Effects of Postharvest Treatments on Yield and Composition of Coriander Herb Oil

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The effects of the postharvest treatments of chopping and storage on the yield and composition of coriander herb oils from pilot-scale steam distillations are reported. Chopping the plant material gave an average 10.4 L/ha increase in oil yield. The oil composition is also changed by chopping and storage. The relative levels of the aldehydes [(*E*)-2-decenal is the major one] fall and the relative levels of alcohols rise with increased time of storage. However, oil yields drop after storage for more than 4 h. Small-scale solvent extracts confirmed these results.

INTRODUCTION

Coriander, *Coriandrum sativum* L. (family Apiaceae or Umbelliferae), is one of the essential oil plants being investigated by Crop and Food Research as a potential new crop in New Zealand. The main objective of this coriander research is to produce coriander spice (or fruit) oil. However, we have also investigated the production of coriander herb oil. This oil has a potential use as a replacement for the fresh herb in processed ethnic foods of Pacific rim countries. Herb oil is steam distilled from the vegetative parts (stalks and leaves), flowers, and unripe fruits of coriander (Purseglove et al., 1981).

There is considerable confusion in the chemical literature over the composition of coriander herb oil. The first analysis found about 95% aldehydes, with 10% decanal. 2-Decenal and 8-methyl-2-nonenal were also present (Carlblom, 1936). Schratz and Qadry (1966) analyzed the volatile oil composition of two coriander cultivars (one German, the other Indian) at weekly intervals during the complete cycle of development. Three compounds, (*E*)-2-tridecenal, decanal, and borneol, were present in high, medium, and low quantities throughout the life cycle of the vegetative organs. MacLeod and Islam (1976) studied a Likens–Nickerson extract of fresh coriander leaves, using GC–MS to identify the major components as 7-dodecenal (21%), dodecanal (16%), and decanal (10%). The position of the double bond in the major component was based on its mass spectrum, and the stereochemistry was not assigned. Potter and Fagerson (1990) also studied a Likens–Nickerson extract of fresh coriander leaves, but they reported a very different composition. The major components were (*E*)-2-decenal (46%), (*E*)-2-dodecenal (10%), 2-decen-1-ol (9%), (*E*)-2-tetradecenal (6%), (*E*)-2-undecenal (6%), decanal (4%), and decan-1-ol (4%). Most of these identifications were confirmed by GC–MS analyses of authentic compounds, except for 2-decen-1-ol, whose stereochemistry was not determined. This analysis agreed with the results of Mookherjee et al. (1989) on the volatiles from living coriander leaves.

We now describe detailed studies of pilot-scale steam distillations of coriander herb oil, including the dramatic effects of postharvest treatments on oil yield and composition.

EXPERIMENTAL PROCEDURES

Coriander Supply and Charge Preparation. The coriander used for these experiments was from a 1-ha block grown on a Wingatui silt loam on Invermay farm, Mosgiel. The crop was sown on November 19, 1991 at a seeding rate of 13.5 kg/ha. Seed sown was second generation of an unnamed seed line purchased from Kieft Seeds, Holland, in 1989. The seed is assumed to be *C. sativum* var. *microcarpum*, with the whole fruit having a thousand seed weight of 7.25 g. The study consisted of three separate runs (see below). Herbage for each run was harvested from randomly selected locations of the block. Herbage yield (fresh weight) for run 1 averaged 24030 kg/ha, for run 2 averaged 14750 kg/ha, and for run 3 averaged 22770 kg/ha. At the commencement of run 1 the stems were green, lower leaves were starting to senesce, fruits were present on the primary, secondary, and tertiary umbels (primary umbels were green and full), the quaternary umbels were in flower, and the petals on the fifth umbels were opening. By the conclusion of the third run (15 days later) the fruits on the primary umbel had just started to change from green to yellow, the lower portion of the main stem had started to turn yellow, and the lower leaves had senesced. Plants were harvested to ground level using a motorized scrub cutter and transported back to the distillery, where the postharvest treatments were applied. For distillation of unchopped coriander herb, bundles of whole plants were cut into three sections immediately before distillation to aid uniform packing of the bin. Where the herbage was chopped before distillation, a motorized chaff-cutter was used (nominal chop size of 5–20 mm). Where the crop was stored for a designated period between chopping and distillation, it was retained in closed synthetic wool packs in the distillery at room temperature.

