JOURNAL OF
AGRICULTURAL AND
FOOD CHEMISTRY

J. Agric. Food Chem. 2002, 50, 1581−1586 1581

RP 1279
4 18/09

Variability in Fatty Acid and Triacylglycerol Composition of the Oil of Coconut (*Cocos nucifera* L.) Hybrids and Their Parentals

LUCITA R. LAURELES,[†] FELICITO M. RODRIGUEZ,[†] CONSORCIA E. REAÑO,[†] GERARDO A. SANTOS,[‡] ANTONIO C. LAURENA,[†] AND EVELYN MAE TECSON MENDOZA*,[†]

Institute of Plant Breeding, College of Agriculture, University of the Philippines Los Baños, College 4031, Laguna, Philippines, and Philippine Coconut Authority, Zamboanga Research Center, San Ramon, Zamboanga City, Philippines

The fatty acid profiles and triacylglycerol (TAG) compositions of oils from the solid endosperm of different Philippine coconut hybrids and their parentals were determined by using gas chromatography (GC) and high-performance liquid chromatography (HPLC). In general, varietal differences in fatty acid composition were observed. Lauric acid (C12) content was significantly higher in the hybrids PCA 15-8 (50.45%) and PCA 15-9 (50.26%) by about 3.16% points as compared to other hybrids, and higher in Tacunan Green Dwarf (50.50%) among the parentals. Among the fatty acids, lauric acid exhibited the least variation. In general, none of the hybrids had higher fatty acid content than their parentals. The HPLC chromatogram of triacylglycerols (TAG) showed 8 major peaks which differ in carbon number (CN) by two: identified as TAG CN 30, 32, 34, 36, 38, 40, 42, and 44. TAGs CN 30 (4.08%) and CN 34 (19.20%) were found to be significantly higher in PCA 15-9 than in the other hybrids. CN 36 was highest (21.94−23.66%) in all hybrids and parentals. The TAG CNs varied significantly among hybrids and parents, i.e., in CN 30, 32, and 34, which are high in medium chain triacylglycerols (MCTs), and in CN 30 (for parentals only), 40, 42, and 44 (the latter two for parentals only), and none in CN 36. MCTs calculated for two hybrids and their parents ranged from 13.81% to 20.55%.

KEYWORDS: Coconut hybrids; coconut varieties; fatty acid profile; triacylglycerol composition; TAG carbon number; variability

INTRODUCTION

About 50% of coconut oil consists of fatty acids of medium chain length (C6 − C12) of which the major fatty acid is lauric acid (C12). Notably, coconut oil has the largest proportion of the C6, C8, and C10 fatty acids among the palm oils. It is also the most saturated compared with palm, soybean, and corn oils, and animal fats such as butter, tallow, and lard (*1*−*3*).

The highly saturated nature of coconut fatty acids has been implicated in increased cholesterol synthesis in the body and could thus contribute to higher incidence of heart disease. This contention, however, has been refuted scientifically. Kintanar (*4*), Blackburn et al. (*5*), and Dayrit et al. (*6*) presented exhaustive reviews of available scientific data which showed that coconut oil is not hypercholesterolemic and atherogenic. Kaunitz (*7*) reported that medium chain triacylglycerols (MCTs) of coconut oil fed to rats reduced storage fat accumulation, serum and tissue cholesterol, and linoleate requirements. Sylianco et al. (*8*) showed the antigenotoxic activity of coconut oil against six genotoxins and it was found to be superior to that exhibited by soybean oil.

Eighty percent of the world production of oil and fat is used for food, whereas approximately 14% is for nonfood uses, and 6% is for feed. For nonfood uses, lauric-derived fatty acids are utilized in the production of soaps, plastics, rubbers, and elastomers (about 60%), and the rest is used for production of derivatives such as alkanolamides, esters, quaternary ammonium compounds, and alcohols, etc. (about 30%).

To date, various information on the fatty acid composition of oil from maturing coconut and from 32 mature coconut cultivars and hybrids in the Philippines has been reported (*9*, *10*). Rosell et al. (*2*) analyzed 23 samples of coconut oil from five countries. A review of the work done on the triacylglycerol of coconut (*1*) showed that the oil consists of 70 to more than a hundred triacylglycerols belonging to 14 groups. About 22% of the triacylglycerols in coconut oil are MCTs which contain C6 to C12 fatty acids (*11*). These medium-chain fatty acids are easily absorbed, transported, distributed, and metabolized, unlike the long-chain fatty acids (*12*).

This study looked into the fatty acid and triacylglycerol composition of the oils of different coconut hybrids and their

* Corresponding author (email: emtm@laguna.net).
[†] Institute of Plant Breeding, University of the Philippines Los Baños.
[‡] Philippine Coconut Authority, Zamboanga Research Center.

