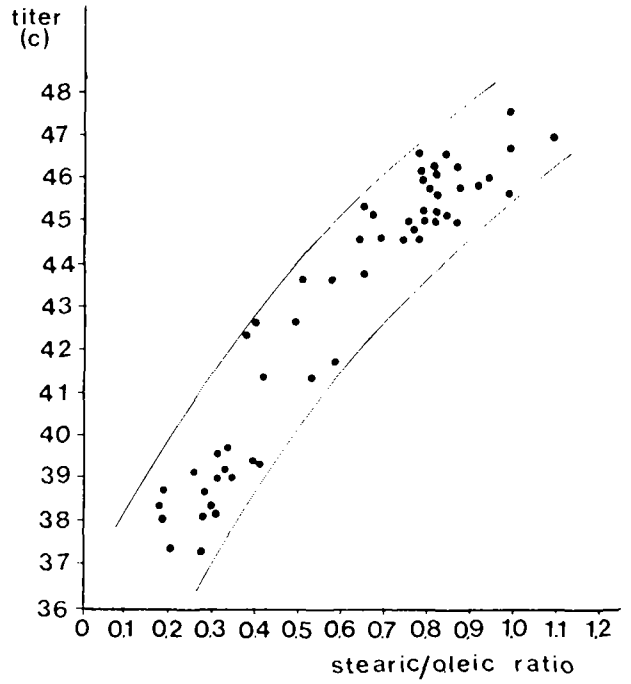

FIG. 2. Effect of stearic/oleic ratio on the titer of beef tallow.

Titers and percentages of the main fatty acids of 60 Uruguayan commercial beef tallows are summarised in Table I. Titers were determined with a method similar to AOCS method Cc 12-59. Fatty acid composition was determined by gas liquid chromatography as their methyl esters on SP-2330 10% (AOCS method Ce 2-66 and Ce 1-62).

Linear relationships were found. The straight line equations were obtained by means of the least squares approximation:

Myristic (%) = -0.03 (titer) + 4.1
Palmitic (%) = -0.20 (titer) + 34.3
Palmitoleic (%) = -0.54 (titer) + 28.2
Stearic (%) = 2.30 (titer) − 75.5
Oleic (%) = -1.53 (titer) + 107.0
Linoleic (%) = 0.03 (titer) + 0.6

Little change is found in the myristic, palmitoleic and linoleic percentages as the titer varies. The values for palmitic, stearic and oleic acids are plotted in Figure 1.

A progressive increase was found in titer with an increase in the stearic/oleic ratio (Fig. 2).

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Nutritional and Toxicological Evaluation of Mango Kernel Oil

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ABSTRACT

Mango-kernel fat is a solid fat at room temperature and has a melting point of ca. 35 C. The fat was analyzed for its physico-chemical properties. It is rich in equal amounts of stearic and oleic acids (42%). Nutritional and toxicological evaluation of this fat was carried out by multigeneration breeding studies in weanling albino rats, feeding them mango-kernel fat or groundnut oil (GNO) at a 10% level in a 20% protein diet that was adequate in vitamins and minerals. The feed-efficiency ratio and growth rate of rats fed mango-kernel fat were comparable with the control group. Studies of calcium, phosphorous and nitrogen balance showed that the retention of these nutrients was not adversely affected by the mango-fat intake. The apparent digestibility of mango fat was comparable with GNO when fed to rats. Toxicological evaluation of the fat showed a comparable reproductive performance with the GNO-fed animals. Liver serum total cholesterol, triglycerides and total lipids were found to be within normal levels. The organ weights of the various tissues of the animals of both groups in the last generation were comparable. Histopathological studies of various organs revealed no abnormalities. These studies indicate that mango-kernel fat can substitute for any solid fat without adverse effect.

INTRODUCTION

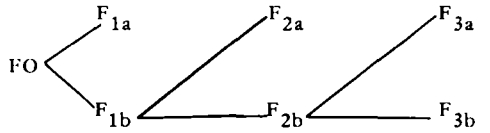
In India, interest in developing new sources of oils and fats has grown. The main reason is the acute shortage of traditional edible oils. Hence, a large variety of unconventional oils, obtained from widely grown plants, were screened to find out whether they were usable for edible purposes. Studies on *H. Sabdariffa* oil and *cleome viscosa* oil have been reported (1) from these laboratories.

