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Fatty acid composition of serum and tissue lipids in male Indian desert gerbils (*Meriones hurrianae*; Jerdon) and Wistar rats

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Introduction

Using albino rats extensive biochemical data have been generated even though all these data can not be extrapolated to human beings. There are striking differences between rats and humans with respect to metabolic pathways *(Suckling & Jackson 1993)*. This is particularly true with regard to lipid metabolism where differences occur in long chain polyunsaturated fatty acids and fatty acid composition of cholesterol esters which play a very important role in cardiovascular diseases *(Swell et al. 1960)*. Some animal models such as rabbits, guinea pigs, pigs and monkeys are used for studies of atherosclerosis because of some similarities in lipid composition and metabolism. The serum lipids in rats contain higher proportions of arachidonic acid as compared to that of humans *(Wood et al. 1993, Purushothama et al. 1994, Vijaya Kumar et al. 1999)*. Several attempts have been made to use Mongolian gerbils *(Meriones unguiculatus)* in studies of lipid metabolism *(Robinson 1980, Mercer & Holub 1979, Temmermanet al 1988 ,1989)*. Over the last 14 years our Institute has maintained a colony of outbred Indian desert gerbils *(Meriones hurrianae;* Jerdon*)* which has now been listed in the International Index of Laboratory Animals *(Festing, 1993)*. Haematological and biochemical base line data, feeding habits together with details of breeding and husbandry have been reported earlier *(Saibaba et al. 1988, 1992, 1994, 1995)*. The Indian desert gerbils differ from albino rats having a smaller body size, pigmented skin colour and gall bladder. Little information is available on fatty acid composition of serum and tissue lipids in Indian desert gerbils.

The present investigation examined lipid profiles of serum and together with fatty acid composition of total lipids, and various lipid fractions of serum and different organs i.e., liver, heart, kidney and testes. The results obtained for Indian desert gerbils were compared with that of albino rats.

Materials and methods

Animals

Male Indian desert gerbils *(Meriones hurrianae;* Jerdon) {outbred-Indian Desert Gerbil, IND-Cft [2c]} weighing about 69±4.7g (6 weeks old; n=7 per group) and male albino rats of Wistar strain {outbred-Wistar, IND-Cft[2c]} weighing 160±11.8g (6 weeks old; n=7 per group) maintained in the Central Food Technological Research Institute animal house were used. Rats were housed individually while gerbils were housed in pairs in sterilized standard polypropylene cages (size 410 X 280 X 150 mm) with stainless steel top grill having facilities for keeping pelleted feed and water in glass bottles. Clean paddy husk and river sand supplied by a local contractor were used as bedding materials and changed twice a week. Paddy husk and sand were free from extraneous matters, dust and stones. Normal environmental conditions maintained throughout the studies were as follows: Temperature: 25.0 ± 2°C; lighting: 12h L (6.00 AM - 6.00 PM) and 12h D, relative humidity: 50-60%. Animals were provided with pelleted feed

(Krishnakumari et al. 1989) and water (protected Municipal tap water) ad libitum. The feed was supplemented with 1% vitamin mix *(Chapman et al. 1959)* and 2% mineral mix *(Hubbel et al. 1937)*. The pelleted feed provided 17% protein, 11.3% fat, 68.7% carbohydrate. The major fatty acid composition of the diet are palmitic acid (C16:0) 11.6%, stearic acid (C18:0) 1.6%, oleic acid (C18:1) 30.0%, linoleic acid (C18:2) 49.8%, linolenic acid (C18:3) 1.8%, eicosapentaenoic acid (C20:5) 0.56% and docosahexaenoic acid (C22:6) 0.45% . The health status was routinely monitored by a qualified veterinarian and Animal welfare officer, Government of India. All the animals maintained good health. They were also routinely screened for pathogens which were found to be absent. Animals were also free from zoonotic diseases.

Blood and tissue sampling

After 4 weeks, the animals were starved for 16h, and sacrificed under ether anesthesia. Blood was collected from heart by inserting 18G needle attached to a 10mL syringe. Serum was obtained by centrifuging the blood at 600 X g for 15 minutes at 4^0C in a table top refrigerated centrifuge (Hermle Z 360k, Berthhold Hermle, Gosheim, Germany). Various organs were immediately removed, washed thoroughly with cold saline, blotted, weighed and stored at -20^0C prior to analysis.

