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A General and Stereoselective Synthesis of the Capsaicinoids *via* the Orthoester Claisen Rearrangement

Harumi Kaga,* Kouhei Goto, Tomiki Takahashi, Masao Hino, Takashi Tokuhashi† and Kazuhiko Orito†*

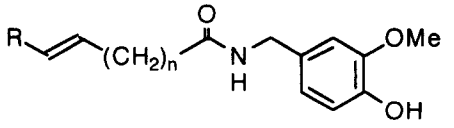
Hokkaido National Industrial Research Institute, Sapporo 062, Japan

†Laboratory of Organic Synthesis, Division of Molecular Chemistry, Graduate School of Engineering, Hokkaido University, Sapporo 060, Japan

Abstract: Capsaicin, a main pungent principle of hot pepper, and its 15 analogs have been efficiently synthesized. The key step of this synthetic sheme is the orthoester Claisen rearrangement, which transformed allylic alcobols **2A-C** to (*E*)-alkenoates **3A-C** (*E*/*Z* > 100) in a highly stereoselective manner. The subsequent carbon chain elongations on **3** based on the cyanation or the malonic acid ester synthesis afforded (*E*)-alkenoic acids **8**, which were converted to the corresponding acid chloride and then coupled with vanillylamine to give capsaicinoids. HPLC and CE (capillary electrophoresis) analyses of these capsaicinoids were also carried out.

INTRODUCTION

Capsaicin (**C-10**), a pungent principle of hot red pepper fruits (*Capsicum* species) is an important ingredient of spices, preservatives and drugs, and is reported to exhibit various biological activities,[1,2] including recent findings of mutagenic and carcinogenic activities,[3-5] and an enhancement of energy metabolism resulting from an increase in adrenal nerve activity.[6,7] More than 15 natural capsaicinoids have been identified as closely related *N*-vanillylamides of C_8 ~ C_{13} branched (*E*)-alkenoic or alkanoic acids;[8] bisnorcapsaicin (**C-8**),[3] norcapsaicin (**C-9**),[3] nordihydrocapsaicin (**HC-9**),[9,11] nordihydrocapsaicin II (**HCII-9**),[10,12] capsaicin (**C-10**), dihydrocapsaicin (**HC-10**), homocapsaicin (**C-11**),[9,13] homodihydrocapsaicin (**HC-11**), homocapsaicin I (**CI-11**),[9,10] homodihydrocapsaicin I (**HCI-11**),[9,10,13] homocapsaicin II (**CII-11**),[12] homodihydrocapsaicin II (**HCII-11**),[10,12] bishomocapsaicin (**C-12**),[13] and trishomocapsaicin (**C-13**).[13] Among them, capsaicin and dihydrocapsaicin are the major components of most *Capsicum* species.[3,10,13,14] In the present synthesis, capsaicin and its analogs are tentatively classified into three groups, which are capsaicinoids (R = isoropyl) (**C-8** ~ **C-13**), capsaicinoids I (R = isobutyl) (**CI-9** ~ **CI-13**), and capsaicinoids II (R = *sec*-butyl) (**CII-9** ~ **CII-13**), according to the terminal branches of fatty acid moieties.[9]



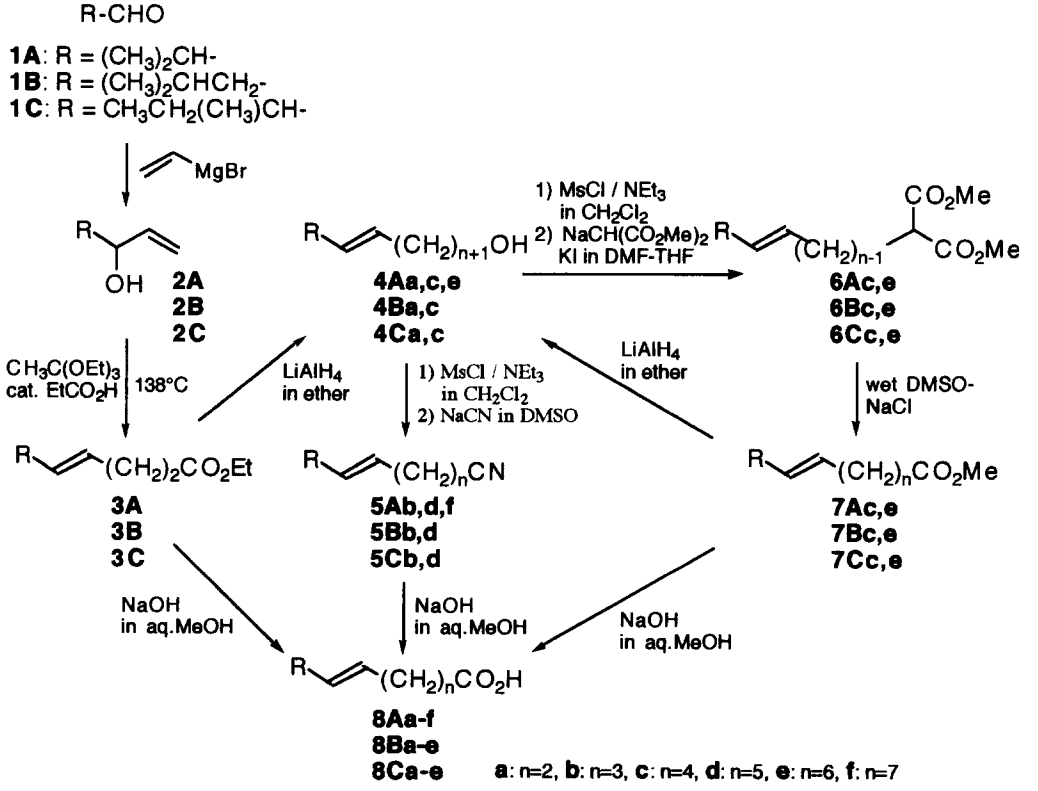
capsaicin (**C-10**) R = $(CH_3)_2CH$-, n = 4
capsaicin I (**CI-10**) R = $(CH_3)_2CHCH_2$-, n = 3
capsaicin II (**CII-10**) R = $CH_3CH_2(CH_3)CH$-, n = 3

There are limitations on the data concerning diverse and potent biological effects[1-7] of capsaicinoids in studies dealing with the main or total capsaicinoids, since natural capsaicinoids are always contaminated with closely related amides, and it is not easy to obtain certain amounts of minor components in a pure state. Furthermore, synthetic capsaicinoids are always accompanied by their *Z* isomers, which do not occur in nature.[1a,3,15,16] Thus, we have studied the stereoselective synthetic route towards capsaicinoids, and also their HPLC and CE (capillary electrophoresis) analyses.

RESULTS AND DISCUSSION

Synthesis of Capsaicinoids.

There have been several interesting synthetic routes reported towards capsaicin characterized by their own key reactions[3,17-21] for the introduction of an *E* double bond at the C_6 position of the side chain of capsaicin (**C-10**). Gannett and coworkers[3] developed a general method based on *E*-olefination by the reductive elimination of a benzoyloxy-sulphone[22] for the synthesis of capsaicinoids (**C-8** ~ **C-13**). We reported nitrous acid-induced isomerization of *Z* olefins to *E* olefins[23] for the general synthesis of capsaicinoids.[15,24] However, both of these procedures showed moderate *E/Z* selectivity of at most 9:1. In order to clarify the true biological activities, to find the novel biological activities and to examine the safety of capsaicinoids, an alternative procedure specific to *E* olefins, leading to pure capsaicinoids together with their individual spectral and physical data is required. Vig et al. reported the synthesis of capsaicin by the vinyl ether Claisen rearrangement, in which an *E/Z* ratio of the produced olefin was not noted.[21] Hoping to produce the *E* isomer more selectively, we studied an alternative approach by the orthoester Claisen rearrangement, since it was reported to achieve a higher *E* selectivity in the formation of a C-C double bond.[25] Allylic alcohol **2A** was produced by treatment of isobutyraldehyde **1A** with vinyl magesium bromide at room temperature in 73% yield, and was subsequently subjected to the orthoester Claisen rearrangement by heating with triethyl orthoacetate in the presence of a catalytic amount of propionic acid at 138 °C for 3h. (*E*)-6-Methyl-4-heptenoate **3A**, a common precursor of capsaicinoids (**C-8** ~ **C-13**), was thus obtained exclusively (*E/Z* > 100 by a capillary GLC analysis) in the 73% isolated yield (Scheme 1). Two other allylic alcohols,

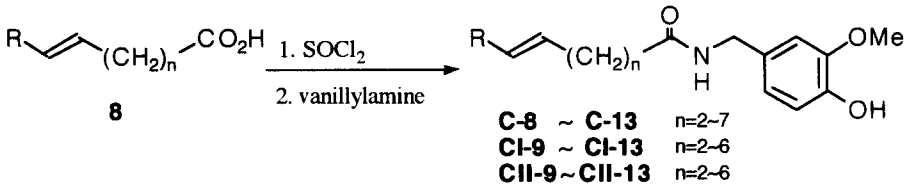


Scheme 1

2B and **2C**, prepared by the Grignard reaction of the corresponding aldehydes, **1B** and **1C**, were treated under similar Claisen rearrangement conditions to give (*E*)-4-octenoate **3B** and **3C** in a highly stereoselective manner (*E*/*Z* > 100) and in good yields. The generality of this key reaction was thus proven.

Alkaline hydrolysis of ester **3A** gave acid **8Aa** in 89% yield. Other homologs **8Ab-f** were prepared *via* carbon chain elongations of **3A** with a methylene unit by cyanation or malonic acid ester synthesis, as illustrated in Scheme 1. Ethyl ester **3A** was treated with $LiAlH_4$ at room temperature to give alcohol **4Aa** in 86% yield, and was converted to the corresponding mesylate,[21] which was followed by treatment with sodium salt of dimethyl malonate in a DMF-THF in the presence of potassium iodide at 80 °C for 3 h to give malonate **6Ac** in 83% yield. Subsequent demethoxy-carbonylation of **6Ac** to monoester **7Ac** was achieved by heating in a wet DMSO-NaCl at 170 °C for 3 h in 91% yield. In the same manner, nitrile **5Ab** was also obtained in 89% yield by treatment of the mesylate of **4Aa** with sodium cyanide in DMSO.[26] Both **5Ab** and **7Ac** were hydrolyzed to the corresponding carboxylic acids **8Ab** and **8Ac**, respectively. **7Ac** was again reduced with $LiAlH_4$ to give alcohol **4Ac** in 96% yield. The above-mentioned procedures were repeated for coversion of **4Ac** to the *E* olefinic C_{11} ~ C_{13} acids **8Ad-f** [**4Ac→5Ad→8Ad, 4Ac→6Ae→7Ae→8Ae, 7Ae→4Ae→5Af→8Af**]. Finally, each of these acids (**8Aa-f**) was treated with thionyl chloride, and the resultant acid chloride was subsequently treated with vanillylamine in the manner described previously by us[15] to give capsaicinoids **C-8** ~ **C-13** in excellent yields, respectively (Scheme 2).

The capsaicinoids I (**CI-9** ~ **CI-13**) and capsaicinoids II (**CII-9** ~ **CII-13**) were readily prepared from ethyl ester **3B** and **3C** in a similar process to the **A** series. All the capsaicinoids thus obtained were found to be crystalline materials and to be able to be recrystallized from certain solvents, as described in Experimental. These results indicate that the present method, as well as the method specific to the dihydrocapsaicinoids previously reported by us,[27] guarantees a practical synthesis of the pure capsaicinoids.[28]

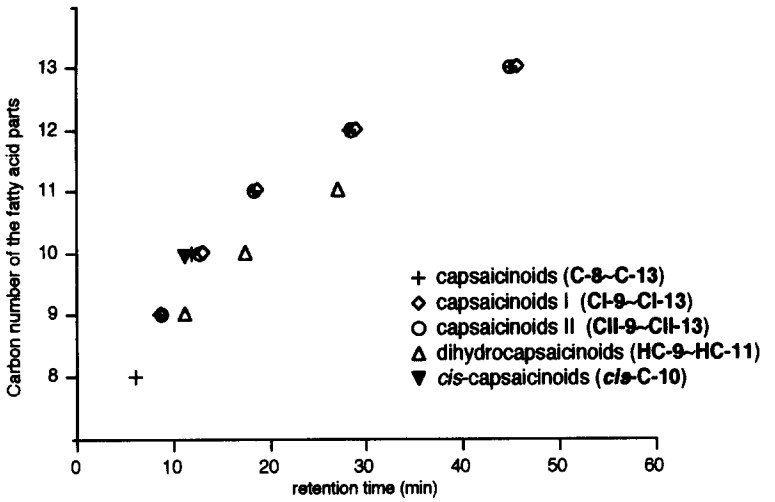


Scheme 2

HPLC and CE Analysis of Capsaicinoids.

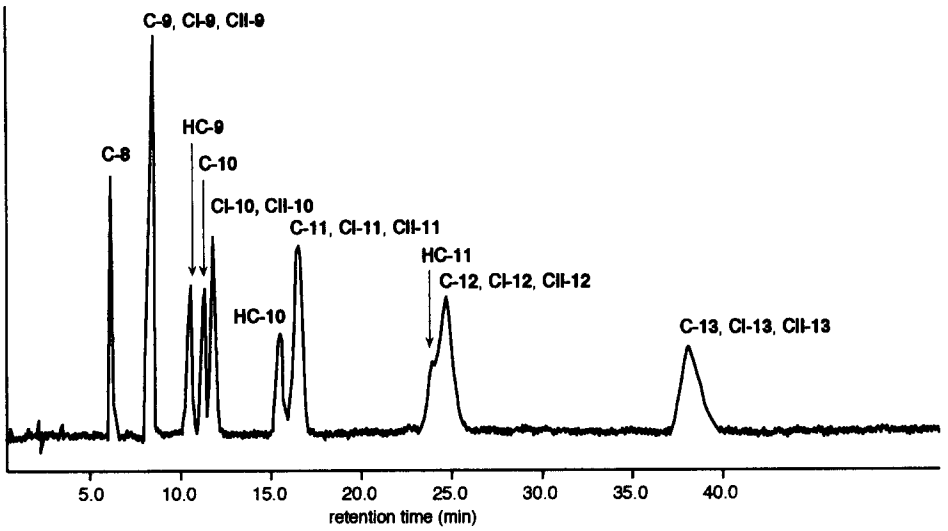
Separation and purification of capsaicinoids from hot pepper extracts by high performance methods, such as reversed-phase HPTLC,[29-32] GLC[12,33-37] and HPLC,[3,9-13,37-39] have been reported. We examined the separation of the synthesized capsaicinoids using HPLC and CE (capillary electrophoresis) columns. When HPLC analysis of the capsaicinoid mixtures was undertaken using reversed phase column [C_{18} 5 μm column; 4.6 mm × 250 mm, eluting with CH_3CN:H_2O (1:1, v/v), with a flow rate of 1ml/min at room temperature], capsaicinoids in each of the four groups of capsaicinoids, capsaicinoids I, capsaicinoids II, and dihydrocapsaicinoids were separated clearly, as shown in Figure 1. However, separation of capsaicinoids with the same carbon number was not satisfactory (Figure 2). Dihydrocapsaicinoids eluted separately at flow rates close to those of one carbon higher capsaicinoids. *cis*-Capsaicin (***cis*-C-10**) and dihydronorcapsaicin (**HC-9**)[27] eluted together and faster than capsaicin (**C-10**) by 1.2 min.

Analysis using a capillary electrophoresis system was also carried out. Under the conditions [capillary column 75 μm ID × 60 cm; buffer 20% MeOH, 10 mM cyclodextrine, 50 mM SDS, 20 mM Na_3BO_3; 20 kV; injection 3 sec], each group of capsaicinoid mixture was separated well, as shown in Figures 3, 4, 5 and 6. A mixture of 20 samples including dihydrocapsaicinoids and *cis*-capsaicin was also tested under the same conditions (Figure 7). Capsaicinoids with carbon numbers 8, 9, 10 of their fatty acid parts were found to be separable, but those with higher carbon number (11~13) flowed out together in each group.



