Phytochemistry, Vol. 20, No. 9, pp. 2149–2151, 1981.
Printed in Great Britain.

0031–9422/81/092149–03 $02.00/0
© 1981 Pergamon Press Ltd.

VARIATION IN AMOUNTS OF LINALOL AND GERANIOL PRODUCED IN TEA SHOOTS BY MECHANICAL INJURY*

TADAKAZU TAKEO

National Research Institute of Tea, Kanaya-chō, Haibara-gun, Shizuoka-ken, Japan

(*Received* 31 *July* 1980)

Key Word Index—*Camellia sinensis*; Theaceae; tea shoots; linalol; geraniol; genetic variation; black tea aroma.

Abstract—The content of linalol and geraniol produced in injured shoots by mechanical means varies. Tea shoots of the cultivar *assamica* gave mainly linalol while cultivar *sinensis* produced mainly geraniol. Japanese domestic clones and the hybrids of Assam and China showed intermediate characteristics. Variation in the amounts of monoterpene alcohols formed in the shoots is related to the flavor properties of black tea made from the same shoots. The amounts of monoterpene alcohols produced are greater in the younger parts of a shoot. Furthermore, the potential for monoterpene alcohol formation in the shoots is higher at an early stage in maturity.

INTRODUCTION

Variations in the relative amounts of monoterpene alcohols and their oxides in the steam distillates of black tea aroma reflect differences in the flavor properties of tea [1, 2]. Furthermore, there are differences in the composition of volatiles in the aroma of black tea according to the geographical location of the tea plants [3–9]. In a previous paper [10], it was shown that linalol and geraniol, produced by hydrolytic breakdown of non-volatile, bound forms, accumulated in the shoots.

This paper reports that the amounts of linalol and geraniol produced in the shoots are determined by the tea cultivar chosen for study and that these differing amounts of monoterpene alcohol produced influence the flavor properties of black tea.

RESULTS

Concentration of monoterpene alcohol in different parts of a shoot

The amounts of monoterpene alcohols produced by different parts of shoot are shown in Table 1. Compared with the stems, the buds and leaves have considerably higher potential for the formation of monoterpene alcohols. The buds, especially, show the highest potential.

Concentration of monoterpene alcohol in the shoots at different stages of maturity

Table 2 indicates the changes in amounts of monoterpene alcohols in the shoots at different stages of maturity.. Considerable amounts were detected in the shoots at the early stage of maturity when bud and leaf opened. The maximum concentrations were observed at the three-leaf stage. Then, the concentrations decreased gradually with maturity.

Cultivar variation in monoterpene alcohol composition

The content of linalol and geraniol and the ratio of linalol content to total monoterpene alcohol (Index) are shown for different cultivars in Table 3. The clones of the *assamica* cultivar, which were imported from Malaya and Sri Lanka and cultured in a greenhouse, have an Index of 1.0. By contrast, clones of the *sinensis* type which were transplanted from Taiwan, have values between 0.07 and 0.31. The domestic clones of Japan and the hybrids of Assam and China, which have been selected as clones for black tea manufacture in Japan, have intermediate values between these two extremes. Furthermore, the new shoots of *Camellia japonica* and *C. sazanka* produced only linalol, without any geraniol.

As shown in Fig. 1, the total monoterpene alcohol content was higher in the clones having lower values for the Index, except in the cultivars of *assamica*. A hyperbolic relation exists between the Index and the content of monoterpene alcohol.

Table 1. Monoterpene alcohol content of different parts of a tea shoot

	Assam clone 50*		Benihomare†	
	Linalol	Geraniol	Linalol	Geraniol
Bud	123	20	5	176
1st leaf	25	9	4	39
2nd leaf	20	7	—	—
3rd leaf	12	7	—	—
Stem	6	6	10	33

Values are ng/g fr. wt.

* Clone 50 was plucked at the stage of a bud and 3 leaves opening.

† Benihomare was plucked at the early stage of a bud and a leaf opening.

* Part 2 in the series "Black Tea Aroma and its Formation". For Part 1, see ref. [9].

Table 2. Changes in amounts of monoterpene alcohols with shoot maturity

Clone	Early* Amount	Early* Index	Middle* Amount	Middle* Index	Late* Amount	Late* Index
Hathumomiji	8.4† (105)‡	0.54	10.7 (178)	0.71	6.8 (196)	0.75
Yabukita	8.4 (99)	0.26	8.3 (184)	0.51	5.8 (129)	0.55
Benihomare	22.2 (404)	0.22	22.2 (444)	0.24	13.9 (463)	0.27
C-7	19.7 (179)	0.09	25.7 (367)	0.07	13.6 (247)	0.13
C-3	15.8 (150)	0.14	17.8 (274)	0.10	7.4 (164)	0.19

* Early stage: A bud and 2 leaves opening
Middle state: A bud and 3 leaves opening } (1980, spring).
Late state: A bud and 5 leaves opening
† ng/g fr. wt.
‡ ng/100 shoots.
Index: linalol (ng)/total terpene alcohol (ng).

