Technical

Positional Distribution of the Fatty Acids in the Triglycerides of Mango (*Mangifera indica*) Kernel Fat

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ABSTRACT

Triglycerides of mango seed kernel fat contain, depending on the variety, 32.4–44.0% of stearic acid and 43.7–54.5% of oleic acid. Palmitic and linoleic acids represent, respectively, 5.9–9.1% and 3.6–6.7% of the fatty acids. The triglycerides also contain minor amounts of arachidic and linolenic acids. Palmitic, stearic and arachidic acids were almost exclusively distributed among the *sn*-1- and *sn*-3-positions. Oleic acid represented 85–89% of the fatty acids at the *sn*-2-position. Oleic acid at the *sn*-1- and *sn*-3-positions showed a preference for the *sn*-1-position. Linoleic acid was mainly esterified at the *sn*-2-position. The amounts of saturated fatty acids, i.e., palmitic and stearic acids, and of oleic acid, at the *sn*-1- and *sn*-3-positions, were linearly related to their respective contents in the total triglycerides.

INTRODUCTION

Mango fruit is widely cultivated in subtropical and tropical regions where it is as popular as the apple in the moderate regions. In 1978 the mango world production was 13.8 million tons of which 9.7 million tons were produced in India and Pakistan (1).

The industrial processing of mango fruit leaves a considerable amount of stones, which represents up to 25% of the weight of the fruit and which goes to waste. Recent work on the processing of mango stones shows that the fat, extracted from the mango kernel by solvent extraction, is edible. This fat is characterized by a high stearic and oleic acid content and a melting point of 40 C. It has been estimated that in India alone, 30,000 tons of mango seed fat could be industrially obtained each year (2,3).

Little investigation has been done on the composition of the mango kernel fat. We therefore studied the kernel fat of different mango varieties grown in Zaïre and report herein the positional distribution of the fatty acids within the triglycerides of this fat.

MATERIALS AND METHODS

The stones of ripe mango fruits of the varieties Amini, Gedong, Gedong Gilletii, Golock, Haden, M'Vuazi I, M'Vuazi II, M'Vuazi III and M'Vuazi IV were obtained from the Agricultural Research Centre of M'Vuazi, Zaïre. The varieties M'Vuazi II and M'Vuazi III were obtained from the variety Haden by selection. All other varieties were obtained from different cultivars. In the laboratory, the kernels were drawn out of the stones and lyophylized in a Lyolabo apparatus (Secfroid, Lausanne, Switzerland).

The lyophylized kernels were extracted with chloroform/methanol (2:1 v/v) as described by Folch et al. (4). The triglycerides were isolated from the crude fat by preparative thin layer chromatography (TLC) on Silica Gel G with petroleum ether (40-60 C)/diethyl ether/acetic acid (80:20:1, v/v/v).

The positional distribution of the fatty acids within the triglycerides was determined as described by Brockerhoff (5). Briefly, the triglycerides were hydrolyzed with pancreatic lipase (Steapsin, Sigma Chemical Co., St. Louis, MO) and the degradation products were separated by TLC. The diglycerides were converted to phosphatidylphenol with phenyldichlorophosphate. The synthetic phosphatidylphenol was hydrolyzed with phospholipase A_2 from the venom of *Crotalus atrox* (Sigma).

The lipids were converted to methyl esters with methanol using sulfuric acid as a catalyst. A Hewlett-Packard F&M 5750 gas chromatograph equipped with 2 stainless steel columns (6 ft x 3 mm id) packed with 10% SP-2330 on 100/200 mesh Chromosorb WAW (Supelco, S.A., Crans, Switzerland) was used for the separation of the fatty acid methyl esters.

The fatty acids incorporated at position 1 were obtained from the composition of the lyso-*sn*-1-acyl-3-phosphatidylphenol. Position 2 was given by the *sn*-2-monoglycerides fraction isolated after degradation of the triglycerides with Steapsin. Position 3 was calculated as 2 x *sn*-2,3-diacyl-1-phosphatidylphenol–*sn*-2-monoglycerides (method I) and from 3 x triglycerides–*sn*-2-monoglycerides–lyso-*sn*-1-acyl-3-phosphatidylphenol (method II). The mean differences between the *sn*-3 fatty acid percentages calculated by the 2 methods for each fatty acid of all varieties are presented in Table I.