Analytical methods

Tissue lipids were extracted by the Bligh and Dyer procedure (1959). Total cholesterol was measured by the method of Zlatkis and Zak (1969) and free cholesterol was measured by the above procedure after precipitating free cholesterol with digitonin *(Sperry and Webb 1950)*. Phospholipids were estimated by using ferrous ammonium thiocyanate reagent according to Stewart (1980). Triglycerides were measured by the method described by Fletcher (1968). HDL cholesterol concentration was measured after precipitating LDL and VLDL by heparin and manganese chloride as described by Warnick and Albers (1978). Liver microsomes were prepared by the method as described by Kamp and Wirtz (1974). Protein was determined in liver microsomes according to Lowry et al. (1951) using bovine serum albumin as reference standard.

Phospholipids and cholesterol esters were separated on silica gel G thin layer chromatography plates using hexane: ether: acetic acid (80:20:1) (v/v) solvent system *(Wood 1973)*. The corresponding bands were detected by exposing the plates to iodine vapour and scraped from plates and extracted with chloroform: methanol (2:1) twice. The total lipids, phospholipids and cholesterol esters were saponified with 0.5N methanolic potassium hydroxide at 65^0C for 1 h. The fatty acids were methylated with boron trifluoride in methanol *(Morrison & Smith 1964)* and methylated fatty acids were analysed by gas liquid chromatography using Shimadzu 14B Gas chromatograph as described earlier by Bina Joe & Lokesh (1997).

Statistics

Statistical analysis of the results was carried out using student's t-test *(Snedecor & Cochran, 1967)*.

Results

The food efficiency ratio (FER) defined as gain in body weight per gram of food intake multiplied by a factor of 100 was comparable for Indian desert gerbils and Wistar rats (Table 1). While gerbils on an average consumed 9.3 g of diet per day, the rats consumed 13. 4g diet per day. The average intake of water per day per gram body weight of gerbils were 0.035 mL per day while that of rats were 0.04 mL per day. The liver weights relative to body weight were comparable between rats and gerbils. However the relative mean weights of heart, kidney and testes were lower by 44%, 48% and 64% respectively in gerbils as compared to that of rats.

Serum and liver lipid constituents

Total cholesterol in serum of gerbils was 18% lower compared to the values for rats (Table 2). Approximately 27% of total cholesterol in gerbils and 21% in rats exists as free cholesterol. Both rats and gerbils have higher levels of HDL as compared to LDL + VLDL and HDL levels in these species are comparable. However, gerbils

Table 1. Food efficiency ratio and organ weights of gerbil and rat

Parameter	Desert Gerbil	Wistar Rat
Initial body weight (g)	69.0±5.6	160.0±4.8
Gain in body weight after 4 weeks (g)	70.4±8.9	98.8±4.9
Food intake (g/day)	9.3±1.25	13.4±2.45
*Food Efficiency Ratio (FER)	27.2±1.8	26.3±0.8
Organ weights (g/100g body weight)		
Liver	2.67±0.23	2.60±0.13
Kidney	0.428±0.080[a]	0.824±0.054
Testes	0.541±0.060[a]	1.498±0.140
Heart	0.215±0.020[a]	0.385±0.021

Mean values of ±SD of 7 animals in each species
[a]p <0.001 as compared to that found in rats

$$\text{* Food efficiency ratio} = \frac{\text{Gain in body weight (g)}}{\text{food intake (g)}} \times 100$$

Table 2. Serum and liver lipid profile of gerbil and rat

Lipid constituent	Gerbil	Rat
SERUM (mg/dL)		
Cholesterol	50.30 ± 4.20[a]	60.20 ± 4.30
Free cholesterol	13.80 ± 2.19	12.80 ± 1.89
HDL cholesterol	30.90 ± 2.80	32.50 ± 2.10
LDL+VLDL cholesterol	19.40 ± 2.10[a]	27.70 ± 1.80
Phospholipids	98.10 ± 8.90[a]	73.40 ± 5.50
Triglycerides	76.90 ± 10.20	81.10 ± 8.20
LIVER (mg/g)		
Cholesterol	2.28 ± 0.23[a]	3.10 ±0.34
Phospholipids	15.40 ± 2.80[a]	21.40 ± 1.80
Triglycerides	3.80 ± 0.91	4.10 ± 0.76
Protein	180.10 ± 5.20	182.80 ± 6.50
Microsomal cholesterol		
(µg/mg protein)	20.70 ± 0.90[b]	17.60 ± 1.80
Microsomal Phospholipids	110.80 ± 5.20[c]	94.80 ± 12.60
(µg/mg protein)		
Cholesterol/phospholipid		
ratio in microsomes	0.187	0.185