HPLC was performed on an ODS column , eluting with CH_3CN and H_2O (1:1, v/v) at a rate of 1 ml / min. Mixed capsaicinoid samples, each consisting of 1ml of 0.005 Mol solution of the appropriate capsaicinoid in CH_3CN and H_2O (1:1, v/v), were prepared for each group (**C, CI, CII, HC** and ***cis*-C-10**). The resultant five chromatograms were transformed into the above graph.

Figure 1. Reversed phase HPLC analysis of capsaicinoids



HPLC was performed on an ODS column with CH_3CN and H_2O (1:1, v/v) at a rate of 1 ml / min, A solution of 19 capsaicinoid samples, each consisting of 1µl of 0.005 Mol solution of the appropriate capsaicinoid in CH_3CN and H_2O (1:1, v/v), were prepared, and injected.

Figure 2. Reversed phase HPLC chromatogram of a mixture of capsaicinoids

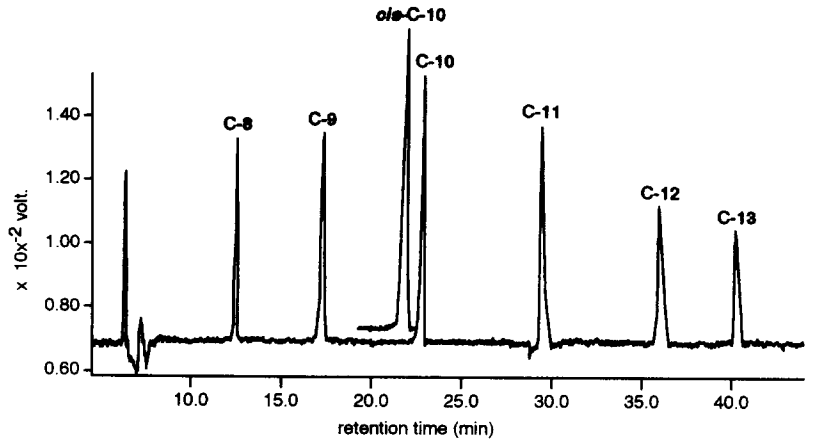


Figure 3. CE chromatogram of capsaicinoids (**C-8~C-13**) and *cis*-capsaicin (***cis*-C-10**)

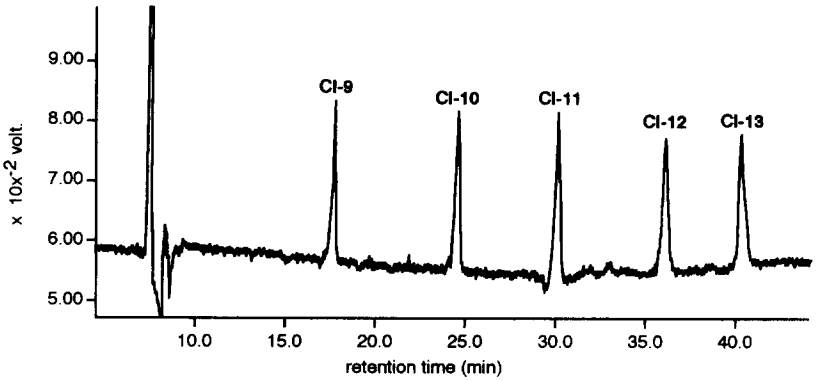


Figure 4. CE chromatogram of capsaicinoids I (**CI-9~CI-13**)

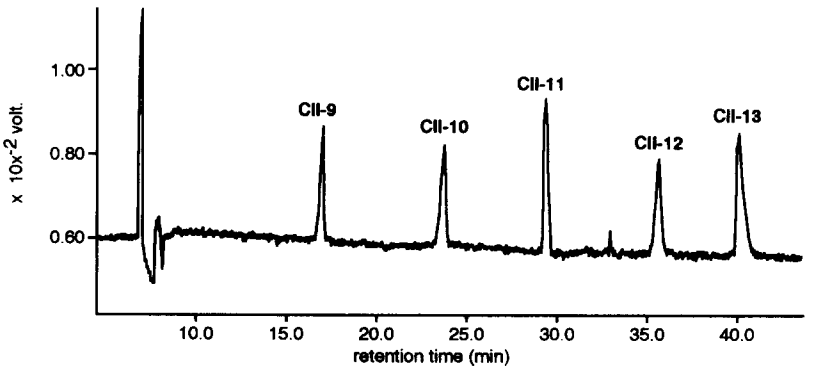


Figure 5. CE chromatogram of capsaicinoids II (**CII-9~CII-13**)

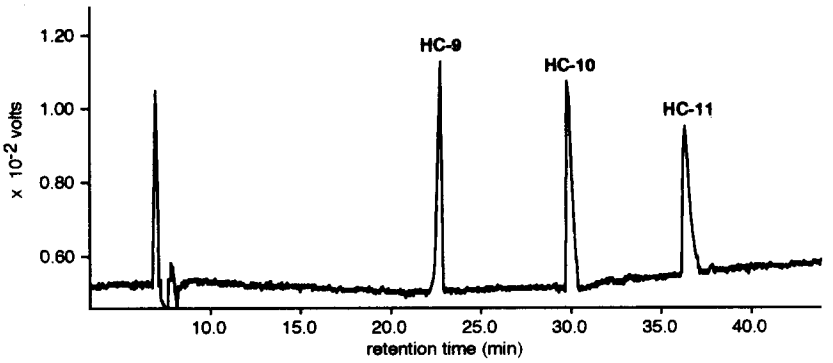
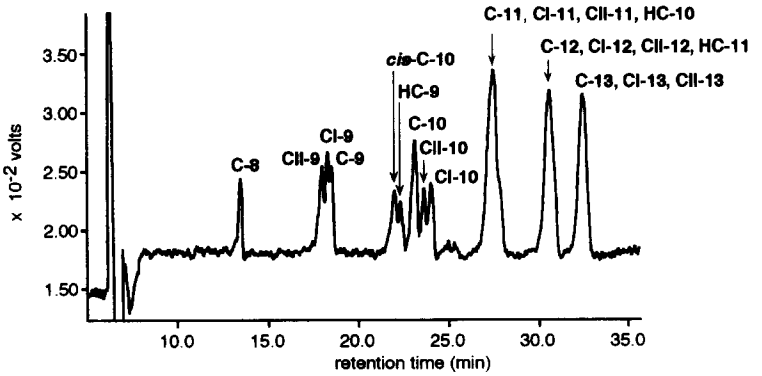


Figure 6. CE chromatogram of dihydrocapsaicinoids (**HC-9~HC-13**)



Capillary electrophoresis analysis was carried out on a capillary column (75 mm ID x 60 cm fused silica with buffer (20% MeOH, 10 mM cyclodextrine, 50 mM SDS and 20 mM Na_3BO_3) at 20 kV. Sample solutions of capsaicinoids were prepared from 0.01 Mol solution of each capsaicinoid in MeOH, and injected for 3 sec.

Figure 7. CE chromatogram of a mixture of capsaicinoids and *cis*-capsaicin

Summary.

In this study, a general and stereoselective synthetic route towards the capsaicinoid family has been developed. This could accommodate all of the 16 homologs of the natural and unnatural (artificial) capsaicinoids (**C-8 ~ C-13**), capsaicinoids I (**CI-9 ~ CI-13**) and capsaicinoids II (**CII-9 ~ CII-13**), starting from esters **3A**, **3B** and **3C**, which were obtained by the orthoester Claisen rearrangement in highly stereoselective manner, respectively. Analysis of these capsaicinoids was also carried out by HPLC and CE.

EXPERIMENTAL

Melting points were determined on a 500-D Yanagimoto micromelting point apparatus and were uncorrected. Boiling points were uncorrected. Infrared spectra were recorded on a 1650-FTIR (Perkin Elmer) spectrophotometer. ^1H and ^{13}C NMR spectra were measured in $CDCl_3$ solution with Me_4Si as an internal standard (δ = 0 ppm) and registered on a JEOL GX-270 (270 MHz) and α-500 (^1H, 500 MHz; ^{13}C, 125 MHz) spectrometers. Mass spectra were obtained on an INCOS 50 (Finnigan MAT Instruments, Inc.) at 70 eV under electron impact conditions. Gas chromatography was carried out on a GC 14A (Shimadzu) instrument [Shimadzu, CBP-5 column, 25 m × 0.32 mm ID × 0.5 μm; injector temperature 200 °C; detector temperature 250 °C; carrier gas He; flow rate 2.0 ml / min; split ratio 1:50]. Column chromatography and thin layer chromatography for analytical purpose were performed on silaca gel, Merck Art. 7734 and 5715, respectively. HPLC was performed on an ODS column (Gasukuro Kogyo, 4.0 mm × 250 mm, 5μm) with a Waters M45 pump [CH_3CN and H_2O (1:1, v/v), 1 mL / min] and UV detector (Lambda-Max Model 480, 254 nm), using 0.005 Mol solution of each capsaicinoid in CH_3CN and H_2O (1:1, v/v). Capillary electrophoresis analysis was carried out on an Waters Quanta 4000 [capillary column, 75 μm ID × 60 cm fused silica; buffer 20% MeOH, 10 mM cyclodextrine, 50 mM SDS, 20 mM Na_3BO_3; 20 kV; UV detection 185 nm; sample, 0.01 Mol solution in MeOH; injection 3 sec].

4-Methyl-1-penten-3-ol (2A). *Typical procedure for preparation of allyl alcohols* **2**. To a stirred solution of vinylmagnesium bromide-THF (110 ml, Aldrich, 1 M solution, 0.11 mol) at 0 °C was added dropwise isobutyraldehyde (**1A**, 7.2 g, 98 mmol) in dry THF (30 ml) in the course of 15 min. The mixture was allowed to be stired at room temperature for 15 h. Saturated NH_4Cl solution (15 ml) was then added, and THF was evaporated. The residue was acidified with 10 % H_2SO_4 to pH 3, extracted with ether (30 ml × 2). The combined ether layers were washed with saturated brine, dried over anhydrous $MgSO_4$, and evaporated. The oily residue was distilled to give allyl alcohol **2A** (7.3 g, 73%), b.p. 122-123 °C / 760 mmHg (lit.[21] b.p. 116 °C). IR (neat) 3372, 993, 921 cm^{-1}; ^1H NMR δ 0.91 and 0.94 (each 3H, d, J = 6.7 Hz, 2 CH_3), 1.47 (1H, br. d, OH), 1.74 (1H, octet, J = 6.6 Hz, C_4-H), 3.87 (1H, br. q, J = 5.5 Hz, C_9-H), 5.16 (1H, dt, J = 10.4, 1.2 Hz, C_1-cis -H), 5.23 (1H, dt, J = 17.1, 1.4 Hz, C_1-trans -H), 5.87 (1H, ddd, J = 17.1, 10.4, 6.4 Hz, C_2-H); EIMS *m/z* (rel. int.) 100 (M^+, 1), 85 (5), 57 (100). Anal. Calcd for $C_6H_{12}O$: C, 71.95; H, 12.08. Found: C, 72.23; H, 11.90.

5-Methyl-1-hexen-3-ol (2B). Isovaleraldehyde (**1B**, 6.03 g, 70 mmol) gave **2B** (5.3 g, 73%), b.p. 53-54 °C / 16 mmHg. IR (neat) 3332, 989, 920 cm^{-1}; ^1H NMR δ 0.93 (6H, dd, J = 6.6, 1.8 Hz, 2 CH_3), 1.33 (1H, ddd, J = 13.6, 7.7, 5.9 Hz, C_{4a}-H), 1.47 (1H, ddd, J =14.3, 8.1, 6.2 Hz, C_{4b}-H), 1.58 (1H, br. s, OH), 1.75 (1H, nonet, J = 6.6 Hz, C_5-H), 4.17 (1H, br. q, J = 6.6 Hz, C_3-H), 5.09 (1H, dt, J = 10.3, 1.3 Hz, C_1-cis-H), 5.23 (1H, dt, J = 17.2, 1.3 Hz, C_1-trans- H), 5.87 (1H, ddd, J = 17.2, 10.3, 6.2 Hz, C_2-H); EIMS *m/z* (rel. int.) 114 (M^+, 0.04), 113 [(M - H) $^+$, 0.1], 96 [(M - H_2O) $^+$, 6], 72 [(M - Me_2CH) $^+$, 21], 57 ($Me_2CHCH_2^+$, 100), 43 ($C_3H_7^+$, 66), 41 (20). Anal. Calcd for $C_7H_{14}O$: C, 73.63; H, 12.36. Found: C, 73.66; H, 12.31.

4-Methyl-1-hexen-3-ol (2C). 2-Methylbutyraldehyde (**1C**, 6.03 g, 70 mmol) gave **2C** (6.33 g, 79%), b.p. 53-54 °C / 16 mmHg. IR (neat) 3354, 992, 922 cm^{-1}; ^1H NMR δ 0.89 (3H, d, J = 6.6 Hz, C_6-H), 0.92 (3H, d, J = 7.3 Hz, C_4-CH_3), 1.07 - 1.23 (1H, m, C_4-H), 1.41 (1H, br. d, J = 4.7 Hz, OH), 1.41 - 1.60 (2H, m, C_5-H), 3.34 - 4.04 (1H, m, C_3-H), 5.15 (1H, dq, J = 10.3, 1.8 Hz, C_1-cis-H), 5.23 (1H, dt, J = 16.9, 1.5 Hz, C_1-trans-H), 5.87 (1H, dddd, J = 16.9, 10.3, 6.2, 1.8 Hz, C_2-H); EIMS *m/z* (rel. int.) 114 (M^+, 0.04), 99 [(M - CH_3) $^+$, 0.7], 96 [(M - H_2O) $^+$, 1.4], 57 ($C_4H_9^+$, 100). Anal. Calcd for $C_7H_{14}O$: C, 73.63; H, 12.36. Found: C, 73.42; H, 12.20.

(*E*)-Ethyl 6-methyl-4-heptenoate (3A). *Typical procedure for preparation of esters* **3**. A mixture of **2A** (5.52 g, 55 mmol), triethylorthoacetate (62.6 g, 0.39 mol) and propionic acid (245 mg, 3.3 mmol) was heated to 138 °C for 3 h using a Claisen distilled head under an atmosphere of argon. EtOH was then distilled off within a half hour, and the residue was distilled to give ester **3A** (7.30 g, 73%), b.p. 88-89 °C / 16 mmHg, which was found to be an *E*-major ester in a 220 : 1 *E* / *Z* ratio by GC analysis (column temperature,

130 °C; retention time, 4.8 min / 4.6 min). IR (neat) 1739, 971 cm^{-1}; ^1H NMR δ 0.95 (6H, d, J = 7.0 Hz, 2 CH_3), 1.25 (3H, t, J = 7.1 Hz, CO_2CCH_3), 2.22 (1H, partly hidden octet, J = 6.6 Hz, C_6-H), 2.31 - 2.39 (2H, m, C_3-H), 2.33 (2H, td, J = 6.2, 1.3 Hz, C_2-H), 4.13 (2H, q, J = 7.1 Hz, CO_2CH_2), 5.35 (1H, dt, J = 15.4, 5.5 Hz, C_5-H), 5.4 (1H, dd, J = 15.4, 5.9 Hz, C_5-H); EIMS *m/z* (rel. int.) 170 (M^+, 15), 169 [(M - H)$^+$, 20], 124 (18), 95 (48), 82 (100), 69 (20), 55 (47), 41 (46). Anal. Calcd for $C_{10}H_{18}O_2$: C, 70.54; H, 10.66. Found: C, 70.44; H, 10.57.