10.1021/jf010832w CCC: $22.00 © 2002 American Chemical Society
Published on Web 02/09/2002

parentals in the Philippines to determine variation and interactions among and within the cultivars and hybrids. Moreover, there was emphasis on the use of appropriate methods for sampling and statistical analysis of data, which were not given due importance in earlier studies. The application of the results with regard to breeding strategies for coconut is discussed. Results are expected to aid in developing appropriate breeding strategies for coconut and to guide in the selection of coconut cultivars and hybrids with appropriate fatty acid and triacylglycerol composition for various food and nonfood industries. The identification of cultivars with higher MCTs will strongly contribute to the wider utilization of such cultivars and to the improvement of the nutritional quality of the coconut oil.

MATERIALS AND METHODS

Materials. Seventeen coconut cultivars and hybrids were collected from the germplasm collection of the Philippine Coconut Authority, Zamboanga Research Center (PCA-ZRC), in San Ramon, Zamboanga City. For each cultivar or hybrid, five trees were chosen at random; five mature nuts were harvested from each tree. The nuts were dehusked, split, and grated. The grated endosperm was mixed thoroughly, dried (70° C), and subjected to oil extraction using a portable oil presser fabricated by PCA-ZRC. The oils were collected in a beaker, filtered, and placed in clean vials. The remaining moisture in the oil samples was removed by placing them in an oven (30 °C) overnight. The oil samples were stored under nitrogen at <0 °C until analysis. The samples of coconut endosperm were grated and then oven dried at 70 °C. The oil was extracted by organic solvent (chloroform/methanol, 2:1, v/v) using the method of Pham et al. (*13*).

Fatty Acid Analysis. The fatty acid methyl esters of the oils were prepared by using the standard methods (*14*). Hexane (1 mL) was added to 2 drops of oil, and the tube was shaken for 2 s. Methanolic NaOH (200 μL, 2 N) was added, and the test tube was covered with a cork. The mixture was shaken vigorously for 10 s, placed in a water bath at 50 °C for 20 s, and shaken for 10 s. Methanolic HCl (200 μL, 2 N) was added and the mixture was shaken again for several seconds. The organic layer containing the fatty acid methyl esters was removed and used for gas chromatography (GC) analysis. A Shimadzu GC-8A gas chromatograph equipped with a 0.5-m glass column packed with 10% SE-52 and a flame ionization detector was routinely used in the fatty acid composition analysis. Column oven temperature was programmed from 70 to 220 °C at the rate of 10 °C per min. Detection and injection ports were maintained at 240 °C. When the temperature of 220 °C was reached, the chromatograph was run isothermally until the last peak came out. A Shimadzu C-R1B Chromatopac integrator was used to record separations and retention times. Peaks were identified by comparison with standards and retention time. Hydrogen and air flow rates were 100 and 20 kPa, respectively. Nitrogen carrier gas flow was 100 kPa (~1.0 kg/cm^2).

Identification of fatty acids was done by the use of standards such as caprylic (C8:0), capric (C10:0), and lauric (C12:0) acids. Percent fatty acid was obtained by dividing the peak area of the individual fatty acid by the sum of all peak areas obtained for fatty acids.

Separation and Analysis of Triacylglycerols. Triacylglycerols (TAGs) of the oils of coconut hybrids and cultivars were separated using high-performance liquid chromatography (HPLC) based on the method of Omachi et al. (*15*). The oil extracted (300–350 mg) was dissolved in 10 mL of tetrahydrofuran, and 20 μL of this solution was subjected to HPLC (Waters 510, high performance liquid chromatograph) with two connected columns of 250 × 4.0 mm (i.d.) Lichrosorb RP-18 (Merck, particle size 5 mm), and a Waters 410 RI refractometer as detector. Samples were run isocratically using a mixture of acetonitrile/tetrahydrofuran/dichloromethane (6:2:1) at a flow rate of 1 mL/min. The fractions containing the peaks were collected from five to eight chromatographic runs for GC. For determination of the fatty acid composition of each TAG, the eluates corresponding to one peak were pooled and the solvent was evaporated. The fatty acid methyl esters of the isolated TAGs were prepared based on the standard methods (*14*). The percentage of each TAG was obtained by simultaneous equation using matrix algebra.

The carbon numbers of the major peaks were identified by using the standard retention time of saturated TAG standards tricaprylin (8:0), tricaprin (10:0), trilaurin (12:0), trimyristin (14:0), and tripalmitin (16:0) and based on the linear regression equation of the plot between TAG carbon number and log retention volume for saturated TAG standards.

Only PCA-14 and PCA-19 and their parents, Tagnanan Tall and Catigan Green Dwarf, and Tacunan Green Dwarf and Tagnanan Tall, respectively, were subjected to analysis of the fatty acid composition of their triacylglycerols.

RESULTS AND DISCUSSION

Fatty Acid Composition. Table 1 shows that the fatty acid profile of the endosperm oil varies in the different coconut hybrids and cultivars. Analysis of variance showed a majority of the fatty acids varied significantly among hybrids and parents, and between dwarf and tall parents (**Table 2**).

