Lipid Composition of Coconut Cake Oil

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Lipid classes and fatty acids were analyzed in expeller and rotary extracted coconut oils and corresponding solvent extracted cake oils. Triacylglycerols (84.0 to 93.1%); 1,2 diacylglycerols (1.5 to 5.1%); 1,3 diacylglycerols (1.2 to 2.1%); monoacylglycerols (1.0 to 7.0%); free fatty acids (1.0 to 2.6%); phospholipids (0.03 to 0.4%) and glycolipids (0.2 to 0.35%) were present in these oils. Fatty acid composition of triacylglycerols, phospholipids and glycolipids resembled each other and differed from those of 1,2 and 1,3 diacylglycerols which in turn were similar.

Coconut oil has been used extensively for edible and nonedible purposes all over the world (1,2). Detergent industries depend mainly on coconut and palm kernel oils for lauric acid (3,4). Production of coconut oil was 2.7 million metric tons (MT) during 1984-85 and is expected to increase further during the years to come (5). Solvent extraction and mechanical expression are the two methods used for coconut oil extraction (2). Though solvent extraction is used in many coconut oil-producing countries (6), mechanical expression by rotaries and expellers is the only procedure used in India, the third largest coconut producer in the world. About 85% of the residual oil, which is used in industries due to its low quality, can be extracted using solvents (7). Available literature gives no information on lipid class composition of rotary- and expeller-extracted coconut oils and corresponding solvent extracted cake oils. This study points out suitable methods of improving the quality of cake oils so that they meet the quality requirements for edible grade coconut oil.

MATERIALS AND METHODS

The coconut oil extracted by rotaries, expellers and corresponding cake oil (solvent-extracted cake oils) were collected from production centers. Refractive index and color of the oils were determined by Abbe refractometer and Lovibond Tintometer, respectively. The chemical constants, IV, SV, AV, PV, Polenske and Retchert-Meissle values were determined as described in AOCS (8).

Preparative thin layer chromatography (TLC) was carried out on 0.8 mm silica gel G to separate the total lipids into classes. Development with chloroform separated the total lipids into neutral and polar lipids. The neutral lipids were further separated into triacylglycerols (TAG), diacylglycerols (DAG), monoacylglycerols (MAG) and free fatty acids (FFA), using hexane/diethyl ether/acetic acid (70:30:1). The polar lipids were further separated into phospholipids (PL) and glycolipids (GL) by column chromatography on silica gel. Acetone was used for eluting GL and methanol to recover PL (9). Identity of various chromatographic fractions was established using reference standards (Sigma Chemical Co., St. Louis, Missouri).

TABLE 1

Physicochemical Characteristics of Coconut Oils

	Rotary oil	Expeller oil	Rotary cake oil	Expeller cake oil
Color (Y + 5R)	8	0.4	9.5	64
Refractive index	1.4518	1.452	1.4518	1.4525
Acid value	2.5	0.5	2.8	4.5
Peroxide value	nil	nil	tr	tr
Saponification value	256	254.4	256	263
Iodine value	8.8	10.3	10.2	10.4
Polenske value	11.7	10.7	11.2	11.5
Retchert Meissle	7.8	8.5	8.3	8.4
Nonsaponifiable matter	0.1	0.05	0.18	0.4

Neutral lipid classes (TAG; 1,2-DAG; 1,3-DAG; MAG and FFA) were estimated using methyl heptadecanoate (17:0) as internal standard (10). Using gas chromatographic (GC) data, mean molecular weights of the fatty acids were calculated and used to compute factors to estimate the lipid classes. GL was quantitated from the hexose content using anthrone reagent (11) and PL from the phosphorous content (12). They were calculated as monogalactosyl diglyceride and phosphatidylcholine (13).

Fatty acid compositions of various lipid classes were determined by GC. The lipid classes were transesterified using anhydrous methanol containing sodium methoxide. FFA were esterified directly with diazomethane. A Hewlett-Packard 5840A GC unit equipped with flame ionization detector (FID) and a glass column (6') packed with 10% FFAP on chromosorb W-AW was used for the analysis. Injection port and detectors were maintained at 250 and 300 C, respectively, and the column was programmed from 90 to 160 C at 5 C/min, maintaining a carrier gas flow of 30 ml/min.