(*E*)-Ethyl 7-methyl-4-octenoate (3B). Allyl alcohol **2B** (5.60 g, 49 mmol) gave **3B** (8.14 g, 90%), b.p. 100-101.5 °C / 16 mmHg, which was found to be a pure *E*-ester by GC analysis (column temperature, 135 °C; retention time, 6.4 min). IR (neat) 1738, 970 cm^{-1}; ^1H NMR δ 0.86 (6H, d, J = 6.6 Hz, 2 CH_3), 1.25 (3H, t, J = 7.0 Hz, CO_2CCH_3), 1.58 (1H, nonet, J = 6.6 Hz, C_7-H), 1.86 (2H, t, J = 6.6 Hz, C_6-H), 2.26 - 2.41 (4H, m, $C_{2,3}$-H), 4.13 (2H, q, J = 7.0 Hz, CO_2CH_2), 5.35 - 5.51 (2H, m, $C_{4,5}$-H); EIMS *m/z* (rel. int.) 185 [(MH)$^+$, 23], 184 (M^+, 7), 138 [(M - EtOH)$^+$, 100], 95 (52), 88 (79), 81 (39), 71 (70), 69 (45), 55 (75), 43 (62), 41 (78). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.75; H, 10.80.

(*E*)-Ethyl 6-methyl-4-octenoate (3C). Allyl alcohol **2C** (4.46 g, 39.1 mmol) gave **3C** (6.33 g, 87%), b.p. 70-71 °C / 3.2 mmHg, which was found to be an *E*-major ester in a 240 : 1 *E* / *Z* ratio by GC analysis (column temperature, 135 °C; retention time, 6.2 min / 6.1 min). IR (neat) 1739, 971 cm^{-1}; ^1H NMR δ 0.83 (3H, t, J =7.3 Hz, C_8-H), 0.94 (3H, d, J = 6.6 Hz, C_6-CH_3), 1.25 (3H, t, J = 7.2 Hz, CO_2CCH_3), 1.27 (2H, partly hidden quint d, J = 7.3, 2.8 Hz, C_7-H), 1.96 (1H, septet, J = 6.6 Hz, C_6-H), 2.25 - 2.41 (4H, m, $C_{2,3}$-H), 4.13 (2H, q, J = 7.2 Hz, CO_2CH_2), 5.26 - 5.43 (2H, m, $C_{4,5}$-H); EIMS *m/z* (rel.int.) 184 (M^+, 7), 138 [(M - EtOH)$^+$, 11], 110 (23), 95 (100), 81 (70), 55 (55), 41 (32). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.67; H, 10.96.

(*E*)-6-Methyl-4-hepten-1-ol (4Aa).[40] *Typical procedure for preparation of alcohols* **4**. To a stirred suspension of $LiAlH_4$ (2.05 g, 54.1 mmol) in dry ether (230 ml) at 0 °C was added dropwise a solution of **3A** (7.68 g, 45.1 mmol) in dry ether (65 ml) in the course of 20 min. The mixture was allowed to be stirred at room temperature for 15 h. The mixture was then quenched by addition of saturated Na_2SO_4 solution, and filtered through anhydrous Na_2SO_4. The filtrate was evaporated, and the residue was short-path distilled to give **4Aa** (4.95 g, 86%), b.p. 88.5-89 °C / 15 mmHg (lit.[19] b.p. 87 °C / 14 mmHg, lit.[21] b.p. 90 °C / 15 - 20 mmHg). IR (neat) 3332, 969 cm^{-1}; ^1H NMR δ 0.97 (6H, d, J = 7.0 Hz, 2 CH_3), 1.29 (1H, br. t, J = 5.4 Hz, OH), 1.64 (2H, quint, J = 6.7 Hz, C_2-H), 2.07 (2H, q, J = 6.6 Hz, C_3-H), 2.24 (1H, octet, J = 6.6 Hz, C_6-H), 3.65 (2H, br. q, J = 6.0 Hz, C_1-H), 5.37 (1H, dt , J =15.4, 5.5 Hz, C_4-H), 5.42 (1H, dd, J = 15.38, 5.5 Hz, C_5-H); EIMS *m/z* (rel.int.), 128 (M^+, 12), 110 [(M - H_2O)$^+$, 12], 95 (84), 82 (100), 69 (82), 55 (75), 43 (74), 41 (90). Anal. Calcd for $C_8H_{18}O$: C, 74.94; H, 12.58. Found: C, 75.15; H, 12.54.

(*E*)-7-Methyl-4-octen-1-ol (4Ba). Ester **3B** (7.95 g, 43.1 mmol) gave **4Ba** (5.75 g, 94%), b.p. 102-103 °C / 15 mmHg. IR (neat) 3331, 968 cm^{-1}; ^1H NMR δ 0.87 (6H, d, J = 7.0 Hz, 2 CH_3), 1.26 (1H, t, J = 5.5 Hz, OH), 1.58 (1H, partly hidden nonet, J = 6.6 Hz, C_7-H), 1.64 (2H, quint, J = 6.7, C_2-H), 1.87 (2H, dd, J = 6.6, 5.5 Hz, C_2-H), 2.09 (2H, br. q, J = 6.5 Hz, C_3-H), 3.66 (2H, q, J = 6.1 Hz, C_1-H), 5.33 - 5.51 (2H, m, $C_{4,5}$-H); EIMS *m/z* (rel. int.) 142 (M^+, 4), 124 (23), 109 (19), 95 (13), 81 (100), 69 (38), 55 (46), 43 (41), 41 (55). Anal. Calcd for $C_9H_{18}O$: C, 75.99; H, 12.76. Found: C, 75.74; H, 12.84.

(*E*)-6-Methyl-4-octen-1-ol (4Ca). Ester **3C** (2.78 g, 15.1 mmol) gave **4Ca** (2.06g, 96%), b.p. 70-71 °C / 1.2 mmHg. IR (neat) 3334, 971 cm^{-1}; ^1H NMR δ 0.84 (3H, t, J = 7.3 Hz, C_8-H), 0.93 (3H, d, J = 6.6 Hz,C_6-CH_3), 1.17 - 1.33 (3H, m, C_7-H and OH), 1.64 (2H, quint, J = 7.0 Hz, C_2-H), 1.97 (1H, septet, J = 6.7 Hz, C_6-H), 2.08 (2H, q, J = 6.7 Hz, C_3-H), 3.66 (2H, q, J = 5.9 Hz, C_1-H), 5.30 (1H, dd, J = 15.4, 6.2 Hz, C_5-H), 5.38 (1H, dt, J = 15.4, 5.9 Hz, C_4-H); EIMS *m/z* (rel. int.) 142 (M^+, 10), 124 [(M - H_2O)$^+$, 9], 109 (13), 95 (100). Anal. Calcd for $C_9H_{18}O$: C, 75.99; H, 12.76. Found: C, 75.88; H, 12.72.

(*E*)-8-Methyl-6-nonen-1-ol (4Ac).[40] Ester **7Ac** (2.30 g, 12.5 mmol) gave **4Ac** (1.88 g, 96%), b.p. 87-87.5 °C /3.5 mmHg. IR (neat) 3332, 968 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 6.6 Hz, 2 CH_3), 1.29 (1H, br. s, OH), 1.33 - 1.43 (4H, m, $C_{3,4}$-H), 1.57 (2H, quint, J = 6.8 Hz, C_2-H), 1.96 - 2.20 (2H, m, C_5-H), 2.22 (1H, octet, J = 6.6 Hz, C_8-H), 3.64 (2H, t, J = 6.6 Hz, C_1-H), 5.33 - 5.37 (2H, m, $C_{6,7}$-H); EIMS *m/z* (rel. int.) 156

(M^+, 8), 138 (5), 123 (14), 110 (10), 95 (69), 82 (81), 69 (100), 55 (889), 41 (87). Anal. Calcd for $C_{10}H_{20}O$: C, 76.86; H, 12.90. Found: C, 76.89; H, 12.97.

(*E*)-9-Methyl-6-decen-1-ol (4Bc). Ester **7Bc** (2.85 g, 14.4 mmol) gave **4Bc** (2.28 g, 93%), b.p. 88.5-89 °C / 1.5 mmHg. IR (neat) 3332, 968 cm^{-1}; ^1H NMR δ 0.87 (6H, d, J = 6.6 Hz, 2 CH_3), 1.25 (1H, br. s, OH), 1.33 - 1.42 (4H, m, $C_{3,4}$-H), 1.57 (1H, partly hidden nonet, J = 6.6 Hz, C_9-H), 1.58 (2H, quint, J = 6.6 Hz, C_2-H), 1.84 - 1.89 (2H, m, C_8-H), 2.09 (2H, br. q, J = 6.5 Hz, C_5-H), 3.64 (2H, br. q, J = 5.7 Hz, C_1-H), 5.36- 5.40 (2H, m, $C_{6,7}$-H); EIMS *m/z* (rel. int.) 170 (M^+, 8), 152 (7), 137 (5), 95 (53), 81 (54), 67 (100), 55 (75), 43 (47), 41 (56). Anal. Calcd for $C_{11}H_{22}O$: C, 77.58; H, 13.02. Found: C, 77.36; H, 12.90.

(*E*)-8-Methyl-6-decen-1-ol (4Cc). Ester **7Cc** (1.44 g, 7.3 mmol) gave **4Cc** (1.14 g, 92%), b.p. 94-95 °C / 2.2 mmHg. IR (neat) 3332, 969 cm^{-1}; ^1H NMR δ 0.84 (3H, t, J = 7.3 Hz, C_{11}-H), 0.95 (3H, d, J = 7.0 Hz, C_8-CH_3), 1.20 (1H, br. s, OH), 1.27 (2H, br. quint, J = 7.7 Hz, C_9-H), 1.35 - 1.38 (4H, m, $C_{3,4}$-H), 1.57 (2H, br. quint, J = 6.8 Hz, C_2-H), 1.88 - 2.0 (1H, partly hidden m, C_8-H), 2.00 (2H, q, J = 6.7 Hz, C_5-H), 3.64 (2H, br. q, J = 5.9 Hz, C_1-H), 5.27 (1H, dd, J = 15.4, 6.6 Hz, C_7-H), 5.36 (1H, dt, J = 15.4, 5.9 Hz, C_6-H); EIMS *m/z* (rel. int.) 170 (M^+, 1.4), 152 [$(M - H_2O)^+$, 1.6], 123 [$(M - H_2O - Et)^+$, 29], 95 (34), 81 (70), 70 (52), 55 (100), 41 (50). Anal. Calcd for$C_{11}H_{22}O$: C, 77.58; H, 13.02. Found: C, 77.38; H, 13.00.

(*E*)-10-Methyl-8-undecen-1-ol (4Ae).[40] Ester **7Ae** (1.19g, 5.6 mmol) gave **4Ae** (968 mg, 94%), b.p. 76-77 °C / 0.14 mmHg. IR (neat) 3332, 968 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 7.0 Hz, 2 CH_3), 1.20 (1H, br. s, OH), 1.31 (6H, m, $C_{3,4,5}$-H), 1.56 (4H, m, $C_{2,6}$-H), 1.96 (2H, m, C_7-H), 2.16 - 2.28 (1H, m, C_{10}-H), 3.64 (2H, q, J = 6.0 Hz, C_1-H), 5.33 - 5.36 (2H, m, $C_{8,9}$-H); EIMS *m/z* (rel. int.) 184 (M^+, 6), 166 [$(M - H_2O)^+$, 6], 123 (14), 109 (22), 95 (53), 82 (63), 69 (100), 55 (89), 41 (80). Anal. Calcd for $C_{12}H_{24}O$: C, 78.19; H, 13.13. Found: C, 78.07; H, 13.07.

(*E*)-7-Methyl-5-octenenitrile (5Ab). *Typical procedure for preparation of nitriles* **5**. To a stirred solution of **4Aa** (645 mg, 5.0 mmol) and Et_3N (0.84 ml, 6.0 mmol) in CH_2Cl_2 (16 ml) was dropwise added MsCl (0.43 ml, 5.5 mmol) at 0 °C during the course of 5 min. The mixture was stirred for 30 min at 0 °C, and 1h at room temperature, and then diluted with CH_2Cl_2 (10 ml), poured into cold water (20 ml). The organic layer was washed with saturated brine (10 ml), and filtered through a pad of anhydrous $MgSO_4$ and silica gel to give a crude mesylate of **4Aa** (1.05 g, Ca. 100%). To a mixture of the mesylate in DMSO (5 ml) was added sodium cyanide (296 mg, 6.0 mmol), and the mixture was heated at 140 °C for 3 h under an atmosphere of argon. The resulting mixture was poured into cold water (20 ml), and extracted with ether-hexane (1/1, 15 ml × 3), washed with saturated brine (10 ml), dried over $MgSO_4$, and evaporated. The crude residue was purified by column chromatography on silica gel (20 g, ether : hexane = 1:10) to give **5Ab** as a colorless oil (613 mg, 89%). An analytical sample was prepared by short-path distillation to give 568 mg, b.p. 95.5-96 °C / 16 mmHg, which was found to be an *E*-major nitrile in a 120:1 *E/Z* ratio by GC analysis (column temperature, 130 °C; retention time, 4.6 min / 4.4 min). IR (neat) 2246, 972 cm^{-1}; ^1H NMR δ 0.97 (6H, d, J = 6.6 Hz, 2 CH_3), 1.72 (2H, quint, J = 7.1 Hz, C_3-H), 2.14 (2H, q, J = 7.0 Hz,C_4-H), 2.19 - 2.34 (1H, partly hidden m, C_7-H), 2.32 (2H, t, J = 7.3 Hz, C_2-H), 5.27 (1H, dtd, J = 15.4, 6.6, 1.3 Hz, C_5-H), 5.48 (1H, ddt, J = 15.4, 6.6, 1.3 Hz, C_6-H); EIMS *m/z* (rel. int.) 138 [$(M + H)^+$, 22], 137 (M^+, 24), 136 [$(M - H)^+$, 21], 122 (44), 108 (33), 94 (49), 69 (100), 55 (40), 41 (58). Anal. Calcd for $C_9H_{15}N$: C, 78.77; H, 11.02; N, 10.21. Found: C, 78.79; H, 11.06; N, 9.91.

(*E*)-8-Methyl-5-nonenenitrile (5Bb). Alcohol **4Ba** (659 mg, 4.6 mmol) gave **5Bb** (638 mg, 91%), b.p. 110-111 °C / 16 mmHg, which was found to be a pure *E*-nitrile by GC analysis (column temperature, 130 °C; retention time, 6.9 min). IR (neat) 2246, 971 cm^{-1}; ^1H NMR δ 0.87 (6H, d, J = 7.0 Hz, 2 CH_3), 1.60 (1H, nonet, J = 6.6 Hz, C_8-H), 1.73 (2H, quint, J = 7.1 Hz, C_3-H), 1.89 (2H, td, J = 7.0, 1.1 Hz, C_7-H), 2.16 (2H, q, J = 6.9 Hz, C_4-H), 2.33 (2H, t, J = 7.2 Hz, C_2-H), 5.25 - 5.36, 5.44 - 5.54 (2H, each m, $C_{5,6}$-H); EIMS *m/z* (rel. int.) 152 [$(M + H)^+$, 13], 151 (M^+, 4), 136 [$(M - CH_3)^+$, 23], 123 [$(M - 28)^+$, 51], 108 [$(M - Pr)^+$, 43], 81 (100), 69 (58), 43 (75), 41 (93). Anal. Calcd for $C_{10}H_{17}N$: C, 79.40; H, 11.34; N, 9.26. Found: C, 79.27; H, 11.19; N, 9.18.

(*E*)-7-Methyl-5-nonenenitrile (5Cb). Alcohol **4Ca** (696 mg, 4.9 mmol) gave **5Cb** (629 mg, 85%), b.p.

70-71 °C / 1.3 mmHg, which was found to be an *E*-major nitrile in a 150:1 *E/Z* ratio by GC analysis (column temperature, 130 °C; retention time, 6.7 min / 6.4 min). IR (neat) 2246, 973 cm^{-1}; ^1H NMR δ 0.84 (3H, t, *J* = 7.3 Hz, C_9-H), 0.96 (3H, d, *J* = 6.6 Hz, C_7-CH_3), 1.28 (2H, quint d, *J* = 7.2, 1.8 Hz, C_8-H), 1.73 (2H, quint, *J* = 7.2 Hz, C_3-H), 1.99 (1H, septet, *J* = 6.8 Hz, C_7-H), 1.15 (2H, q, *J* = 6.7 Hz, C_4-H), 2.33 (2H, t, *J* = 7.1 Hz, C_2-H), 5.28 (1H, dt, *J* = 15.4, 6.2 Hz, C_5-H), 5.36 (1H, dd, *J* = 15.4, 7.0 Hz, C_6-H); EIMS *m/z* (rel. int.) 151 (M^+, 20), 136 [(M - CH_3)$^+$, 40], 122 [(M - Et)$^+$, 76], 81 (78), 55 (100), 41 (76). Anal. Calcd for $C_{10}H_{17}N$: C, 79.40; H, 11.34; N, 9.26. Found: C, 79.48; H, 11.25; N, 9.17.

