(https://debug.globalseafood.org)

Aquafeeds

Optimized feed management for intensively reared tilapia

1 July 2012

By Ingrid Lupatsch, Ph.D.

Tilapia can be fed lower-energy and protein diets because they consume higher amounts of feed than carnivores

The daily requirements of tilapia depend on fish size, growth potential and composition of weight gain.

Tilapia are farmed worldwide in inland aquaculture in various kinds of facilities and production strategies. The majority of the fish are still grown extensively in polyculture, but more and more, intensive monoculture systems in which pelleted feed is the only source of energy and nutrients are being used.

As herbivores, tilapia are perceived to be a suitable choice for culture, as one of the recurring questions in aquaculture is whether the farming of carnivorous species is sustainable. Carnivores are thought to require 45 to 50 percent dietary protein in their feeds, while most omnivores and herbivores require only 24 to 32 percent protein in feed. This gives the impression that herbivorous species are more efficient converters of protein into growth.

However, expressions of protein requirements based solely on dietary inclusion levels are incomplete if feed intake is not considered. Protein intake is the product of the protein content of the feed and the total amount of feed consumed. As such, the protein demand per kg of fish produced will give a clearer picture of the overall efficiency of the species in question.

Calculating requirements

The general assumption is that the daily energy requirement of a growing fish is the sum of its needs for maintenance plus growth, as described by the following formula:

$$\text{Energy Need (kJ/day)} = A \times \text{Body Weight (kg)}^{0.80} + C \times \text{Energy Gain (kJ/day)}$$

A = Maintenance requirement
C = Cost of production in units of dietary energy to deposit energy as growth.

A similar equation is used for the quantification of protein, except for the use of exponent B = 0.70 for body weight:

$$\text{Protein Need (g/day)} = A \times \text{Body Weight (kg)}^{0.70} + C \times \text{Protein Gain (g/day)}$$

The advantage of this approach is that protein and energy needs are expressed primarily as absolute requirements per fish body mass and anticipated weight gain, and then only secondarily as a percentage of the feed.

Maintenance requirements

In trials performed at the Fish Culture Station in Ginossar, Israel, using male *Oreochromis niloticus* x *O. aureus* tilapia, the efficiency of energy and protein utilization for maintenance and growth was derived from feeding groups of tilapia at increasing levels from no feed up to maximum voluntary intake. The feed was formulated to supply 400 g crude protein and 19 MJ gross energy per kilogram. Digestibility of protein and energy were determined beforehand.

During the six-week trials, two experiments were performed using fish of 100 and 300 g initial weight. Energy and protein gain were determined by comparative carcass analyses.

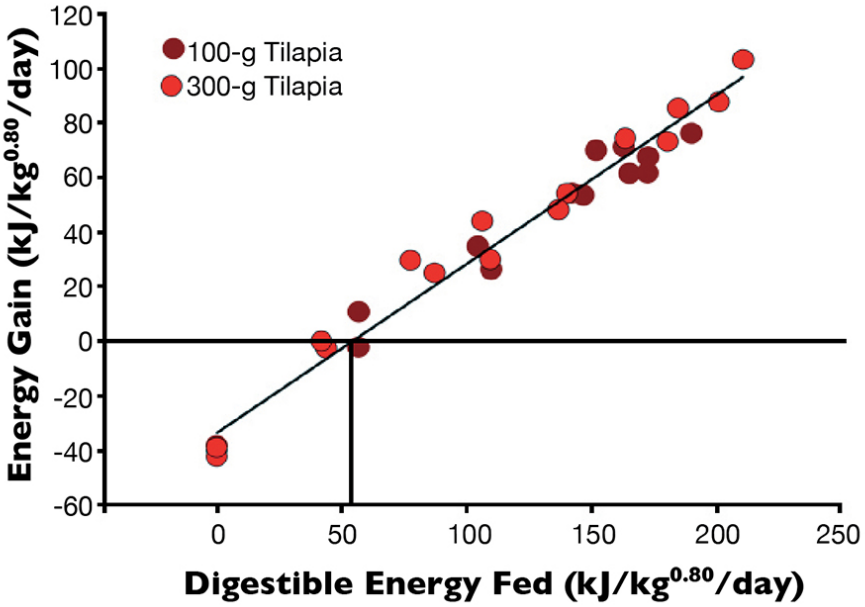

Fig. 1: Daily energy retention per unit metabolic weight of kg0.80 in tilapia of two size groups fed increasing levels of daily energy.

As shown in Figure 1, as more energy was consumed, energy was gained until the fish refused to eat more. Figure 1 also shows the relationship between daily energy consumed (X) and energy retained (Y) is linear and can be described by the following equation:

$$\text{Weight Gain (g)} = 0.12 \times \text{Body Weight (g)}^{0.547}$$

During starvation, the tilapia lost energy, as expected. The daily energy requirement for maintenance with no energy gain or loss can be found where the y axis is 0. According to the equation above, the daily maintenance requirement would amount to 34.40/0.62 = $D.E.^{maint}$= 55.5 kJ x $(kg)^{0.80}$.