Mean values of ±SD of 7 animals in each species
[a]p <0.001, [b]p <0.005, [c]p <0.01 as compared to that found in rats

had 30% lower amount of serum associated LDL + VLDL cholesterol as compared to that found in rats. There was no difference in triglyceride levels between species but phospholipids in serum were 34% higher in gerbils compared to rats. Total cholesterol and phospholipid levels in the liver of gerbils were 26 and 28% lower as found in rats. Triglycerides and protein levels in the liver of gerbils and rats were similar. Microsomal cholesterol concentration in gerbils was significantly higher compared to rats. However, the ratio of cholesterol to phospholipids in liver microsomal fraction of rats and gerbils were similar.

Fatty acid composition of serum lipids

Significant differences were observed in the polyunsaturated fatty acid (PUFA) levels of serum total lipids of rats and gerbils (Table3). Linoleic acid (18:2) levels were 46% higher, but arachidonic acid (20:4) levels were 66% lower in gerbil serum total lipids as compared to rats. While the ratio of 18:2 to 20:4 in rats was 1.15, it was 5.0 in gerbils indicating lower delta 6 desaturase activity which is responsible for conversion of linoleic acid to arachidonic acid. Palmitic acid level was lower by 19% in gerbils but oleic acid level showed 20% increase in gerbil total lipids as compared to rats. These trends in PUFA were also reflected in the phospholipid fraction of serum lipids to a lesser extent (Table 3) for linoleic and arachidonic acids. Differences in the PUFA levels of cholesterol esters were found in gerbils as compared to those found in rats. Linoleic acid levels were higher by 204% while arachidonic acid levels were lower by 98% in cholesterol ester fraction of gerbils as compared to those found in rats. The PUFA levels were significantly different in the total lipids and cholesterol ester fraction of gerbils as compared to those found in rats.

Fatty acid composition of liver lipid fractions

The total lipid fraction in gerbil liver showed 33% higher levels of oleic acid and 69% lower in levels of arachidonic acid compared to rats (Table 4). The phospholipid fractions of gerbil liver contained 62% higher level of linoleic acid and 45% lower level of arachidonic acid as compared to rats. Similarly in the cholesterol ester fraction, gerbils contained 27% higher levels of linoleic acid but a 75% lower level of arachidonic acid as compared to rats. While the percentage of arachidonic acid in gerbil liver cholesterol ester fraction is same as that found in the serum, the percentage of arachidonic acid in rat liver cholesterol ester fractions was 10 times lower than that found in serum fraction (Tables 3 and 4).

Total fatty acid composition of different organs

The fatty acid composition of total lipids from heart, kidney and testes were analysed in rats and gerbils (Table 5). The linoleic acid level was higher by 25 and 21% in gerbil heart and kidney respectively as compared to that found in rats. However, no major differences in fatty acid composition of lipids from testes of rats and gerbils were observed.

Discussion

The aim of the present investigation was to compare the lipid profiles of Indian desert gerbils and rats with a veiw to identify the similarities and also differences, if any, between the two species. It was also aimed at identifying closer similarities between gerbils and humans so that this animal model may be considered to generate data which may be extrapolatable to humans. Albino rats are most frequently used in biochemical research for generating data having a bearing on cardiovascular diseases, cancer, arthritis and other diseases of interest to mankind. Rats are also used in nutritional studies in evaluating safety aspects of food components, food additives, food contaminants and in toxicological studies. Even though very useful data have been generated from such studies which can be directly extrapolated to human situation, there are certain responses in which rats differ from that of humans *(Suckling and Jackson 1993)*. Lipid metabolism particularly that related to polyunsaturated fatty acids and alterations in cholesterol levels in serum in response to dietary factors differ significantly between rats and humans. This will impede research efforts when one intends to understand events leading to cardiovascular diseases in

Table 3. Fatty acid composition of total lipids, phospholipids and cholesterol esters in sera from gerbils and rats

