(https://www.globalseafood.org)

Health & Welfare

Advances in triglyceride, fatty acid nutrition in penaeid shrimp

1 October 2004
By Martin Perez-Velazquez, Ph.D. and Addison L. Lawrence, Ph.D.

Requirements for particular nutrients vary between species

Dietary lipids are necessary for the growth, survival, and normal metabolic functions of all organisms. Among them, triglycerides, also called triacylglycerols, are the main form in which humans ingest and accumulate fat. Typically, when excess calories are ingested and not used immediately, they are converted to triglycerides and transported to fat cells for storage. On the other hand, fatty acids, another type of lipids, are major components of cell membranes.

Many organisms, including shrimp, are not capable of biological synthesis of some fatty acids. These essential fatty acids must be supplied in the diet. Both triglycerides and fatty acids have caught the eyes of shrimp nutritionists. Various advances have been made in this field of study.

Recommended dietary levels

In many early studies, kuruma prawns (*Marsupenaeus japonicus)* and Indian shrimp (*Fenneropenaeus indicus)* were the most studied shrimp species. As evaluated by growth response and survival, the levels of dietary triglycerides recommended by researchers for these shrimp varied 6 to 8 percent. Triglycerides of marine origin, such as fish oil, were reported to have greater nutritional value than triglycerides of vegetable origin like coconut oil.

Researchers observed an interaction between dietary triglycerides and other nutrients and sources of energy. For example, requirements for triglycerides can be overestimated when protein requirements are not met. For dietary fatty acids, it was found that penaeid shrimp could not synthesize long-chain (18 carbon atoms or longer) polyunsaturated fatty acids (PUFAs) of the linolenic (omega-3) or linoleic (omega-6) families, and they are not able to elongate them to highly unsaturated fatty acids (HUFAs).

In general, omega-3 fatty acids had superior nutritional value over omega-6 fatty acids. When comparing HUFAs and PUFAs, the former offered greater nutritional quality, exemplified by the HUFAs docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which supported better growth and survival than the PUFA linolenic acid.

After 1997, research on triglycerides and fatty acid nutrition focused on the two most commercially important cultured species in the world: black tiger shrimp (*Penaeus monodon)* and Pacific white shrimp (*Litopenaeus vannamei)*. These studies provide a better understanding of the qualitative and quantitative requirements for these nutrients.

Neutral lipids in feed

Considering that free fatty acids, ethyl esters, methyl esters and triglycerides have been indistinctly used in studies of lipid nutrition in shrimp, one study evaluated their value as a source of neutral lipid in experimental feeds for *P. monodon*. Shrimp fed triglycerides had higher weight gain (94 ± 6 percent) than those fed free fatty acids (84 ± 7 percent), ethyl esters (73 ± 7 percent), or methyl esters (54 ± 5 percent). It was concluded that neutral lipid in the form of triglycerides should be preferred over other lipid types and that free fatty acids could be used for fine adjustment of the fatty acid profile.

Source of dietary triglycerides

Researchers further examined the value of a variety of oils as sources of triglycerides in shrimp feeds. In two independent studies with Pacific white shrimp, an identical pattern of the growth-promoting effects of oils was reported. Menhaden oil best promoted growth, followed by linseed oil, soybean oil, and coconut oil.

However, results of a different nature were found for black tiger shrimp. They had significantly greater growth when fed linseed oil, canola oil, or soybean oil, as compared to cod liver oil or lard.

These findings showed that the nutritive value of the oils employed was dependent upon the species, and the concept that marine fish oils promoted better growth than vegetable oils was no longer valid.

Activity of omega-3, omega-6 fatty acids

A research study compared the nutritional values of dietary linolenic acid and linoleic acid with arachidonic acid, eicosapentaenoic acid, and docosahexaenoic acid, as well as omega-3 HUFAs in combination, all included at 0.5 percent of the diet. All the HUFAs produced significantly greater weight gains than the PUFAs (Fig. 1).