The same data set can also be used to establish the relationship between protein intake (X) and protein gain (Y), referring to a metabolic body weight of $kg^{0.70}$.

$$\text{Feed Intake (g)} = 0.14 \times \text{Body Weight (g)}^{0.600}$$

This defines the requirement of protein for maintenance and the cost in terms of dietary protein needed to deposit protein as growth. According to the equation above, the daily maintenance requirement for digestible protein would amount to 0.30/0.47 = $D.P.^{maint}$ = 0.64 g $(kg)^{0.70}$.

Growth prediction, feed intake

Another basic piece of information needed in developing feeding standards is the growth potential of the fish. Therefore one of the first steps is to establish a workable growth model for tilapia grown under optimum conditions. Another prerequisite is a prediction of the actual amount of feed the fish can physically consume. This is needed to adjust the energy and nutrient density of a potential feed. It may also be necessary to define these parameters for different stocks or strains.

Tilapia initially weighing 20 g were stocked into 1-m^3 tanks and hand fed up to four times daily using the same feed as mentioned above. Any leftover feed was collected and weighed. The tilapia were weighed every 14 days, and absolute weight gain as well as daily feed intake were calculated for the period between successive weight recordings.

The corresponding body weight was the geometric weight of the fish during this period. Thus, two data sets were obtained, referring daily weight gain and feed intake to increasing fish weights at a temperature of 27 degrees C.

Fig. 2: Daily feed intake and weight gain of tilapia at 27 degrees C.

Fig. 2 depicts the daily feed intake and weight gain of the tilapia. The equation defining the relationship between daily weight gain and fish size appears below:

The daily feed intake, depending on fish size and temperature, can be described with the same general equation:

Composition of weight gain

The composition of the weight gain is an additional factor for quantifying subsequent energy and protein requirements. To determine the body composition of tilapia of different sizes along the growth cycle, fish were sampled at the start and during the duration of the growth trial.

Fig. 3: Body composition of tilapia at increasing sizes.

The following values describe the composition of tilapia for increasing weights along the growth cycle (also see Figure 3):

Formulations, feeding regimes

Using the approach described above, daily requirements for energy and protein in growing tilapia can be calculated for a specific body weight (Table 1).

Lupatsch, Predicted feed requirements, Table 1

	50 g	50 g	Body Weight 250 g	Body Weight 250 g	400 g	400 g
Weight gain (g/day)	1.02	1.02	2.46	2.46	3.18	3.18
Feed intake (g/day)	1.46	1.46	3.84	3.84	5.10	5.10
Energy Requirements						
$D.E.^{maint}$(kJ/fish/day)	5.05	5.05	18.31	18.31	26.66	26.66
$D.E.^{growth}$ (kJ/fish/day)	11.26	11.26	29.67	29.67	39.37	39.37
$D.E.^{m+g}$ (kJ/fish/day)	16.31	16.31	47.98	47.98	66.04	66.04
Protein Requirements						
$D.P.^{maint}$ (g/fish/day)	0.079	0.079	0.243	0.243	0.337	0.337
$D.P.^{growth}$ (g/fish/day)	0.348	0.348	0.838	0.838	1.084	1.084
$D.P.^{m+g}$ (g/fish/day)	0.426	0.426	1.081	1.081	1.421	1.421
Feed Formulation						
Gross energy content of feed (MJ/kg)	**16**	**19**	**16**	**19**	**16**	**19**
Required feed intake (g/fish/day)	1.27	1.07	3.75	3.16	5.16	4.34
Resulting crude protein content of feed (g/kg)	393	467	339	403	324	385
Feed-conversion ratio	1.25	1.05	1.52	1.28	1.62	1.37
D.P.:D.E. ratio (g/MJ)	26.1	26.1	22.5	22.5	21.5	21.5

Assuming digestibility of 80 and 85% for energy and protein, respectively.

Table 1. Predicted feed requirements and feed-conversion ratios for tilapia of different sizes at 27° C.

The absolute daily anticipated protein requirement of tilapia is dependent on fish size and weight gain, regardless of dietary energy content. Therefore, as demonstrated in Table 1, the protein level expressed as a percentage of the feed changes according to the selected gross energy content of 16 or 19 MJ/kg.

Also, the dietary protein:daily energy ratio decreases with increasing fish size and decreasing growth potential. This is caused by the changing energy:protein ratio in the fish bodies and the increasing proportion of energy used for maintenance with increasing fish size. With higher maintenance demand in relation to weight gain, feed-conversion ratios also increase with increasing fish weight.

Perspectives

As shown in Table 1, it is possible to come up with a series of feed formulations to meet the energy and protein requirements of a fish.

Thus, an advantage of herbivores or omnivores such as tilapia is that they can be fed lower-energy and protein diets because they consume higher amounts of feed than carnivores. However, it is important to recognize that even tilapia can reach physical limits in consuming all the feed needed to acquire the energy and protein needed for maximum growth (Table 1).

(Editor's Note: This article was originally published in the July/August 2012 print edition of the Global Aquaculture Advocate*.)*

Author

INGRID LUPATSCH, PH.D.

Centre for Sustainable Aquaculture Research
Swansea University
Singleton Park, Swansea SA2 8PP United Kingdom

i.lupatsch@swansea.ac.uk (mailto:i.lupatsch@swansea.ac.uk)