(*E*)-9-Methyl-7-decenenitrile (5Ad). Alcohol **4Ac** (392 mg, 2.5 mmol) gave **5Ad** (347 mg, 84%), b.p. 80.5-81 °C / 1.8 mmHg, which was found to be an *E*-major nitrile in a 95:1 *E/Z* ratio by GC analysis (column temperature, 140 °C; retention time, 8.1 min / 7.9 min). IR (neat) 2246, 970 cm^{-1}; ^1H NMR δ 0.96 (6H, d, *J* = 7.0 Hz, 2 CH_3), 1.33 - 1.51 (4H, m, $C_{4,5}$-H), 1.66 (2H, quint, *J* = 7.2 Hz, C_3-H), 1.99 (2H, q, *J* = 6.4 Hz, C_6-H), 2.23 (1H, octet, *J* = 6.6 Hz, C_9-H), 2.34 (2H, t, *J* = 7.2 Hz, C_2-H), 5.33 (1H, dt , *J* = 15.4, 5.0 Hz, C_7-H), 5.40 (1H, dd, *J* = 15.4, 5.5 Hz, C_8-H); EIMS *m/z* (rel. int.) 165 (M^+, 7), 150 [(M - CH_3)$^+$, 22], 122 (27), 69 (100), 55 (50), 41 (58). Anal. Calcd for $C_{11}H_{19}N$: C, 79.94; H, 11.59; N, 8.48. Found: C, 80.08; H, 11.57; N, 8.36.

(*E*)-10-Methyl-7-undecenenitrile (5Bd). Alcohol **4Bc** (762 mg, 4.5 mmol) gave **5Bd** (724 mg, 90%), b.p. 104-105 °C / 3 mmHg, which was found to be a pure *E*-nitrile by GC analysis (column temperature, 140 °C; retention time, 12.9 min). IR (neat) 2246, 969 cm^{-1}; ^1H NMR δ 0.87 (6H, d, *J* = 6.6 Hz, 2 CH_3), 1.35 - 1.51 (4H, m, $C_{4,5}$-H), 1.58 (1H, partly hidden nonet, *J* = 6.6 Hz, C_{10}-H), 1.66 (2H, quint, *J* = 7.1 Hz, C_3-H), 1.86 (2H, td, *J* = 5.9, 1.1 Hz, C_9-H), 2.01 (2H, q, *J* = 6.4 Hz, C_6-H), 2.33 (2H, t, *J* = 7.2 Hz, C_2-H), 5.35 - 5.40 (2H, m, $C_{7,8}$-H); EIMS *m/z* (rel. int.) 180 [(M + H)$^+$, 32], 179 (M^+, 19), 164 (21), 150 (16), 136 (85), 122 (80), 108 (54), 94 (52), 81 (30), 69 (91), 55 (100), 43 (56), 41 (88). Anal. Calcd for $C_{12}H_{21}N$: C, 80.38; H, 11.81; N, 7.81. Found: C, 80.33; H, 11.96; N, 7.67.

(*E*)-9-Methyl-7-undecenenitrile (5Cd). Alcohol **4Cc** (652 mg, 3.8 mmol) gave **5Cd** (602 mg, 88%), b.p. 83-84 °C / 0.4 mmHg, which was found to be a pure *E*-nitrile by GC analysis (column temperature, 160 °C; retention time, 7.2 min). IR (neat) 2246, 971 cm^{-1}; ^1H NMR δ 0.84 (3H, d, *J* = 7.3 Hz, C_{11}-H), 0.95 (3H, d, *J* = 6.6 Hz, C_9-CH_3), 1.27 (2H, quint d, *J* = 7.3, 1.8 Hz, C_{10}-H), 1.36 - 1.49 (4H, m, $C_{4,5}$-H), 1.66 (2H, quint, *J* = 7.3 Hz, C_3-H), 1.97 (1H, partly hidden septet, *J* = 7.0 Hz, C_9-H), 2.00 (2H, q, *J* = 6.5 Hz, C_6-H), 2.33 (2H, t, *J* = 7.2 Hz, C_2-H), 5.27 (1H, partly hidden dt, *J* = 15.4, 6.2 Hz, C_7-H), 5.33 (1H, dd, *J* = 15.4, 5.9 Hz, C_8-H); EIMS *m/z* (rel. int.) 179 (M^+, 6), 164 [(M - CH_3)$^+$, 8], 150 [(M - Et)$^+$, 49], 83 (46), 70 (58), 55 (100), 41 (41). Anal. Calcd for $C_{12}H_{21}N$: C, 80.38; H, 11.81; N, 7.81. Found: C, 80.23; H, 11.76; N, 7.71.

(*E*)-11-Methyl-9-dodecenenitrile (5Af). Alcohol **4Ae** (676 mg, 3.7 mmol) gave **5Af** (640 mg, 90%), b.p. 108-109 °C / 1.3 mmHg, which was found to be a pure *E*-nitrile by GC analysis (column temperature, 170 °C; retention time, 8.1 min). IR (neat) 2246, 969 cm^{-1}; ^1H NMR δ 0.96 (6H, d, *J* = 6.6 Hz, 2 CH_3), 1.31 - 1.34 (6H, m, $C_{4,5,6}$-H), 1.39 - 1.47 (2H, m, C_7-H), 1.66 (2H, quint, *J* = 7.1 Hz, C_3-H), 1.96 (2H, q, *J* = 5.9 Hz, C_8-H), 2.22 (1H, octet, *J* = 6.4 Hz, C_{11}-H), 2.33 (2H, t, *J* = 7.0 Hz, C_2-H), 5.33 - 5.36 (2H, m, $C_{9,10}$-H); EIMS *m/z* (rel. int.) 193 (M^+, 3), 178 [(M - CH_3)$^+$, 8), 69 (100), 56 (80), 41 (59). Anal. Calcd for $C_{13}H_{23}N$: C, 80.76; H, 11.99; N, 7.25. Found: C, 80.75; H, 12.16 ; N, 7.20.

(*E*)-Methyl 2-methoxycarbonyl-8-methyl-6-nonenoate (6Ac). *Typical procedure for preparation of malonates* **6**. Alcohol **4Aa** (4.2 g, 32.8 mmol) was treated with MsCl (2.82 ml, 36.1 mmol) to be quantitatively converted to the mesylate (6.7 g), according to the procedure for preparation of **5Ab**. To a stirred suspension of NaH (2.36 g of 50 % in mineral oil, 49.2 mmol) in a mixture of DMF / THF (2:1, 180 ml) was dropwise added dimethyl malonate (5.6 ml, 49 mmol) at 0 °C, and the mixture was stirred at room temperature for about 15 min till NaH disappeared. To this sodio malonate mixture was added a solution of the above mesylate in dry THF (60 ml), and KI (6.37 g, 38.4 mmol), and then the resulting mixture was heated at 80 °C for 3.5 h. After cooling to room temperature, the reaction mixture was quenched with saturated NH_4Cl solution (100 ml), diluted with water (100 ml), and extracted with ether-hexane (1/1, 100 ml × 5). The combined organic layers were washed with saturated brine (150 ml), dried over anhydrous

$MgSO_4$, and evaporated *in vacuo*. The crude residue was purified by silica gel column chromatography (200 g, ether: hexane = 1:10) to give **6Ac** (6.61 g, 83%), b.p. 101-102 °C / 0.55 mmHg. IR (neat) 1750, 1738, 971 cm^{-1}; ^1H NMR δ 0.95 (6H, d, J = 7.0 Hz, 2 CH_3), 1.37 (2H, quint, J = 7.7 Hz, C_4-H), 1.90 (2H, q, J = 7.8 Hz, C_3-H), 2.00 (2H, q, J = 6.8 Hz, C_5-H), 2.22 (1H, octet, J = 6.6 Hz, C_8-H), 3.36 (2H, t, J = 7.5 Hz, C_2-H), 3.74 (6H, s, 2 OCH_3), 5.30 (1H, dt, J = 15.8, 5.5 Hz, C_6-H), 5.40 (1H, dd, J = 15.4, 5.9 Hz, C_7-H); EIMS *m/z* (rel. int.) 243 [(M + H)$^+$, 71], 242 (M$^+$, 41), 210 (46), 145 [$CH_2CH(COO\ CH_3)_2^+$, 91], 132 [$CH(COO\ CH_3)_2^+$, 100], 81 (79), 69 (51), 55 (65), 41 (75). Anal. Calcd for $C_{13}H_{22}O_4$: C, 64.44; H, 9.15. Found: C, 64.34; H, 9.14.

(*E*)-Methyl 2-methoxycarbonyl-9-methyl-6-decenoate (6Bc). Alcohol **4Ba** (3.77 g, 26.5 mmol) gave **6Bc** (5.57 g, 82%), b.p. 107-108 °C / 0.4 mmHg. IR (neat) 1750, 1738, 970 cm^{-1}; ^1H NMR δ 0.86 (6H, d, J = 6.6 Hz, 2 CH_3), 1.38 (2H, quint, J = 7.6 Hz, C_4-H), 1.57 (1H, nonet, J = 6.6 Hz, C_9-H), 1.86 (2H, t, J = 6.2 Hz, C_8-H), 1.91 (2H, q, J = 7.7 Hz, C_3-H), 2.02 (2H, q, J = 6.6 Hz, C_5-H), 3.36 (1H, t, J = 7.5 Hz, C_2-H), 3.74 (6H, s, 2 OCH_3), 5.28 - 5.46 (2H, m, $C_{6,7}$-H); EIMS *m/z* (rel. int.) 257 [(M + H) $^+$, 49], 256 (M$^+$, 28), 224 (23), 164 (51), 145 [$CH_2CH(COOCH_3)_2^+$, 100], 132 [$CH(COOCH_3)_2^+$, 99], 55 (41). Anal. Calcd for $C_{14}H_{24}O_4$: C, 65.59; H, 9.44. Found: C, 65.59; H, 9.39.

(*E*)-Methyl 2-methoxycarbonyl-8-methyl-6-decenoate (6Cc). Alcohol **4Ca** (1.67 g, 11.7 mmol) gave **6Cc** (2.52 g, 84%), b.p. 119-120 °C / 0.9 mmHg. IR (neat) 1749, 1737, 972 cm^{-1}; ^1H NMR δ 0.83 (3H, d, J = 7.3 Hz, C_{10}-H), 0.94 (3H, d, J = 6.6 Hz, C_8-CH_3), 1.27 (2H, quint d, J = 7.2, 1.8 Hz, C_9-H), 1.38 (2H, quint, J = 7.7, C_4-H), 1.88 - 1.96 (1H, mostly hidden m, C_8-H), 1.91 (2H, q, J = 7.8 Hz, C_3-H), 2.01 (2H, q, J = 6.5 Hz, C_5-H), 3.37 (1H, t, J = 7.5 Hz, C_2-H), 3.74 (6H, s, 2 OCH_3), 5.27 - 5.32 (2H, m, $C_{6,7}$-H); EIMS *m/z* (rel. int.) 257 [(M + H)$^+$, 27], 256 (M$^+$, 34), 224 (22), 163 (58), 145 [$CH_2CH(COOCH_3)_2^+$, 84], 132 [$CH(COOCH_3)_2^+$, 100], 95 (64), 81 (59), 67 (69), 55 (97), 41 (70). Anal. Calcd for $C_{14}H_{24}O_4$: C, 65.59; H, 9.44. Found: C, 65.46; H, 9.38.

(*E*)-Methyl 2-methoxycarbonyl-10-methyl-8-undecenoate (6Ae). Alcohol **4Ac** (2.32 g, 13.7 mmol) gave **6Ae** (2.75 g, 75%), b.p. 94-95 °C / 0.03 mmHg. IR (neat) 1750, 1738, 972 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 6.6 Hz, 2 CH_3), 1.27 - 1.36 (6H, m, $C_{4,5,6}$-H), 1.86 - 1.96 (4H, m, $C_{3,7}$-H), 2.21 (1H, octet, J = 6.6 Hz, C_{10}-H), 3.36 (1H, t, J = 7.5 Hz, C_2-H), 3.74 (6H, s, 2 OCH_3), 5.31 - 5.35 (2H, m, $C_{8,9}$-H), EIMS *m/z* (rel. int.) 270 (M$^+$, 20), 239 [(M - OCH_3)$^+$, 19], 240 [(M - CH_3OH)$^+$, 20], 145 (82), 69 (91), 55 (100), 41 (96). Anal. Calcd for $C_{15}H_{26}O_4$: C, 66.63; H, 9.69. Found: C, 66.55; H, 9.70.

(*E*)-Methyl 2-methoxycarbonyl-11-methyl-8-dodecenoate (6Be). Alcohol **4Bc** (1.05 g, 6.2 mmol) gave **6Be** (1.56 g, 89%), b.p. 118-120 °C / 0.25 mmHg. IR (neat) 1749, 1737, 969 cm^{-1}; ^1H NMR δ 0.86 (6H, d, J = 6.6 Hz, 2 CH_3), 1.27 - 1.37 (6H, m, $C_{4,5,6}$-H), 1.57 (1H, nonet, J = 6.6Hz,C_{11}-H), 1.83 - 1.90 (4H, m, $C_{3,10}$-H), 1.94 - 1.96 (2H, m, C_7-H), 3.35 (2H, d, J = 7.7 Hz, C_2-H), 3.74 (6H, s, 2 OCH_3), 5.34 - 5.38 (2H, m, $C_{8,9}$-H); EIMS *m/z* (rel. int.) 284 (M$^+$, 15), 252 [(M - CH_3OH)$^+$, 11], 145 [$CH_2CH(COOCH_3)_2^+$, 58], 132 [$CH(COOCH_3)_2^+$, 44], 95 (39), 81 (30), 69 (41), 67 (52), 55 (100), 41 (87). Anal. Calcd for $C_{16}H_{28}O_4$: C, 67.57; H, 9.93. Found: C, 67.14; H, 9.79.

(*E*)-Methyl 2-methoxycarbonyl-10-methyl-8-undecenoate (6Ce). Alcohol **4Cc** (1.35 g, 7.9 mmol) gave **6Ce** (1.87 g, 83%), b.p. 119-120 °C / 0.23 mmHg. IR (neat) 1750, 1738, 971 cm^{-1}; ^1H NMR δ 0.84 (3H, d, J = 7.5 Hz, C_{12}-H), 0.94 (3H, d, J = 7.0 Hz,C_{10}-CH_3), 1.22 - 1.37 (8H, m, $C_{4,5,6,11}$-H), 1.85 - 2.0 (1H, mostly hidden m, C_{10}-H), 1.89 (2H, br. q, J = 6.2 Hz, C_3-H), 1.96 (2H, q, J = 7.5 Hz, C_7-H), 3.36 (1H, t, J = 7.5 Hz, C_2-H), 3.73 (6H, s, 2 OCH_3), 5.25 (1H, dd, J = 15.4, 6.6 Hz, C_9-H), 5.30 (1H, dt, J = 15.4, 5.9 Hz, C_8-H); EIMS *m/z* (rel. int.) 284 (M$^+$, 19), 25 [(M - OCH_3)$^+$, 14], 145 [$CH_2CH(COOCH_3)_2^+$, 62], 135 [$CH(COO\ CH_3)_2^+$, 43], 55 (100), 41 (53). Anal. Calcd for $C_{16}H_{28}O_4$: C, 67.57; H, 9.93; O, 22.49. Found: C, 67.47; H, 10.16.