Cocoa-butter fat, which is not produced in India, is much valued for its use in the confectionery and bakery industries. Cocoa-butter fat is a unique, naturally occurring fat and has a chemical composition of monounsaturated glycerides (MU) and diunsaturated glycerides (DU) with palmito-oleo-stearin as a dominant glyceride (2). It is solid at room temperature and has a melting point of ca. 36 C. These physical and chemical properties are essential for a fat used in the confectionery or bakery industry. In certain countries, such as Malayasia, a cocoa-butter substitute named "Coberine" is prepared from palm oil by suitable

technology. India is rich in a number of indigenous fats with high MU and DU and low linoleic acid. Among them, sal (*Shorea robusta*), kokum (*Garcina Indica*) and mango (*Mangifera Indica*) fat have received great attention as they are plentiful.

India produces 7-8 million tons of mangoes every year. Mango-kernel has a fat content of 6-12% on the basis of dry kernels. Hence, India has the Potential to produce 30,000 tons of mango-kernel oil (MKO) annually (3). Processed mango fat is obtained by solvent extraction and acetone fractionation at a low temperature to segregate solid fractions that have physical properties close to those of cocoa-butter fat (4). Mango fat is a cream-colored solid at room temperature, melting at 35 C. The Indian Standard Institute has laid down specifications of 3 grades of mango fat refined-for edible consumption, raw grade I-for hydrogenated vegetable oil (vanaspathi) and raw grade II - for soap (5). The enriched kernel strach is used as a sizing material and an animal feed (6). The processed mango fat has been studied for its effects on blood lipids and lipoproteins in rats (7).

No studies had been conducted so far on the nutritional quality and toxicological safety of mango fat. Thus, a systematic study was undertaken, using the protocol followed in the study of *H. Sabdariffa* and *cleome viscosa* oils reported from these laboratories (1).



Scheme I. Propagation of rats fed experimental diets.

EXPERIMENTAL PROCEDURE

Refined and bleached MKO was obtained in bulk from M/s. K.N. Oil Mills, Mahasumundi, Madhya Pradesh (India) for the experiment.

The physico-chemical constants of the oil were determined by conventional methods (8). The fatty acid composition of the MKO methyl ester was determined by using gas liquid chromatography (GLC) (650 -Aerograph) on 15% DEGS column on chromosorb-W; 45-60 mesh and a flame ionization detector (FID). GNO was used as the standard. Separations were carried out isothermally at 200 C and the peak concentrations were calculated by triangulation.

Nutritional and Toxicological Evaluation

Nutritional and toxicological evaluations of MKO were carried out by feeding a diet containing 10% MKO or GNO, in 20% protein, with adequate vitamins (9a) and minerals (9b) to 15 male and 15 female weanling, albino rats of the wistar strain for 22 weeks. Weekly body weights and food intake were recorded. The feed-efficiency ratio was calculated from this data. Multigeneration breeding studies in rats were done exactly as described for mesta oil and cleome oil (Scheme 1) (1). The apparent digestibility of the oil was calculated by the oil intake and the oil excreted through the urine and feces. At the end of the third generation, the liver and serum total lipids, total cholesterol (10) and triglycerides (11) were estimated. The animals were transferred to metabolic cages for 7 days and the excreta collected. Nitrogen, calcium and phosphorous (12) in the diets, urine

TABLE I

Physico-chemical characteristics of mango-kernel fat	
Melting point	34.5 C
Acid value	0.28
Iodine value	48.9
Saponification value	190.4
Unsaponifiable fraction	7.4%

Fatty acid profile of mango-kernel fat by GLC	
Fatty acid	Percentage
14:0 (Myristic)	0.2
16:0 (Palmitic)	7.6
18:0 (Stearic)	41.1
18:1 (Oleic)	42.77
18:2 (Linoleic)	7.7
18:3 (Linolenic)	0.4

TABLE II

Growth Performance of Rats Fed 10% GNO or MKO Over 3 Generations

	Gain in body weight in g over 22 weeks (15F + 15M)				FER[a] (Weight gain)/(Food intake) X 100	
	GNO		MKO			
Generations	Males	Females	Males	Females	GNO	MKO
I F_0	335.67 ± 10.09	207.00 ± 16.09	267.67 ± 44.17	148.00 ± 2.65	15.48 ± 3.82	16.33 ± 0.3
II F_1	288.67 ± 21.93	191.67 ± 13.04	300.67 ± 8.51	160.87 ± 10.4	18.48 ± 3.82	21.08 ± 1.85
III F_2	288.67 ± 20.22	177.33 ± 4.98	296.25 ± 22.4	172.67 ± 18.35	22.65 ± 4.9	21.08 ± 3.1

[a]FER = Feed efficiency ratio = body weight gain/food intake X 100.
Values are mean ± SEM.