Table 3. Variations in terpene alcohol content among different tea cultivars

Cultivar	Clone		Total terpene alcohols (ng/g)	Index*
Camellia sinensis cv *assamica*	Sri Lanka	1	18	1.00
		21	11	1.00
	Bō (Malaya)	11	13	1.00
		17	15	1.00
		44	12	1.00
		45	7	1.00
		50	15	1.00
	Cambodia		5	0.76
Assam × China hybrid (selected in Japan)	Hathumomiji		11	0.70
	Benifuji		10	0.60
	Sathumabeni		9	0.53
	Tadanishiki		21	0.47
	Indo		14	0.21
	Benihomare		22	0.24
Camellia sinensis cv *sinensis* (domestic clones in Japan)	Sayamakaori		7	0.69
	Yamakai		4	0.68
	Z-1		4	0.66
	Koro		7	0.62
	Yabukita		8	0.51
	Asathuyu		14	0.50
	Tamamidori		11	0.47
	Asahi		9	0.44
	Kurasawa		9	0.30
	Fujimidori		12	0.12
Camellia sinensis cv *sinensis* (transplanted from Taiwan)	Formosa wild clone		14	0.31
	Fuchou		6	0.23
	Hwan kuan		21	0.17
	Chin shin dar pan		29	0.16
	Dar yei wu lon		17	0.10
	C-3		18	0.10
	Jein lan		25	0.09
	Chin shin		33	0.07
	C-7		26	0.07

* Index: linalol content/total terpene alcohol content.

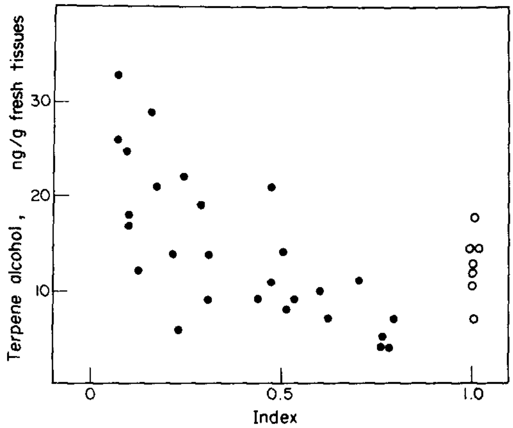

Fig. 1. Relation between monoterpene alcohol content and ratio of linalol content to total monoterpene alcohol content (Index). ○: the cultivars of *assamica*; ●: other clones.

Production of monoterpene alcohols during black tea manufacture

The GC traces for the volatiles in black teas derived from two typical clones, Hathumomiji and Benihomare are shown in Fig. 2. The Hathumomiji clone is similar to the *assamica* cultivars in its potential for monoterpene alcohol formation and has a high Index value (Table 3). The Benihomare clone is similar to the *sinensis* cultivars from Taiwan with low Index values. The tea made from the Hathumomiji clone showed the high relative content of linalol while the tea of the Benihomare clone contained large amounts of geraniol in the volatile fraction. These results show that the potential for monoterpene alcohol formation in fresh shoots is reflected in the composition of monoterpene alcohol in the volatile fraction of black tea made from the same shoots.

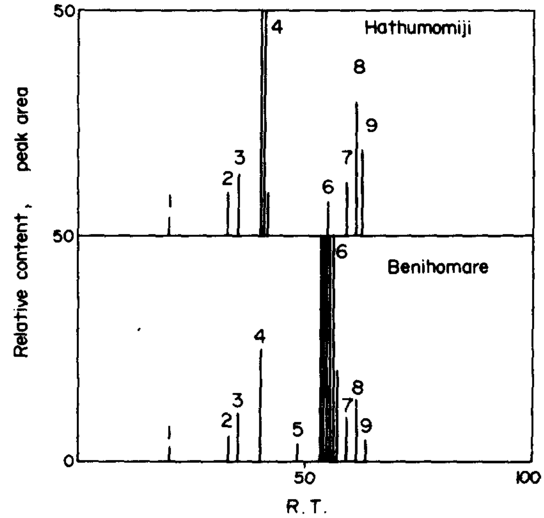

Fig. 2. Gas chromatograms of the volatiles of black tea made from clones of Hathumomiji and Benihomare. Relative content: the peak area of an inner standard compound (ethyl decanoate), to which are added 40 ng/200 g of tea before steam distillation, set at 1, and peak areas of 9 volatiles are calculated. 1. *cis*-2-Penten-1-ol. 2. 1-Octen-3-ol. 3. Linalol oxide. 4. Linalol. 5. Unknown. 6. Geraniol. 7. Benzyl alcohol. 8. 2-Phenylethanol. 9. *cis*-Jasmone.

EXPERIMENTAL

Material. Tea shoots, consisting of two leaves and a bud, were plucked in the clonal garden and the greenhouse of National Research Institute of Tea. The tea cultivars were selected among the clones of *Camellia sinensis* cv *sinensis* and cv *assamica*.

Preparation and assay of volatile fractions. All operations were carried out as described previously [6, 9].

Manufacture of black tea. The manufacture of black tea on a miniature scale was carried out in the experimental factory.

REFERENCES

1. Saijo, R. and Takeo, T. (1973) *Agric. Biol. Chem.* **37**, 1367.
2. Selvendran, R. R., Reynolds, J. and Galliard, T. (1978) *Phytochemistry* **17**, 233.
3. Yamanishi, T., Kobayashi, A., Nakamura, H., Uchida, A., Mori, S., Ohsawa, L. and Sasakura, S. (1968) *Agric. Biol. Chem.* **32**, 379.
4. Saijo, R. (1972) *Study of Tea.* No. 44, 31.
5. Nguyen, T. T. and Yamanishi, T. (1975) *Agric. Biol. Chem.* **39**, 1263.
6. Hara, T. and Kubota, E. (1976) *Study of Tea,* No. 50, 68.
7. Aisaka, H., Kosuge, M. and Yamanishi, T. (1978) *Agric. Biol. Chem.* **42**, 2157.
8. Kosuge, A. and Aisaka, G. (1980) *Eiyō to Shokuryō* 33, 101.
9. Takeo, T. (1981) *Phytochemistry* **20**, 2145.