# CHAPTER 6

# FEEDS AND FEEDING THE FISH

The objective of feeding fish is to provide the nutritional requirements for good *health*, optimum growth, optimum yield and minimum waste within reasonable cost so as to optimize profits (Schmittou et al., 1998). Every farmer should be particular about the quality of feed fed to the fish because it is the feed that determines the:

(i) Nutrient loading (and ultimately *carrying capacity*) in the pond, hence water quality within the culture system
(ii) Fish growth rate,
(iii) Economic viability of the enterprise. 60-70% of variable production costs in a normal *production cycle* is due to feed.
(iv) *Health* status of the fish.

## 6.1. Feed Quality

The quality of feed refers to the nutritional as well as the physical characteristics of the feed that allow it to be consumed and digested by the fish. The feed should contain all the nutrients required by the fish, in the right proportions for good performance (growth and *health*). The specific nutrient requirements for fish vary with the fish's size and reproductive state. Table 6.1 below presents the nutritional requirements of catfish. The nutrients within the feed should also be easily accessible to the fish and be digestible.

The physical attributes of the feed determine the degree to which the feed affects water quality and consumption rates by the fish. The physical attributes of a good feed, therefore, are:

1. The ingredients used in the feed should be finely ground. The pellets will have uniform colour and you should not be able to distinguish morsels of maize for example.
2. The feed must be without fines or dust. If too many fines are in the feed, too much will be wasted in the form of a powder that floats on the water surface. Tilapia may eventually consume this powder but larger catfish will not.
3. The pellet should be firm with a water stability of at least 30 minutes. The pellet's water stability refers to the time it takes for the pellet to completely fall apart in water. **Plate 6.1** shows what good pellets should look like. Proper cooking

assures that the starches have gelatinized and this helps hold the pellet together.

4. The pellets should be of uniform size and of correct size so the fish can swallow them. A size of about $\frac{1}{4}$ the gape of the mouth is advised.
5. The feed should be palatable to the fish with a good taste, smell and feel. Fish will spit out or only slowly consume feed that is not palatable.

One of the major differences between feeding fish and feeding terrestrial animals is that once fish have been fed, the excess feed cannot be retrieved from the water in pond, unless an extruded floating pellet is used, and even this is impractical. Land animals are fed from containers and excess feed can be retrieved, but even land animals have problems when there are too many fines in the feed. The fish in this case will be unable to eat all the feed and obtain all the nutrients it needs for growth as the feed will have disintegrated before they can consume it. This results in poor growth performance and a higher risk of poor water quality. Therefore, the higher the quality of feed that is used, the less wasted feed and the easier it is to manage pond water quality. With better water quality, the greater the pond's potential *carrying capacity*.

Catfish do much better when the starches in the feed are adequately cooked, which is more likely to happen with extruded feeds, as opposed to pelleted feeds. However, some pellet mills will cook the ingredients. A farmer can tell by checking the integrity of the pellets.

If the pellets of feed can float, it usually means that the ingredients have been cooked. Floating feed provides an added advantage in that the farmer not only knows when the fish have started feeding, but the farmer will know when the fish have stopped feeding. Even though catfish are thought to feed on the pond's bottom, they are easily trained to feed wherever the food is, even at the surface. Therefore, it is much easier for the farmer to evaluate feeding response when using a floating feed. However, floating feed often costs more. It is therefore up to the farmer to decide if floating feed is worth the added expense by evaluating fish performance and feed conversion