Lauric acid (C12), the major fatty acid of coconut, ranged from 47.29% (PCA 15-5) to 50.45% (PCA 15-8) among the hybrids, and 48.11% (Tagnanan Tall) to 50.50% (Tacunan Green Dwarf) among the parentals. The values obtained for C12 of parents Tacunan Green Dwarf (TACD), Catigan Green Dwarf (CATD), Bago-Oshiro (BAOT), West African Tall (WAT), Laguna Tall (LAGT), and hybrids PCA 15-8 and PCA 15-5 were within the range (40.98% to 58.09%) of those results reported earlier (*2, 10*). The lauric acid value for Laguna Tall (49.70%) agreed with the results reported by Banzon and Resureccion (*9*), but del Rosario et al. (*10*) reported a slightly higher value of 51.61%. Very high lauric acid contents of 58.09% for two hybrids from the Philippines were reported by del Rosario et al. (*10*). Rosell et al. (*2*), reported the highest lauric acid content of 52.6% and 48.7% among coconut oil samples from Sri Lanka and the Philippines, respectively.

Among the hybrids, PCA 15-8 and PCA 15-9 had the highest contents of lauric acid: 50.26% and 50.45%. These were up to 3.16% points higher than the lauric acid contents of the other hybrids. A comparison of the hybrids with their respective parents showed different trends. Whereas the lauric acid levels of the rest of the seven hybrids were not significantly different from that of the parent with lower lauric acid content, the lauric acid contents of PCA 15-8 and PCA 15-9 approximated the values for that of the parent with higher lauric acid content, which in both cases is Tacunan Green Dwarf.

No hybrid exceeded the lauric acid content, or other fatty acid content, of the parents. This may be attributed to the very little variation existing among the parents used, as revealed by the nonsignificance of the variation detected between dwarf and tall populations (**Table 2**).

PCA 15-7, PCA 15-8, and PCA 15-9 had the highest contents of caprylic acid: 7.49, 7.51, and 8.59%, respectively, which were up to 2.24% points higher than the caprylic acid content of other hybrids. Significant differences among hybrids were detected for all fatty acids analyzed except myristic acid. PCA 15-9 showed high contents of fatty acids of C12 and lower, and low contents of fatty acids of C14 and higher. This was the same trend observed with the hybrid's female parent (Tacunan Green Dwarf).

Tacunan Green Dwarf (TACD) had the highest C6, C10, and C12 contents: 0.60, 7.01, and 50.50% respectively, among the eight parentals analyzed. Lauric acid ranged from 48.11 to 50.50%. Caprylic acid contents in West African Tall and Tacunan Green Dwarf were significantly higher (8.30% and 8.26% respectively) than those in other parentals. It is interesting to note that Tacunan Green Dwarf is the female parent of both PCA 15-8 and PCA 15-9, the two hybrids with the highest contents of lauric acid among the hybrids analyzed.

Table 1. Fatty Acid Profile of the Oils in Different Coconut Cultivars and Hybrids (wt %)[a]

	fatty acid							
variety/hybrid	6:0 caproic	8:0 caprylic	10:0 capric	12:0 lauric	14:0 myristic	16:0 palmitic	18:0 +18:1 stearic + oleic	18:2 linoleic
Bago-Oshiro Tall (BAOT)	0.52 bc	7.40 cd	6.28 abc	48.95 abc	19.61 abc	8.71 bcd	5.48 de	3.05 efg
Baybay Tall (BAYT)	0.46 dc	7.64 bc	6.48 abc	48.31 bc	18.66 abcd	8.46 cde	6.80 abc	3.19 defg
Laguna Tall (LAGT)	0.56 ab	7.64 bc	6.55 abc	49.70 ab	18.07 d	8.34 cde	6.02 bcde	3.13 efg
Tagnanan Tall (TAGT)	0.41 d	6.70 def	6.00 de	48.11 bc	19.87 a	9.12 abcd	6.56 abcd	2.30 defg
West African Tall (WAT)	0.53 abc	8.30 ab	6.43 abc	49.32 ab	19.78 ab	7.39 f	5.32 e	2.92 fgh
Catigan Green Dwarf (CATD)	0.41 d	6.29 f	5.86 dc	48.74 abc	18.83 abcd	9.11 abcd	6.73 abc	4.02 ab
Malayan Red Dwarf (MRD)	0.43 d	6.26 f	5.65 d	49.33 ab	19.04 abcd	8.95 abcd	6.91 ab	3.41 cde
Tacunan Green Dwarf (TACD)	0.60 a	8.26 ab	7.01 a	50.50 a	17.73 d	7.76 ef	5.29 e	2.86 gh
PCA 15-1 (CATD × LAGT)	0.52 abc	6.82 cdef	5.96 dc	48.37 bc	18.51 bcd	9.20 abc	6.95 ab	3.72 abc
PCA 15-2 (MRD × TAGT)	0.48 bcd	7.01 cdef	6.18 dc	48.27 bc	18.09 d	9.12 abcd	7.47 a	3.36 cdef
PCA 15-3 (MRD × BAYT)	0.46 dc	6.71 def	5.97 dc	47.48 c	18.91 abcd	9.62 ab	7.63 a	3.23 cdefg
PCA 15-4 (CATD × TAGT)	0.42 d	6.35 ef	5.88 dc	47.91 bc	18.51 bcd	9.50 ab	7.36 a	4.07 a
PCA 15-5 (CATD × BAOT)	0.46 dc	6.52 ef	5.93 dc	47.29 c	18.78 abcd	9.81 a	7.61 a	3.63 bcd
PCA 15-6 (CATD × PYT)	0.45 de	7.17 cde	6.15 dc	47.36 c	18.21 d	9.51 ab	7.52 a	3.49 dce
PCA 15-7 (MRD × PYT)	0.52 abc	7.49 bcd	6.36 abc	48.85 abc	18.20 d	8.82 bcd	6.90 ab	2.86 hg
PCA 15-8 (TACD × BAOT)	0.47 dc	7.51 bcd	6.38 abc	50.45 a	18.79 abc	8.18 def	5.69 cde	2.51 h
PCA 15-9 (TACD × TAGT)	0.52 abc	8.59 a	6.97 ab	50.26 a	18.28 cd	7.70 ef	5.17 e	2.56 h
mean	0.48	7.21	6.24	48.96	18.70	8.79	6.56	3.26
C. V. (%)	16.10	11.64	10.85	3.54	6.83	10.23	16.96	13.70