RESULTS AND DISCUSSION

The triglycerides of mango seed kernel fat contain mainly stearic and oleic acids, which represent together ca. 85% of the fatty acids. The remaining fatty acids are palmitic, linoleic, linolenic and arachidic acids.

The distribution of the fatty acids among the 3 hydroxyl groups of the glycerol moiety of the triglyceride molecules is shown in Table II. The saturated fatty acids, i.e., pal-

TABLE I

Differences between the Fatty Acid Percentages for the *sn*-3-Position of the Glycerol Moiety of the Triglycerides Calculated by Methods I & II

Fatty acid	Difference (mole %)		
	Mean	Range	
16:0	1.04	-1.6	1.8
18:0	0.56	-2.3	2.4
18:1	-1.37	-2.5	1.2
18:2	-0.46	-1.8	1.0
18:3	0.41	-1.0	0.6
20:0	-0.29	-0.7	0.3

TABLE II

Positional Distribution of Fatty Acids in Mango Kernel Triglycerides

Variety	Compound and position	Fatty acids (mole %)					
		16:0	18:0	18:1	18:2	18:3	20:0
Amini	TG	6.7	44.0	43.7	3.6	0.5	1.5
	1	11.0	57.1	29.3	1.7	—	0.9
	2	0.6	1.1	89.8	8.0	0.5	—
	3	8.5	73.8	12.0	1.1	1.0	3.6
Gedong	TG	7.8	34.0	51.1	4.9	0.7	1.5
	1	12.8	48.7	33.7	2.7	0.5	1.6
	2	—	0.8	88.9	9.0	1.3	—
	3	10.6	52.5	30.7	3.0	0.3	2.9
Gedong Gilletii	TG	8.7	37.5	46.6	5.5	0.4	1.3
	1	11.9	53.6	30.2	3.1	—	1.2
	2	0.4	1.3	86.2	11.3	0.8	—
	3	13.8	57.6	23.4	2.1	0.4	2.7
Golock	TG	8.0	32.6	50.8	6.7	0.6	1.3
	1	13.3	44.4	36.2	4.3	0.4	1.4
	2	—	0.6	85.2	12.9	1.3	—
	3	10.5	52.9	31.2	2.9	—	2.5
Haden	TG	7.8	36.2	49.5	4.9	0.3	1.3
	1	12.9	49.6	34.2	2.6	—	0.7
	2	—	0.7	86.8	11.7	0.8	—
	3	10.2	58.5	27.7	0.4	—	3.2
M'Vuazi I	TG	7.6	38.6	47.2	4.3	0.7	1.6
	1	11.1	57.6	28.5	1.7	—	1.1
	2	0.4	1.4	87.8	9.8	0.6	—
	3	11.3	56.8	25.3	1.4	1.5	3.7
M'Vuazi II	TG	5.9	32.4	54.5	5.5	0.5	1.2
	1	10.3	45.5	40.9	2.6	0.2	0.5
	2	0.3	1.0	86.6	11.0	1.1	—
	3	7.1	50.7	36.0	2.9	0.2	3.1
M'Vuazi III	TG	7.6	32.7	53.4	4.6	0.6	1.1
	1	12.7	47.2	38.1	1.6	—	0.4
	2	0.4	1.5	88.3	9.2	0.6	—
	3	9.7	49.4	33.8	3.0	1.2	2.9
M'Vuazi IV	TG	9.1	35.7	48.2	4.8	0.6	1.6
	1	12.7	52.8	31.6	1.7	—	1.2
	2	0.5	1.2	86.3	11.0	1.0	—
	3	14.1	53.1	26.7	1.7	0.8	3.6

mitic, stearic and arachidic acids, are, as has been found for other plant triglycerides, almost exclusively incorporated at the outer positions of the glycerol backbone of the triglycerides (6). Arachidic acid is asymmetrically distributed between positions 1 and 3; an excess is located at position 3. A similar asymmetrical incorporation of arachidic acid has previously been reported for peanut oil and cacao butter triglycerides (7). Oleic and linoleic acids are mainly incorporated at the *sn*-2-position. The amount of oleic and linoleic acids found at position 2 agreed fairly well with the theoretical amounts for both acids as predicted by the Evans hypothesis, assuming that the saturated fatty acids are equally distributed among the *sn*-1- and *sn*-3-positions and that the remaining places are proportionally filled by oleic, linoleic and linolenic acids (8).