**Table 6.1:** Basic Nutrients Necessary for African catfish Growth

| Nutrient | Uses | Desired Levels in Diet |
|---|---|---|
| Protein | • Provides the proper ratio of amino acids<br>• Necessary for the building muscle, connective tissues, blood, enzymes, hormones, etc.<br>• Diets lower than 28% protein result in fatty fish. | 32% |
| Dietary Energy | • Not a nutrient in itself, but required to drive chemical reactions for tissue maintenance, growth and activity.<br>• Too much energy in the feed reduces feed intake and result into fatty fish which reduces dress out yield and shortens shelf-life of frozen products.<br>• Energy/protein ratios should be balanced for best results. | 8.5 – 9.5 Kcal/g protein |
| Fats | • Major source of energy for fish.<br>• Means by which fat soluble nutrients like some vitamins (e.g., E and D) can be absorbed by the body<br>• Hormones, some sub-cellular components as well as structural elements of the cells.<br>• Flesh texture and flavour depend on fattiness of the fish<br>• Fats add flavor to feed and act as an attractant<br>• Too much fat in feed results into fatty fish and fatty feeds are difficult to pellet and spoil easily. | 4 - 6 %; increase as protein level increases |
| Carbohydrates | • Poor source of energy for fish. Fish do not digest complex carbohydrates well enough for them to be their major source of energy from feed. But is a cheap filler.<br>• Carbohydrates are used in fish feeds to provide the binder and expansion characteristics required for pelletizing and extruding. | 20-35% |
| Fiber | • Not really a nutrient. Fish hardly require it and when fiber is high, digestibility of the feed is decreased. Excess fiber will increase pollution of the pond. | < 4% |
| Minerals and Vitamins | • Minerals are the inorganic component of the feed<br>• Wide variety of functions<br>• Structural component of hard and soft tissues<br>• Cofactors and/or activators of enzymes<br>• Osmo-regulators and acid-base balance<br>• Production of membrane potentials | Vitamin C – 50 ppm |

Adapted from Robinson, 2006.

## 6.2. Feeding Fish in Commercial Ponds with Nutritionally-Complete Diets (Pellets)

Obtaining best performance results from fish feed is not dependent on pellet quality alone. Better results are obtained when fish are fed correctly using the right techniques that ensure all fish have access to the feed, the fish's nutritional needs are being met and that no excess feed is fed. Feeding fish correctly means:

(i) giving feed of the correct nutritional quality for the specified age of fish,
(ii) feeding the right feed size for easy consumption,
(iii) feeding the correct amounts,
(iv) feeding at the right time(s) each day.

When fish are fed correctly, growth rates are good and uniform across the population, feed conversion ratios (*FCR*s) are low and pond water quality is better managed.

### 6.2.1. Selecting a Feed

When selecting a feed, bear in mind the following:

(i) The species of fish being cultured. Different species have different nutritional requirements. The nutritional requirements for catfish are listed in table 6.1 above.
(ii) The age and size of the fish. Juvenile fish require higher protein in their feed. For grow-out production, a feed with a protein level of 32% is adequate (see feeding chart in appendix 5).
(iii) The quality of Feed being used.
(iv) The anticipated feed conversion (*FCR*) of the feed. The cost-effectiveness of the feed being used is governed by the *FCR*s obtained. For commercial grow-out ponds, *FCR*s should never go above 2.

**Choosing the Right Feed**

**Poultry Farmers:**
Would you buy maize bran to feed to your layers or broilers raised under a deep litter system? Why would you rather purchase layers mash or broilers mash to feed the birds, since maize bran is cheaper?

The reasons you opt for the correct feed for the right bird are the same reasons you should opt for quality feed for fish. All poultry farmers know that when one compares one's production when maize bran is fed versus the correct feed, yields are higher when the correct feed is fed and the costs of production are lower when the correct feed is fed, despite the fact that the unit cost of the poultry mash is higher than that of maize bran.

**Dairy Farmers:**
Assume you had a cross-bred cow. If you fed it only dry grass, would you expect the cow to give you 15 litres per day? Definitely not. If it did, you would regard it an absolute miracle straight from heaven. If you provided this same cow with better quality pasture plus legumes, the yield would go up to about 5-7 litres per day. If on the other hand you topped this with some concentrate, you could get up to 10 litres per day or more.

How many of you dairy farmers think it would be a good idea to feed your dairy animals with maize bran instead of dairy meal? Several of you would make such a decision cautiously as the maize bran might destroy the benefits in yield that you would have obtained from giving the right pasture only; milk yield would drop and the cows might fall sick instead. In such situations where you cannot obtain the correct concentrate, most dairy farmers would opt to continue giving the best pasture they have access to and having reduced yields, rather than making losses by feeding disproportionate amounts of maize bran.

