INFLUENCE OF RAPESEED OIL FEEDING ON THE LIPASE ACTIVITIES OF RAT HEART

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SUMMARY. Feeding high doses of fat increases the lipase activity of rat heart.The heparin-releasable activity in the hearts of rapeseed oil-fed rats remains high after prolonged feeding (10 days), whereas this activity in olive oil fed rats returns to normal values in the same period. After 10 days rapeseed oil feeding the non-releasable lipase activity in the hearts is enhanced significantly, when compared to the activity measured after 3 days. The results suggest an adaptation of heart lipases to dietary fat.

Triglycerides accumulate in the hearts of rats fed a high erucic-acid containing rapeseed oil diet[1]. The fat content of the hearts is highest after 3 to 6 days feeding and is rapidly lowered after 6 days[2]. The fat accumulation in the hearts has been ascribed to the inhibition of the β-oxidation by erucic acid[3] and by a lower rate of the overall metabolism of erucic acid in the heart[4]. Gumpen and Norum[5] suggested that the fat accumulation might arise from an impaired input/output of free fatty acids by the hearts. Rat hearts can take up free fatty acids from the serum directly. Serumtriglycerides can be taken up after previous hydrolysis by heart lipoprotein lipase, in which the heparin-releasable part of this enzyme activity is involved[6]. An impaired input/output of free fatty acids in the hearts could, therefore, be related with changes in the lipoprotein lipase activity of the hearts during rapeseed oil feeding. The heparin-releasable and non-releasable lipase activities of rat hearts were estimated selectively by in vitro heart perfusions. Control hearts were obtained from rats fed a diet containing high levels of olive oil. Olive oil does not introduce gross fat accumulation in heart.

METHODS. Groups of male Wistar rats, weighing 250 to 300 g, were given for 3 or 10 days fat-rich diets consisting of 50 cal% rapeseed oil (48% C 22:1 n-9) or 50 cal% olive oil (78% C 18:1 n-9) and further 27 cal% carbohydrate (maize starch), 23 cal% casein, different salts and vitamins. The rats had constant access to water and food.

Lipase activity was measured by the method of Kelley[7], which was modified as described elsewhere[8].Rat hearts were perfused according to the Langendorff technique with a modified Tyrode solution at a pressure of 100 cm H_2O and at 33 ± 3°C. After 5 min the perfusion medium was replaced by one containing, in addition, 20% (v/v) rat serum and 4.5 I.U. heparin/ml (Organon, Oss, The Netherlands). The hearts were perfused with 50 ml of the latter medium. The lipase activities of the perfusates, which were cooled to 0°C immediately after collection, were estimated within 4 h. The lipoprotein lipase activity of the heart tissues was determined in total acetone powder homogenates[9].

RESULTS

The average weights of the hearts of the rats were 1.04 ± 0.10 g for the rapeseed oil fed rats, 0.98 ± 0.08 g for the olive oil fed rats and 0.90 ± 0.04 g for the rats fed laboratory chow.

TABLE I shows the heparin-releasable lipase activities as well as the residual activities in the hearts of rats fed various diets. It can be seen from this TABLE that both activities are

TABLE I

LIPASE ACTIVITIES OF RAT HEART AFTER THE FEEDING OF DIFFERENT DIETS DURING 3 DAYS.

Rats were fed various diets for 3 days as described under METHODS. Then their hearts were perfused in vitro and lipase activities were estimated in the perfusates and in acetone powders of the perfused hearts. The activities are expressed in nmoles of free fatty acid released per min per heart ± standard deviation.

Diet		Lipase activity in perfusates	Lipase activity in the hearts after perfusion	Total lipase activity per heart
Rapeseed oil	(n=5)	253 ± 101	374 ± 150	627
Olive oil	(n=5)	294 ± 67	343 ± 124	637
Laboratory chow	(n=3)	83 ± 32	202 ± 30	285

elevated in the rats fed a diet with a high fat content when compared to rats fed the normal laboratory chow. The variation in the measured activities is large as can be seen from the standard deviations. The total lipase activity in the hearts of the groups fed olive oil or rapeseed oil is not significantly different. After 10 days feeding, however, the pattern has changed considerably (TABLE II). The lipase activity of the olive oil fed group is lowered, due mainly to a lowering in the heparin-releasable lipase activity. The lipase of the rapeseed oil fed rats, however, is further elevated, as a result of an increase of the non-releasable or residual activity.

DISCUSSION

From the data shown it can be seen that the lipase activities of ratheart are greatly influenced by fat feeding. Both the heparin-releasable and the non-releasable lipase activities are significantly enhanced, irrespective of the nature of the fat consumed. The enhanced activity of the heparin-releasable part of the lipase will lead to an increased uptake of serumtriglycerides in the rat hearts[6]. Gumpen and Norum[5] calculated that an increased flow of

TABLE II

LIPASE ACTIVITIES OF RAT HEART AFTER FEEDING DIFFERENT DIETS DURING 10 DAYS.

Two groups of 6 rats were fed a rapeseed oil-rich or an olive oil-rich diet for 10 days. Then their hearts were perfused. The perfusates of 3 rats of each group were pooled and lipase activities were estimated. The same was done with acetone-powders of the hearts. The activities are expressed in nmoles of free fatty acid released per min per heart ± standard deviation.

Diet	Lipase activity in perfusates	Lipase activity in the hearts after perfusion	Total lipase activity per heart
Rapeseed oil	296 ± 28	504 ± 64	800
Olive oil	120 ± 7	324 ± 16	444

only 3% of the daily fat intake to the hearts can account for the triglyceride accumulation in the rapeseed oil fed rats. Our results show that this increased flow may be caused by the elevated lipoprotein lipase activity of the rat hearts. In the olive oil fed rats the lipoprotein lipase activity of the hearts is equally enhanced by the diet. Oleic acid (the major component of olive oil) is however rapidly metabolized, in contrast to erucic acid (component of rapeseed oil).

When the rats are maintained on the olive oil diet for a longer period (10 days), the heparin-releasable lipase activity is lowered to an almost normal level (TABLE II). However, in the rapeseed oil fed animals this activity remains elevated, allowing a continuous flow of triglycerides to the hearts.

From TABLE II it can be seen that, contrary to the olive oil feeding experiments, the non-releasable lipase activity in the rapeseed oil fed rats is further elevated after 10 days feeding. The role of this lipase activity if not very well understood. It is not clear whether it is operative in vivo inside the heart cells or not. That an active lipase in the cardiocytes is present was shown by Olson and Hoeschen[10], since triglycerides were shown to serve as an energy source during substrate-free perfusion. It was found also (E.A.M. de Deckere, Unilever Research, unpublished) that hearts of rapeseed oil fed rats continue to beat much longer during substrate-free perfusion than hearts of control rats. The removal of the triglycerides from the hearts could be explained by increased lipolysis of the endogenous triglycerides, which is in accordance with the observation that the FFA content of hearts from rats fed rapeseed oil, remains elevated[2]. Perhaps then a flux of FFA from the hearts to the blood would exist, aiding the removal of fat. Part of the FFA might then be directed towards the liver, in which Gumpen and Norum[5] were able to demonstrate increased levels of erucyl-carnitine. That liver metabolism is indeed affected by prolonged rapeseed oil feeding is also suggested by our finding[11] of increased liver lipase activity.

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