Pilot Still Distillation Equipment. To reduce the head space within the still pot, the chopped herbage was packed (packing density of 0.521 g/cm^3) on top of baled barley straw (packing density 0.0584 g/cm^3) to within 110 mm of the top of the stainless steel bin (volume of 0.150 m^3). The unchopped material occupied the whole volume of the bin. The base of the bin was a 20-mm stainless steel mesh. For run 1 the charge was steam distilled for 40 min. Extending the distillation of 084, 086, and 087 (Table 1) a further 40 min increased the estimate of oil content by an average of 20%. Therefore, for runs 2 and 3, the distillation time was extended to 80 min. For all runs a steam flow rate of 36 kg/h was used and controlled by passing steam regulated to 150 kPa through a gate valve calibrated against condensate flow. Steam was distributed into the base of the still pot through a 38 mm i.d., open-ended stainless steel pipe. The pressure in the still was equivalent to atmospheric for all runs.

The condenser consisted of a 1.5-m stainless steel, eight-tube (15 mm i.d.) in-shell condenser inclined at 15° to the horizontal.

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Table 1. Details of Coriander Herb Distillation Runs

run	storage time (h)	herb treat[a]	distiltn time (min)	no. of distiltn	date distilled	fresh wt of charge (kg)	crop DM content (%)	oil vol (mL)	oil codes (IY92/)
1	0	NC	40	1	March 26, 1992	20.4	23.4	14.6	082
	8.5	C	40	1	March 26, 1992	25.5	22.7	30.5	083
	0	C	40	1	March 27, 1992	25.0	22.7	31.8	084
	0	NC	40	1	March 28, 1992	23.1	22.7	19.5	085
	0	C	40	1	March 31, 1992	34.5	22.9	45.6	086
	0	NC	40	1	March 31, 1992	24.7	25.1	28.6	087
2	0	C	80	1	April 1, 1992	28.5	23.1	43.5	088
	2	C	80	1	April 1, 1992	29.0	23.5	49.1	089
	4	C	80	1	April 1, 1992	29.5	24.5	46.1	091
	6	C	80	1	April 1, 1992	29.0	24.1	39.2	090
	24	C	80	1	April 2, 1992	28.0	23.0	22.3	092
3	0	C	80	4	April 6–9, 1992	17.0–42.5	23.8	17.1–54.0	095, 097, 100, 103
	2	C	80	4		17.0–43.3	23.8	24.5–49.8	096, 099, 101, 104

[a] Herbage pretreatment before distillation: NC, coriander herb not chopped; C, coriander herb chopped before storage and distillation.

The condensate temperature was maintained at 40 ± 1 °C by a PID controller regulating the coolant water flow rate. The sensor for the controller was located in the condensate outflow stream from the condenser.

The separator used to disengage the condensed oil from the water consisted of a 20-L glass aspirator vessel (diameter of 270 mm, height of 400 mm). The condensate entered the top of the aspirator through a funnel and 15 mm i.d. U-tube with the outflow 10 cm below the water surface. The outflow from the aspirator was controlled through a glass stopcock. At the start of each distillation the separator was filled with cold tap water. A distinct boundary between the cold water and the condensate was maintained until the cold water was fully discharged from the aspirator at 50 min into the distillation. Oil floating on the surface of the condensed water was removed at the end of each run and oil yield measured in a 25-mL graduated pipet to within 0.1 mL. The still was steamed for 5 min to clean the unit between distillations.

Postharvest Treatments. The experiment consisted of three separate runs, details of which are presented in Table 1. Run 1 was undertaken to learn whether chopping influenced the composition of the coriander herb oil. A single sample was chopped and then stored for 8.5 h before distillation to determine if storage after chopping had influenced the composition of the coriander herb oil. Having identified that storage had a major effect on oil composition, run 2 was undertaken to define the effect of length of storage on oil composition. Run 2 consisted of single distillations of chopped coriander herb stored for 0, 2, 4, 6, or 24 h before distillation (Table 1). Because the unreplicated results from run 2 suggested oil yield increased going from 0 to 2 h of storage, this was checked in run 3. This run consisted of four replicate distillations after 0 or 2 h of storage over a period of 5 days (Table 1). For runs 1 and 3 the effect of chopping and time (respectively) was tested by analysis of variance with distillation date as a blocking factor. For run 2, a regression of yield on log(time + 1) was performed to test for an exponential decrease in yield with time, both with and without the 0-h data.