(*E*)-Methyl 8-methyl-6-nonenoate (7Ac).[41] *Typical procedure for preparation of esters* **7**. A mixture of **6Ac** (3.9 g, 16.1 mmol), DMSO (16 ml), NaCl (1.18 g, 20.1 mmol), and distilled water (1.07 g, 59.5 mmol) was heated at 170 °C for 3 h. After cooling, the reaction mixture was poured into cold water (20 ml), extracted with ether / hexane (1/1, 20 ml × 3), washed with brine (10 ml), dried over anhydrous

$MgSO_4$, and evaporated. The residue was purified by a short silica gel column chromatography (20 g, ether / hexane = 1 / 30) to give **7Ac** (2.70 g, 91%). Short-path distillation gave an analytical sample of **7Ac** (2.56 g, 86%), bp 110-111 °C / 18 mmHg, which was found to be an *E*-major ester in a 115:1 *E*/*Z* ratio by GC analysis (column temperature, 140 °C; retention time, 6.3 min / 6.1 min). IR (neat) 1743, 970 cm^{-1}; ^1H NMR δ 0.96 (6H, d, *J* = 6.6 Hz, 2 CH_3), 1.37 (2H, quint, *J* = 7.5 Hz, C_4-H), 1.63 (2H, quint, *J* = 7.6 Hz, C_3-H), 1.99 (2H, q, *J* = 6.5 Hz, C_5-H), 2.22(1H, partly hidden octet, *J* = 6.6 Hz, C_8-H), 2.31 (2H, t, *J* = 7.5 Hz, C_2-H), 3.67 (3H, s, OCH_3), 5.31 (1H, dt, *J* = 15.4, 5.5 Hz, C_6-H), 5.39 (1H, dd, *J* = 15.4, 5.3 Hz, C_7-H); EIMS *m/z* (rel. int.) 184 (M^+, 12), 152 (26), 137 (27), 97 (31), 87 (25), 69 (100), 55 (71), 41 (74). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.58; H, 10.98.

***(E)*-Methyl 9-methyl-6-decenoate (7Bc).** Malonate **6Bc** (5.46 g, 21.3 mmol) gave **7Bc** (3.91 g, 93%), b.p. 121-122 °C / 15 mmHg, which was found to be a pure *E*-ester by GC analysis (column temperature, 150 °C; retention time, 7.4 min). IR (neat) 1743, 969 cm^{-1}; ^1H NMR δ 0.87 (6H, d, *J* = 6.6 Hz, 2 CH_3), 1.38 (2H, quint, *J* =7.5 Hz, C_4-H), 1.57 (1H, partly hidden nonet, *J* = 6.6 Hz, C_9-H), 1.63 (2H, quint, *J* = 7.3 Hz, C_3-H), 1.86 (2H, t, *J* = 6.1 Hz, C_8-H), 2.01 (2H, br. q, *J* = 6.5 Hz, C_5-H), 2.31 (2H, t, *J* = 7.5 Hz, C_2-H), 3.67 (3H, s, OCH_3), 5.35 -5.40 (2H, m, $C_{6,7}$-H); EIMS *m/z* (rel. int.) 199 [(M + H)$^+$, 41], 198 (M^+, 42), 166 (45), 69 (94), 55 (78), 41 (100). Anal. Calcd for $C_{12}H_{22}O_2$: C, 72.68; H, 11.18. Found: C, 72.71; H, 11.31.

***(E)*-Methyl 8-methyl-6-decenoate (7Cc).** Malonate **6Cc** (3.17 g, 12.4 mmol) gave **7Cc** (2.12 g, 86%), b.p. 110-112 °C / 11 mmHg, which was found to be an *E*-major ester in a 220:1 *E*/*Z* ratio by GC analysis (column temperature, 150 °C; retention time, 7.2 min / 7.0 min). IR (neat) 1743, 972 cm^{-1}; ^1H NMR δ 0.84 (3H, d, *J* = 7.3 Hz, C_{10}-H), 0.95 (3H, d, *J* = 7.0 Hz, C_8-CH_3), 1.27 (2H, quint d, *J* =7.2, 1.7 Hz, C_9-H), 1.40 (2H, quint, *J* = 7.5 Hz, C_4-H), 1.63 (2H, quint, *J* = 7.6 Hz, C_3-H), 1.95 (1H, partly hidden septet, *J* = 7.0 Hz, C_8-H), 2.00 (2H, q, *J* = 7.0 Hz, C_5-H), 2.31 (2H, t, *J* = 7.5 Hz, C_2-H), 3.67 (3H, s, OCH_3), 5.27 (1H, dd, *J* = 15.4, 6.2 Hz, C_7-H), 5.34 (1H, partly hidden dt, *J* = 15.4, 6.2 Hz, C_6-H); EIMS *m/z* (rel. int.) 198 (M^+, 14), 167 (13), 137 (37), 95 (47), 70 (52), 55 (100), 41 (58). Anal. Calcd for $C_{12}H_{22}O_2$: C, 72.68; H, 11.18. Found: C, 72.53; H, 11.11.

***(E)*-Methyl 10-methyl-8-undecenoate (7Ae).** Malonate **6Ae** (2.34 g, 8.6 mmol) gave **7Ae** (1.63 g, 89%), b.p. 92-93 °C / 1.3 mmHg, which was found to be an *E*-major ester in a 105:1 *E*/*Z* ratio by GC analysis (column temperature, 160 °C; retention time, 8.1 min / 7.8 min). IR (neat) 1743, 970 cm^{-1}; ^1H NMR δ 0.95 (6H, d, *J* = 7.0 Hz, 2 CH_3), 1.27 - 1.36 (6H, m, $C_{4,5,6}$-H), 1.62 (2H, br. quint, *J* = 7.3 Hz, C_3-H), 1.96 (2H, br. q, *J* = 4.8 Hz, C_7-H), 2.22 (1H, partly hidden octet, *J* = 6.5 Hz, C_{10}-H), 2.30 (2H, t, *J* = 7.5 Hz, C_2-H), 3.67 (3H, s, OCH_3), 5.32 - 5.36 (2H, m, $C_{8,9}$-H); EIMS *m/z* (rel. int.) 212 (M^+, 17), 181 [($M - OCH_3$)$^+$, 23], 180 [($M - CH_3OH$)$^+$, 21], 157 (18), 137 (15), 125 (32), 69 (100), 55 (81), 41 (75). Anal. Calcd for $C_{13}H_{24}O_2$: C, 73.53; H, 11.39. Found: C, 73.51; H, 11.31.

***(E)*-Methyl 11-methyl-8-dodecenoate (7Be).** Malonate **6Be** (1.49 g, 5.2 mmol) gave **7Be** (1.05 g, 89%), b.p. 103-104 °C / 1.4 mmHg, which was found to be a pure *E*-ester by GC analysis (column temperature, 180 °C; retention time, 7.1 min). IR (neat) 1743, 969 cm^{-1}; ^1H NMR δ 0.87 (6H, d, *J* = 6.6 Hz, 2 CH_3), 1.28 - 1.38 (6H, m, $C_{4,5,6}$-H), 1.57 (1H, partly hidden nonet, *J* = 6.6 Hz, C_{11}-H), 1.60 (2H, quint, *J* = 6.6 Hz, C3-H), 1.85 (2H, br. t, *J* = 6.1 Hz, C_{10}-H), 1.98 (2H, br. q, *J* = 5.5 Hz, C_7-H), 2.30 (2H, t, *J* = 7.7 Hz, C_2-H), 3.67 (3H, s, OCH_3), 5.35 - 5.38 (2H, m, $C_{8,9}$-H); EIMS *m/z* (rel. int.) 226 (M^+, 18), 16], 194 [($M - CH_3OH$)$^+$, 23], 171 (21), 152 (20), 139 (40), 69 (92), 55 (100), 41 (77). Anal. Calcd for $C_{14}H_{26}O_2$: C, 74.28; H, 11.58. Found: C, 74.21; H, 11.59.

***(E)*-Methyl 10-methyl-8-undecenoate (7Ce).** Malonate **6Ce** (1.51 g, 5.3 mmol) gave **7Ce** (1.08 g, 90%), b.p. 92-93 °C / 0.5 mmHg, which was found to be an *E*-major ester in a 170:1 *E*/*Z* ratio by GC analysis (column temperature, 180 °C; retention time, 6.9 min / 6.8 min). IR (neat) 1743, 971 cm^{-1}; ^1H NMR δ 0.84 (3H, d, *J* = 7.3 Hz, C_{12}-H), 0.94 (3H, d, *J* = 6.6 Hz,C_{10}-CH_3), 1.27 (2H, partly hidden quint d, *J* = 7.3, 2.2 Hz, C_{11}-H), 1.28 - 1.36 (6H, m, $C_{4,5,6}$-H), 1.62 (2H, br. quint, *J* = 7.3 Hz, C_3-H), 1.96 (2H, q, *J* = 6.5 Hz, C_7-H), 1.90 - 1.96 (1H, mostly hidden m, C_{10}-H), 2.30 (2H, t, *J* = 7.5 Hz, C_2-H), 3.67 (3H, s, OCH_3), 5.25 (1H, dd, *J* = 15.4, 7 Hz, C_9-H), 5.33 (1H, dt, *J* = 15.4, 6.2 Hz, C_8-H); EIMS *m/z* (rel. int.) 226 (M^+, 16), 195 [(M -

$OCH_3)^+$, 14], 125 (28), 83 (51), 81 (36), 70 (74), 55 (100), 41 (49). Anal. Calcd for $C_{14}H_{26}O_2$: C, 74.28; H, 11.58. Found: C, 73.74; H, 10.99.

(*E*)-6-Methyl-4-heptenoic acid (8Aa).[40] *Typical procedure for preparation of acids* **8** *from esters* **3** *and* **7**. Ester **3A** (558 mg, 3.28 mmol) in a solution of 50% aqueous MeOH (4 ml) containing 15% NaOH was refluxed for 3 h. The mixture was acidified with saturated aqueous $NaHSO_4$ solution, saturated with $(NH_4)_2SO_4$, and extracted with ether-hexane (1:1, 10 ml × 3). The extracts were combined, washed with saturated brine (5 ml), dried over anhydrous $MgSO_4$, and evaporated. The crude product was short-path distilled to give acid **8Aa** (415 mg, 89%), b.p. 78-79 °C / 0.95 mmHg (lit.[18] b.p. 72-73 °C / 0.7 mmHg). IR (neat) 3500-2400, 1712, 970 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 6.6 Hz, 2 CH_3), 2.26 (1H, partly hidden octet, J = 6.8 Hz, C_6-H), 2.31 (2H, t, J = 6.4 Hz, C_3-H), 2.39-2.45 (2H, m, C_2-H), 5.35 (1H, dt, J = 15.4, 5.5 Hz, C_4-H), 5.46 (1H, dd, J = 15.4, 6.2 Hz, C_5-H); EIMS *m/z* (rel. int.) 142 (M^+, 7), 82 (100), 69 (41), 67 (39), 55 (34), 41 (75). Anal. Calcd for $C_8H_{14}O_2$: C, 67.57; H, 9.93. Found: C, 67.48; H, 9.94.

(*E*)-7-Methyl-4-octenoic acid (8Ba). Ester **3B** (560 mg, 3.0 mmol) gave **8Ba** (404 mg, 85%), b.p. 100-101 °C / 1.2 mmHg. IR (neat) 3500-2400, 1712, 969 cm^{-1}; ^1H NMR δ 0.86 (6H, d, J = 6.6 Hz, 2 CH_3), 1.58 (1H, nonet, J = 6.6 Hz, C_7-H), 1.87 (2H, t, J = 6.2 Hz, C_6-H), 2.33 (2H, q, J = 6.4 Hz, C_3-H), 2.39 - 2.46 (2H, m, C_2-H), 5.39 (1H, dt, J = 15.4, 5.5 Hz, C_4-H), 5.49 (1H, dd, J = 15.4, 6.2 Hz, C_5-H); EIMS *m/z* (rel. int.) 156 (M^+, 5), 138 [(M - H_2O) $^+$, 10)], 55 (54), 43 ($C_3H_7^+$, 79), 41 (100). Anal. Calcd for $C_9H_{16}O_2$: C, 69.19; H, 10.32. Found: C, 68.98 ; H, 10.54.

(*E*)-6-Methyl-4-octenoic acid (8Ca). Ester **3C** (937 mg, 5.1 mmol) gave **8Ca** (766 mg, 96%), b.p. 99-100 °C / 1 mmHg. IR (neat) 3500-2400, 1712, 970 cm^{-1}; ^1H NMR δ 0.83 (3H, t, J = 7.3 Hz, C_8-H), 0.94 (3H, d, J = 6.6 Hz, C_6-CH_3), 1.27 (2H, quint d, J = 7.2, 2.6 Hz, C_7-H), 1.97 (1H, septet, J = 6.8 Hz, C_6-H), 2.32 (2H, q, J = 5.5 Hz, C_3-H), 2.40 - 2.45 (2H, m, C_2-H), 5.31 - 5.37 (2H, m, $C_{4,5}$-H); EIMS *m/z* (rel. int.) 156 (M^+, 18), 127 [(M - Et) $^+$, 21], 109 (22), 95 [(M - CH_3COOH) $^+$, 100), 81 (93), 55 (69), 41 (52). Anal. Calcd for $C_9H_{16}O_2$: C, 69.19; H, 10.32. Found: C, 69.31 ; H, 10.41.

(*E*)-10-Methyl-8-undecenoic acid (8Ae).[40] Ester **7Ae** (540 mg, 2.5 mmol) gave **8Ae** (448 mg, 89%), b.p. 105-106 °C / 0.13 mmHg. IR (neat) 3500-2400, 1713, 969 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 6.6 Hz, 2 CH_3), 1.31 - 1.37 (6H, m, $C_{4,5,6}$-H), 1.64 (2H, quint, J = 7.0 Hz, C_3-H), 1.96 (2H, q, J = 5.9 Hz, C_7-H), 2.22 (1H, octet, J = 6.5 Hz, C_{10}-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.32 - 5.36 (2H, m, $C_{8,9}$-H); EIMS *m/z* (rel. int.) 198 (M^+, 3), 81 (10), 69 (52),55 (65), 41 (100). Anal. Calcd for $C_{12}H_{22}O_2$: C, 72.68; H, 11.18. Found: C, 72.83; H, 11.29.

(*E*)-11-Methyl-8-dodecenoic acid (8Be). Ester **7Be** (570 mg, 2.5 mmol) gave **8Be** (484 mg, 90%), b.p. 117-117.5 °C / 0.13 mmHg. IR (neat) 3500-2400, 1711, 968 cm^{-1}; ^1H NMR δ 0.87 (6H, d, J = 6.6 Hz, 2 CH_3), 1.26-1.39 (6H, m, $C_{4,5,6}$-H), 1.57 (1H, partly hidden nonet, J = 6.6 Hz, C_{11}-H), 1.63 (2H, partly hidden quint, J = 7.0 Hz, C_3-H), 1.86 (2H, t, J = 5.9 Hz, C_{10}-H), 1.97 (2H, br. q, J = 5.3 Hz,C_7-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.35 - 5.39 (2H, m, $C_{8,9}$-H); EIMS *m/z* (rel. int.) 212 (M^+, 4), 109 (6), 95 (6), 81 (15), 69 (40), 55 (67), 43 (57), 41 (100). Anal. Calcd for $C_{13}H_{24}O_2$: C, 73.53; H, 11.39. Found: C, 73.51; H, 11.53.

(*E*)-10-Methyl-8-dodecenoic acid (8Ce). Ester **7Ce** (941 mg, 4.2 mmol) gave **8Ce** (794 mg, 90%), b.p. 114-115 °C / 0.1 mmHg. IR (neat) 3500-2400, 1711, 969 cm^{-1}; ^1H NMR δ 0.84 (3H, t, J = 7.3 Hz, C_{12}-H), 0.94 (3H, d, J = 7.0 Hz, C_{10}-CH_3), 1.27 (2H, partly hidden d quint, J = 1.8, 7.1 Hz, C_{11}-H), 1.30 - 1.37 (6H, m, $C_{4,5,6}$-H), 1.64 (2H, q, J = 5.5 Hz, C_3-H), 1.95 (1H, partly hidden septet, J = 6.2, Hz, C_{10}-H), 1.97 (2H, q, J = 6.6 Hz, C_7-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.25 (1H, dd, J = 15.4, 7 Hz, C_9-H), 5.33 (1H, dt, J = 15.4, 6.2, C_8-H); EIMS *m/z* (rel. int.) 212 (M^+, 3), 123 (45), 109 (2), 95 (7), 83 (19), 81 (19), 70 (44), 55 (100), 41 (91). Anal. Calcd for $C_{13}H_{24}O_2$: C, 73.53; H, 11.39. Found: C, 73.38; H, 11.53.