[a] DMRT: In a column, means followed by a common letter are not significantly different at 5% level. ns, not significant. The fatty acids are given as a percentage relative to the total fatty acids. The different coconut hybrids and cultivars were collected from the germplasm collection of the Philippine Coconut Authority, Zamboanga Research Center, San Ramon, Zamboanga City. In each cultivar/hybrid, five (5) trees were chosen at random. For each tree, five mature nuts were harvested. The coconut meat of the five nuts per tree was grated and combined, and a representative sample was taken for oil extraction.

Table 2. Analysis of Variance of the Different Fatty Acids of Various Coconut Cultivars and Hybrids

		mean square[a]							
source of variation	Df	6:0 caproic	8:0 caprylic	10:0 capric	12:0 lauric	14:0 myristic	16:0 palmitic	18:0 + 18:1 stearic + oleic	18:2 linoleic
population	16	0.031**	5.196**	1.433**	10.375**	3.767**	5.079**	7.645**	1.950**
hybrids (H)	8	0.018**	4.391**	1.172*	13.021**	0.879ns	4.787**	7.611**	2.708**
parents (P)	7	0.048**	6.631**	1.885**	5.953*	6.220**	4.044**	4.852**	1.341**
among talls (T)	4	0.032**	3.332**	0.481ns	4.475ns	6.330**	4.135**	4.169*	0.153ns
among dwarfs (D)	2	0.103**	13.208**	5.338**	8.028*	4.992*	5.493**	7.945**	3.368**
D vs T	1	0.004ns	6.673**	0.598ns	7.787ns	8.240*	0.780ns	1.395ns	2.038**
P vs H	1	0.012ns	1.443ns	0.311ns	17.531*	9.390*	13.669**	25.552**	0.078ns
trees (population)	67	0.006	0.704	0.458	2.982	1.630	0.809	1.239	0.199
C. V. (%)		16.10	11.64	10.85	3.54	6.83	10.23	16.96	13.70

[a] ** Significant at 1% level; * significant at 5% level; ns, not significant.

Although hybrid vigor in terms of lauric acid (C12) content was not observed in the hybrids, the results suggest that the high levels of C12 in PCA 15-8 and PCA 15-9 were inherited from their dwarf parent Tacunan. It is also interesting to note that the two hybrids PCA 15-8 and PCA 15-9 had relatively high, or the highest, levels of caproic acid, caprylic acid, capric acid, lauric acid, and myristic acid among the hybrids, but had lower levels of palmitic, [stearic + oleic], and linoleic acid contents. A similar trend was observed with the different fatty acid contents of Tacunan Green Dwarf.

Parental variation which was detected for all fatty acids consisted of variation among tall parents, among dwarf parents, and between tall and dwarf parents. Among tall parents, variation was significant for all fatty acids except capric and lauric acid contents. Among dwarf parents, variation was significant for all fatty acids. Between dwarf and tall parents, variation was significant only with caprylic and palmitic acids. Notably, variation was least with lauric acid and increased as the carbon chain increased and decreased. Thus it may be difficult to increase lauric acid content in coconut oil by conventional breeding; nonconventional approaches such as genetic engineering may be more appropriate.