Fatty acids (%)	Total lipids		Phospholipids		Cholesterol esters	
	Gerbil	Rat	Gerbil	Rat	Gerbil	Rat
C 14:0	0.68	0.72	0.21	0.87	0.51	1.60
	±0.02	±0.07	±0.01	±0.30	±0.03[a]	±0.27
C 16:0	16.40	20.40	16.90	19.00	16.30	15.20
	±1.60[a]	±1.40	±0.92	±1.00	±0.35	±0.97
C 16:1	2.40	nd	nd	0.64	nd	3.10
	±0.40			±0.29		±0.22
C 18:0	8.50	8.20	11.80	9.80	7.80	4.00
	±0.86	±1.30	±2.10	±1.10	±0.90[a]	±0.81
C 18:1	30.20	25.10	29.80	28.60	32.40	0.70
	±2.50[b]	±2.00	±1.30	±1.30	±0.41[a]	±0.42
C 18:2	34.00	23.30	31.40	26.80	38.70	12.70
	±1.80[a]	±1.60	±0.40[a]	±1.00	±1.50[a]	±0.52
C 18:3	0.40	0.46	1.30	1.68	1.86	0.62
	±0.04	±0.08	±0.06	±1.00	±0.17	±0.08
C 20:0	0.21	0.33	nd	nd	nd	nd
	±0.01	±0.05				
C 20:4	6.80	20.30	7.01	11.00	1.23	50.80
	±0.30[a]	±2.40	±0.15[a]	±0.90	±0.02[a]	±1.33
C 20:5	0.59	0.78	0.58	0.95	0.81	0.50
	±0.17	±0.03	±0.18	±0.15	±0.05	±0.08
C 22:6	0.56	0.60	0.88	0.69	0.29	0.72
	±0.07	±0.04	±0.07	±0.17	±0.07	±0.04
Ratio						
C:18:2 / C:20:4	5.00	1.15	4.43	2.43	31.40	0.25
Saturated (S)						
fatty acids %	26.0	29.7	28.9	30.0	24.6	20.8
Polyunsaturated						
fatty acid (P) %	42.4	45.7	40.0	41.1	42.9	65.1
P/S Ratio	1.63	1.54	1.38	1.37	1.75	3.13

Mean values ± S.D. of 7 animals in each species
[a]$p < 0.001$, [b]$p < 0.005$ as compared to that found in rats
nd - not detected

Table 4. Fatty acid composition of various liver lipid fractions of rat and gerbil

Fatty acids (%)	Total lipids		Phospholipids		Cholesterol esters	
	Gerbil	Rat	Gerbil	Rat	Gerbil	Rat
C 14:	0.36	0.60	nd	nd	0.97	1.89
	±0.03	±0.20			±0.08	±0.66
C 16:0	20.30	18.60	15.90	17.50	17.50	20.70
	±1.70	±1.30	±0.12[b]	±0.98	±1.30[b]	±1.70
C 16:1	nd	1.60	nd	nd	4.50	2.70
		±0.30			±0.80[b]	±0.02
C 18:0	5.40	5.00	13.20	15.20	7.10	5.90
	±2.20	±0.39	±0.29[b]	±1.20	±0.90	±0.60
C 18:1	34.00	25.60	23.80	20.90	38.30	40.10
	±1.60[a]	±0.79	±1.60[b]	±1.40	±1.00	±2.30
C 18:2	32.30	30.00	30.70	19.00	26.20	20.60
	±0.48[c]	±1.80	±1.04[a]	±1.80	±2.10[a]	±2.30
C 18:3	0.53	0.39	0.64	0.80	1.70	1.50
	±0.06	±0.13	±0.06	±0.07	±0.13	±0.03
C 20:0	0.31	0.24	nd	nd	nd	nd
	±0.02	±0.04				
C 20:4	5.24	17.10	13.90	25.30	1.40	5.50
	±0.80[a]	±2.10	±0.08[a]	±1.80	±0.35[a]	±0.92
C 20:5	0.77	0.62	0.37	0.74	0.65	0.40
	±0.07	±0.14	±0.07	±0.07	±0.09	±0.10
C 22:6	0.84	0.80	0.55	0.71	0.66	0.53
	±0.11	±0.06	±0.19	±0.17	±0.04	±0.19
Ratio						
C 18:2 / C 20:4	6.16	1.75	2.21	0.75	18.70	3.74