TABLE III

Nitrogen, Calcium and Phosphorous Retention in Rats

Fat in the diet	Fat absorption %	Intake/week/rat mg	Retention %	Intake/week/rat mg	Retention %	Intake/week/rat mg	Retention %
GNO	98.62	2260	50.55	70.77	43.79	118.95	69.4
MKO	98.06	2240	43.75	66.82	34.07	98.55	65.5

TABLE IV

Reproductive Performance of Rats (12M + 12 F) Fed 10% GNO or MKO in 3 Generations

Parameters	First generation F_0				Second generation F_{1b} adults				Third generation F_{2b} adults			
	First mating		Second mating		First mating		Second mating		First mating		Second mating	
	F_{1a}		F_{1b}		F_{2a}		F_{2b}		F_{3a}		F_{3b}	
	GNO (12)	MKO (12)	GNO (12)	MKO (12)	GNO (12)	MKO (12)	GNO (12)	MKO (12)	GNO (12)	MKO (12)	GNO (12)	MKO (12)
Percentage of conception%	100	100	100	100	100	100	100	100	100	100	100	100
Mean litter size	9.4 ± 0.71	9.58 ± 0.61	9.25 ± 0.33	6.41 ± 6.21	9.61 ± 0.66	10.01 ± 1.08	10.85 ± 1.20	10.46 ± 6.41	9.41 ± 3.41	10.9 ± 2.86	8.83 ± 0.12	9.54 ± 3.01
Mean birth weight	5.2 ± 0.01	5.10 ± 1.05	5.03 ± 0.17	5.10 ± 1.02	5.10 ± 0.98	5.70 ± 1.31	5.21 ± 1.62	5.45 ± 1.00	5.10 ± 0.86	5.13 ± 0.23	4.90 ± 1.40	5.14 ± 1.62
Mean weanling weight (21 days)	18.4 ± 0.98	22.20 ± 1.80	25.60 ± 1.46	25.90 ± 7.10	30.10 ±10.50	25.60 ± 1.20	37.50 ±11.14	33.60 ±12.78	26.50 ± 0.80	22.05 ± 2.40	27.90 ± 1.61	25.50 ± 1.23
Mean days for delivery from the time of mating	27.0 ± 0.34	27.00 ± 0.41	26.70 ± 0.33	27.50 ± 0.21	26.70 ± 0.81	26.70 ± 0.54	25.60 ± 0.34	25.80 ± 0.33	27.00 ± 0.73	25.00 ± 0.93	28.00 ± 0.65	25.40 ± 0.60
Preweanling mortality	10.62	13.04	17.10	19.40	2.72	2.63	1.53	Nil	9.7	6.6	8.4	6.6

M = Males: F= Females. Values are mean ± SEM. Number in parentheses is number of animals.

TABLE V

Total Cholesterol, Triglycerides and Lipid Content of Serum and Liver of Rats Fed 10% GNO or MKO: Mean (12M + 12F) at the End of the Study (F_{2b} Adults)

Fat	Total cholesterol		Total lipids		Triglycerides	
	Serum mg/100 ml	Liver mg/100 g	Serum mg/100 ml	Liver g/100 g	Serum g/100 ml	Liver mg/100 g
GNO	75.05 ± 2.50	189.50 ± 7.45	0.58 ± 0.01	5.01 ± 0.03	111.13 ± 13.15	29.31 ± 2.12
MKO	74.55 ± 2.43	180.62 ± 8.61	0.62 ± 0.01	5.20 ± 0.025	155.14 ± 14.22	29.74 ± 2.17

Values are mean ± SEM. M = males: F = females. Numbers in parentheses are number of animals.