According to this study, *L. vannamei* satisfied their requirements for essential fatty acids with HUFAs from either omega-3 (EPA and DHA) or omega-6 (e.g., arachidonic acid) families. Regardless of the families they belonged to, the nutritional values of fatty acids for this species appeared to be determined by chain length and degree of unsaturation, differing from reports for other penaeid shrimp species in which fatty acids of the omega-3 family had greater essential values than those of the omega-6 family.

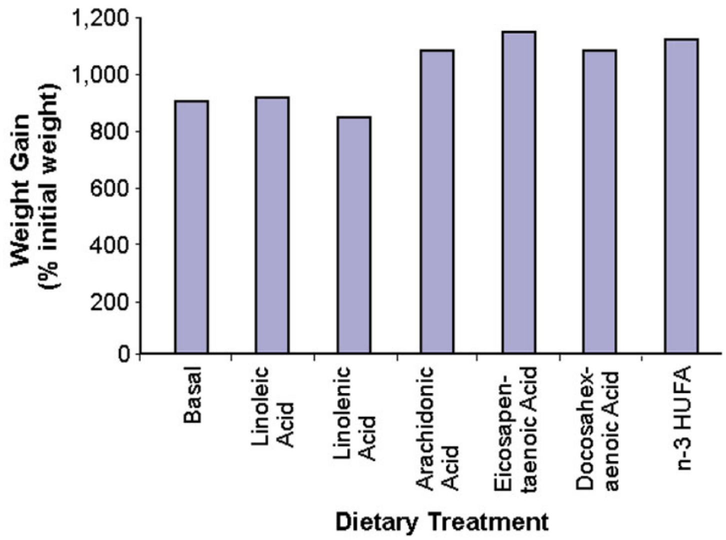

Fig. 1: Weight gain of juvenile L. vannamei fed different omega-3 and omega-6 polyunsaturated and highly unsaturated fatty acids.

Quantitative requirements for essential fatty acids

The estimated quantitative requirements for essential fatty acids by penaeid shrimp are shown in Table 1. The essential fatty acid requirements appear to be largely dependent upon the species. The lower requirements for *L. vannamei* may be a reflection of differences in feeding habits, for *L. vannamei* are omnivorous, whereas *P. monodon* and *Marsupenaeus japonicus* are considered carnivorous species.

Relatively large variations occur in the requirements reported for a particular fatty acid even for the same species. This is likely due to the diverse methods researchers employ.

In fact, differences are found in some key factors of the methods used, such as the source of fatty acids (triglycerides or free fatty acids), total lipid level, and the size and age of shrimp. Standardization of experimental diets and methods is warranted in order to more accurately analyze and compare results.

Perez-Velazquez, Estimated essential fatty acid requirements, Table 1

Fatty Acid	***M. japonicus****	**Percentage of Diet** ***P. monodon***	***L. vannamei***
Linoleic acid	0.25	1.5	0.1

Linolenic acid	0.25	1.0-2.5	0.1
Docosahexaenoic acid	DHA + EPA = 0.9	0.9-1.44	DHA + EPA = 0.4
Eicosapentaenoic acid	DHA + EPA = 0.9	0.9	DHA + EPA = 0.4
Arachidonic acid	0.1	Not evident	0.2
Total	1.5	4	0.8

Table 1. Estimated essential fatty acid requirements of penaeid shrimp.

Conclusion

Significant advances have been made in the study of triglycerides and fatty acid nutrition in postlarval and juvenile penaeid shrimp, but the establishment of quantitative requirements is still under way. Future studies should address the essential fatty acid requirements of shrimp at later life stages and to marketable size. Standardization of methods is also needed to make effective comparisons of results.

(Editor's Note: This article was originally published in the October 2004 print edition of the Global Aquaculture Advocate*.)*

Authors

MARTIN PEREZ-VELAZQUEZ, PH.D.

Departmento de Investigaciones Científicas y Tecnológicas
Universidad de Sonora
Rosales y Niños Héroes
s/n A. P. 1819 C. P. 83000
Hermosillo, Sonora, México

mperezv@correom.uson.mx (mailto:mperezv@correom.uson.mx)

ADDISON L. LAWRENCE, PH.D.

Texas A & M University System
Shrimp Mariculture Project
Port Aransas, Texas, USA