GC Analyses. Coriander herb oils were analyzed as 1% solutions in hexane, using a Perkin-Elmer Autosystem gas chromatograph under the control of Perkin-Elmer Omega (version 5.0) software. The column was a 9.5-m J&W DB-1, with H_2 carrier gas (linear velocity 43 cm/s). Injections (0.5 μL) were made into a split (100:1) injector at 260 °C. The flame ionization detector was at 310 °C. A temperature program of 5 °C/min, from 50 to 260 °C, was assumed to show the maximum number of components that could be resolved on this column. DB-1 Kovats retention indices (RIs) of major peaks were measured by coinjection of a herb oil with *n*-alkanes (C7, 8, 9, 10, 11, 12, 14, 16, 18, 20, and 22) on this temperature program (Table 2). RIs were also measured on a 30-m J&W DB-Wax column, with similar operating conditions (Table 2). The same number of components was resolved on the DB-1 column using a faster two-stage temperature program (50–90 °C at 10 °C/min, then 90–260 °C at 45 °C/min) so this was used to analyze all of the oils, extracts, and fractions. GC peaks of area greater than 0.2% in the oil IY92/083 (see below) were labeled peak 1 to peak 30. Peaks due to linalool, decanal, (*E*)-2-decenal, (*E*)-2-dodecenal, and (*E*)-2-tetradecenal were used as references to correct retention time fluctuations between runs. The unscaled levels of these 30 peaks in each oil were initially analyzed using principal component analysis (PCA) to help with recognition of composition patterns (Aries et al., 1991). In some cases particular components for various treatment sets were analyzed by analysis of variance.

Table 2. Identification of Coriander Herb Oil Components

peak	RI DB-1	RI DB-Wax	identity	identification method GC	RI	GC–MS	NMR
1	900		nonane	+	+	–	–
2			unknown	–	–	–	–
3	1085	1552	linalool	+	+	–	+
4			unknown	–	–	–	–
5			unknown	–	–	–	–
6	1183	1498	decanal	+	+	–	+
7			unknown	–	–	–	–
8	1234	1643	(*E*)-2-decenal	–	+	–	+
9	1254	1823	(*E*)-2-decen-1-ol	–	+	+	+
10	1259	1769	decan-1-ol	+	+	+	+
11			unknown	–	–	–	–
12	1287		undecanal	–	+	–	+
13			unknown	–	–	–	–
14	1338		(*E*)-2-undecenal	–	+	–	+
15	1356		(*E*)-2-undecen-1-ol	–	+	+	+
16	1362		unknown	–	–	–	–
17			unknown	–	–	–	–
18	1387		dodecanal	–	+	–	+
19	1439	1860	(*E*)-2-dodecenal	–	+	–	+
20	1457	2029	(*E*)-2-dodecen-1-ol	–	–	+	+
21			unknown	–	–	–	–
22	1544		(*E*)-2-tridecenal	–	+	–	–
23			unknown	–	–	–	–
24			unknown	–	–	–	–
25	1645	2078	(*E*)-2-tetradecenal	–	+	–	+
26	1666		(*E*)-2-tetradecen-1-ol	–	+	–	–
27			unknown	–	–	–	–
28	1751		(*E*)-2-pentadecenal	–	+	–	–
29	1830		unknown	–	–	–	–
30	1858		(*E*)-2-hexadecenal	–	+	–	–

Component Identifications. A subsample (1 mL) of coriander herb oil IY92/083 (8.5-h storage, see Table 1) was subjected to silica gel column chromatography (20 g of Davisil, 60 Å, 35–70 μm). The column was developed with hexane/ethyl acetate (50 mL each 19:1, 9:1, and 4:1), and 10 mL fractions were collected. These were all analyzed by GC, and those with similar compositions were combined. ^1H (200 MHz) spectroscopy and ^{13}C (50 MHz) NMR spectroscopy (Varian Gemini) were used to examine $CDCl_3$ solutions (^1H spectra were referenced to TMS at 0.00 ppm and ^{13}C spectra to $CDCl_3$ at 77.00 ppm).

Fractions eluted with 9:1 hexane/ethyl acetate contained mostly unbranched (*E*)-2-alkenals: ^1H NMR (shift in ppm, multiplicity, couplings in Hz) 9.48 (d, 7.9), 6.82 (dt, 15.6, 6.8), 6.10 (ddt, 15.6, 7.9, 1.4), 2.32 (qd, 6.9, 1.4), 1.5 (m), 1.3 (m), 0.87 (t, 6); ^{13}C NMR 194.13, 159.02, 132.96, 32.71, 31.9–28.9 (several signals), 27.83, 22.59, 14.03. There was also a small signal due to alkanals (9.85 ppm, t, 2 Hz). Attempts to establish the chain

Table 3. Average Yields of Coriander Herb Oils

run	storage time (h)	herb treat[a]	% oil recovery (mL/100 g of dry wt)	oil yield (L/ha)
1	0	NC	0.380	20.1
	0 + 8.5	C	0.557	30.5
		LSD	0.1269	2.86
3	0	C	0.529	28.6
	2	C	0.538	29.2
		LSD	0.1287	10.49

[a] Herbage pretreatment before distillation: NC, coriander herb not chopped; C, coriander herb chopped before storage and distillation.

lengths of these compounds by GC–MS were frustrated by their ready oxidation to the corresponding carboxylic acids. The major alkanal was identified as decanal by comparison of its RI values (Table 2) with published data (Jennings and Shibamoto, 1980) and by GC coinjection. There were lower levels of undecanal and dodecanal. The chain lengths of the (*E*)-2-alkenals were identified by comparison with the GC retention data of Potter and Fagerson (1990) relative to the *n*-alkanals (Table 2).

