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The effect of lipids of various origin on basal metabolic rate of rats

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With 3 tables

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The research work on the influence of various kinds of lipids on energy exchange began about fourty years ago. Since then several papers on that subject have been published (*Wesson* and *Burr*, 1931; *Jacquot* et al., 1959; *Petrović*, 1961, 1961 a, 1964; *Greco* et al., 1962). Except the first mentioned authors, all the others established a decrease of oxygen consumption when animal fats were taken, and an increase of the consumption of oxygen with the intake of vegetable oils.

Our purpose was to study the influence of small quantities of various food lipids on the energy exchange and the time interval needed for the manifestation of this influence.

Materials und methods

The study was carried out on four groups of male albino rats, weighing at the beginning of the experiment between 190 g and 262 g. Each group consisted of 5 animals.

The first three groups were fed with the diets whose composition is presented in table 1.

Table 1. Food composition (g)

Food composition	Experimental groups I	II	III
Wheat flour	465	465	465
Rough ground wheat	465	465	465
Skimmed milk powder	450	450	450
Pork fat	75		37.5
Soyabean oil		75	37.5
Cod-liver oil	13.5	13.5	13.5
Bone powder	30	30	30
Water	350	350	350
Lipids (percent)	5.9	5.9	5.9
Energetic value (Cal/100 g)	340	340	340

Group IV (controls) received special laboratory rat cakes (Veterinary Institute, Zemun), in which lipid content was 1.7% and caloric value 370/100 g. In those cakes vegetable fat was exclusively present.

In order to adapt the rats to the food, the first six days at the beginning of the experiment rats of groups I, II and III received food as shown on table 1. Group IV was given a special food for laboratory rats.

After this preparation period, i.e. on the 7th day, basal energy turnover was measured for the first time. One experimental period consisted of six weeks, from the 7th day to the 49th day of the experiment.

Seven weeks after the experiment began, the second experimental period was started. Rats receiving animal fat (group I) changed their diet to the food with vegetable oil, and the group which had been fed with vegetable oil (group II) received animal fat. That period of the diet lasted 5 weeks. Throughout the whole experimentation group III was kept on a diet containing the same quantity of fat in which 50% of lipids were of vegetable origin and 50% of animal origin.

The rats were kept at a laboratory temperature of about 20° C, and oxygen consumption was measured in the appapratus by *Giaja* (1955) once a week, at 30° C. The rats were kept without food during about 20 hours before each measurement. The results are presented in Cal/kg/24 h for each group.

The daily food consumption was calculated by the difference between the given food and its remainder. The results were presented as the means per one week and per one rat. Body weight was measured once a week, and the results presented in the same way.

The data were statistically analysed by *Gosset's* (1908) method.

Results

The results presented in table 2 have suggested, in the 1st experimental period, a more rapid energy exchange in rats fed with animal fat, than in rats fed with vegetable oil. The difference proved to be highly significant ($t = 3.587$, $p < 0.001$).

In order to confirm this finding, the nutrition was changed, so that group I received the ration with oil, and group II the ration with animal fat. After this change in nutrition the basal metabolic rate augmented in both groups for a while, but already on the 14th resp. 21st day after the change of diets, a diminution of basal metabolic rate was found in comparison with the values obtained seven resp. fourteen days before. Through the entire experimental period the lowering of basal metabolic rate was smaller in group II (9.32 Cal/kg/24 h) than in the group I (10.34 Cal/kg/24 h). This difference in the decrease of basal metabolic rate was not significant ($t = 0.194$; $0.8 < p < 0.9$). These results, although statistically not significant, agreed well with results of the first period of nutrition, when the rats of group I had a greater basal metabolic rate than group II. The prolongation of the second period of nutrition probably would result in a statistically significant difference.