Mean values ± S.D. of 7 animals in each species
[a]p <0.001, [b]p <0.005, [c]p <0.01 as compared to that found in rats
nd - not detected

Table 5. Fatty acid composition of total lipids of heart, kidney and testes of gerbil and rat

Fatty acids (%)	Heart		Kidney		Testes	
	Gerbil	Rat	Gerbil	Rat	Gerbil	Rat
C 14:0	0.53	0.48	0.90	0.77	0.50	0.78
	±0.05	±0.08	±0.30	±0.15	±0.02	±0.38
C 16:0	16.70 ±1.01[a]	13.00 ±0.72	22.00 ±1.30	22.00 ±0.96	20.50 ±1.02[c]	24.00 ±2.73
C 16:1	3.51	1.87	2.30	2.10	5.00	6.00
	±0.89[b]	±0.49	±0.31	±0.19	±0.93	±1.01
C 18:0	2.91	3.20	3.30	3.90	4.20	3.40
	±0.62	±0.28	±0.41	±0.62	±0.74	±0.34
C 18:1	32.50	30.00	26.80	27.10	31.30	28.00
	±1.29[b]	±0.95	±2.30	±0.56	±0.73	±3.71
C 18:2	35.90	28.80	32.00	26.50	32.80	30.50
	±2.90[a]	±2.02	±3.60[a]	±1.30	±2.80	±3.80
C 18:3	0.67	0.89	0.80	0.81	0.57	0.86
	±0.25	±0.35	±0.11	±0.03	±0.23	±0.07
C 20:0	0.30	0.42	0.62	0.48	0.39	0.71
	±0.02	±0.08	±0.34[a]	±0.02	±0.09	±0.18
C 20:4	7.70	21.20	11.20	16.80	4.70	5.60
	±1.40[a]	±2.09	±1.11[a]	±0.78	±0.97	±0.86
Ratio						
C 18:2/	4.66	1.36	2.86	1.58	6.98	5.44
C 20:4						

Mean values ± S.D. of 7 animals in each species
[a]p <0.001, [b]p <0.005, [c]p <0.05 as compared to that found in rats

humans using rats as animal models since both fatty acids and cholesterol plays a pivotal role in the etiology of the diseases *(Liu et al. 1995, Gurr 1996)*. To overcome this, several sensitive models such as monkeys, rabbits, pigs and guinea pigs have often been used. However several factors such as the size of the animal, its food consumption pattern, the economics and difficulties in handling bigger animals limits the use of larger animals for routine laboratory studies. Hence alternate animals have been tried in the past for this purpose. One animal model which is receiving considerable attention over a long period of time for studies on lipid metabolism is Mongolian gerbil *(Meriones unguiculatus)* *(Hegsted & Gallaagher 1967, DiFrancesco et al. 1990, Mercer & Holub 1979, Mercer & Holub 1981)*.

Albers and Gordon (1962) recognised that the fatty acid composition of cholesterol ester fractions in Mongolian gerbils differed from rats. While Mongolian gerbil predominantly contained linoleic acid and trace amounts of arachidonic acid in serum lipids, rats contained more arachidonic acid under fasting conditions, equivalent amounts with linoleic acid when food was given ad libitum, and less arachidonic acid in comparison to linoleic acid when the diet contained 1.5% cholesterol and 0.5% cholic acid. However no such alterations in PUFA levels were observed when gerbils were

either starved or fed ad libitum. PUFA levels were drastically decreased in various organs of Mongolian gerbils fed a fat deficient diet indicating an extremely dynamic fatty acid metabolism in these animals *(Coniglio & Harris 1977)*. As in humans and rats the minimum requirement of essential fatty acid (linoleic acid) in gerbils are 1-2 en % in the diet *(Chu & Hegsted 1981, Reeves et al. 1993)*. Studies using fats of different degrees of unsaturation indicated that alterations in serum cholesterol levels of gerbils achieved in response to different oils are similar to those seen in men fed the same oils. Recent studies from Hayes group *(Pronczuk et al. 1994, 1995)* indicated that plasma lipids are affected similarly by dietary lauric and palmitic acid in Mongolian gerbils and in a sensitive model like monkeys. Further they also demonstrated by feeding purified diets containing blended fats, that 89% of alterations in total cholesterol levels in serum of gerbils can be accounted by levels of myristic and linoleic acid in the diet *(Pronczuk et al. 1994)*. These observations are similar to that found in humans. They further noticed that Mongolian gerbils are more sensitive than either humans or cebus monkeys in their response to dietary fatty acids. These studies indicate the suitability of using the gerbil model for studying lipid metabolism.

