RELATIONSHIP BETWEEN GROWTH OF ANIMALS AND POLYUNSATURATED FATTY ACID

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Since the experiments by Allan *et al.*⁽¹⁾ and Burr *et al.*⁽²⁾, it has been generally recognized that animals stop to grow if the polyunsaturated fatty acid is not given. The reason why the polyunsaturated fatty acid is necessary for the growth of animals was given by Ara's study⁽³⁾.

The present experiment was performed to investigate the degree of response of animals to the diet deficient in the polyunsaturated fatty acid in various stages of their growth.

EXPERIMENT I

On the Relationship between the Growth of Animals in Various Stages and a Diet Deficient in the Polyunsaturated Fatty Acid

Experimental Method: Albino rats of non-pure strain were divided into 5 groups. Each group consisted of 5 rats having an average and a range of body weight as follows: Group I, 52 g (50–55 g); Group II, 60 g (57–62 g); Group III, 65 g (63–67 g); Group IV, 73 g (70–75 g); and Group V, 53 g (50–55 g).

Table 1.
Composition of Polyunsaturated Fatty Acid Deficient Diet

Starch	80%	(Starch and casein were extracted with hot alcohol for 10 hours)
Casein	16 "	
Inorganic Salts (McCollum)	4 "	
Vitamins (per 100 g of the diet)		
B ₁	0.5 mg	
B ₂	0.5 "	
B ₆	0.5 "	
Nicotinic acid	1.0 "	
B ₁₂	2 gamma	

An aliquot of the unsaponifiable matter in cod liver oil
(equivalent to 1 cc of the cod liver oil)

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Group V served as a control.

Group I-IV were given a diet deficient in the polyunsaturated fatty acid, the composition of which is shown in Table 1. Group V, the control, received a diet of the same composition except that linseed oil containing the polyunsaturated fatty acid was supplemented at 1% level of the diet. The growth responses of animals of each group were checked.

Results: Results are shown in Table 2. All the rats of Group I died during 49-56 days (average 52 days) of feedings (average body weight being 92 g at their deaths). In Group II, all the rats died during 56-72 days (average 67

Table 2.
Weight Responses of Rats in Various Growth Stages to Polyunsaturated Fatty Acid Deficient Diet

Group of rats (5 rats in each group)	Initial body weight (g)	Final body weight (g)	Weight increase (g)	Experimental period (days)	Dead or alive at termination of experiment
I	50-55	80-105	30- 55	49-56	All dead
Average	52	92	42	52	Dead
II	57-62	85-130	25-70	56-72	All dead
Average	60	107	47	67	Dead
III	63-67	135-145	70-80	75-79	All dead
Average	65	140	75	77	Dead
IV	70-75	170-180	100-105	78-85	All dead
Average	73	175	102	82	Dead
V (Control)	50-55	180-185	120-130	86	All alive
Average	53	183	130	86	Alive

days) of feeding (average body weight being 107 g). In Group III, the feeding period was 75-79 days (average 77 days) when all the rats died. In Group IV, all the rats died after feeding for 78-85 days (average 82 days). In Group V, all the rats survived through 86 days of observation period. Average growth-curves of Groups I-V are illustrated in Figures 1-5, respectively.

EXPERIMENT II

Study on the Amounts of Polyunsaturated Fatty Acids in Muscles of the Mature and the Immature Rats

In Experiment I, it was found that the younger the animals, the less resistant they were to the polyunsaturated fatty acid deficiency. A reason for this may be that the younger the animals, the more rapidly they grow, that is, the more

Fig. 1 Average growth-curve of Group I rats.

Fig. 2 Average growth-curve of Group II rats.

Fig. 3 Average growth-curve of Group III rats.

Fig. 4 Average growth-curve of Group IV rats.

Fig. 5 Average growth-curve of Group V rats.

vigorously new cells are formed, leading to the greater demand for the polyunsaturated fatty acid. There is, however, another possibility that the cells in younger animals may require more of the unsaturated fatty acid to compose their lipid than do the cells in adult animals. The experiment was undertaken to make this point clear.

Experimental Method: Albino rats of non-pure strain were used. The animals weighing 130–140 g were classed as a mature group and those weighing 60–70 g as an immature group. They were given only water and starved to death. The lipid of muscles was fractionated into the fat and the phosphatide and the amounts of the polyunsaturated fatty acids in each fraction were determined by Miura's method⁽⁴⁾. Polybrominated fatty acids higher than octabrominated fatty acid were expressed as the arachidonic acid.

Results: As shown in Table 3, the amount of linoleic acid in the polyunsaturated fatty acid in the fat was 5.5% in the mature and 29.2% in the immature group, and that in the phosphatide was 33.1% in the mature and 42.3% in the immature group, indicating the amount of linoleic acid in either fraction was much more in the immature than in the mature group. The amounts of linolenic and arachidonic acids were also slightly more in the immature than in the mature group.

Table 3.
*Amounts of Various Unsaturated Fatty Acids Constituting
Muscle Cells in Mature and Immature Rats*

Fatty acid	Mature rats		Immature rats	
	Fat (%)	Phosphatide (%)	Fat (%)	Phosphatide (%)
Oleic	84.0–90.0	50.2–60.0	50.5–68.6	28.3–75.4
Average	86.6	54.1	60.2	47.5
Linoleic	3.0–7.1	28.0–35.8	22.4–33.7	19.4–62.6
Average	5.5	33.1	29.2	42.3
Linolenic	4.0–5.6	6.3–8.4	4.7–7.9	3.8–8.3
Average	4.9	7.6	6.0	6.2
Arachidonic	2.0–3.8	4.0–5.5	2.0–7.6	1.1–7.6
Average	2.8	4.9	4.4	3.8

DISCUSSION AND SUMMARY

1) When groups of rats of various body weights were fed on a diet deficient in the polyunsaturated fatty acid, all the animals in Group I (average body

weight of 52 g), Group II (average body weight of 60 g), Group III (average body weight of 65 g), and Group IV (average body weight of 73 g) died during 56, 72, 79, and 85 days, respectively. Whereas in Group V, the control (average body weight of 53 g), all the animals were still alive after 86 days of feeding, this being ascribed to the supplementation to the diet with linseed oil containing the polyunsaturated fatty acid. The data also indicate that the younger the animals the less resistant they are to the polyunsaturated fatty acid deficiency.

2) There was a marked difference in the linoleic acid content of the unsaturated fatty acid in the fat of the lipid constituents of muscles between the mature (5.5%) and the immature rats (29.2%). The linoleic acid contents in the phosphatide was 33.1% in the mature and 42.3% in the immature rats. The amounts of linolenic and arachidonic acids were slightly more in the immature than in the mature rats.

3) The above results indicate that the younger animals die in the earlier period of feeding the polyunsaturated fatty acid deficient diet, because they require more of the polyunsaturated fatty acid to construct their cells.

4) According to Ara's data on the lipid constituents of animal cells⁽³⁾, the iodine number of the fatty acid of fat is 100 and that of phosphatide is 115. When the iodine number of fatty acid is more than 100, it cannot be attained by oleic acid alone but the polyunsaturated fatty acid must be participated. The present study revealed that the younger the animals the more of the polyunsaturated fatty acid they require.

LITERATURE

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