In groups III and IV the energy exchange decreased, too, because of the growth of the animals. During the experiment this decrease had in both groups approximately the same value of about 11 Cal/kg/24 h. In groups I and II the diminution of energy exchange was smaller than in groups III and IV. In group II the reduction was smallest, presumably because of the stimulative effect of animal fat on oxidation after the

Table 2. Basal metabolic rate of the rats (Cal/kg/24 h)

Days	Group I		Group II		Group III		Group IV	
	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period
7th	144.28		139.29		145.73		147.46	
14th	135.42		127.22		139.11		151.27	
21st	138.52		130.10		139.98		150.90	
28th	135.41		121.30		128.64		144.74	
35th	146.11		128.38		133.19		150.80	
42nd	135.04		128.36		126.97		139.89	
49th	133.40		127.50		132.26			
56th		144.47		129.85		125.64		144.45
63rd		131.22		131.38		135.94		141.27
70th		123.11		119.80		106.37		142.27
77th		119.49		110.23		126.03		128.49
84th		121.56		106.70		117.12		124.73
$\bar{x}$	138.31	127.97	128.91	119.59	135.12	123.59	147.51	136.24
SE	±1.89	±3.14	±1.76	±2.88	±2.42	±4.34	±2.41	±2.44
Decrease of basal metabolic rate	10.34		9.32		11.53		11.27	
Difference		1.02						
t		0.194						
p		>0.8						

The $\bar{x}$ values were calculated without using the mean values for each week, but using the values for each individual rat.

change of the regimen. In group I the diminution of energy exchange was more marked than in group II, but below the values of groups III and IV. The reason could be the extended effect of animal fat from the previous period.

After the change of the regimen, the difference in oxygen consumption in groups I and II could be noticed a week later.

The greatest quantity of food was consumed by group IV and the body weights exceeded (table 3) those of other groups. The food consumption in group I was higher than in group III and in group II. The body weights in group I were higher than in group II throughout the whole experiment. The smallest food consumption in both experimental periods caused the lowest body weights in group II.

Discussion

In the greater part of publications presented till now, there was established an effect opposite to our findings: animal fats decreased and vegetable oils increased the energy exchange in experiments on animals (*Jacquot* et al., 1959; *Petrović*, 1960; *Petrović* et al., 1961, 1961 a), on men

Table 3. Food consumption and body weight of the rats

Days	Food consumption g/24h								Days	Body weight (g)							
	Group I		Group II		Group III		Group IV			Group I		Group II		Group III		Group IV	
	1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period		1st period	2nd period	1st period	2nd period	1st period	2nd period	1st period	2nd period
1–7	15.0		15.0		15.0		16.0		7th	228.8		233.0		221.0		183.0	
8–14	15.0		15.0		15.0		16.0		14th	228.6		236.0		224.4		206.4	
15–21	15.0		15.0		15.0		16.0		21st	221.0		232.6		221.8		216.8	
22–28	15.0		15.0		15.0		16.0		28th	220.2		231.4		222.2		223.4	
29–35	19.5		14.3		17.9		22.6		35th	225.6		218.2		229.6		235.8	
36–42	19.4		14.8		18.3		21.0		42nd	238.2		222.6		238.6		255.0	
43–49	18.3		16.3		18.9		21.8		49th	246.6		237.8		247.2		–	
50–56		16.5		15.0		18.1		21.5	56th		251.4		238.0		253.2		282.0
57–63		16.4		13.2		16.5		20.8	63rd		263.2		245.8		261.8		279.8
64–70		16.2		13.9		14.5		19.9	70th		266.2		250.0		265.2		291.4
71–77		17.8		14.1		16.3		20.0	77th		268.4		251.8		266.4		295.2
78–84		16.9		14.8		16.5		20.8	84th		273.2		258.0		268.6		291.4

(*Petrović* et al., 1960; *Plećaš* et al., 1971), and in tissue cultures (*Greco* et al., 1962). That effect was explained by the stimulation of iodine captation in the thyroid (*Štenberg* and *Plotnikova,* 1960; *Petrović* et al., 1961 a, 1964) and its increased function in the course of feeding with oils. The epidemiological data would be in accordance with this explanation, because the children fed predominantly with animal fats more frequently showed goitre, in spite of iodine prophylaxis, than the children in whose nutrition oils prevailed (*Petrović,* 1960; *Petrović* et al., 1964; *Ramzin,* 1959). The blocking of iodine fixation in the thyroid could be induced by hypercholesterolaemia, too (*Dimitrijević* et al., 1968), which is regularly caused by animal fats (*Clarke* et al., 1966). This could be the mechanism of their effect on energy exchange.

