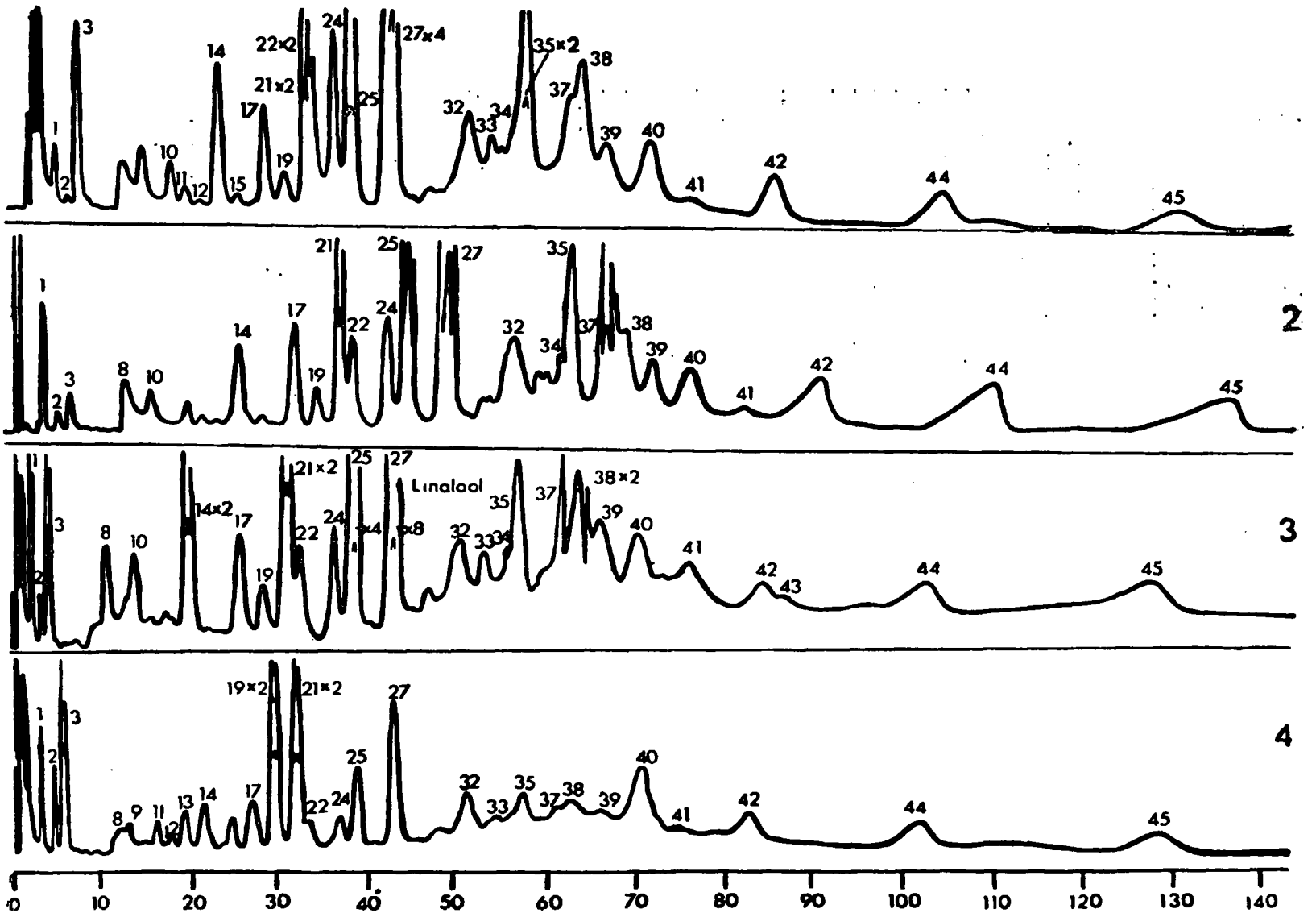

FIGURE 1 — *Gas chromatogram of the aroma concentrate of samples* 1, 2, 3 *and* 4 (*Reference* — TABLE 1)

TABLE 1 — *Comparison of the aroma pattern of four kinds of Ceylon teas (reference to* FIGURE 1)