TABLE VI

Mean Organ Weights of Rats Sacrificed at the End of Each Generation Expressed as the Percentage of Body Weights (12M + 12F in Each Group)

Organs	First generation (F_0)		Second generation (F_{1b})		Third generation (F_{2b})	
	GNO	MKO	GNO	MKO	GNO	MKO
Liver	3.1 ± 0.092	3.44 ± 0.137	4.59 ± 0.22	4.81 ± 0.29	3.49 ± 0.11	3.77 ± 0.09
Kidney	0.573 ± 0.016	0.6591 ± 0.025	0.69 ± 0.02	0.70 ± 0.02	0.64 ± 0.02	0.64 ± 0.09
Lungs	0.47 ± 0.03	0.6 ± 0.06	0.34 ± 0.024	0.34 ± 0.02	0.54 ± 0.05	0.42 ± 0.017
Spleen	0.20 ± 0.009	0.21 ± 0.018	0.21 ± 0.009	0.21 ± 0.006	0.213 ± 0.01	0.184 ± 0.009
Heart	0.28 ± 0.012	0.36 ± 0.013	0.29 ± 0.015	0.34 ± 0.017	0.38 ± 0.01	0.30 ± 0.01
Testes	0.79 ± 0.03	0.87 ± 0.04	0.81 ± 0.05	0.79 ± 0.03	0.85 ± 0.02	0.85 ± 0.05
Ovaries	0.22 ± 0.010	0.24 ± 0.01	0.23 ± 0.01	0.26 ± 0.01	0.29 ± 0.01	0.20 ± 0.01
Pancreas	0.44 ± 0.039	0.49 ± 0.038	0.52 ± 0.02	0.59 ± 0.04	0.35 ± 0.01	0.339 ± 0.02
Thymus	—	—	0.14 ± 0.004	0.27 ± 0.05	0.076 ± 0.005	0.074 ± 0.003

Values are mean ± SEM.

and feces were estimated. The percentage of retention of each nutrient was calculated from this data.

Reproductive performance was assessed by parameters – percentage of conception, mean litter size, mean birth weight, mean weanling weight, preweanling mortality and mean number of days taken to deliver from the date of mating. Organ weights, e.g., livers, spleens, lungs, hearts and testes or ovaries of the animals at each point of sacrifice were determined and expressed as the percentage of their body weights. The above tissues were fixed in 10% buffered neutral formalin and sections were cut at 6 μ and stained with haematoxylin eosine and examined under light microscope.

RESULTS AND DISSCUSSION

The physico-chemical characteristics and the fatty acid profile of MKO used in the experiment are represented in Table I. The oil is rich in equal amounts of stearic and oleic acids and low in linoleic acid (7.7%). The fat melts at 34.5 C. The Nutritional quality of the mango-kernel fat, as assessed by the growth performance and feed-efficiency ratio, is presented in Table II. The GNO-fed males and females of the first generation gained more weight than the corresponding MKO-fed animals although the gain was not statistically significant. But in the second and third generations the animals seemed to catch up with the GNO group, as seen in the Table II. The feed-efficiency ratio of MKO-fed animals was comparable with the corresponding GNO group. Table III represents the absorption of the fat and the retention of nitrogen, calcium and phosphorous. The data compares very well with the control group, showing the the fat intake did not adversely affect the absorption or use of these nutrients. Sundaravalli et al. (13) had similar results when feeding 10% sal fat in the diet. Table IV represents the reproductive performance of MKO or GNO fed animals over 3 generations and each generation at 2 matings. As judged by the parameters – percentage of conception, mean litter size, mean birth weight, mean weanling weight, preweanling mortality and mean number of days taken for delivery from the day of mating – they are essentially the same in both the groups, indicating that MKO contributes to as good a reproductive performance as the GNO group.

Table V represents the serum and liver lipid profile at the end of the third generation. Serum and liver total cholesterol and total lipid levels are alike in MKO- and GNO-fed animals. Serum triglycerides of MKO-fed rats showed a slight elevation (155.14 ± 14.22) in absolute values over the GNO group (111.13 ± 13.14), but the difference is not statistically significant. The liver triglycerides are alike in both the groups.

The organ weights of the various tissues of the animals sacrificed at the end of each generation did not show any significant difference between the 2 groups (Table VI). Histopathological examination of their tissues, e.g., heart, liver, kidney, lungs and spleen, did not reveal any abnormal findings in any of the groups.

Thus, this study suggests that MKO in the diet has a good nutritional value, is toxicologically safe and probably can replace cocoa-butter fat in the confectionery industry. Studies reported on the MKO liver-lipid profile (7) also supports our findings.

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