Distribution of Volatile Compounds in Peach Fruit

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Summary

Volatile compounds emitted from the skin, flesh, and whole fruit of 'Hakuho' peaches (*Prunus persica* Batsch) as influenced by fertilizer levels were determined by a head-space method. Lactones, the main volatiles contributing to the "fruity aroma" of peaches, existed at higher concentrations in the flesh than in the skin; they were highest in moderately fertilized trees. However, other volatiles such as aldehyde, alcohol, and ester, which produce "green aroma", were more abundant in the skin, especially in highly fertilized trees. Less volatiles were emitted from the whole fruit than from the flesh and skin. Within a fruit, volatile compounds were distributed mainly in the flesh, with approximately 97–98 % of lactones and 86–89 % of other volatile compounds.

Key Words: flesh, peach, skin, volatile compounds, whole fruit.

Introduction

The intensity and diversity of volatile compounds are very important factors which contribute to peach flavor. Qualitative and quantitative volatile emissions from ripe fruit have been studied by a number of workers (Engel et al., 1988; Horvat et al., 1990; Kakiuchi and Ohmiya, 1991) and after storage duration (Meredith et al., 1989; Robertson et al., 1990). Jia et al. (1999) reported the effect of fertilizer application levels on the concentration of volatile compounds of 'Hakuho' peaches. The result showed that trees applied with excessive fertilizers produced fruit with lower levels of "fruity aromas" but with higher levels of "green aromas", compared to moderately fertilized trees. However, these investigations dealt only with the juice. In this paper we investigate the distribution of volatile compounds from whole fruit and its parts when grown under different fertilizer levels.

Materials and Methods

Four-year-old 'Hakuho' peach (*Prunus persica* Batsch) trees were applied with 3 levels of complete liquid fertilizers (OHTSUKA HOUSE), containing 160 ppm-N (H), 80 ppm-N (M), and 40 ppm-N (L) twice a week from bud break to the end of stone hardening stage; the levels were then lowered to half in each plot. Experimental variables were as described previously (Jia et al., 2000).

At shipping maturity, thirty fruits per treatment were harvested in the Okayama University orchard during the 1999 season. Fruits were stored at room temperature for

3 days, then analysed. Half of the samples was separated into skin and flesh, and the rest kept whole. The skin, which was hand-peeled from the fruit, included cells of the epidermis and the hypodermis; the flesh was sliced into 1.5 cm³; the whole fruit was kept intact.

Skins, flesh, and whole fruits were placed in desiccators (4 liter) housed within a thermostat (26°C), to which 100 µmol·kg⁻¹ of 2-octanol was added as an internal standard. The vessel was continuously flushed with liquid oxygen. The trapped headspace volatiles were collected on a Tenax-TA column (50cm × 0.8cm) for 4 hr, then analyzed by a gas chromatography (GC) (SHIMADZU GC-14A). The GC condition was identical with those described in the previous report (Jia et al., 1999).

Table 1. Proportion of fresh weight of the skin and flesh in 'Hakuho' peach fruit grown under different fertilizer levels.

Treatment ^z	Harvest date	Proportion (%)		
		Whole fruit	Flesh	Skin
L	July 13	100	81.6b ^x	4.1a
		(189.8) ^y	(154.8)	(7.7)
M	July 15	100	88.0a	3.5b
		(182.5)	(160.6)	(6.3)
H	July 19	100	80.5b	3.4b
		(180.3)	(144.2)	(5.9)

^z Applied complete liquid fertilizer contained 40 ppm (L), 80ppm (M), and 160 ppm (H) of N. The levels were lowered to half of each at the end of stone hardening stage.

^y Fresh weight (grams per fruit) is indicated in parentheses.

^x Significant difference by Duncan's multiple range test ($P < 0.05$) for values within a column.

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Results and Discussion

A high proportion of skin was found in the L treatment and that of the flesh in the M treatment (Table 1).

Of the major volatile compounds extracted from the skin, flesh, and whole fruit (Table 2, 3), the lowest concentration were obtained from the whole fruit in each treatment. However, the distribution of the compounds was not equal between skin and flesh fractions or within treatments. The most important difference found was that *t*-2-hexenal, *cis*-3-hexenol, 2-(E)-hexanol, (E)-acetate, and benzaldehyde, which generated the "green aroma", existed at higher concentrations in the skin than in the flesh and whole fruit (Table 2), whereas the lactones, γ -hexalactone, γ -decalactone, and δ -deca-

lactone, which contribute to the "fruity aroma of peaches", were more abundant in the flesh than in the skin and whole fruit fractions (Table 3). The highest concentrations of "green aroma" volatiles were found in the H treatment and those of "fruity aroma" in the M treatment, which agrees with our previous report (Jia et al., 1999).

A comparison of the total amounts of volatile compounds, distributed in the fruit flesh and skin (Table 4) reveal that a high proportion of each volatile compound emanated from the flesh. The biggest difference among the fruit parts was that of lactones, which constituted more than 97 % of the volatiles in the flesh in each treatment.

Extensive studies on the distribution of volatile com-

Table 2. Concentrations ($\mu\text{g} \cdot \text{kg FW}^{-1}$) of aldehyde, alcohol, and ester^z extracted from the skin, flesh, and whole fruit of 'Hakuho' peach fruit grown under different fertilizer levels.