A fraction eluted with 4:1 hexane/ethyl acetate contained mostly linalool, by comparison with the NMR spectrum of authentic material, GC coinjection, and RI values.

Later fractions contained 2-alken-1-ols and an alkan-1-ol. The alkanol was identified as decan-1-ol by GC–MS (*m/e* 140 $M^+ - H_2O$), GC coinjection, and RI values. The major 2-alken-1-ol was identified as 2-decen-1-ol by GC–MS (*m/e* 156 M^+ and 138, $M^+ - H_2O$) and RI value. Two other components were 2-undecen-1-ol (m/e 170, M^+ and 152 M^+-H_2O) and 2-dodecen-1-ol (*m/e* 184 M^+ and 166 $M^+ - H_2O$). The double-bond stereochemistry could not be determined from the ^1H NMR spectrum because the double-bond proton signals were almost coincident and gave a second-order splitting pattern (5.54–5.78 ppm). The ^{13}C NMR spectrum showed appropriate signals for (*E*)-2-alken-1-ols [see Pritzkow et al. (1979)]: 63.82 (C1), 128.79 (C2), 133.58 (C3), and 32.20 (C4) ppm.

An early GC peak was identified as nonane by coinjection. These component identifications are summarized in Table 2.

Solvent Extractions. To study the change in composition in more detail, it was desirable to have a small-scale extraction method. Hexane (20 mL) was added to chopped coriander herb samples (10 g) and stirred occasionally at distillery room temperature for 10 min, and then extracts were filtered through cotton wool. Solvent was removed on a rotary evaporator at 40 °C, and then extracts were redissolved in hexane plus 0.05% anisole (1 mL) for GC analysis as above.

Solvent extractions were done in conjunction with run 2 steam distillations (Table 1). A subsample of each batch of coriander herb was extracted as soon as chopping was completed (five extracts). Duplicate subsamples of stored, chopped herb were extracted just before distillation (eight extracts). Duplicate small batches of whole coriander herb (10 plants) were stored unchopped for corresponding times to the bulk chopped samples (2, 4, 6, and 24 h) and then chopped and extracted immediately (eight extracts).

Volatiles in Separator Water. To identify oil components lost in the water draining from the separator, a water sample (10 mL) was taken at the conclusion of two distillations (oils 088 and 091, Table 1). The sample was extracted with chloroform (2 × 5 mL), the solvent removed by rotary evaporation, and the organic extract redissolved in hexane (1 mL) for GC analyses.

RESULTS

Pilot Still Distillations. Oil volumes, recoveries (relative to dry weight), and oil yields for the three runs have been summarized in Tables 1 and 3, and in Figure 1. Purseglove et al. (1981) reported that oil content of coriander herb maximized (about 0.1–0.2% on a fresh weight basis) at the flowering stage. Our recoveries fall within this range if the herb was chopped before distillation (average 0.125% on a fresh weight basis). The mean oil recovery from whole plants was significantly ($P < 0.05$) less than the recovery from chopped herb (run 1, Table 3). Chopping increased oil yield by an average of 10.4 L/ha.

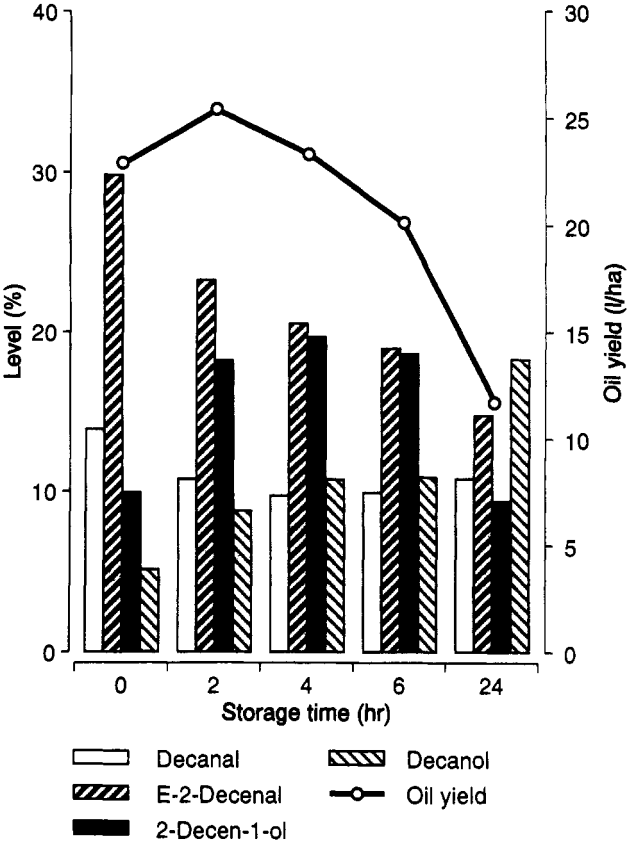

Figure 1. Effect of storage on oil yield and component levels from chopped coriander herb.