Earlier studies have indicated that both rats and Mongolian gerbils are HDL dominated species *(Pronczuk et al. 1994)*. Indian desert gerbil is also a HDL dominated species whose levels are similar to that found in rats. While Mongolian gerbils have a plasma cholesterol levels similar to that of humans, *(Mercer & Holub, 1979)* and the plasma cholesterol levels in Indian desert gerbils are similar to that of Wistar rats. In both Mongolian gerbils and rats greater than 70% of cholesterol in the plasma is in ester form as in the case of humans *(Swell et al. 1960, Scott et al. 1963, Albers & Gordon 1962)*. However, there are striking differences in the nature of fatty acid in cholesterol ester fraction of rats and gerbils, while rats predominantly contain arachidonic acid, both gerbils and humans contain very little arachidonic acid but very high levels of linoleic acid in the cholesterol ester fraction. It was earlier reported by Swell et al. (1960) that animal species which are susceptible to atherosclerosis have lower levels of arachidonic acid in plasma cholesterol ester fractions. The white carnean pigeons which develop spontaneous atherosclerosis have lower concentrations of arachidonic acid in cholesterol ester fraction than the atherosclerosis resistant racer pigeons *(Young & Middleton 1966)*. Recently Liu et al. (1995) analyzed the fatty acid composition of cholesterol ester fractions from 14 vertebrate species including man and suggested that the ratio of palmitate/arachidonate (16:0/20:4) in plasma cholesterol ester fraction gives a better indication of atherogenic susceptibility of individual species. While this ratio was found to be 1.51 in the case of man, the highly susceptible species such as rabbit and guinea pig showed a ratio of 16.5 and 12.58 and that of resistant species such as rat, mouse, cat and dog showed a ratio less than 1.0. The ratio of 16:0 to 20:4 in cholesterol ester fractions of Indian desert gerbils is 12.5 which is similar to the values reported for guinea pig and rabbits which are the most susceptible species for atherosclerosis. It is also interesting to note that though Indian desert gerbils contained only 18.0% more 18:2 in serum phospholipid fraction as compared to that found in rats, it was found to be higher by 312% in cholesterol ester fraction of gerbils as compared to that found in rats. Similarly rat serum phospholipids contained 57.0% higher arachidonic acid as compared to that found in gerbils but its level in cholesterol ester fraction was 41 fold higher as compared to that found in gerbils. This observation indicates a high degree of fatty acid specificity of Lecithin:cholesterol acyltransferase (LCAT) enzyme which prefers arachidonic acid in case of rats while that in gerbils linoleic acid is preferred for esterification of cholesterol. The specificity of LCAT in gerbils towards linoleic acid is similar to that of humans. It is known that most of the cholesterol ester present in human plasma is derived from the LCAT reaction, where as in rat a major portion of cholesterol ester is derived from the intestinal and hepatic Acyl COA: cholesterol acyltransferase (ACAT) reaction *(Glomset 1979*

and *Ueno et al.1986).* However such studies are yet to be conducted in Indian desert gerbils.

In conclusion, the limited data generated from this study, indicate that the fatty acid composition of Indian desert gerbils are closer to that of humans than rats. The theoretical calculations derived from studies of Liu et al. (1995) indicate that the Indian desert gerbil may be a sensitive species to study atherosclerosis. The fatty acid composition of Indian desert gerbil also indicate that it is a good model to study regulation of delta 6 desaturase enzyme, Lecithin:cholesterol acyltransferase activity and eicosanoid metabolism.

Summary

Serum lipids and fatty acid composition of total lipids, phospholipids and cholesterol ester fractions of serum, liver, heart and testes of male Indian desert gerbils (*Meriones hurrianae;* Jerdon) were analysed and compared with Wistar rats. Triglycerides in serum and liver were similar in gerbils and rats. Significant differences in the distribution of polyunsaturated fatty acids in different lipid fractions were observed between gerbils and rats. Total lipids, phospholipids and cholesterol ester fractions in rats contained higher levels of arachidonic acid than in gerbils.

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