Treatment ^y	Fruit part	Aldehyde		Alcohol			Ester	Total
		<i>t</i> -2-hex	Benzal	<i>cis</i> -3-hex	2-(E)-hex	Linalool	(E)-acetate	
L	Flesh	35.2	181.3	121.9	178.6	20.3	25.3	562.6
	Skin	344.8	312.6	241.0	230.4	19.6	605.2	1753.7
	Whole fruit	16.4	33.2	36.8	18.5	14.6	45.0	164.6
M	Flesh	26.3	224.1	156.8	155.8	32.2	16.3	611.5
	Skin	349.2	378.8	264.4	212.9	36.4	808.1	2049.8
	Whole fruit	15.5	44.2	58.4	34.6	32.7	25.6	211.1
H	Flesh	57.8	222.9	161.0	213.7	19.2	31.5	706.1
	Skin	331.4	381.5	283.6	311.8	44.7	781.8	2134.7
	Whole fruit	46.4	52.4	61.6	42.4	14.2	33.2	250.2
LSD (%)	Flesh	10.4	26.1	18.9	43.7	ns	ns	66.2
	Skin	ns	38.5	23.2	35.8	ns	131.8	353.6
	Whole fruit	15.0	ns	12.9	13.2	ns	ns	58.8

^z *t*-2-hex, *t*-2-hexenal; Benzal, Benzaldehyde; *cis*-3-hex, *cis*-3-hexenol; 2-(E)-hex, 2-Ethyl-hexanol; (E)-acetate, Ethyl-acetate.

^y See Table 1.

Table 3. Concentrations ($\mu\text{g} \cdot \text{kg FW}^{-1}$) of lactones^z extracted from skin, flesh, and whole fruit of 'Hakuho' peach fruit grown under different fertilizer levels.

Treatment ^y	Fruit part	γ -hexal	γ -octal	γ -decal	δ -decal	γ -dodecal	Total
L	Flesh	1454.0	69.2	1033.8	618.9	29.7	3205.5
	Skin	977.0	29.5	464.7	236.4	218.3	1925.9
	Whole fruit	82.2	18.0	39.5	58.9	37.5	236.2
M	Flesh	1374.0	26.8	1420.1	657.0	99.9	3577.8
	Skin	717.3	38.9	542.9	295.7	326.6	1921.5
	Whole fruit	75.5	29.3	28.2	65.4	38.3	236.6
H	Flesh	1054.1	38.0	1043.8	522.1	57.7	2715.7
	Skin	551.1	14.3	448.6	238.2	231.9	1484.1
	Whole fruit	75.8	18.7	15.1	55.5	29.2	194.3
LSD (5%)	Flesh	193.5	16.2	139.8	50.6	17.9	245.4
	Skin	143.6	12.5	32.2	28.1	40.5	269.1
	Whole fruit	ns	ns	2.8	ns	8.2	ns

^z γ -hexal, γ -hexalactone; γ -octal, γ -octalactone; γ -decal, γ -decalactone; δ -decal, δ -decalactone; γ -dodecal, γ -dodecalactone.

^y See Table 1.

Table 4. Amount of volatile compounds ($\mu\text{g} \cdot \text{fruit}^{-1}$) contained in the skin and flesh of 'Hakuho' peach fruit grown under different fertilizer levels.

Treatment ^z	Aldehyde+Alcohol +Ester		Lactones	
	Flesh	Skin	Flesh	Skin
L	459.1b ^y (86.5) ^x	71.9a (13.5)	2615.7b (97.1)	79.0a (2.9)
M	538.1b (88.2)	71.7a (11.8)	3148.5a (97.9)	67.3a (2.1)
H	564.9a (88.9)	70.4a (11.1)	2172.6c (97.8)	49.0b (2.2)

^z See Table 1.

^y Significant difference by Duncan's multiple range test ($P < 0.05$) for values within a column.

^x Distributions between flesh and skin are indicated in parentheses.

pounds in grape berries have shown that the varietal aroma of grapes is mainly localized in the internal cell layers of the skin and less in the pulp and juice (Castino, 1988). Radford et al. (1974) found similar low concentrations of flavor compounds in the pulp fraction for citrus, apple, and mango fruits, which suggest this may be a general phenomenon.

Our analyses revealed that in the peach fruit more 'fruity aroma' substances exist in the flesh tissue than the skin, but 'green aroma' volatiles are predominantly in the skin rather than in the flesh. Moderate fertilizer application increases flesh 'fruity aroma', whereas excessive fertilization increases 'green aroma' in the skin.

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モモの香気成分の果実内分布

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摘 要

モモ「白鳳」果実の皮、果肉あるいは果実全体から発散される揮発成分をヘッドスペース法で定量し、併せて施肥濃度の影響も調査した。モモの香りの主成分である lactone 類は、皮よりも果肉に高濃度で存在し、適濃度の施肥をした果実に最も多かった。他の揮発成分のアルデヒド、アルコール、エステルは、青臭さを与えるが、果肉より皮の方が濃度が高く、施肥区の中では高濃度区の方が高かった。果実全体から発散される揮発成分の量は、皮や果肉に比べてわずかであった。果実1個の皮と果肉中に含まれる揮発成分の分布をみると、lactone 類は 97~98 % が、他の揮発成分は 86~89 % が果肉中に存在した。