The amounts of the saturated fatty acids (palmitic and stearic acids) and oleic acid, incorporated at the *sn*-1- and *sn*-3-positions, were linearly related to their respective content in the total triglycerides (Fig. 1). These findings, however, have to be considered with caution because of the relatively small differences in fatty acid composition of the mango kernel triglycerides. The variety Amini was excluded from the calculation because the positional distribution of the fatty acids within the triglycerides of this variety was obviously different from the other varieties. This has been observed for the triglycerides of the kernel fat of the variety Amini obtained from the crops of 2 successive years.

de la Roche et al. (9) and Fatemi and Hammond (10), who respectively described the positional distribution of the fatty acids within the triglycerides of different strains of maize and soya, also reported the positional distribution of some strains deviated from the general pattern. This

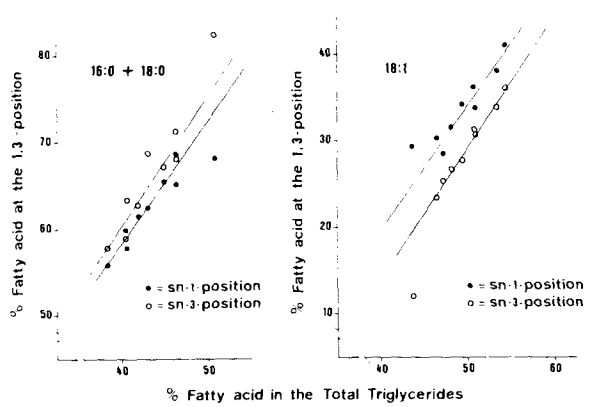

FIG. 1. Relationship between the percentages of the saturated fatty acids (palmitic and stearic acids) and of oleic acid at the *sn*-1- and *sn*-3-positions of the glycerol moiety of the triglycerides and the contents of each of these acids in the total triglycerides. Linear regressions: *sn*-1-position, 16:0 + 18:0:y = 1.40x + 2.13; 18:1:y = 1.40x - 35.93; *sn*-3-position, 16:0 + 18:0:y = 1.54x - 0.95; 18:1:y = 1.51x − 46.50.

indicates that there is, within each species, more than one mechanism responsible for the distribution of the fatty acids among the 3 positions of the glycerol molecule.

From this study and from previously reported stereospecific analyses of the triglycerides of maize (9), soya (10) and peanut oil (11,12), it may be stated that within a given species, the amount of a certain fatty acid incorporated at the different positions of the glycerol moiety of the triglycerides is related to the content of this fatty acid in the oil. The oils examined in these studies were obtained from mature seeds and therefore contain triglycerides synthesized during the development of the seeds and during the period in which the fatty acid composition of the oil of the seeds changes (13,14). It will therefore be of interest to investigate whether the mechanism responsible for the placement of the fatty acids on the 3 positions of the glycerol molecule retains its specificity during the development of the oilseeds (15).