Triacylglycerol (TAG) Profile. An HPLC chromatogram of triacylglycerol of coconut oil of hybrids and parentals is shown in **Figure 1**. The chromatograms showed a clear separation of TAG components with acetonitrile/tetrahydrofuran/dichloromethane (6:2:1) as the solvent system for reversed-phase HPLC system. The major TAGs were eluted in peaks 1 to 12. The peaks were identified and grouped into eight major TAGs by comparing with TAG standards and based on the linear relationship between carbon number and log retention volume of the saturated triacylglycerol standards. In this study, isolation of TAG was done by directly injecting the lipid on HPLC. The preparative TLC step prior to HPLC was eliminated. No difference in the TAG fractions separated by HPLC, with or without TLC pretreatment, was shown earlier in winged bean oil and coconut oil (*13, 15*).

The chromatogram of TAGs showed eight major peaks, which differ in carbon number by two, starting from CN 30 to CN 44. The chromatogram of the eight major peaks corresponds

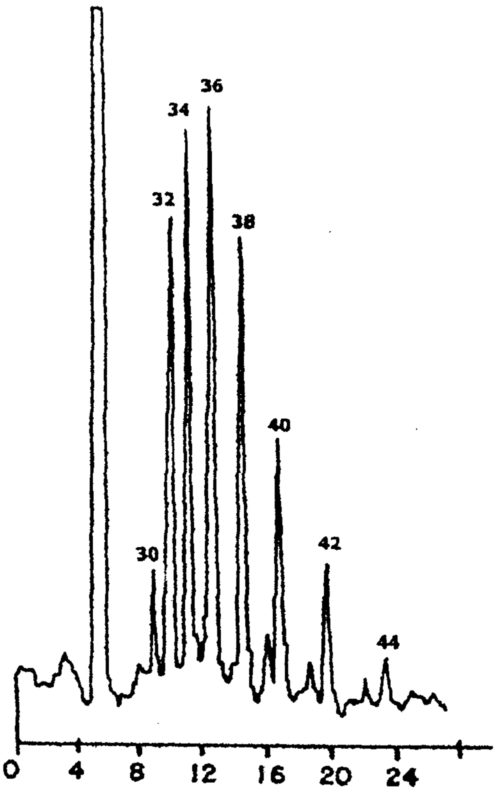

Figure 1. Sample HPLC Chromatogram of the triacylglycerol composition of the oils of different coconut cultivars and hybrids. Conditions were the following: column, two columns of Lichrosorb RP-18 (250 × 4.0 mm); eluent, acetonitrile/tetrahydrofuran/dichloromethane (6:2:1), 1 mL/min; detector, RI.

well with that of coconut oil triacylglycerol reported by Plattner et al. (*16*) and Bezard et al. (*17*). Lower carbon numbers such as CN 28 and carbon numbers higher than C44 were not determined because of very small peaks. Thus, eight major peaks were considered, from CN 30 to CN 44. Bezard et al. (*17*) reported seven more minor peaks for coconut oil.

Triacylglycerol Composition. Table 3 shows varying triacylglycerol profiles of the oils from the solid endosperm of the different coconut hybrids and cultivars. Triacylglycerol composition varied significantly among hybrids and parentals, and between dwarfs and talls of parentals (**Table 4**). TAG of CN 36 was highest (21.94−23.66%) in all hybrids and parentals analyzed.

Variation in triacylglycerol contents consisted of variation among tall parents, among dwarf parents, and between tall and dwarf parents. Only triacylglycerols CN 34 and 40 varied significantly among hybrids. CN 30 and CN 34 were found significantly higher (4.08% and 19.20%, respectively) in PCA 15-9 than in other hybrids analyzed. TAG CN 36 had the highest levels which ranged from 22.72% to 23.66%.

Among parents, triacylglycerol CN 30, 32, 34, 40, and 42 varied significantly. TAG CN 30 and CN 32 were found significantly higher in Tacunan Green Dwarf (4.52 and 15.88%, respectively) and West African Tall (4.02 and 15.88%, respectively). Significant differences in TAG CN 30, 32, 34, 38, 40, and 42 were observed among dwarf parents. Among the tall parents, TAG CN 32, 34, 38, 40, 42, and 44 varied significantly. TAG CN 36 did not differ significantly among cultivars and hybrids. Similar to the observation with fatty acids, variation in CN 36 was least and this increased with increase or decrease of carbon number. The TAG values obtained by Rosell et al. (*2*) were in the range of the values reported herein.

TAG Fatty Acid Composition of Selected Coconut Hybrids and Parentals. Analysis of the fatty acid composition of the different HPLC fractions of triacylglycerols was done only on selected hybrids (PCA 15-4 and PCA 15-9) and their parentals (West African Tall, Tagnanan, Catigan, and Tacunan) (**Table 5**). C12 was observed to be highest in the TAG CN 32 of the hybrid PCA 15-4 (63.98%) and in TAG CN 34 of PCA 15-9 (65.08%). Among the parentals, Tacunan had the highest level of 64.58% for C12 in TAG CN 36 followed by Catigan in TAG CN 34 of 61.26%.