(*E*)-7-Methyl-5-octenoic acid (8Ab).[40] *Typical procedure for preparation of acids* **8** *from nitriles* **5**. Nitrile **5Ab** (512 mg, 3.73 mmol) in a solution of 50% aqueous MeOH (4 ml) containing 15% NaOH was refluxed for 15 h. After the same work-up for **8Aa**, purification by short-path distillation gave acid **8Ab** (530 mg, 91%), b.p. 98-99 °C / 1.0 mmHg (lit.[18] b.p 86-87 °C / 0.7 mmHg). IR (neat) 3500-2400, 1711, 970 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 7.0 Hz, 2 CH_3), 1.70 (2H, quint, J = 7.3 Hz, C_3-H), 2.04 (2H, q, J = 6.8 Hz,

C_4-H), 2.23 (1H, partly hidden octet, J = 6.6 Hz, C_7-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.30 (1H, dt, J = 15.4, 6.2 Hz, C_5-H), 5.42 (1H, dd, J = 15.4, 6.2 Hz, C_6-H); EIMS *m/z* (rel. int.) 156 (M^+, 9), 138 [(M - H_2O) $^+$, 4], 81 (54), 69 (97), 55 (63), 41 (100). Anal. Calcd for $C_9H_{16}O_2$: C, 69.19; H, 10.32. Found: C, 69.07; H, 10.49.

(*E*)-8-Methyl-5-nonenoic acid (8Bb). Nitrile **5Bb** (485 mg, 3.2 mmol) gave **8Bb** (504 mg, 92%), b.p. 94.5-95 °C / 0.3 mmHg. IR (neat) 3500-2400, 1709, 969 cm^{-1}; ^1H NMR δ 0.87 (6H, d, J = 6.6 Hz, 2 CH_3), 1.58 (1H, nonet, J = 6.6 Hz, C_8-H), 1.70 (2H, quint, J = 7.2 Hz, C_3-H), 1.87 (2H, t, J = 6.2 Hz, C_7-H), 2.06 (2H, q, J = 6.8 Hz, C_4-H), 2.35 (2H, t, J = 7.2 Hz, C_2-H), 5.34 (1H, dt, J = 15.4, 6.2 Hz, C_6-H), 5.43 (1H, dt, J = 15.4, 6.6 Hz, C_5-H); EIMS *m/z* (rel. int.) 170 (M^+, 20), 152 [(M - H_2O) $^+$, 7], 81 (47), 69 (87), 56 (78), 43 ($C_3H_7^+$, 73), 41 (100). Anal. Calcd for $C_{10}H_{18}O_2$: C, 70.54; H, 10.66. Found: C, 70.36; H, 10.59.

(*E*)-7-Methyl-5-nonenoic acid (8Cb). Nitrile **5Cb** (526 mg, 3.5 mmol) gave **8Cb** (533 mg, 90%), b.p. 94-95 °C / 0.29 mmHg. IR (neat) 3500-2400, 1709, 971 cm^{-1}; ^1H NMR δ 0.84 (3H, d, J = 7.3 Hz, C_9-H), 0.95 (3H, d, J = 7 Hz, C_7-CH_3), 1.27 (2H, d quint, J = 1.8, 7.7 Hz, C_8-H), 1.71 (2H, quint, J = 7.3 Hz, C_3-H), 1.97 (1H, partly hidden septet, J = 6.8 Hz, C_7-H), 2.05 (2H, q, J = 6.6 Hz, C_4-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.29 - 5.32 (2H, m, $C_{5,6}$-H); EIMS *m/z* (rel. int.) 170 (M^+, 13), 152 [(M - H_2O)$^+$, 9], 141 [(M - Et)$^+$, 8], 123 (28), 81 (72), 70 (68), 55 (100), 41 (66). Anal. Calcd for $C_{10}H_{18}O_2$: C, 70.54; H, 10.66. Found: C, 70.39; H, 10.61.

(*E*)-9-Methyl-7-decenoic acid (8Ad).[40] Nitrile **5Ad** (242 mg, 1.5 mmol) gave **8Ad** (240 mg, 89%), b.p. 101-102 °C / 0.2 mmHg. IR (neat) 3500-2400, 1712, 969 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 7.0 Hz, 2 CH_3), 1.24 - 1.45 (4H, m, $C_{4,5}$-H), 1.64 (2H, quint, J = 7.3 Hz, C_3-H), 1.97 (2H, br. q, J = 5.9 Hz, C_6-H), 2.22 (1H, octet, J = 6.3 Hz, C_9-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.31 (1H, dt, J = 15.4, 5.5 Hz, C_7-H), 5.39 (1H, dd, J = 15.4, 5.5 Hz, C_8-H); EIMS *m/z* (rel. int.) 184 (M^+, 4), 81 (12), 69 (64), 56 (45), 55 (67), 41 (100). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.76; H, 10.98.

(*E*)-10-Methyl-7-undecenoic acid (8Bd). Nitrile **5Bd** (662.3 mg, 3.7 mmol) gave **8Bd** (694 mg, 95%), b.p. 112.5-113 °C / 0.21 mmHg. IR (neat) 3500-2400, 1713, 968 cm^{-1}; ^1H NMR δ 0.86 (6H, d, J = 6.6 Hz, 2 CH_3), 1.33 - 1.39 (4H, m, $C_{4,5}$-H), 1.50 - 1.62 (1H, partly hidden nonet, J = 6.6 Hz, C_{10}-H), 1.64 (2H, quint, J = 7.4 Hz, C_3-H), 1.86 (2H, t, J = 6.1 Hz, C_9-H), 1.99 (2H, br. q, J = 4.8 Hz, C_6-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.35 - 5.39 (2H, m, $C_{7,8}$-H); EIMS *m/z* (rel. int.) 198 (M^+, 4), 95 (14), 81 (12), 69 (32), 55 (69), 43 ($C_3H_7^+$, 57), 41 (100). Anal. Calcd for $C_{12}H_{22}O_2$: C, 72.68; H, 11.18. Found: C, 72.82; H, 11.18.

(*E*)-9-Methyl-7-undecenoic acid (8Cd). Nitrile **5Cd** (349 mg, 2 mmol) gave **8Cd** (341 mg, 88%), b.p. 112-113 °C / 0.2 mmHg. IR (neat) 3500-2400, 1711, 969 cm^{-1}; ^1H NMR δ 0.84 (3H, d, J = 7.5 Hz, C_{11}-H), 0.94 (3H, d, J = 6.6 Hz, C_9-CH_3), 1.27 (2H, partly hidden quint d, J = 6.7, 1.8 Hz, C_{10}-H), 1.32 - 1.37 (4H, m, $C_{4,5}$-H), 1.64 (2H, quint, J = 7.3 Hz, C_3-H), 1.94 (1H, partly hidden septet, J = 6.6 Hz, C_9-H), 1.99 (2H, q, J = 6.1 Hz, C_6-H), 2.35 (2H, t, J = 7.5 Hz, C_2-H), 5.26 (1H, dd, J = 15.4, 6.6 Hz, C_8-H), 5.33 (1H, dt, J = 15.4, 5.9 Hz, C_7-H); EIMS *m/z* (rel. int.) 198 (M^+, 3), 109 (10), 83 (20), 81 (16), 70 (39), 69 (22), 55 (100), 41 (86). Anal. Calcd for $C_{12}H_{22}O_2$: C, 72.68; H, 11.18. Found: C, 72.52; H, 11.22.

(*E*)-11-Methyl-9-dodecenoic acid (8Af). Nitrile **5Af** (577 mg, 3.0 mmol) gave **8Af** (589 mg, 93%), b.p. 116-116.5 °C / 0.11 mmHg. IR (neat) 3500-2400, 1711, 968 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 6.6 Hz, 2 CH_3), 1.28 - 1.36 (8H, m, $C_{4,5,6,7}$-H), 1.63 (2H, quint , J = 7.3 Hz, C_3-H), 1.96 (2H, br. q, J = 5.3 Hz, C_8-H), 2.22 (1H, octet, J = 6.1 Hz, C_{11}-H), 2.35 (2H, t, J = 7.3 Hz, C_2-H), 5.33 - 5.36 (2H, m, $C_{9,10}$-H); EIMS *m/z* (rel. int.) 212 (M^+, 2), 95 (6), 81 (11), 69 (65), 55 (74), 41 (100). Anal. Calcd for $C_{13}H_{24}O_2$: C, 73.53; H, 11.39. Found: C, 73.41; H, 11.52.

(*E*)-8-Methyl-6-nonenoic acid (8Ac).[40] Ester **7Ac** (457 mg, 2.5 mmol) gave **8Ac** (386 mg, 92%), b.p. 95-95.5 °C / 0.33 mmHg (lit.[19] b.p. 130-132 °C / 12 mmHg, lit.[21] b.p. 120-122 °C / 5 - 6 mmHg). IR (neat) 3500-2400, 1714, 969 cm^{-1}; ^1H NMR δ 0.96 (6H, d, J = 7.0 Hz, 2 CH_3), 1.40 (2H, quint, J = 7.6 Hz, C_4-H), 1.64 (2H, quint, J = 7.6 Hz, C_3-H), 2.00 (2H, q, J = 6.6 Hz, C_5-H), 2.22 (1H, octet, J = 6.6 Hz, C_8-H), 2.36 (2H, t, J = 7.5 Hz, C_2-H), 5.32 (1H, partly hidden dt, J = 15.4, 5.9 Hz, C_6-H), 5.40 (1H, dd, J = 15.4, 5.5 Hz, C_7-H); EIMS *m/z* (rel. int.) 170 (M^+, 4), 152 [(M - H_2O)$^+$, 2], 137 (4), 69 (90), 55 (66), 41 (100). Anal. Calcd for $C_{10}H_{18}O_2$: C, 70.54; H, 10.66. Found: C, 70.35; H, 10.83.

(*E*)-9-Methyl-6-decenoic acid (8Bc). Ester **7Bc** (710 mg, 3.6 mmol) gave **8Bc** (581 mg, 88%), b.p. 101.5-102 °C / 0.21 mmHg. IR (neat) 3500-2400, 1713, 968 cm^{-1}; ^1H NMR δ 0.87 (6H, d, J = 6.6 Hz, 2 CH_3), 1.41 (2H, quint, J = 7.5 Hz, C_4-H), 1.59 (1H, partly hidden nonet, J = 6.6 Hz, C_9-H), 1.65 (2H, quint, J = 7.6 Hz, C_3-H), 1.86 (2H, dd, J = 6.8, 5.7 Hz, C_8-H), 2.02 (2H, q, J = 6.5 Hz, C_5-H), 2.35 (2H, t, J = 7.3 Hz, C_2-H), 5.35 - 5.40 (2H, m, $C_{6,7}$-H); EIMS *m/z* (rel. int.) 184 (M^+, 20), 123 (14), 111 (17), 95 (25), 81 (47), 69 (74), 56 (76), 55 (77), 43 ($C_3H_7^+$, 65), 41 (100). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.74; H, 10.93.

(*E*)-8-Methyl-6-decenoic acid (8Cc). Ester **7Cc** (683 mg, 3.4 mmol) gave **8Cc** (584 mg, 92%), b.p. 110-111 °C / 0.4 mmHg. IR (neat) 3500-2400, 1712, 970 cm^{-1}; ^1H NMR δ 0.84 (3H, d, J = 7.5 Hz, C_{10}-H), 0.95 (3H, d, J = 6.6 Hz, C_8-CH_3), 1.27 (2H, d quint, J = 1.8, 7.2 Hz, C_9-H), 1.41 (2H, quint, J = 7.0 Hz, C_4-H), 1.65 (2H, quint, J = 7.5 Hz, C_3-H), 1.95 (1H, partly hidden septet, J = 6.7 Hz, C_8-H), 2.01 (2H, q, J = 6.7 Hz, C_5-H), 2.36 (2H, t, J = 7.5 Hz, C_2-H), 5.28 (1H, dd, J =15.4, 6.2 Hz, C_7-H), 5.33 (1H, dt, J = 15.4, 5.9, C_6-H); EIMS *m/z* (rel. int.) 184 (M^+, 15), 155 [(M - Et)$^+$, 29], 137 (20), 95 (35), 83 (36), 70 (16), 55 (100), 41 (59). Anal. Calcd for $C_{11}H_{20}O_2$: C, 71.69; H, 10.94. Found: C, 71.76; H, 11.00.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-6-methyl-4-heptenamide (Nornorcapsaicin; C-8).[41] A stirred solution of acid **8Aa** (290 mg, 2.0 mmol) and thionyl chloride (0.53 ml, 6.1 mmol) was refluxed for 2 h, and the excess reagent was removed *in vacuo*. The resultant acid chloride was dissolved in dry ether (8 ml), and added to a stirred suspension of vanillyl amine (688 mg, 4.5 mmol) in dry ether (12 ml). The mixture was allowed to be stirred at room temperature for 2 h, and refluxed for 2 h. Precipitated salt was removed by suction filtration, and the filtrate was concentrated. The residue was purified by silica gel column chromatography to give a colorless solid (535 mg, 95%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of nornorcapsaicin **C-8** (486 mg, 86%), m.p. 60-61 °C. IR (neat) 3539, 3440, 3300 (NH, OH), 1646 (C=O), 1516 (ArC=C), 971 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.93 (6H, d, J = 6.7 Hz, 2 CH_3), 2.21 (1H, octet, J = 6.7 Hz, C_6-H), 2.26 (2H, t, J = 6.6 Hz, C_2-H), 2.33 (2H, q, J = 7.1 Hz, C_3-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, J = 5.5 Hz, CH_2Ar), 5.35 (1H, dt, J = 15.3, 6.4 Hz, C_4-H), 5.44 (1H, dd, J = 15.3, 6.7 Hz, C_5-H), 5.64 (1H, s, OH), 5.72 (1H, br. s, NH), 6.76 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.46 (2 CH_3), 28.57 (C_3), 30.92 (C_6), 36.73 (C_2), 43.53 (ArC), 55.93 (ArOC), 110.72 ($C_{2'}$), 114.36 ($C_{5'}$), 120.82 ($C_{6'}$), 125.16 (C_4), 139.19 (C_5), 130.29, 145.12, 146.65 ($C_{1',3',4'}$), 172.29 (C_1); EIMS *m/z* (rel. int.) 277 (M^+, 17.2), 152 ($ArCH_2NH^+$, 10.2), 137 ($ArCH_2^+$, 100), 122 (12.6), 94 (12.2), 55 (21.3), 41 (26.2). Anal. Calcd for $C_{16}H_{23}NO_3$: C, 69.29; H, 8.36; N, 5.05. Found: C, 69.47 ; H, 8.55; N, 5.01.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-7-methyl-5-octenamide (Norcapsaicin; C-9).[41] Acid **8Ab** (296 mg, 1.9 mmol) gave the crude **C-9** (476 mg, 86%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of **C-9** (398 mg, 72%), m.p. 42.5-44 °C. IR (neat) 3540, 3442, 3299 (NH, OH), 1643 (C=O), 1516 (ArC=C), 1275, 1215 (C-O), 971 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.94 (6H, d, J = 6.7 Hz, 2 CH_3), 1.72 (2H, quint, J = 7.4 Hz, C_3-H), 2.02 (2H, q, J = 7.0 Hz, C_4-H), 2.19 (2H, t, J = 7.5 Hz, C_2-H), 2.21 (1H, partly hidden octet, J = 6.6 Hz, C_7-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, J = 5.8 Hz, CH_2Ar), 5.30 (1H, dt, J = 15.3, 6.1 Hz, C_5-H), 5.37 (1H, dd, J = 15.3, 6.1 Hz, H_6-H), 5.65 (2H, br. s, NH, OH), 6.76 (1H, dd, J = 8.2, 1.8 Hz, $C_{6'}$-H), 6.81 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 8.2 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.60 (2 CH_3), 25.51 (C_3), 30.96 (C_7), 31.92 (C_4), 36.03 (C_2), 43.54 (ArC), 55.93 (ArOC), 110.70 ($C_{2'}$), 114.35 ($C_{5'}$), 120.83 ($C_{6'}$), 125.85 (C_5), 138.81 (C_6), 130.35, 145.12, 146.68 ($C_{1',3',4'}$), 172.72 (C_1); EIMS *m/z* (rel. int.) 291 (M^+, 15), 195 (16), 152 ($ArCH_2NH^+$, 13), 137 ($ArCH_2^+$, 100), 122 (9), 55 (11), 41 (14). Anal. Calcd for $C_{17}H_{25}NO_3$: C, 70.07; H, 8.65; N, 4.81. Found: C, 69.93; H, 8.84; N, 4.76.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-8-methyl-6-nonenamide (Capsaicin; C-10).[41] Acid **8Ac** (357 mg, 2.1 mmol) gave the crude **C-10** (590 mg, 92%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **C-10** (538 mg, 84%), m.p. 67.5-68.5 °C (lit.[19] m.p. 65 °C, lit.[3,14,21] m.p. 64-65 °C). IR (neat) 3540, 3443, 3293 (NH, OH), 1643 (C=O), 1601, 1516 (ArC=C), 1276 (C-O), 970 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.95 (6H, d, J = 6.7 Hz, 2 CH_3), 1.38 (2H, quint, J = 7.6 Hz, C_4-H), 1.65 (2H, quint, J = 7.6 Hz, C_3-H), 1.99 (2H, q, J = 7.0 Hz, C_5-H), 2.20 (2H, t, J = 7.5 Hz, C_2-H), 2.21 (1H, partly hidden octet, J