REFERENCES

1. FAO Production Yearbook Vol. 32, edited by Food and Agriculture Organization of the United Nations, FAO Statistics Series No. 22, Rome, Italy, 1979, p. 177.
2. Ikramul Haq, M.Y., and A.F.M. Ehteshamuddin, Sci. Ind. 8:207 (1971).
3. Narasimha Char, B.L., B.R. Reddy and S.D. Thirumala Rao, JAOCS 54:494 (1977).
4. Folch, J., M. Lees and G.H.S. Stanley, J. Biol. Chem. 226:497 (1957).
5. Brockerhoff, H., in "Methods in Enzymology," edited by J.M. Lowenstein, Vol. 35-Part B, Academic Press, New York, 1975, pp. 315-325.
6. Litchfield, C., Fette, Seifen, Anstrichm. 75:223 (1973).
7. Brockerhoff, H., and M. Yurkowski, J. Lipid Res. 7:62 (1966).
8. Evans, C.D., D.G. McConnell, G.R. List and C.R. Scholfield, JAOCS 46:421 (1969).
9. de la Roche, I.A., E.J. Weber and D.E. Alexander, Lipids 6:531 (1971).
10. Fatemi, S.H., and E.G. Hammond, Ibid. 12:1032 (1977).
11. Sanders, T.H., Ibid. 14:630 (1979).
12. Van Pee, W., J. Van Hee, L. Boni and A. Hendrikx, JAOCS 56:901 (1979).
13. Young, C.T., M.E. Mason, R.S. Matlock and G.R. Waller, Ibid. 49:314 (1972).
14. Roehm, J.N., and O.S. Privett, Lipids 5:353 (1970).
15. Weber, E.J., Ibid. 8:295 (1973).

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Destruction of Zearalenone in Contaminated Corn[1]

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ABSTRACT

Several chemical and physical treatments were investigated as possible methods for destroying zearalenone in contaminated corn. An ammoniation process which significantly lowers aflatoxin levels had no effect on zearalenone contamination in yellow corn. Also, treatments of propionic acid, acetic acid, hydrochloric acid, sodium bicarbonate and hydrogen peroxide failed to reduce toxin levels. High-temperature treatment (150 C) had no effect on zearalenone. Formaldehyde, in vapor form from paraformaldehyde crystals or in aqueous solutions, destroyed significant quantities of zearalenone in naturally contaminated yellow corn meal and in spiked corn grits and animal feed. Samples treated with aqueous formaldehyde must be dried at 50 C or more to cause effective destruction of zearalenone. Levels as high as 10 ppm zearalenone in animal feed and 8 ppm in ground corn were reduced to less than 0.5 ppm with formaldehyde. Ammonium hydroxide and formaldehyde partially destroyed zearalenone in highly contaminated ground corn. Levels as high as 33.5 ppm were reduced to 12 ppm by 3% ammonium hydroxide and to 2.1 ppm by 3.7% formaldehyde. No treatment used in this study significantly reduced zearalenone levels in whole-kernel corn.

INTRODUCTION

Zearalenone (Fig. 1), a secondary metabolite with estrogenic properties, is produced by some *Fusarium* species that colonize several cereal grains in the field and in storage. If grain infected with *Fusarium roseum* "Graminearum" is stored under conditions of high moisture (>23%) and warm days followed by cold nights, large amounts of zearalenone may be produced. When such grain is fed to animals, especially swine, a hyperestrogenic condition known as "estrogenic syndrome" (1) has been produced. Zearalenone has been detected in corn, wheat, sorghum, barley, sesame meal, oats, hay and commercial animal feeds. This toxin has been detected in cereal grains in several countries througout the world and high levels of contamination have been documented (2,3). Reviews on the chemistry of zearalenone and its derivatives (4,5) have been published; however, limited information is available on procedures or methods to inactivate zearalenone in contaminated cereal grains. This paper reports our initial efforts to destroy zearalenone and thus, detoxify contaminated corn or corn products.

EXPERIMENTAL PROCEDURES

Preliminary Tests

Initially, pure crystalline zearalenone was added to white corn grits (Quaker Quick Grits) to give toxin levels of 3.0

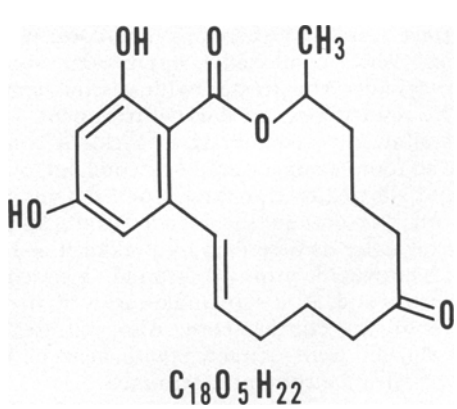

FIG. 1. Structure of zearalenone-6-(10-hydroxy-6-oxo-*trans*-1-undecenyl)-β-resorcyclic acid lactone.

[1] Presented at the AOCS meeting, San Francisco, April 1979.