The mole percentages of the different fatty acids in each of the CN groups have been recorded (available from the authors) and are summarized in terms of medium chain triacylglycerols (MCTs) in **Table 6**. MCTs ranged from 13.81 to 20.55%. The

Table 3. Triacylglycerol Profile of Different Coconut Cultivars and Hybrids (wt %)[a]

cultivar or hybrid	triacylglycerol carbon number							
	30	32	34	36	38	40	42	44
Bago-Oshiro Tall (BAOT)	3.38 dc	14.71 b	19.27 b	23.01 ab	18.89 bcdef	12.08 ef	6.18 fg	2.47 de
Baybay Tall (BAYT)	3.37 dc	13.39 cde	18.49 cd	21.94 c	17.78 ij	12.58 cde	8.30 b	4.17 a
Laguna Tall (LAGT)	3.32 cde	13.35 cde	18.16 ed	22.50 bc	18.07 ghij	13.39 bc	8.05 bc	3.16 bcd
Tagnanan Tall (TAGT)	3.24 cde	13.17 de	18.12 ed	22.44 bc	19.38 bcd	13.28 bc	7.32 bcdef	3.05 bcd
West African Tall (WAT)	4.02 b	15.88 a	20.64 a	23.17 ab	18.01 hij	10.98 g	5.38 g	1.91 e
Catigan Green Dwarf (CATD)	2.62 g	11.09 g	15.48 h	22.64 bc	19.64 b	14.86 a	9.71 a	3.99 ab
Malayan Red Dwarf (MRD)	2.78 gf	11.24 g	16.29 g	23.38 ab	20.43 a	15.43 a	7.76 bcd	2.68 de
Tacunan Green Dwarf (TACD)	4.52 a	15.88 a	19.17 cb	22.39 bc	16.77 k	11.32 fg	6.80 def	3.14 bcd
PCA 15-1 (CATD × LAGT)	3.08 def	13.12 de	17.26 f	22.72 abc	19.49 bc	13.53 b	7.60 bcde	3.20 bcd
PCA 15-2 (MRD × TAGT)	3.11 def	13.60 cde	17.88 def	22.98 ab	18.71 defgh	13.42 bc	7.09 bcdef	3.22 bcd
PCA 15-3 (MRD × BAYT)	3.08 def	12.98 ef	17.63 ef	22.88 abc	19.40 bcd	13.79 b	6.92 cdef	3.36 abcd
PCA 15-4 (CATD × TAGT)	2.89 efg	12.42 f	17.26 f	22.95 ab	19.50 bc	13.64 b	7.60 bcde	3.74 abc
PCA 15-5 (CATD × BAOT)	3.11 def	13.23 de	18.06 de	23.00 ab	16.78 cdefg	13.16 bcd	7.51 bcde	3.14 bcd
PCA 15-6 (CATD × PYT)	3.46 dc	13.69 dc	18.61 bcd	23.66 a	19.05 bcde	12.18 ef	6.72 def	2.64 de
PCA 15-7 (MRD × PYT)	3.64 c	13.97 c	18.52 bcd	23.05 ab	18.50 efghi	12.36 de	6.92 cdef	3.02 bcd
PCA 15-8 (TACD × BAOT)	3.32 cde	13.54 cde	18.33 de	23.18 ab	18.24 fghij	13.09 bcd	6.96 cdef	3.34 abcd
PCA 15-9 (TACD × TAGT)	4.08 b	15.07 b	19.20 bc	22.75 abc	17.56 j	11.96 efg	6.45 efg	2.93 cd
mean	3.35	13.53	18.12	22.86	18.73	13.02	7.26	3.13
C. V. (%)	12.46	4.94	4.25	4.02	4.01	6.89	16.17	29.57

[a] In a column, means followed by a common letter are not significantly different at 5% level. The different coconut hybrids and cultivars were collected from the germplasm collection of the Philippine Coconut Authority, Zamboanga Research Center. In each cultivar or hybrid, five trees were chosen at random. For each tree, five mature nuts were harvested. The coconut meat of the five nuts per tree was grated and combined, and a representative sample was taken for extraction.

