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STUDIES ON THE DIETARY FACTORS IMPARING CARBOHYDRATE METABOLISM OF RATS

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ABSTRACT

The ratio of nutrients which might impair carbohydrate metabolism was studied using male albino rats fed with various kind of diet.

It was clarified that both the increased ratio of fat and the decreased ratio of carbohydrate+protein in the total calory consumed were the important dietary factor for the impairment of carbohydrate metabolism. The importance of this dietary ratio was discussed.

Several authors have demonstrated that the amounts of circulating glucose in rats fed on a high-fat diet was increased, and these amounts were higher than those in animals fed on a diet rich in carbohydrates[1)2)]. A reduction in carbohydrate in the diet has been reported to cause the tissues to use up less carbohydrate and increase gluconeogenesis from protein[3)]. Generally because high fat diet unevitably decreases the content of not only carbohydrate, but also protein in the diets, the role of protein and carbohydrate must be explored. The object of this study was to clarify the effect of carbohydrate and protein in the diet on the impaired carbohydrate metabolism of rats fed on a high fat diet, and also to investigate the ratio of nutrient imparing carbohydrate metabolism.

EXPERIMENTAL

80 male rats of the Wistar strain, weighing approximately 100 g were separated into 8 group, and were fed on various diet. Each rats had free access to the diet and water. The composition of diet was expressed as g% of the total amount of diet. Group 1 was designated as the control group, and was fed on a standard diet (fat, 10%; carbohydrate, 62%; protein, 24%). Group 2, 3 and 4 were designated as the high-fat diet. Group 2 was fed on a diet (fat, 48%; carbohydrate, 24%; protein 24%), group 3 was fed on a diet (fat, 40%; carbohydrate, 21%; protein, 35%) and group 4 was fed on a diet (fat, 20%; carbohydrate, 28%; protein, 48%). Group 5 was designated as the high-protein diet. Group 5 was fed on a diet (fat, 10%; carbohydrate, 22%; protein, 64%), and group 6 was designated as the high carbohydrate diet and

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was fed on a diet (fat, 10%; carbohydrate, 80%; protein, 6%). Group 7 and 8 were designated as the low-fat diet. Group 7 was fed on a diet (fat, 5%; carbohydrate, 80%; protein, 11%), and group 8 was fed on a diet (fat, 5%; carbohydrate, 11%; protein, 80%).

Minerals were given to each group in macculum salts (4% of diet), vitamins mixture (B_1, 40 r; B_2, 60 r; Nicotinic acid, 200 r; pantotenic acid, 200 r; PABA, 0.5 mg; Biotin, 1 r; B_{12}, 0.1 r; Folic acid, 5 r; choline, 10 mg; Inositol, 3 mg. VA, 300 IU; VD, 30 IU; VB_6, 60 r; VE, 1.2 mg; VC, 1.0 mg; VK, 0.1 mg) was given to each rat per 10 g of diet. As for macculum salts, KJ 30 g, Fe citrate 100 g, $MgSO_4 \cdot 7H_2O$ 500 g, Lactate 1300 g, Na_2HPO_4 200 g, KH_2PO_4 1100 g, Lactate 1300 g, Na_2HPO_4 200 g, KH_2PO_4 1100 g, Kcl 150 g, Nacl 50 g, $CaHPO_4 \cdot 2H_2O$ 500 g were mixed, and then 0.4 g of the mixture was used in 10 g of diet. 0.3 g of cellulose powder was also added to the 10 g of diet. Fat in diet was composed from cotton seed oil and butter (60:40, w/w). Protein was milk casein, carbohydrate was glucose. The rats were allowed to eat the synthetic diet and drink water ad libitum for 100 days. The amount of circulating glucose was measured in 0.05 ml blood obtained from the tail vein of rat by a Hagedorn-Jensen method, before and after glucose loading on the 100th day.

Glucose loading was orally conducted using gastric tube.

RESULTS

Mean body weight of the rats in the each group showed significant difference. The rats in the group 1 weighed on an average 230 g on the 100th day. The rats in the groups 2, 3, 4, 5 and 6 weighed on a average 372, 358, 297, 260 and 162 g respectively. The rats in the group 7 and 8 showed a significant decrease of body weights. The rats in the group 7 and 8 weighed 91 and 93 g. Rats in high fat diet group showed good appetite resulting in the increase of their body weight. On the contrary rats in low fat diet group showed disturbed appetite resulting in the decrease of their body weight. Fat in the synthetic diet may be the important factor for the appetite of rats. The total quantity of diet consumed by each group on the 98th days is well coincident with the body weight (Table 1).