The storage of chopped coriander herb resulted in a significant ($P < 0.05$) decline in oil recovery from 2 to 24 h of storage (Figure 1). Although the pilot distillations were not replicated, the results of the small-scale duplicated solvent extraction method (see below, Solvent Extraction) confirmed that oil recovery declined with increased time of storage. This reduction in oil content equates to a reduction in oil yield of 2 L/ha with storage up to 6 h, increasing to 11 L/ha if the crop were chopped and stored for 24 h. It was observed that the temperature of the stored chopped material rose above that of the room temperature with increasing length of storage (by the end of 24 h of storage the chopped herb had a temperature of 38 °C compared to the room temperature of 19 °C). This suggests that fermentation had started and was possibly contributing to the loss of oil. The results of run 2 also suggested that storage for 2 h before distillation produced a greater oil yield than distillation of the chopped herb immediately. However, from replicated distillations in run 3, storing the chopped herb for 2 h before distilling gave no significant ($P > 0.05$) increase in oil yield (Table 3).

Oil Composition. The full GC analyses of the 19 oils produced in this work are available as supplementary material. The PCA showed that over 98% of the variance of the data set was accounted for in the first three PCs. Therefore, the variance of the oil samples is well represented by plots of these three PCs (Figures 2 and 3). The first PC (which represented 86% of the variance) is most related to the variation of (*E*)-2-decenal levels (eigenvector −0.76), followed by (*E*)-2-decen-1-ol (eigenvector +0.48). The corresponding components and eigenvectors for the second PC (7% of the variance) are (*E*)-2-decen-1-ol

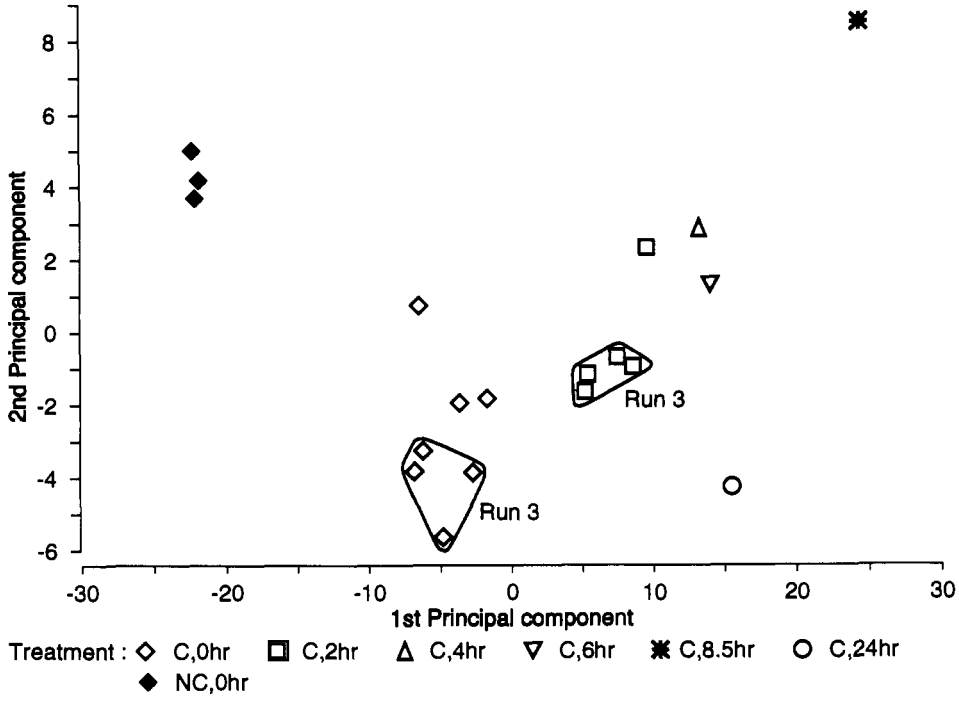

Figure 2. Principal component analysis of 19 coriander herb oils: first and second principal components.