Table 4. Analysis of Variance of the Different Triacylglycerol Carbon Number of Various Coconut Cultivars and Hybrids[a]

		mean square							
sources of variation	df	CN 30	CN 32	CN 34	CN 36	CN 38	CN 40	CN 42	CN 44
population	16	2.372**	17.102**	13.677**	1.663ns	8.277**	12.713**	9.172**	2.882ns
hybrids (H)	8	1.235ns	8.387ns	9.731**	0.708ns	2.772ns	7.243*	4.758ns	2.698ns
parents (P)	7	3.814**	32.811**	26.417**	2.234ns	13.979**	23.808**	18.222**	5.444*
among talls (T)	4	1.008ns	12.098*	10.517**	2.405ns	4.795*	8.444*	16.089**	6.816*
among dwarfs (D)	2	11.118**	74.127**	37.657**	2.666ns	36.992**	49.453**	21.951**	4.420ns
D vs T	1	0.533ns	34.922*	70.623**	0.713ns	5.460ns	36.359**	19.798*	1.936ns
P vs H	1	0.468ns	0.328ns	0.672ns	4.818ns	1.620ns	0.031ns	5.150ns	0.489ns
trees (population)	68	0.654	4.59	2.639	1.599	1.608	3.309	3.094	2.258
C. V. (%)		24.15	15.83	8.96	5.53	6.77	13.97	24.24	48.05

[a] ** Significant at 1% level; * significant at 5% level; ns, not significant.

Table 5. Fatty Acid Composition (mol %) of TAG Carbon Numbers 32–38 in Coconut Oil Triacylglycerols of Two Dwarf and Two Tall Parentals and Two Hybrids by GC

		fatty acid (mol %)						
parental or hybrid	TAG CN	C6 caproic	C8 caprylic	C10 capric	C12 lauric	C14 myristic	C16 palmitic	C18:0,18:1, C18:2 stearic, oleic, linoleic
				dwarf				
Tacunan	32	1.66	15.57	14.26	51.25	12.70	3.99	0.61
Catigan		3.31	12.06	10.31	54.86	17.32	0.58	1.56
Tacunan	34	2.80	13.20	12.60	42.20	13.60	13.60	2.00
Catigan		1.72	20.23	5.15	61.26	8.40	2.86	0.38
Tacunan	36	1.70	18.94	5.68	64.58	7.01	1.32	0.76
Catigan		0.86	8.21	8.64	41.90	14.25	10.80	15.33
Tacunan	38	0.60	11.16	9.96	56.17	16.73	3.39	1.99
Catigan		0.21	6.88	13.75	48.33	13.96	7.92	8.96
				tall				
West African	32	0.98	23.35	11.38	40.04	10.79	7.05	6.40
Tagnanan		1.75	8.53	6.56	31.51	24.29	11.38	15.97
West African	34	2.43	28.83	7.15	50.28	4.75	4.92	1.63
Tagnanan		1.05	11.60	4.22	46.62	10.76	19.41	6.33
West African	36	0.98	17.79	10.89	52.37	14.88	1.95	1.14
Tagnanan		0.63	9.24	6.93	44.96	22.27	9.24	6.72
West African	38	0.84	12.39	6.67	57.77	12.91	7.02	2.41
Tagnanan		2.71	4.06	4.51	39.73	12.87	9.03	27.09
				hybrid				
PCA 15-9	32	0.79	13.17	12.57	42.12	13.57	15.77	2.00
PCA 15-4		1.24	3.31	5.18	63.98	16.98	6.42	2.90
PCA 15-9	34	1.12	18.32	5.72	65.08	7.06	1.34	0.76
PCA 15-4		0.62	8.71	5.19	53.53	17.43	12.66	1.87
PCA 15-9	36	0.60	11.16	9.96	56.18	16.73	3.39	1.99
PCA 15-4		0.21	6.81	7.87	41.06	29.15	8.30	6.60
PCA 15-9	38	0.22	6.34	5.91	45.95	16.19	9.63	15.75
PCA 15-4		1.89	14.26	5.45	35.43	24.11	9.85	9.01

hybrid PCA 15-9 had 19.92% total MCT, closely following Tacunan Green Dwarf which had 20.55%. MCTs were observed to be present in TAG CN 32, 34, and 36, but not in 38. Trilaurin or C12, C12, C12 combination seems to be a major component of TAG 36 because lauric acid represents nearly 60% of the total fatty acids in this group.

These results indicate that, in breeding for high MCTs, the strategy could be toward increasing C8 and C10, since there is little variation seen in C12 content as well as in CN 36 content.

The results of this study support the possibility of increasing selected fatty acid contents by varietal improvement and provide a sound scientific basis for adopting certain strategies. They also provide coconut growers the knowledge and option of planting specific cultivars or hybrids to provide the appropriate raw material for food, health, and nonfood industries.

Table 6. Medium Chain Triacylglycerols (MCT) in the Two Dwarf and Two Tall Parentals and Two Hybrids

cultivar or hybrid	probable TAG types	mol % into the total TAGs	total MCT (mol %)
Tagnanan Tall (TAGT)	8, 12, 12	2.48	13.81
	10, 10, 12	1.58	
	10, 12, 12	4.67	
	12, 12, 12	5.08	
West African Tall (WAT)	8, 12, 12	4.27	19.25
	10, 10, 12	2.72	
	10, 12, 12	6.22	
	12, 12, 12	6.04	
Catigan Green Dwarf (CATD)	8, 12, 12	3.73	16.12
	10, 10, 12	2.36	
	10, 12, 12	5.21	
	12, 12, 12	4.82	
Tacunan Green Dwarf (TACD)	8, 12, 12	5.01	20.55
	10, 10, 12	3.47	
	10, 12, 12	4.78	
	12, 12, 12	7.29	
PCA 15-4	8, 12, 12	4.45	16.23
	10, 10, 12	2.53	
	10, 12, 12	5.05	
	12, 12, 12	4.80	
PCA 15-9	8, 12, 12	3.95	19.92
	10, 10, 12	2.80	
	10, 12, 12	6.69	
	12, 12, 12	6.48	