RESULTS AND DISCUSSION

Physicochemical characteristics (Table 1). The physicochemical characteristics of the coconut oils extracted by expellers and rotaries and corresponding solvent-extracted residual cake oils were determined. All oils except the expeller cake oil were clear and very light in color. The expeller cake oil was deep brown in color with a tintometer reading of 64 (1 inch cell, Y + 5R). The brown color may be due to the presence of charred sugars, or free amino acid aldose complex polymers or copolymers as found in palm kernel (14). In palm kernel this complex formation is reported to take place above 120 C. The heat generated during expeller extraction of coconut oil can be above 120 C (15), which could cause a similar complex formation in coconut cakes. The rotary cake oil was free from such coloring matter due to relatively low heat generation (15). Minute cake

particles up to 25 μ size were also detected in cake oils. Chemical characteristics of the oils recorded only minor variations except in the expeller cake oil in which acid value, saponification value and nonsaponifiable matter content were comparatively higher.

Lipid class composition (Table 2). TAG was the major lipid class of the coconut oils as observed in all storage lipids (16). The proportion of TAG in palm species has been reported to exceed 95% (17), but in coconut oils it was less than 93.1%, and the highest proportion was observed in expeller oil. Partial glycerides which can influence the physical characteristics of the oil (18) were present in measurable amounts, but lowest in expeller oil. Their contents were relatively high in the cake oils, probably because of the lipolytic degradation by microorganisms (19). Even though lipolytic enzymes were also reported to be present in the palm kernel oil, such observations have not previously been made in coconuts (20). The possibility for microbial contamination is greater in the disintegrated coconut cake due to high moisture, surface area and nutrients (15). The content of 1,2-DAG was up to 5.1% and that of 1,3-DAG was up to 2.1%; these levels were noticed in coconut cake oils. The higher contents of 1,2-DAG may be due to the release of fatty acids from 1- or 3-positions of the TAG

TABLE 2

Lipid Class Composition of Coconut Oils (%)

Lipid classes	Rotary oil	Expeller oil	Rotary cake oil	Expeller cake oil
TAG	89.1	93.1	84.0	90.6
1,2 DAG	2.2	1.5	5.1	2.6
1,3 DAG	1.2	1.4	2.1	1.4
MAG	1.1	1.0	7.0	2.0
FFA	1.5	0.4	1.0	2.6
PL	0.04	0.03	0.03	0.4
GL	0.2	0.2	0.35	0.3

TABLE 3

Fatty acid Composition of Lipid Class (wt %)