= 6.7 Hz, C_8-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, J = 5.8 Hz, CH_2Ar), 5.31 (1H, dt, J = 15.9, 6.1 Hz, C_6-H), 5.37 (1H, dd, J = 15.6, 6.1 Hz, C_7-H), 5.64 (1H, s, OH), 5.66 (1H, br. s, NH), 6.76 (1H, dd, J = 8.2, 2.1 Hz, $C_{6'}$-H), 6.81 (1H, d, J = 2.1 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 8.2 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.64 (2 CH_3), 25.26 (C_3), 29.27 (C_4), 30.95 (C_8), 32.20 (C_5), 36.71 (C_2), 43.52 (ArC), 55.93 (ArOC), 110.66 ($C_{2'}$), 114.34 ($C_{5'}$), 120.79 ($C_{6'}$), 126.46 (C_6), 138.08 (C_7), 130.38, 145.11, 146.68 ($C_{1',3',4'}$), 172.75 (C_1); EIMS *m/z* (rel. int.) 305 (M^+, 19), 152 ($ArCH_2NH^+$, 13), 137 ($ArCH_2^+$, 100), 69 (10), 55 (12), 41 (17). Anal. Calcd for $C_{18}H_{27}NO_3$: C, 70.79; H, 8.91; N, 4.59. Found: C, 70.62 ; H, 8.92 ; N, 4.59.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-9-methyl-7-decenamide (Homocapsaicin; C-11).[41] Acid **8Ad** (220 mg, 1.2 mmol) gave the crude amide **C-11** (335 mg, 88%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **C-11** (305 mg, 80%), m.p. 64.5-65.5 °C (lit.[18] m.p. 64.5-65.5 °C). IR (neat) 3540, 3241, 3300 (NH, OH), 1647 (C=O), 1516 (ArC=C), 1274, 1516 (C-O), 971 (C=C) cm^{-1}; ^{1}H NMR (500 MHz) δ 0.95 (6H, d, J = 7.0 Hz, 2 CH_3), 1.29 - 1.39 (4H, m, $C_{4,5}$-H), 1.65 (2H, quint, J = 7.5 Hz, C_3-H), 1.96 (2H, q, J = 6.4 Hz, C_6-H), 2.19 (2H, t, J = 7.6 Hz, C_2-H), 2.21 (1H, partly hidden octet, J = 6.7 Hz, C_9-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, J = 5.8 Hz, CH_2Ar), 5.31 (1H, dt, J = 15.3, 5.8 Hz, C_7-H), 5.36 (1H, dd, J = 15.3, 5.5 Hz, C_8-H), 5.65 (1H, s, OH), 5.67 (1H, br. s, NH), 6.76 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.81 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.66 (2 CH_3), 25.63 (C_3), 28.78, 29.32 ($C_{4,5}$), 30.95 (C_9), 32.32 (C_6), 36.81 (C_2), 43.52 (ArC), 55.92 (ArOC), 110.67 ($C_{2'}$), 114.34 ($C_{5'}$), 120.79 ($C_{6'}$), 126.80 (C_7), 137.80 (C_8), 130.37, 145.11, 146.67 ($C_{1',3',4'}$), 172.81 (C_1); EIMS *m/z* (rel. int.) 319 (M^+, 17), 152 ($ArCH_2NH^+$, 12), 137 ($ArCH_2^+$, 100), 69 (8), 55 (13), 41 (14). Anal. Calcd for $C_{19}H_{29}NO_3$: C, 71.44; H, 9.15; N, 4.39. Found: C, 71.23; H, 9.27; N, 4.27.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-10-methyl-8-undecenamide (Bishomocapsaicin; C-12). Acid **8Ae** (454 mg, 2.3 mmol) gave the crude amide **C-12** (710 mg, 93%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **C-12** (641 mg, 84%), m.p. 47.5-48.5 °C. IR (neat) 3542, 3440, 3300 (NH, OH), 1644 (C=O), 1515 (ArC=C), 1274, 1215 (C-O), 971 (C=C) cm^{-1}; ^{1}H NMR (500 MHz) δ 0.94 (6H, d, J = 6.7 Hz, 2 CH_3), 1.27 - 1.36 (6H, m, $C_{4,5,6}$-H), 1.65 (2H, quint, J = 7.2 Hz, C_3-H), 1.94 (2H, q, J = 6.2 Hz, C_7-H), 2.19 (2H, t, J = 7.6 Hz, C_2-H), 2.21 (1H, partly hidden octet , J = 6.7 Hz, C_{10}-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, J = 5.8 Hz, CH_2Ar), 5.32 (1H, dt, J = 15.3, 5.8 Hz, C_8-H), 5.36 (1H, dd, J = 15.3, 5.2 Hz, C_9-H), 5.65 (1H, s, OH), 5.67 (1H, br. s, NH), 6.76 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.81 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.68 (2 CH_3), 25.72 (C_3), 28.79, 29.15, 29.44 ($C_{4,5,6}$), 30.96 (C_{10}), 32.41 (C_7), 36.84 (C_2), 43.51 (ArC), 55.92 (ArOC), 110.67 ($C_{2'}$), 114.34 ($C_{5'}$), 120.79 ($C_{6'}$), 126.96 (C_8), 137.67 (C_9), 130.38, 145.11, 146.67 ($C_{1',3',4'}$), 172.85 (C_1); EIMS *m/z* (rel. int.) 333 (M^+, 16), 152 ($ArCH_2NH^+$, 13), 137 ($ArCH_2^+$, 100), 69 (14), 55 (20), 41 (24). Anal. Calcd for $C_{20}H_{31}NO_3$: C, 72.03; H, 9.37; N, 4.20. Found: C, 72.02 H, 9.47; N, 4.21.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-11-methyl-9-dodecenamide (Trishomocapsaicin; C-13). Acid **8Af** (424.7 mg, 2.0 mmol) gave the crude amide **C-13** (624.5 mg, 90%), which was crystallized from ether-hexane (1:3) afforded an analytical sample **C-13** (548 mg, 79%), m.p. 57-58 °C. IR (neat) 3544, 3440, 3301 (NH, OH), 1647 (C=O), 1516 (ArC=C), 1274, 1216 (C-O), 971 (C=C) cm^{-1}; ^{1}H NMR (500 MHz) δ 0.96 (6H, d, J = 6.7 Hz, 2 CH_3), 1.28 - 1.34 (8H, m, $C_{4,5,6,7}$-H), 1.64 (2H, quint, J = 7.4 Hz, C_3-H), 1.94 (2H, q, J = 6.4 Hz, C_8-H), 2.19 (2H, t, J = 7.6 Hz, C_2-H), 2.22 (1H, partly hidden octet, J = 6.7 Hz, C_{11}-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, J = 5.5 Hz, CH_2Ar), 5.32 (1H, partly hidden dt, J = 15.3, 5.8, C_9-H), 5.36 (1H, dd, J = 15.3, 5.2 Hz, C_{10}-H), 5.71 (2H, br. s, OH, NH), 6.75 (1H, dd, J = 8.2, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 8.2 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.67 (2 CH_3), 25.76 (C_3), 28.95, 29.19, 29.25, 29.44 ($C_{4,5,6,7}$), 30.95 (C_{11}), 32.47 (C_8), 36.83 (C_2), 43.50 (ArC), 55.90 (ArOC), 110.67 ($C_{2'}$), 114.35 ($C_{5'}$), 120.76 ($C_{6'}$), 127.06 (C_9), 137.58 (C_{10}), 130.35, 145.11, 146.68 ($C_{1',3',4'}$), 172.89 (C_1); EIMS *m/z* (rel. int.) 347 (M^+, 17), 152 ($ArCH_2NH^+$, 13), 137 ($ArCH_2^+$, 100), 69 (9), 55 (17), 41 (19). Anal. Calcd for $C_{21}H_{33}NO_3$: C, 72.58; H, 9.57; N, 4.03. Found: C, 72.68; H, 9.65; N, 4.06.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-7-methyl-4-octenamide (Norcapsaicin I; CI-9). Acid **8Ba** (291 mg, 1.9 mmol) gave the crude amide **CI-9** (498 mg, 92%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of **CI-9** (465 mg, 86%), m.p. 87.5-88.5 °C. IR (neat) 3540 (NH), 3297