ACKNOWLEDGMENT

We thank the management and various staff of the Philippine Coconut Authority, Zamboanga Research Center, for their assistance in the collection and preparation of samples of the coconut hybrids and cultivars used in this study; Dr. Laura Pham for providing TAG standards; and the IPB BIOCHEM-ASL personnel for all their help. The kind assistance of the PCARRD Crops Research Division, especially the Coconut group, in various aspects, is most gratefully acknowledged.

LITERATURE CITED

(1) Padolina, W. G.; Lucas, L. Z.; Torres, L. G. Chemical and physical properties of coconut oil. *Philipp. J. Coconut Stud.* **1987**, *12*, 4–15.

(2) Rosell, J. B.; King, B. B.; Downes, M. J. Composition of oil. *J. Am. Oil Chem. Soc.* **1985**, *62*, 221–230.

(3) Berger, K. G. Interchangeability of fats and oils. *Coconuts Today* **1983**, *1*, 42–48.

(4) Kintanar, O. L. Is coconut oil hypercholesterolemic and atherogenic. A focused review of the literature. *Trans. Nat. Acad. Sci. Technol., Repub. Philipp.* **1988**, *10*, 371–414.

(5) Blackburn, G. L.; Kater, G.; Mascioli, E. A.; Kowalchuk, M.; Babayan, V. K.; Bistrian B. R. A reevaluation of coconut oil's effect on serum cholesterol and atherogenesis. *Coconuts Today* **1987**, *5*, 56−65.

(6) Dayrit, C. S.; Florentino, R.; Blackburn, G. L.; Mascioli, E.; Babayan, V. K. Coconut oil revisited. *Coconuts Today* **1989**, *7*, 40−43.

(7) Kaunitz, H. Biological and therapeutic effects of "MCT" (medium chain triglycerides) from coconut oil. *Coconuts Today* **1983**, *1*, 27−30.

(8) Sylianco, C. Y.; Mallorca, R.; Serrano, E.; Wu, L. S. A comparison of germ antigenotoxic activity of nondietary coconut oil and soybean oil. *Philipp. J. Coconut Studies* **1992**, *17*, 1−6.

(9) Resurreccion, A. P.; Banzon, J. A. Fatty acid composition of the oil from progressively maturing bunches of coconut. *Philipp. J. Coconut Stud.* **1979**, *4*, 1−15.

(10) Del Rosario, R. R.; Malijan, C. M.; Fuentes, R. A.; Clavero, M. R. S. *Philipp. Agric.* **1989**, *72*, 147−154.

(11) Vander Plank, P.; Rozendaal, A. Restructuring coco-oil fat molecules to make man-made foods and food processors ingredients. *Coconuts Today* **1983**, *1*, 38−45.

(12) Bach, A. C.; Babayan, V. K. Medium chain triglyceride: an update. *Am. J. Clin. Nutr.* **1982**, *36*, 950−962.

(13) Pham, L. S.; Gregorio, M. A.; So, R. S.; Garcia, V. V. Coconut (*Cocos nucifera* L.) var YDLA triglycerides at different stages of maturity. *Philipp. J. Coconut Stud.* **1994**, *19*, 30−32.

(14) Mordret, F. Micromethod for the preparation of methyl ester of neutral fat. In: *Oils and Fats Manual*; Karleskind, C. A., Ed.; Intercept Ltd.: UK, 1996; Vol. 2, p. 1168.

(15) Omachi, M.; Homma, S.; Fujimaki, M. Triacylglycerol composition of winged bean (*Psophocarpus tetragonolobus*). *J. Nutr. Sci. Vitaminol.* **1986**, *33*, 49−54.

(16) Plattner, R. D.; Spencer, G. F.; Kleiman, R. Triglyceride separation by reversed-phase high-performance liquid chromatography. *J. Am. Oil Chem. Soc.* **1977**, *54*, 511−515.

(17) Bezard, J.; Bugaut, M.; Clement, G. Triglyceride composition of coconut oil. *J. Am. Oil Chem. Soc.* **1971**, *48*, 134−139.

Received for review June 28, 2001. Revised manuscript received November 7, 2001. Accepted November 8, 2001. We thank the Philippine Council for Agriculture, Forestry and Natural Resources Research and Resource Development (PCARRD) of the Department of Science and Technology (DOST) and the Institute of Plant Breeding (IPB), College of Agriculture (CA), UPLB for their financial support.

JF010832W