Oil	6:0	8:0	10:0	12:0	14:0	16:0	16:1	18:0	18:1	18:2
Triacylglycerols[a]										
Expeller oil	0.6	8.0	5.7	44.6	19.4	12.4	Tr	2.8	5.5	0.4
Expeller cake oil	0.4	7.1	5.5	46.0	20.6	10.4	Tr	2.9	6.2	0.4
Rotary oil	0.7	9.7	6.5	45.6	17.5	12.4	—	2.2	4.3	0.4
Rotary cake oil	0.6	6.2	4.5	45.0	15.9	15.9	Tr	4.0	6.7	0.7
1,2 Diacylglycerols[a]										
Expeller oil	1.1	6.6	2.4	13.7	11.5	24.2	Tr	16.7	17.6	5.5
Expeller cake oil	2.5	8.2	2.6	11.5	10.9	26.8	Tr	16.2	15.0	5.2
Rotary oil	3.0	7.5	3.9	17.7	12.4	24.2	0.8	14.6	13.0	2.7
Rotary cake oil	2.9	5.7	2.9	16.0	10.4	26.4	Tr	17.0	15.4	1.7
1,3 Diacylglycerols[a]										
Expeller oil	0.9	1.8	2.8	12.5	12.3	28.9	9.2	15.2	12.1	4.0
Expeller cake oil	3.1	4.2	1.8	12.7	10.9	26.9	8.7	15.4	10.9	4.9
Rotary oil	1.8	2.5	1.5	15.5	10.8	20.0	14.0	12.5	14.3	5.8
Rotary cake oil	0.2	1.6	2.4	20.5	15.0	20.9	6.2	12.9	15.5	3.8
Monoacylglycerols[a]										
Expeller oil	2.6	6.8	3.1	20.5	10.6	25.0	5.9	11.4	9.4	4.2
Expeller cake oil	0.6	2.6	2.9	24.7	15.3	27.5	7.4	10.7	7.3	1.1
Rotary oil	1.1	2.6	3.5	24.6	15.6	21.4	7.7	11.6	8.8	3.0
Rotary cake oil	0.7	7.8	7.6	23.9	13.9	28.9	Tr	9.5	5.7	1.3
Free fatty acids[a]										
Expeller oil	0.8	2.7	2.1	4.0	13.5	45.6	Tr	17.7	8.9	2.9
Expeller cake oil	0.9	2.5	2.0	4.5	12.0	40.5	Tr	22.9	10.2	3.5
Rotary oil	4.8	4.3	2.4	5.1	13.7	35.6	—	27.5	3.2	2.3
Rotary cake oil	5.7	4.4	1.7	3.5	8.7	32.0	—	35.2	6.9	1.3
Phospholipids										
Expeller oil	—	2.9	3.0	46.8	22.6	20.2	Tr	2.1	2.3	—
Expeller cake oil	Tr	2.6	5.1	44.6	20.7	17.5	Tr	5.2	4.2	—
Rotary oil	Tr	6.2	5.3	41.1	20.6	17.3	—	4.4	5.0	—
Rotary cake oil	Tr	5.7	5.5	39.3	21.0	19.4	Tr	4.0	5.1	—
Glycolipids										
Expeller oil	Tr	1.4	4.5	36.3	22.5	22.7	—	5.6	6.9	—
Expeller cake oil	0.3	6.2	5.1	38.1	21.3	17.1	—	5.5	6.3	—
Rotary oil	—	2.5	6.3	44.6	19.0	20.9	Tr	2.3	4.5	—
Rotary cake oil	—	6.0	6.0	46.7	17.6	16.1	—	3.8	3.8	—

[a]Also contains 20:0 (0.1 to 1.0%).

or higher rate of synthesis of 1,2-DAG than 1,3-DAG as the biochemical pathway suggests (21). Rotary cake oil also recorded the highest MAG content (7.0%). Significant amounts of FFA in the cake oils can be due to the possibility of lipolysis of glycerolipids (19,20). Contrary to the observation in other edible oils, the PL content was less than 0.04% (22), except in the expeller cake oil. This may be due to inorganic phosphates, as found in palm oils (23). GL predominated over the PL. Higher level of GL in cake oils can be due to the better solubility of GL in the extracting solvents (24).

Fatty acid composition (Table 3). Fatty acid composition of TAG resembled that of the total oil because TAG is the major constituent of coconut oil. The characteristic coconut fatty acid, 12:0, constituted nearly one-half. Other major acids were 14:0 and 16:0. Unsaturated acids were less than 7.0%, and their proportion was relatively high in cake oils. The pattern of fatty acid distribution in 1,2-DAG and 1,3-DAG was different from that of TAG. The 12:0 in DAG was only one-third of that in TAG. Interestingly, it is reported that a "quantum mechanism" of TAG biosynthesis takes place in the coconut kernel (25) in which a glycerol moiety attached to a TAG synthesizing enzyme system is not released until all the three -OH groups are esterified. The TAG synthesis is most active during the latter stages of maturation, as is the production of 12:0 (26). Thus it may be explained that the 12:0 is almost quantitatively transferred to TAG, as observed in palm (*Elaeis guineensis*) oil (27). Another significant difference noted in the expeller cake oil was the intense roasted flavor. Fresh coconut has a mild flavor (28), whereas the high temperature produced during expelling causes a partial roasting which results in the formation of compounds responsible for the roasted flavor (29, 30).

ACKNOWLEDGMENT

Beena Symon and K.P. Padmakumari assisted in GLC analysis.

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[Received August 27, 1986]