Peak No.	tR (min)	Peak assignment	Aroma of effluent	Peak area percentage High-grown No. 1	High-grown No. 2	Low-grown No. 3	Low-grown No. 4
1	2.8	iso-Butanal	sweet	0.7	6.1	2.3	3.2
2	3.8	n-Butanal	sweet	0.5	0.2	3.5	2.2
3	4.6	iso-Pentanal	sweet	4.4	0.4	3.3	8.2
4	5.4	Unknown		—	—	0.1	—
5	6.4	Unkonwn	methional-like	—	—	trace	—
6	7.7	Unknown	greenish	—	—	0.1	trace
7	9.8	iso-Butanol (include unknown)	cheese-like	—	—	trace	0.6
8	11.0	n-Hexanal (n-Butanol)	greenish	—	0.6	2.2	—
8′	11.8	Unknown	sweet and fruity	—	—	—	1.6
9	13.4	1-Penten 3-ol	somewhat stimulant	—	—	3.4	0.9
10	14.2	Unknown	sweet and acidic	0.9	0.5	2.2	1.0
11	16.0	Unknown	blood and metal odour	0.4	0.2	0.1	0.4
12	17.6	iso-Pentanol	sweet alcoholic	0.1	—	0.2	0.4
13	18.7	n-Heptanal	greenish	—		trace	1.6
14	20.3	trans-2-Hexenal (n-Pentanol)	greenish and somewhat cinnamon-like	3.8	1.1	3.3	2.3
15	22.3	Unknown	metalic unpleasant odour	0.2	0.1	trace	0.4
16	23.8	Unknown	Amylacetate-like	—	—	trace	—
16′	24.2	Unknown	greenish	—	—	—	1.5
17	26.0	cis-2-Pentenol	sweet and fruity	3.1	1.7	2.2	2.2
18	26.8	Octanal (include unknown)	Acetamide-like	—	—	trace	—
19	28.5	cis-3-Hexenylacetate	Pear-like	1.0	0.7	0.8	0.1
20	29.4	n-Hexanol (include unknown)	greenish, cinnamaldehyde-like	—	—	trace	9.4
21	31.3	cis-3-Hexenol	grassy-fresh leaf-like	7.7	1.7	3.9	13.0
22	32.7	trans-2-Hexenol	chrysanthemum leaf-like	4.2	1.6	2.3	1.6
23	24.8	trans-2-Octenol (cis-5-member)	somewhat oily	—	—	trace	—
24	36.7	Linalool oxide I (cis-5 member)	Japanese parsley-like	3.2	2.3	2.9	1.5
25	39.0	Linalool oxide II (trans-5 member)	earthy and camphor-like	15.5	15.2	10.2	4.2
26	40.6	Unknown		—	—	0.1	—
27	43.2	Linalool	lily of the valley-like	29.0	36.3	23.7	7.3
28	45.3	Unknown	cucumber-like	trace	0.1	trace	—
29	47.2	3.5.-Octadienone	fresh trepang-like	trace	0.3	0.3	0.7
30	48.6	Unknown	earthy and mould-like	0.2	trace	trace	0.1
31	49.5	Unknown	rose-like	—	0.1	trace	—
32	51.0	Phenylacetaldehyde	rose-like	4.6	3.1	2.3	3.0
33	53.4	Unknown	sweet aroma	0.8	0.3	0.7	0.3
34	56.0	Unknown	menthol-like	0.5	trace	0.7	trace
35	57.2	Linalool oxide III	cucumber-like	6.9	4.5	3.8	2.8
36	60.2	Unknown	greenish	—	—	0.8	—
37	63.1	Methylsalicylate (Nerol)	winter green oil-like	1.1	1.7	5.6	0.7
38	63.8	Geraniol	rose and citrous-like	5.2	3.3	9.6	2.4
39	66.4	Benzyl alcohol	somewhat hay-like	2.2	1.7	3.6	1.0
40	79.7	Phenylethanol	rose-like	3.6	1.8	2.2	9.4
41	75.0	cis-Jasmone	jasmin and hay-like	0.3	0.2	2.9	0.2
42	84.3	Nerolidol	flowery	4.1	3.0	1.4	2.6
43	86.9	Pyrrylmethylketone	stimulant, smoky	—	—	trace	—
44	102.7	Pyrrol aldehyde	bitter, sweet and phenolic	3.9	5.3	2.0	4.3
45	127.8	Inodle ?	somewhat flowery	3.9	3.6	3.5	5.5