It was established that in animals depleted of essential fatty acids the structure and function of mitochondria were altered. Cytochrome oxidase (*Tulpule* and *Williams,* 1955) and succinic dehydrogenase (*Hayashida* and *Portman,* 1963) activities were increased; the activities of DNP-ATP-ase, ATP-ase, MG-ATP-ase were decreased (*Johnson,* 1963). ATP-P_1 exchange and oxidative phosphorylation were also reduced (*Johnson,* 1963). Hence, the augmentation of energy exchange in rats fed with animal fat in our experiments could be the consequence of mitochondrial alterations.

After *Wesson* and *Burr* (1931) deficiency of vegetable oils increased energy exchange, which is in accordance with our experiments. *Štenberg* and *Plotnikova* (1960) established that an excessive quantity of vegetable oils in food (54% of total calories) slowed iodine fixation in the thyroid gland, and, consecutively, the oxidations, too. In our experiments only 5% of the calories issued from the oil. However, it was stated in the mentioned work by *Štenberg* and *Plotnikova* (1960) that just with this percentage of oil the iodine fixation in the thyroid reached its maximal value. Therefore, it could not be assumed that in our experiments the diminution of energy exchange was caused by this quantity of oil in food.

Jacquot and collaborators (1959) found that the active substances in oils were not unsaturated fatty acids, but the peroxides. It could be possible that the content of peroxides in animal fat used in our experiments was greater than in the oil, hence the increase of energy exchange when animal fat was given. The oils, because of the tocopherol present in them, are more stable than the fats towards the oxidations.

In our experiments soya-bean oil was used. As is well known, this oil contains thyreo-suppressible substances, which could also be the cause of decreasing energy exchange when oil was given.

The increased level of calories produced by the rats fed with animal fat in our experiments could be the consequence of the presence of saturated fatty acids. Saturated fatty acids need more oxygen in their intermediary metabolism than unsaturated ones.

There is some evidence (*Miller,* 1967) that unsaturated fatty acids retard protein synthesis. Therefore the decrease of energy exchange under the influence of oils could be explained by the inhibition of oxidative enzymes synthesis.

The alteration of energy expenditure in our experiments was noticed seven days following the change of the regimen. These results were in agreement with *Hayashida*'s and *Portman*'s (1963) statement that arachidonic acid level in mitochondria was decreased seven days after the essential fatty acid deficiency had started. The observations made on children (*Plećaš* and collaborators, 1971) confirm this rather rapid alteration of energy exchange following the reversal of lipids in the regimen. In our experiments the energy exchange was measured the 7th day following the change of the regimen. It could be possible that the alteration of energy expenditure happened earlier.

Our results suggest retardation of basal metabolic rate of rats fed with diet containing 5.9% of vegetable oil, while the diet containing 5.9% of animal fat has an opposite effect. However, this difference is not statistically significant. This effect was rather rapid, and could be noticed 14–21 days from the beginning of the treatment.

Summary

The changes of basal metabolic rate were investigated weekly in three groups of albino rats fed with 5.9% diets of animal lipids, vegetable lipids and both lipids of animal and vegetable origin, respectively. The fourth group, controls, was fed with standard laboratory food with 1.7% of lipids. After six weeks the first two groups of rats alternated their diets and were fed in the same way five weeks more. The results have shown the diminution of basal metabolic rate by oil, but augmentation by the animal fat. This influence of the different sorts of lipids on basal metabolic rate became evident after 2–3 weeks of such treatment.

Zusammenfassung

Einmal wöchentlich wurden Veränderungen des Grundumsatzes bei vier Gruppen der Albino-Ratten untersucht; eine Gruppe bekam Diät, die pflanzliche Fette enthielt, die Diät der zweiten Gruppe enthielt Schweineschmalz, die dritte Gruppe bekam Futter mit gleichen Teilen der pflanzlichen und tierischen Fette. Insgesamt bekam jede Gruppe 5,9% Fett. Die vierte Gruppe (Kontrollgruppe) wurde mit der für Labortiere üblichen Nahrung gefüttert. Gesamtfettgehalt war 1,7%. Nach sechs Wochen wurde die Ernährung der zwei ersten Gruppen gegenseitig gewechselt und so wurden sie fünf weitere Wochen gefüttert. Die Resultate zeigten Verminderung des Grundumsatzes bei Ernährung mit pflanzlichen Fetten, doch eine Steigerung des Grundumsatzes bei Ernährung mit Schweineschmalz. Der Einfluß verschiedener Arten der Lipide auf den Grundumsatz der Ratten wurde erst nach 2–3 Wochen einer solchen Behandlung offensichtlich.

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