

## クルマエビの必須脂肪酸に関する研究I

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## Essential Fatty Acids in the Diet of Prawn—I Effects of Linoleic and Linolenic Acids on Growth

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The requirements of linoleic and linolenic acids for the growth of the prawn, *Penaeus japonicus*, were studied by using a purified diet.

In this feeding experiment conducted for 50 days, the growth of prawn on the diet containing oleic acid was extremely slow. Addition of linoleic and linolenic acids to the diet remarkably improved weight gain. The recovery tests initiated after 30-days of feeding on the lipid free diet showed a rapid increase of growth. From these results, linoleic and linolenic acids were concluded to be essential for the growth of prawn. Also, the nutritive value of linolenic acid for prawn was found to be higher than that of linoleic acid.

In the previous paper<sup>1,2)</sup>, it has been suggested that the fish almost lack the ability of *de novo* syntheses of linoleic and linolenic acids, and may require exogenous acids as essential fatty acids. After that, the existence of some essential fatty acids has been demonstrated by the feeding trials in the chinook salmon<sup>3)</sup>, rainbow trout<sup>4-12)</sup>, carp<sup>13,14)</sup>, and red sea bream<sup>15-17)</sup>. These results have shown that the fish required not only linoleic family ( $\omega 6$  acids) but linolenic family ( $\omega 3$  acids) for the normal growth and high survival, and the requirement of linolenic family was more essential than that of linoleic family.

In crustaceans, the authors have recently reported the effects of various oils, such as soybean, linseed, sardine, pollack, and short necked clam oils supplemented to the basal diet on the growth of the prawn, *Penaeus japonicus*<sup>18,19)</sup>. As the results, it has been assumed that  $\omega 3$  polyunsaturated fatty acids such as linolenic, eicosapentaenoic and docosahexaenoic acids may be more effective than  $\omega 6$  acids for prawn.

This paper deals with the requirements of linoleic and linolenic acids for the growth of the prawn, *P. japonicus*. The effects of eicosapentaenoic and docosahexaenoic acids on the growth of prawn and the resulted fatty acid compositions are going to be reported in the following papers.

### Materials and Methods

**Prawn** The prawn, *P. japonicus*, hatched in Mitsui Norin Kaiyo Sangyo Co., Ltd. was transported to Kamoike Marine Production Laboratory, Faculty of Fisheries, Kago-

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shima University. After the preliminary culture, the prawn of about 0.5 g in body weight was used in this experiment.

**Lipids** Oleic, linoleic, and linolenic acids were purchased from Nu-Chek-Prep Co. (U.S.A.). The purity of these fatty acids was 98–99%. Pollack residual oil obtained by distilling away vitamin A from pollack liver oil, was supplied from Riken Vitamin Oil Co., Ltd. (Japan).

**Artificial diet** The modified artificial diet devised by authors<sup>19,20)</sup> was used as a basal diet in this experiment. Casein and starch were purified with hot ethanol three times to remove traces of lipids. The proportions of lipids in the diets used for Experiments I and II are shown in Table 1 and 2.

Table 1. Composition of dietary lipids in Experiment I

Diet no.	Dietary lipid
1	5% Oleic acid
2	4% Oleic acid and 1% Linoleic acid
3	4% Oleic acid and 1% Linolenic acid
4	5% Pollack residual oil

Table 2. Composition of dietary lipids for recovery test (Experiment II)

Diet no.	Dietary lipid
5	Lipid free—Diet 2 from the 30th day
6	Lipid free—Diet 3 from the 30th day
7	Lipid free

**Feeding method** The prawns were maintained in the troughs (30 liter) equipped with circulating systems by filtration through a sand bed. The troughs were further supplied with the running sea water at the rate of 150 liters per day. Fifteen animals per one trough were used in each experimental, and after the 50-day feeding of each test diet, the average weight and survival of animals were determined.