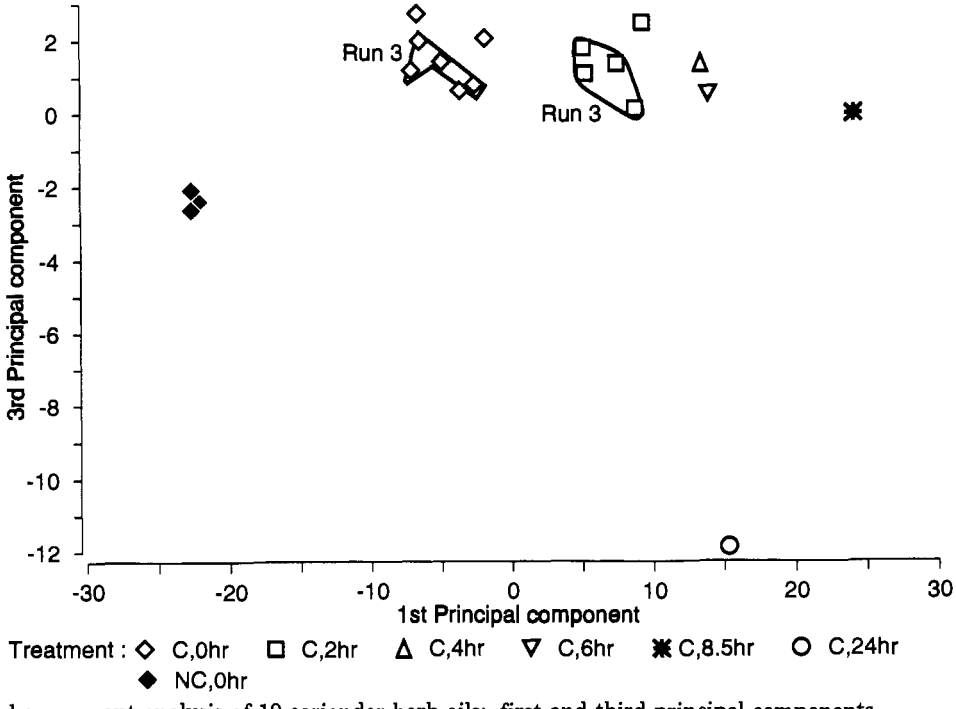

Figure 3. Principal component analysis of 19 coriander herb oils: first and third principal components.

(eigenvector +0.62) and (*E*)-2-decenal (eigenvector +0.51) and for the third PC (5% of the variance) decan-1-ol (eigenvector −0.57) and (*E*)-2-decen-1-ol (eigenvector +0.52). When the oil samples in these plots are labeled according to postharvest treatment (Table 1), patterns of composition related to treatment can be seen (Figures 2 and 3).

The oils obtained (in lower yields, see above) from distillations of unchopped coriander herb are clustered at the negative end of the first PC. This corresponds to these oils having the highest (*E*)-2-decenal (mean 48.2%) and the lowest (*E*)-2-decen-1-ol (mean 1.6%) levels of any of these oils. By contrast, the oil from the sample that was chopped and then stored for 8.5 h had low (*E*)-2-decenal (15.5%) and the highest (*E*)-2-decen-1-ol (27.7%) levels. The two oils in this run from herb samples that were steam distilled as soon as possible after chopping had intermediate (*E*)-2-decenal (mean 32.6%) and (*E*)-2-decen-1-ol (mean 8.5%) levels. The levels of the other aldehydes also seemed to fall with increased time of storage after chopping, to be replaced by the corresponding alcohols.

To check this observation, a second series of distillations was carried out, at different times of storage after chopping (run 2). The oil sample distilled immediately had similar composition to the corresponding oils from run 1 (Figures 2 and 3). The oils from chopped herbage stored for 2, 4, and 6 h all had increased alcohol and reduced aldehyde levels (Figure 1), although not as much as the oil of chopped herbage stored for 8.5 h in run 1. The oil from the herb that was stored for 24 h stood out from the others in terms