(OH), 1646 (C=O), 1516 (ArC=C), 1275 (C-O), 970 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.85 (6H, d, J = 6.7 Hz, 2 CH_3), 1.55 (1H, nonet, J = 6.7 Hz, C_7-H), 1.84 (2H, td, J = 6.7, 0.9 Hz, C_6-H), 2.27 (2H, td, J = 7.8, 1.2 Hz, C_2-H), 2.35 (2H, q, J = 6.9 Hz, C_3-H), 3.88 (3H, s, OCH_3), 4.33 (2H, d, J = 5.5 Hz, CH_2Ar), 5.38 (1H, dt, J = 15, 6.4 Hz, C_4-H), 5.45 (1H, dt, J = 15, 7.0 Hz, C_5-H), 5.68 (1H, s, OH), 5.73 (1H, br. s, NH), 6.75 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.21 (2 CH_3), 28.31 (C_7), 28.65 (C_3), 36.74 (C_2), 41.85 (C_6), 43.56 (ArC), 55.93 (ArOC), 110.73 ($C_{2'}$), 114.36 ($C_{5'}$), 120.82 ($C_{6'}$), 29.32 (C_5), 130.73 (C_5), 130.28, 145.12, 146.66 ($C_{1',3',4'}$), 172.26 (C_1); EIMS m/z (rel. int.) 291 (M^+, 15), 152 (10), 137 ($ArCH_2^+$, 100), 122 (9), 112 (13), 55 (10), 43 ($C_3H_7^+$, 11), 41 (14). Anal. Calcd for $C_{17}H_{25}NO_3$: C, 70.07; H, 8,.65; N, 4.81. Found: C, 69.91; H, 8.76; N, 4.81.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-8-methyl-5-nonenamide (Capsaicin I; CI-10). Acid **8Bb** (332 mg, 2 mmol) gave the crude amide **CI-10** (551 mg, 93%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **CI-10** (515 mg, 87%), m.p. 55-56 °C. IR (neat) 3540, 3442, 3304 (NH, OH), 1649 (C=O), 1515 (ArC=C), 1274, 1216 (C-O), 970 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.85 (6H, d, J = 6.5 Hz, 2 CH_3), 1.56 (1H, nonet J = 6.7 Hz, C_8-H), 1.73 (2H, quint, J = 7.5 Hz, C_3-H), 1.85 (2H, t, J = 6.3 Hz, C_7-H), 2.04 (2H, q, J = 6.8 Hz, C_4-H), 2.19 (2H, t, J = 7.6 Hz, C_2-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, J = 5.5 Hz, CH_2Ar), 5.34 (1H, dt, J = 15.3, 5.7 Hz, C_5-H), 5.38 (1H, dt, J = 15.3, 6.1 Hz, C_6-H), 5.66 (2H, br. s, NH, OH), 6.76 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.81 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 8.1 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.23 (2 CH_3), 25.54 (C_3), 28.39 (C_8), 32.02 (C_4), 36.07 (C_2), 41.93 (C_7), 43.53 (ArC), 55.92 (ArOC), 110.68 ($C_{2'}$), 114.35 ($C_{5'}$), 120.80 ($C_{6'}$), 130.15 (C_5), 130.34 (C_6), 130.28, 145.12, 146.68 ($C_{1',3',4'}$), 172.71 (C_1); EIMS m/z (rel. int.) 305 (M^+, 19), 195 (23), 151 (19), 137 ($ArCH_2^+$, 100), 81 (18), 69 (34), 57 (20), 55 (19), 45 (18), 43 ($C_3H_7^+$, 21), 41 (27). Anal. Calcd for $C_{18}H_{27}NO_3$: C, 70.79; H, 8.91; N, 4.59. Found: C, 70.61 ; H, 9.06; N, 4.63.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-9-methyl-6-decenamide (Homocapsaicin I; CI-11). Acid **8Bc** (338 mg, 1.8 mmol) gave the crude amide **CI-11** (529 mg, 91%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **CI-11** (477 mg, 82%), m.p. 66-67 °C. IR (neat) 3543, 3440, 3303 (NH, OH), 1647 (C=O), 1515 (ArC=C), 1274, 1216 (C-O), 970 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.86 (6H, d, J = 6.6 Hz, 2 CH_3), 1.39 (2H, quint, J = 7.6 Hz, C_4-H), 1.56 (2H, septet, J = 6.7 Hz, C_9-H), 1.67 (2H, quint, J = 7.7 Hz, C_3-H), 1.84 (2H, t, J = 6.4 Hz, C_8-H), 2.01 (2H, q, J = 6.7 Hz, C_5-H), 2.20 (2H, t, J = 7.6 Hz, C_2-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, J = 5.5 Hz, CH_2Ar), 5.35 (1H, dt, J = 15.3, 5.8, C_7-H), 5.38 (1H, dt, J = 15.3, 6.1, C_6-H), 5.63 (1H, s, OH), 5.65 (1H, br. s, NH), 6.76 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.25 (2 CH_3), 25.25 (C_3), 28.44 (C_9), 29.24 (C_4), 32.29 (C_5), 36.70 (C_2), 41.96 (C_8), 43.52 (ArC), 55.93 (ArOC), 110.66 ($C_{2'}$), 114.34 ($C_{5'}$), 120.79 ($C_{6'}$), 129.59 (C_6), 130.75 (C_7), 130.37, 145.11, 146.67 ($C_{1',3',4'}$), 172.75 (C_1); EIMS m/z (rel. int.) 319 (M^+, 13), 152 ($ArCH_2NH^+$, 13), 137 ($ArCH_2^+$, 100), 55 (11), 43 ($C_3H_7^+$, 14), 41 (17). Anal. Calcd for $C_{19}H_{29}NO_3$: C, 71.44; H, 9.15; N, 4.39. Found: C, 71.40 ; H, 9.08; N, 4.33.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-10-methyl-7-undecenamide (Bishomocapsaicin I; CI-12). Acid **8Bd** (279 mg, 1.4 mmol) gave **CI-12** (399 mg, 85%), which was crystallized from ether-hexane (1:3) to afforded an analytical sample of **CI-12** (343 mg, 73%), m.p. 44.5-46 °C. IR (neat) 3539, 3440, 3304 (NH, OH), 1648 (C=O), 1515 (ArC=C), 1274, 1216 (C-O), 970 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.86 (6H, d, J = 6.7 Hz, 2 CH_3), 1.30 - 1.39 (4H, m, $C_{4,5}$-H), 1.57 (1H, nonet, J = 6.7 Hz, C_{10}-H), 1.65 (2H, quint , J = 7.4 Hz, C_3-H), 1.85 (2H, t, J = 6.0 Hz, C_9-H), 1.98 (2H, q, J = 6.1 Hz, C_6-H), 2.21 (2H, t, J = 7.6 Hz, C_2-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, J = 5.5 Hz, CH_2Ar), 5.33 - 5.39 (2H, m, $C_{7,8}$-H), 5.69 (2H, br. s, NH, OH), 6.76 (1H, dd, J = 8.1, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 8.1 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.23 (2 CH_3), 25.62 (C_3), 28.43 , 28.77 ($C_{4,5}$), 29.30 (C_{10}), 32.38 (C_6), 36.79 (C_2), 41.96 (C_9), 43.51 (ArC), 55.90 (ArOC), 110.67 ($C_{2'}$), 114.34 ($C_{5'}$), 120.77 ($C_{6'}$), 129.27, 131.10 ($C_{7,8}$), 130.34, 145.11, 146.67 ($C_{1',3',4'}$), 172.82 (C_1); EIMS m/z (rel. int.) 333 (M^+, 15), 152 ($ArCH_2NH^+$, 11), 137 ($ArCH_2^+$, 100), 81 (11), 69 (21), 55 (16), 43 ($C_3H_7^+$, 19), 41 (24). Anal. Calcd for $C_{20}H_{31}NO_3$: C, 72.03; H, 9.37; N, 4.20. Found: C, 71.99; H, 9.39; N, 4.21.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-11-methyl-8-dodecenamide (Trishomocapsaicin I; CI-13). Acid **8Be** (439 mg, 2.1 mmol) gave **CI-13** (690 mg, 96%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of **CI-13** (582 mg, 81%), m.p. 49.5-51 °C. IR (neat) 3544, 3440, 3300 (NH, OH), 1646 (C=O), 1516 (ArC=C), 1274, 1216 (C-O), 970 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.86 (6H, d, J = 6.7 Hz, 2 CH_3), 1.31 - 1.36 (6H, m, $C_{4,5,6}$-H), 1.57 (1H, nonet, J = 6.7 Hz, C_{11}-H), 1.64 (2H, br. quint, J = 7.2 Hz, C_3-H), 1.86 (2H, t, J = 6.0 Hz, C_{10}-H), 1.97 (2H, br. q, J = 4.6 Hz, C_7-H), 2.19 (2H, t, J = 7.5 Hz, C_2-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, J = 5.5 Hz, CH_2Ar), 5.33 - 5.39 (2H, m, $C_{8,9}$-H), 5.70 (2H, br. s, OH, NH), 6.76 (1H, dd, J = 8, 1.5 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.5 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 8 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 22.23 (2 CH_3), 25.73 (C_3), 28.44, 28.79, 29.14 ($C_{4,5,6}$), 29.43 (C_{11}), 32.49 (C_7), 36.82 (C_2), 41.98 (C_{10}), 43.51 (ArC), 55.90 (ArOC), 110.67 ($C_{2'}$), 114.34 ($C_{5'}$), 120.77 ($C_{6'}$), 129.13, 131.27 ($C_{8,9}$), 130.35, 145.11, 146.68 ($C_{1',3',4'}$), 172.86 (C_1); EIMS *m/z* (rel. int.) 347 (M^+, 11), 152 ($ArCH_2NH^+$, 10), 137 ($ArCH_2^+$, 100), 55 (12), 43 ($C_3H_7^+$, 10), 41 (12). Anal. Calcd for $C_{21}H_{33}NO_3$: C, 72.58; H, 9.57; N, 4.03. Found: C, 72.32; H, 9.54; N, 4.07.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-6-methyl-4-octenamide (Norcapsaicin II; CII-9). Acid **8Ca** (284 mg, 1.8 mmol) gave the crude amide **CII-9** (505 mg, 95%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of **CII-9** (441 mg, 83%), m.p. 77-78 °C. IR (neat) 3539, 3442, 3304 (NH, OH), 1649 (C=O), 1516 (ArC=C), 1274, 1216 (C-O), 971 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.81 (3H, t, J = 7.3 Hz, C_8-H), 0.91 (3H, d, J = 6.6 Hz, C_6-CH_3), 1.22, 1.26 (each 1H, AB type J = 13.4 Hz, each quint J = 7.3 Hz, C_7-H), 1.94 (1H, septet, J = 6.7 Hz, C_6-H), 2.27 (2H, t , J = 7.0 Hz, C_2-H), 2.34 (2H, br. q, J = 5.4 Hz, C_3-H), 3.87 (3H, s, OCH_3), 4.33 (2H, d, J = 5.8 Hz, CH_2Ar), 5.33 (1H, dd, J = 15.3, 6.4 Hz, C_5-H), 5.34 (1H, dt, J = 15.3, 5.4 Hz, C_4-H), 5.79 (1H, s, OH), 5.81 (1H, br. s, NH), 6.75 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.85 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 11.67 (C_8), 20.17 (C_6-CH_3, 28.62 (C_3), 29.62 (C_7), 36.77 (C_2), 38.24 (C_6), 43.52 (ArC), 55.89 (ArOC), 110.74 ($C_{2'}$), 114.38 ($C_{5'}$), 120.79 ($C_{6'}$), 126.49 (C_4), 137.79 (C_5), 130.21, 145.12, 146.68 ($C_{1',3',4'}$), 172.36 (C_1); EIMS *m/z* (relative intensity) 291 (M^+, 16), 152 ($ArCZH_2NH^+$, 10), 137 ($ArCH_2^+$, 100), 122 (9), 55 (16), 41 (14). Anal. Calcd for $C_{17}H_{25}NO_3$: C, 70.07; H, 8.65; N, 4.81. Found: C, 70.28; H, 8.83 ; N, 4.93 .

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-7-methyl-5-nonenamide (Capsaicin II; CII-10). Acid **8Cb** (320 mg, 1.9 mmol) gave the crude amide **CII-10** (523 mg, 91%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **CII-10** (414 mg, 72%), m.p. 52.5-54 °C. IR (neat) 3541, 3441, 3299 (NH, OH), 1650 (C=O), 1515 (ArC=C), 1274, 1215 (C-O), 973 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.82 (3H, t, J = 7.5 Hz, C_9-H), 0.93 (3H, d, J = 6.7 Hz, C_7-CH_3), 1.23, 1.27 (each 1H, AB type J = 13.4 Hz, each quint, J = 7.3 Hz, C_8-H), 1.72 (2H, quint, J = 7.3 Hz, C_3-H), 1.95 (1H, septet, J = 6.7 Hz, C_7-H), 2.03 (2H, q, J = 6.8 Hz, C_4-H), 2.19 (2H, t, J = 7.6 Hz, C_2-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, J = 5.8 Hz, CH_2Ar), 5.25 (1H, dd, J = 15.3, 7.2 Hz, C_6-H), 5.31 (1H, dt, J = 15.3, 6.3 Hz, C_5-H), 5.69 (2H, br. s, OH, NH), 6.76 (1H, dd, J = 8.1, 1.8 Hz, $C_{6'}$-H), 6.81 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.87 (1H, d, J = 8.2 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 11.76 (C_9), 20.35 (C_7-CH_3), 25.57 (C_3), 29.74 (C_8), 31.98 (C_4), 36.04 (C_2), 38.32 (C_7), 43.52 (ArC), 55.91 (ArOC), 110.69 ($C_{2'}$), 114.35 ($C_{5'}$), 120.81 ($C_{6'}$), 127.25 (C_5), 137.43 (C_6) 130.34, 145.12, 146.68 ($C_{1',3',4'}$), 172.73 (C_1); EIMS *m/z* (rel. int.) 305 (M^+, 15), 195 (20), 152 ($ArCH_2NH^+$, 14), 151 (16), 137 ($ArCH_2^+$, 100), 55 (13), 41 (15). Anal. Calcd for $C_{18}H_{27}NO_3$: C, 70.79; H, 8.91; N, 4.59. Found: C, 70.84 ; H, 9.09; N, 4.63.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-8-methyl-6-decenamide (Homocapsaicin II; CII-11). Acid **8Cc** (359 mg, 2 mmol) gave the crude amide **CII-11** (591 mg, 95%), which was crystallized from ether-hexane (1:3) afforded an analytical sample of **CII-11** (529 mg, 85%), m.p. 64.5-65.5 °C. IR (neat) 3540, 3442, 3303 (NH, OH), 1646 (C=O), 1515 (ArC=C), 1275, 1216 (C-O), 972 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.83 (3H, t, J = 7.5 Hz, C_{10}-H), 0.93 (3H, d, J = 6.7 Hz, C_8-CH_3), 1.24, 1.28 (each 1H, AB type J = 13.4 Hz, each quint, J = 7.3 Hz, C_9-H), 1.39 (2H, quint, J = 7.6 Hz, C_4-H), 1.66 (2H, quint, J = 7.6 Hz, C_3-H), 1.94 (1H, partly hidden septet, J = 6.7 Hz, C_8-H), 2.00 (2H, q, J = 7.0 Hz, C_5-H), 2.20 (2H, t, J = 7.6 Hz, C_2-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, J = 5.8 Hz, CH_2Ar), 5.25 (1H, dd, J = 15.3, 7.3 Hz, C_7-H), 5.32 (1H, dt, J = 15.3, 6.4 Hz, C_6-H), 5.68 (2H, br. s, OH, NH), 6.76 (1H, dd, J = 7.9, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, J = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, J = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 11.75 (C_{10}), 20.37 (C_8-CH_3), 25.24 (C_3), 29.30 (C_4), 29.79 (C_9), 32.26 (C_5), 36.69 (C_2), 38.32 (C_8), 43.51 (ArC), 55.91 (ArOC), 110.66 ($C_{2'}$), 114.34 ($C_{5'}$),

120.77 ($C_{6'}$), 127.85 (C_6), 136.71 (C_7), 130.36, 145.11, 146.69 ($C_{1',3',4'}$), 172.78 (C_1); EIMS *m/z* (rel. int.) 319 (M^+, 14), 152 ($ArCH_2NH^+$, 13), 137 ($ArCH_2^+$, 100), 69 (5), 55 (14), 41 (14). Anal. Calcd for $C_{19}H_{29}NO_3$: C, 71.44; H, 9.15; N, 4.39. Found: C, 71.20 ; H, 9.32; N, 4.41.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-9-methyl-7-undecenamide (Bishomocapsaicin II; CII-12). **8Cd** (291 mg, 1.5 mmol)gave **CII-12** (457 mg, 93%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of **CII-12** (378 mg, 77%), m.p. 46.5-48 °C. IR (neat) 3542, 3440, 3299 (NH, OH), 1644 (C=O), 1516 (ArC=C), 1274, 1216 (C-O), 972 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.83 (3H, t, *J* = 7.3 Hz, C_{11}-H), 0.94 (3H, d, *J* = 6.7 Hz, C_9-CH_3), 1.24, 1.28 (each 1H, AB type *J* = 13.4 Hz, each quint *J* = 7.3 Hz, C_{10}-H), 1.31 - 1.39 (4H, m, $C_{4,5}$-H), 1.65 (2H, quint, *J* = 7.6 Hz, C_3-H), 1.95 (1H, partly hidden septet, *J* = 6.7 Hz, C_9-H), 1.97 (2H, q, *J* = 6.9 Hz, C_6-H), 2.19 (2H, t, *J* = 7.6 Hz, C_2-H), 3.88 (3H, s, OCH_3), 4.35 (2H, d, *J* = 5.8 Hz, CH_2Ar), 5.25 (1H, dd, *J* = 15.3, 7.3 Hz, C_8-H), 5.32 (1H, dt, *J* = 15.3, 6.3 Hz, C_7-H), 5.66 (1H, s, OH), 5.67 (1H, br. s, NH), 6.76 (1H, dd, *J* = 8.2, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, *J* = 2.1 Hz, $C_{2'}$-H), 6.86 (1H, d, *J* = 7.9 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 11.75 (C_{11}), 20.42 (C_9-CH_3), 25.62 (C_3), 28.77, 29.37 ($C_{4,5}$), 29.82 (C_{10}), 32.38 (C_6), 36.81 (C_2), 38.34 (C_9), 43.52 (ArC), 55.92 (ArOC), 110.68 ($C_{2'}$), 114.35 ($C_{5'}$), 120.79 ($C_{6'}$), 128.20 (C_7), 136.43 (C_8), 130.37, 145.11, 146.68 ($C_{1',3',4'}$), 172.83 (C_1); EIMS *m/z* (rel. int.) 333 (M^+, 14), 152 ($ArCH_2NH^+$, 12), 137 ($ArCH_2^+$, 100), 55 (21), 41 (15). Anal. Calcd for $C_{20}H_{31}NO_3$: C, 72.03; H, 9.37; N, 4.20. Found: C, 71.88; H, 9.48; N, 4.12.

(*E*)-*N*-(4-Hydroxy-3-methoxybenzyl)-10-methyl-8-dodecenamide (Trishomocapsaicin II; CII-13). **8Ce** (409 mg, 1.9 mmol) gave **CII-13** (628 mg, 94%), which was crystallized from ether-hexane (1:3) to afford an analytical sample of **CII-13** (541 mg, 81%), m.p. 49.5-51 °C. IR (neat) 3544, 3442, 3296 (NH, OH), 1650 (C=O), 1514 (ArC=C), 1275, 1216 (C-O), 972 (C=C) cm^{-1}; ^1H NMR (500 MHz) δ 0.83 (3H, t, *J* = 7.3 Hz, C_{12}-H), 0.94 (3H, d, *J* = 6.7 Hz, C_{10}-CH_3), 1.24, 1.28 (each 1H, AB type *J* = 13.4 Hz, each quint *J* = 7.3 Hz, partly hidden, C_{11}-H), 1.28 - 1.36 (6H, m, $C_{4,5,6}$-H), 1.65 (2H, quint, *J* = 7.4 Hz, C_3-H), 1.91 - 1.97 (1H, mostly hidden m, C_{10}-H), 1.95 (2H, q, *J* = 6.7 Hz, C_7-H), 2.19 (2H, t, *J* = 7.6 Hz, C_2-H), 3.87 (3H, s, OCH_3), 4.35 (2H, d, *J* = 5.5 Hz, CH_2Ar), 5.24 (1H, dd, *J* = 15.3, 7.3 Hz, C_9-H), 5.32 (1H, dt, *J* = 15.3, 6.4 Hz, C_8-H), 5.68 (2H, s, OH, NH), 6.76 (1H, dd, *J* = 8.2, 1.8 Hz, $C_{6'}$-H), 6.80 (1H, d, *J* = 1.8 Hz, $C_{2'}$-H), 6.86 (1H, d, *J* = 8.2 Hz, $C_{5'}$-H); ^{13}C NMR (125 MHz) δ 11.76 (C_{12}), 20.44 (C_{10}-CH_3), 25.74 (C_3), 28.78, 29.15, 29.49 ($C_{4,5,6}$), 29.83 (C_{11}), 32.48 (C_7), 36.83 (C_2), 38.35 (C_{10}) 43.51 (ArC), 55.91 (ArOC), 110.67 ($C_{2'}$), 114.34 ($C_{5'}$), 120.79 ($C_{6'}$), 128.38 (C_8), 136.30 (C_9), 130.37, 145.11, 146.68 ($C_{1',3',4'}$), 172.86 (C_1); EIMS *m/z* (rel. int.) 347 (M^+, 10), 152 ($ArCH_2NH^+$, 12), 137 ($ArCH_2^+$, 100), 55 (21), 41 (15). Anal. Calcd for $C_{21}H_{33}NO_3$: C, 72.58; H, 9.57; N, 4.03. Found: C, 72.49; H, 9.70; N, 3.96.

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