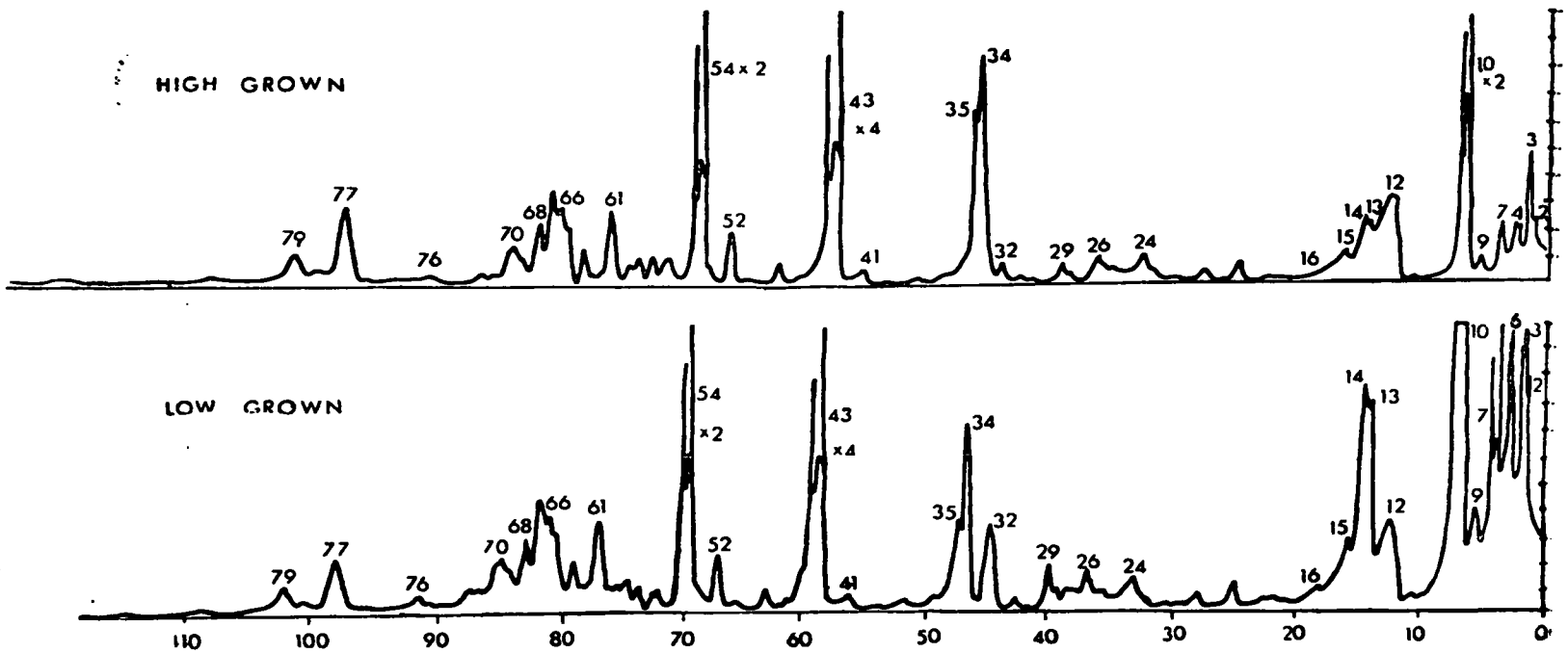

FIGURE 2 — *Chromatograms of head space vapour* (*Reference* — TABLE 2)

2 — In the second method, the vapour above the tea was analysed, without prior steam distillation. This method, known as 'head space vapour analysis' eliminates the necessity for using large samples of tea, as well as the preparation of an aroma concentrate, which is a time-consuming procedure.

TABLE 2—*Comparison of aroma pattern of high-grown and low-grown teas—(Peak area percentage)—(reference to* FIGURE 2)

	St Coombs High-grown		St Joachim low-grown		
Peak No.	(%)	(Value relative to linalool)	(%)	(Value relative to linalool)	Compounds
1-16	28.1	1.20	72.5	11.7	—
34	5.7	0.24	1.4	0.22	cis-3-Hexenol
35	3.1	0.13	0.8	0.13	Benzaldehyde
43	23.5	1.00	6.2	1.00	Linalool
54	7.5	0.32	2.1	0.35	—

Results and discussion

Aroma concentrates

Gas chromatograms of the aroma concentrate from Samples 1, 2, 3 and 4 are shown in Figure 1. Each peak was identified by the retention time, (*ie* the time of its appearance after introduction into the column of the gas chromatograph), and the aroma of the effluent from the column exit, with reference to the data obtained by Yamanishi (1966). The aroma pattern was compared by measuring the area of each peak as a percentage of the total area of all the peaks (Table 1). The most remarkable difference between high—and low-grown teas was in the amount of linalool and linalool oxides. Furthermore, Sample 3, with slight flavour, was found to contain more geraniol and cis-jasmone than the St Coombs Samples 1 and 2. A similar result was obtained using different conditions of gas chromatography. It may be noteworthy that linalool oxides, geraniol and cis-jasmone are all pleasant-smelling compounds. On using a more efficient separating column, the aroma concentrate was found to consist of about 200 different compounds. Many of these compounds have not been identified, but here again, the St Coombs samples showed an abundance of linalool.

Head space vapour

The chromatograms of head space vapour are shown in Figure 2, and the peak assignment and peak area percentage are given in Table 2. In these conditions of chromatography, it is only the very volatile compounds which are analysed, and the difference between high-grown and low-grown teas was firstly, the finding that the total peak area of low-grown tea was much larger than that of high-grown tea. This means that low-grown tea is much more abundant in very volatile compounds than high-grown tea. Secondly, here too, the relative amount of linalool was greater in high-grown than in low-grown tea, but this was due mainly to the relatively high proportion of very volatile compounds (represented by peaks 1-16) in low-grown teas.

Summary

1 — Linalool, linalool oxides, geraniol and cis-jasmone are more abundant in high-grown than in low-grown black tea.

2 — Very volatile compounds are more abundant in low-grown than in high-grown teas.

References

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