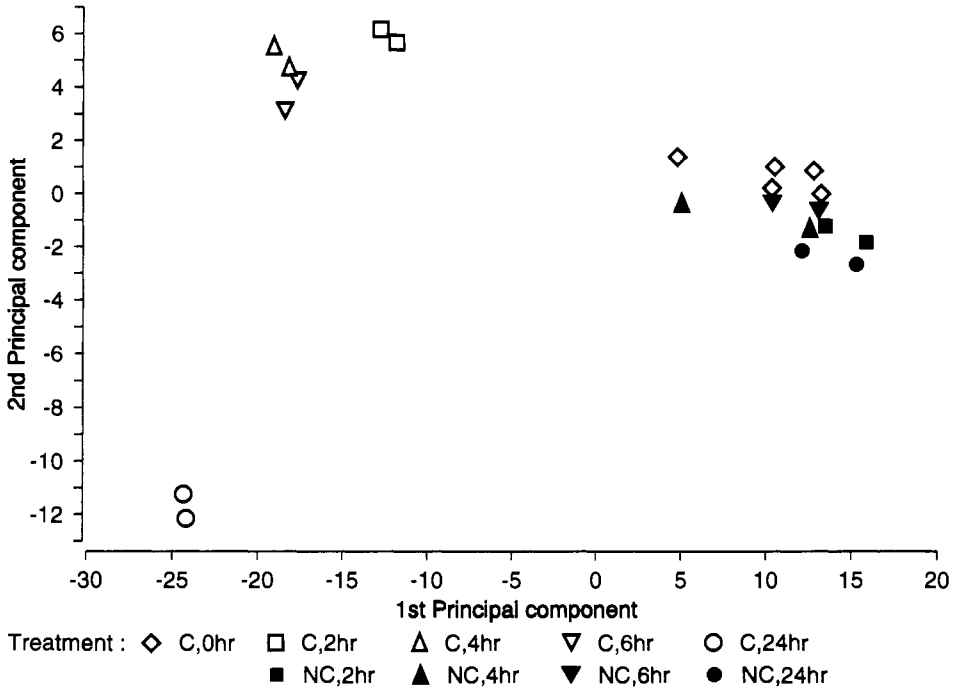

Figure 4. Principal component analysis of 21 coriander herb extracts: first and second principal components.

of the third PC (Figure 3). It had the lowest (*E*)-2-decenal (14.9%) and the highest decan-1-ol (18.4%) levels (Figure 1). However, the (*E*)-2-decen-1-ol level was much lower (8.4%) than in oil from herb stored for 8.5 h.

The replicate distillations in run 3 gave two sets of oils with different compositions (Figures 2 and 3). For example, the mean decanal level in the oil of herb distilled immediately was 14.6% and was 11.3% in the oil of herb stored for 2 h (LSD 1.3%).

Solvent Extraction. The results above are from pilot-scale distillations and should be easy to translate into full-scale production. However, to study the change in composition in more detail, small-scale solvent extractions were done in parallel with run 2 pilot distillations (full GC analyses are available as supplementary material).

The solvent extracts contained higher levels of the less volatile components, especially (*E*)-2-tetradecenal, than did the corresponding steam-distilled oils [higher levels of (*E*)-2-tetradecenal were also found in oils collected from further 40-min distillations in run 1]. Allowing for this, the solvent extracts gave a good guide to the composition of steam-distilled oils from the same plant material.

PCA on components identified by GC analysis of the 21 solvent extracts resulted in 98% of the variance of the data set being accounted for in the first two PCs (Figure 4). The first PC (which represented 89% of the variance) is most related to the variation of (*E*)-2-decenal levels (eigenvector +0.86), followed by (*E*)-2-decen-1-ol (eigenvector −0.26). The corresponding components and eigenvector to which most of the variation is related for the second PC (8% of the variance) are (*E*)-2-tetradecenal (+0.65) and (*E*)-2-decen-1-ol (+0.62). All of the solvent extracts from the freshly chopped material had similar composition (Figure 4), with high aldehyde and low alcohol levels. The solvent extracts from whole plants stored for 2, 4, 6, and 24 h had similar high aldehyde levels. Therefore, storage of whole plant tops at ambient temperature for up to 24 h did not affect composition. The chopped samples stored for 2, 4, and 6 h all gave extracts high in alcohols, which paralleled the compositions of the corresponding steam-distilled oils (see Figure 1). The 24-h extracts were quite different from the others, with decan-1-ol as the major component. We assume that the α,β-unsaturated aldehydes and alcohols oxidized and/or polymerized to nonvolatile compounds, but this was not investigated.

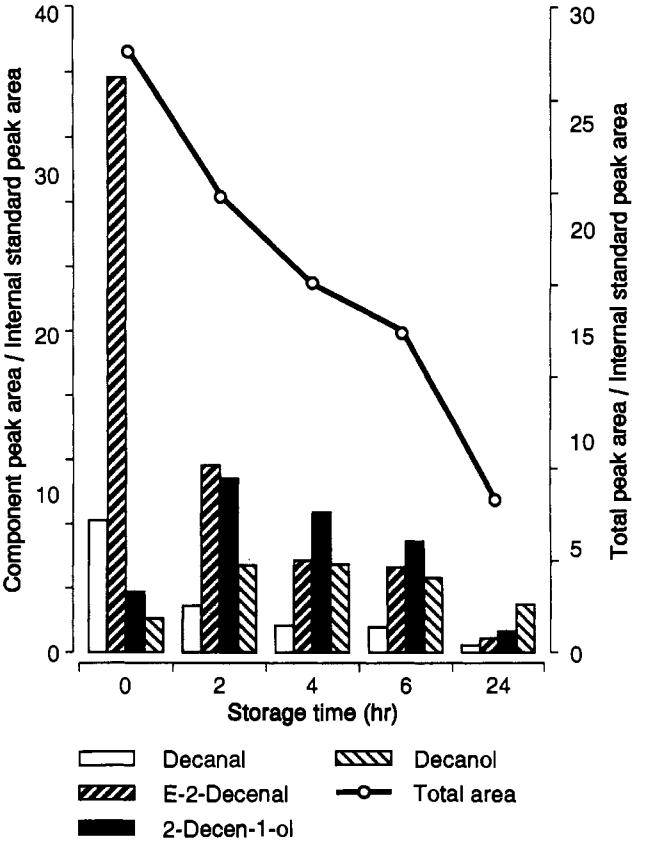

Figure 5. Effect of storage on total volatiles and C10 aldehydes and alcohols from chopped coriander herb extracts.