Table 1 shows the glucose tolerance curve of the rats in each group conducted on the 100th day. The results are expressed as mean blood glucose $\pm$ standard error of seven rats. In the group 1–5, the quantity of total calory consumed by the rat in each group is directly proportional to the amount of blood glucose, especially two hour's value after glucose loading. Rats in the group 7 and 8 lost completely their appetite.

The impaired G.T.T. of rats in the group 7 and 8 may have different pathogenesis from that of group 2~6 and this pathogenesis might be partly

TABLE 1. Glucose tolerance test on the 100th day

group	GTT				The quantity of diet consumed by the rat on the 98th day (g)
	0 (mg/dl)	1 (mg/dl)	2 (mg/dl)	3 hrs (mg/dl)	
1	79.0±5.1	139.0±10.3	122.4± 6.7	84.0±10.1	12.7±3.5
2	109.0±5.7	194.0±10.1	174.5±11.2	151.0± 7.7	20.8±2.6
3	94.0±7.8	159.0±11.7	145.8± 9.2	131.0± 9.4	18.3±5.1
4	88.0±7.3	141.0± 9.5	129.4±10.6	118.0± 7.8	13.1±3.2
5	96.0±9.5	137.0± 8.5	117.0± 7.1	109.0± 6.5	12.8±2.9
6	83.0±7.7	139.0± 7.6	120.1± 9.4	105.0± 9.1	8.6±1.7
7	103.0±4.9	199.0± 9.3	175.0± 8.5	149.0± 8.8	5.3±1.5
8	101.0±4.9	164.0± 9.7	151.1± 9.4	138.0± 4.9	5.4±1.8

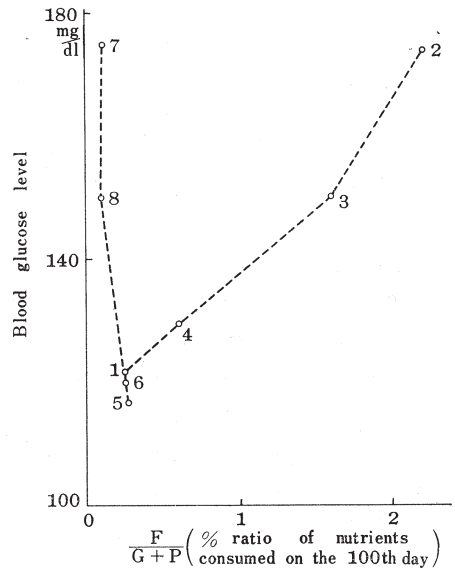

FIG. 1. The relationship between 2 hour's blood glucose and $\frac{F}{G+P}$.
1~8 means number of group.

due to the starvation. There seem to be a complicated relationship between blood glucose in rats and nutrients. $\frac{\text{Fat}}{\text{Glucose+Protein}}$ (% ratio of nutrients in the total calory consumed and was abbreviated to $\frac{F}{G+P}$) has a intimate relation with 2 hour's blood glucose level after glucose loading as shown in Fig. 1.

DISCUSSION

The pathogenic dietary factor important for the diabetic state of rats fed on a high-fat diet must be both the increased ratio of fat and the decreased ratio of carbohydrate+protein in the total calory.

The increase of $\frac{F}{G+P}$ (not only the increased ratio of fat, but also the decreased ratio of carbohydrate plus protein in the total calory) is generally proportional to the amount of blood glucose, and also in a special case (group 7 and 8) the decrease of $\frac{F}{G+P}$ (the increased ratio of carbohydrate plus protein or the decreased ratio of fat in the total calory) is also important. Fat ratio in the synthetic diet is important for the maintenance of the appetite and the body weight of rats. Total calory consumed by rats and $\frac{\text{Fat}}{\text{Glucose+Protein}}$ (% ratio in total calory consumed by rats) have the intimate relationship with the impaired glucose tolerance of rats fed on various diet. The pathogenic dietary factor of rat fed on a high-fat diet may be the increased ratio of fat and the decreased ratio of carbohydrate plus protein in the diet.

SUMMARY

1. 80 male rats were fed with various kind of synthetic diet for 100 days. On the 100th day, glucose tolerance tests were performed. The relationship between the level of circulating blood glucose and the ratio of nutrients in diets were studied.

2. According to the present data, it was apparent that the $\frac{\text{Fat}}{\text{Glucose+Protein}}$ (% ratio of nutrients in the total calory consumed) has a intimate with 2 hours blood glucose level after glucose loading. The importance of this index was discussed.

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