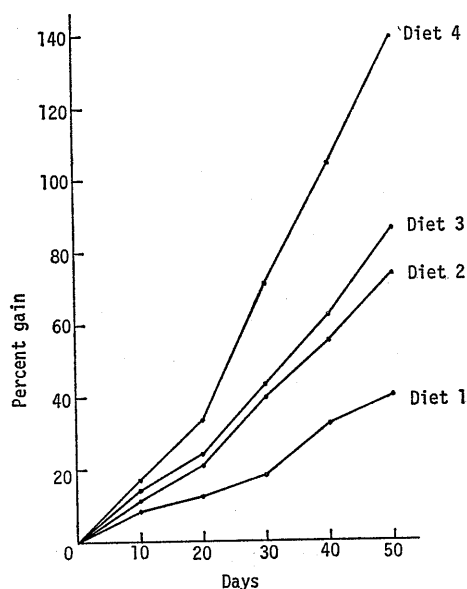
### Results and Discussion

In Experiment I, the effects of dietary linoleic and linolenic acids on the survival and growth of prawn were examined. As shown in Table 3 and Fig. 1, the diet 1 containing oleic acid (18: 1 $\omega$ 9) resulted in poor growth, however the diet 2 with linoleic acid (18: 2 $\omega$ 6) and the diet 3 with linolenic acid (18: 3 $\omega$ 3) remarkably improved weight gain and survival. Further, the diet 4 containing pollack residual oil was found to improve the survival and growth. In comparison with the effects of linolenic and linoleic acids for prawn, linolenic acid of  $\omega$ 3 series was superior to linoleic acid of  $\omega$ 6 series. Also, as the concentration of linoleic and linolenic acids in pollack residual oil was very small, the effective response of pollack residual oil for prawn was presumed to be due to polyunsaturated fatty acids such

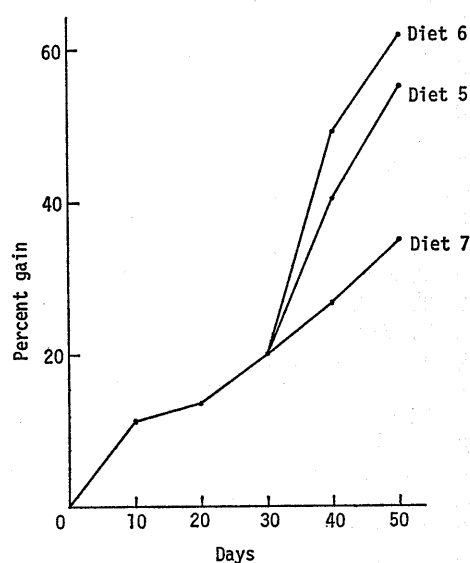
**Table 3.** Effects of dietary linoleic and linolenic acids on the survival and growth of prawn

Diet no.	Feeding period (days)	Survival (%)	Average body weight		Percent gain
			Initial (g)	Final (g)	
1	50	53	0.50	0.70	40.0
2	50	73	0.55	0.98	78.2
3	50	73	0.62	1.15	85.5
4	50	93	0.59	1.40	137.2

as eicosapentaenoic acid (20: 5 $\omega$ 3) and docosahexaenoic acid (22: 6 $\omega$ 3). Concerning the remarkable effects of  $\omega$ 3 polyunsaturated fatty acids, some reports have been recently shown in red sea bream<sup>15,17)</sup> and rainbow trout<sup>21,22)</sup>.

**Fig. 1.** Effects of dietary linoleic and linolenic acids on the growth of prawn.

Diet 1, 5% oleic acid; Diet 2, 4% oleic acid and 1% linoleic acid; Diet 3, 4% oleic acid and 1% linolenic acid; Diet 4, 5% pollack residual oil.

**Fig. 2.** Recovery test of linoleic and linolenic acids on the growth of prawn.

Diet 5, lipid free—4% oleic acid and 1% linoleic acid from the 30th day; Diet 6, lipid free—4% oleic acid and 1% linolenic acid from the 30th day; Diet 7, lipid free.

In Experiment II, after the 30-day feeding on the lipid free diet, the prawns were divided into three groups, and further maintained for 20 days on the lipid free, 4% oleic acid and 1% linoleic acid, and 4% oleic acid and 1% linolenic acid diets, respectively. As shown in Fig. 2, the growth of prawn received the lipid free diet was extremely poor through the feeding period. However, the recovery test initiated from the 30th day indicated a rapid increase of growth.

From these results, the requirements of linoleic and linolenic acids as an essential fatty

acid for the prawn, *P. japonicus*, were elucidated. Also, the nutritive value of linolenic acid for prawn was found to be higher than that of linoleic acid, as well as in rainbow trout<sup>5,11,12)</sup> and carp<sup>13,14)</sup>. Furthermore, it was assumed that the prawn may require not only linoleic and linolenic acids but more highly polyunsaturated fatty acids of  $\omega$ 3 series.

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