A plot of the absolute levels (not the relative, percent, levels) of the total volatiles and the major C10 aldehydes and alcohols (Figure 5) showed the same changes with storage time as described above. The total yield of volatiles dropped significantly ($P < 0.05$) with storage time, in

agreement with the results of the extraction by steam distillation (Figure 1). Aldehyde levels also dropped significantly ($P < 0.05$) with time. However, the absolute levels of the alcohols rose from 0 to 2 h of storage and then dropped significantly ($P < 0.05$).

Volatiles in Separator Water. Some essential oil components are so soluble in water that they never separate into the organic phase, e.g., 2-phenylethanol from steam distillation of rose petals (Moates and Reynolds, 1991). Analyses of solvent extracts of separator water from two of the distillations in run 2 showed higher levels of alcohols, especially linalool, than were found in the separated oils. However, no major new components were present.

DISCUSSION

We have shown that simple postharvest treatments have dramatic and previously unreported effects on the composition and yield of coriander herb oils. Chopping the plants and distilling immediately produced higher oil yields than not chopping. It is important to reiterate that these results are from pilot-scale studies, which could readily be adapted to full-scale production. Production-scale harvesting of the crop would involve direct chopping of the whole above-ground herb directly into the distillation vessel, without separation of plant parts.

Detailed analysis of our coriander herb oils (Table 2) showed the presence of the major components reported by Potter and Fagerson (1990) and by Mookherjee et al. (1989). However, linalool was also present in our oils, since no effort was made to separate fruits, which contain internal oil canals rich in linalool (Purseglove et al., 1981). We did not detect 7-dodecenal, the major component reported by MacLeod and Islam (1976). Potter and Fagerson (1990) suggested two explanations for the difference between their results and those of MacLeod and Islam: either substantial variation between coriander varieties or misinterpretation of mass spectral results. We plan to compare coriander herb oils from different varieties.

Oil yields and compositions are quite constant through the growing season, and crop could be stored (unchopped) for at least 24 h before distillation with no effect on oil composition. Therefore, the change in the oil chemistry is triggered by the chopping of the plant material. This is probably due to the release of an enzyme, stored separately from the oil glands, which reduces the aldehydes to the corresponding alcohols. Formation of volatile alcohols by oxidoreductase activity has been reported in several plant species (Schreier, 1984). However, we could not find any references to oxidoreductase, or alcohol dehydrogenase, in coriander.

This proposed oxidoreductase enzyme might have a defensive function in coriander. Potter and Fagerson (1990) have reviewed the various biological activities of unsaturated aldehydes, including potential antifungal and insect repellant activities. The alkenols also have biological activity. 2-Decen-1-ol has been identified in a secretion from a wasp, where it may serve as a defense or as an aid to roosting aggregation (Hefetz and Batra, 1979). The release of alcohols upon damage by insect herbivores might serve to attract natural predators of the herbivores, thus defending the plant [see Turlings et al. (1990)].

Oils with high levels of alkenals and alkanals, especially (*E*)-2-decenal, were produced from distillation of unchopped coriander plant tops. (*E*)-2-Decenal has been described as having moderate fatty and citrusy (orange) character in its pure form and strong citrusy (orange) character in 0.1% solution (Boelens and van Gemert, 1987). The odor and flavor threshold values for this compound are relatively low, e.g., 0.0003 ppm odor threshold in water (Boelens and van Gemert, 1987). The oils from plants that had just been chopped contained higher levels of alkenols and decan-1-ol. Storage of chopped plant for 2–6 h before distillation produced oils with (*E*)-2-decen-1-ol as the major component. Even to our untrained noses, oils with high alkenol levels had different aromas from oils from unchopped coriander herb. Storage of chopped herb for 24 h before distillation produced a lower yield of an oil with decan-1-ol as the major component. Decan-1-ol has a "floral odour resembling orange flowers; slight, characteristic fatty taste" (Furia and Bellanca, 1975). Thus, a variety of coriander herb oils with different odor and flavor are available by simple postharvest treatments.

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Supplementary Material Available: Full GC analyses of 19 oils and 21 extracts (4 pages). Ordering information is given on any current masthead page.

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