So, what feeding maize bran is to catfish, is what feeding dry grass is to milking cows, or feeding maize bran to layers. A dairy farmer who only feeds dry grass knows that because of the nutritional limits of the food he is giving the cow, it is unlikely that the cow will give the same milk yield as one fed on pasture with legumes as well as concentrate, even if they were of the same breed.

Fish are animals too. They need the correct kind of food in the right quantities if they are to give high yields. Fish need the right food to grow, they don't only need water.

The quality and quantity of feed given an animal is directly affects outputs and returns. The same applies in fish farming. Aquaculture yields, productivity and consequently returns, are directly related to the quality and quantity of food given to the fish.

## 6.2.2. Estimating the Correct Amount to Feed.

In order to avoid over or under feeding the fish, the right amount of feed must be given each time. The amount of feed to be provided to the fish per day, the feeding rate (*ration*), is dependent on the fish's body weight. Fish adjust their food consumption rates to meet their metabolic energy requirements. Therefore, the required *ration* varies with time during the *production cycle* depending on:

a. the fish' size (i.e. its average weight)
b. the pond water quality - notably in terms of water temperature, dissolved oxygen and pollutant levels.

The amount of feed required per *ration* can be estimated with the help of a feeding chart and calculated as follows (see appendix 5):

= average fish size (weight) x feed rate (%) x total number of fish in the pond.

**Equation 5**

**Where,**

The feed rate is the amount recommended in the feeding chart as a percentage of the fish's average weight at that time.Box 4: Examples on Calculating the Daily Feed *Ration*:

**i) If an African catfish of 5 grams requires a *ration* of 8% of its body weight, how much food should it be given per day?**

Amount of feed to be fed per day = 5 grams x 8/100

= **0.4 grams feed per fish per day.**

If there are 1000 fish in the pond, then;

= 0.4 g x 1000 fish

= 400 g of feed should be weighed out for the day

**ii) If a catfish fish of 180 g requires a *ration* of 2.5% of its body weight, how much food should it be given per day?**

Amount of feed to be fed per day = 180 grams x 2.5/100

= **4.5 grams feed to be fed per fish per day, so for 1,000 fish = 4,500g**

**Note:**

1. The daily *ration* calculated above is 4.5 grams for the day **but** what the fish shall actually consume will depend on the water quality as well as other factors on that day. If, for example, the water temperatures or dissolved oxygen levels drop that day for some reason, the fish will consume less feed. Likewise, if there is a lot of dietary energy in the pellet, the fish may get satisfied sooner than they can consume what was calculated out for them.
2. According to the feeding chart, the fish should be receiving 2 meals a day. Therefore, divide 4.5 grams by 2 = 2.25 grams. **Feed about 2.25 grams of feed at each meal. But because water temperatures are normally lower in the mornings, the fish may tend to eat less feed in the morning than they do in the afternoon.**

The *optimum ration* is the one that gives best growth rates, uniform growth and the optimum *FCR*. This is because at this level of feeding,

there is minimum feed wastage and minimum deterioration of water quality. This is often achieved when fish are maintained at a feeding level just below that of *'satiation'*.

**DO NOT** overfeed fish because it results in feed wastage, deterioration of water quality and subsequently poor growth. Overfeeding only serves to reduce your profit margin. Likewise, substantial underfeeding results in poor growth and production.

### 6.2.3. Adjusting the *Ration*

Feeding *rations* should be adjusted either weekly or fortnightly depending on the fish's size. Smaller fish have a much higher metabolic rate and grow at a much faster rate so their *rations* need to be adjusted more frequently (preferably weekly). Feeding *rations* can be adjusted with the aid of feeding charts and occasional *sampling* (at least monthly) to ascertain actual fish sizes and growth rates. At *sampling*, adjust the *ration* based on the average weight of the fish obtained, NOT by the weeks in production.

Fish do not feed at the same intensity every day. The amount of food they take in each day depends on the water quality on that day, notably the temperature and any stressors (low DO, high pH, high ammonia, *disease*, etc.) to which the fish are exposed. Feed *rations* should, therefore, also be adjusted on a daily basis. Therefore, on rainy cold days one needs not to feed if fish show no interest in feeding as a result of lower water temperatures.

Once ponds are at *carrying capacity*, stop feeding fish for growth. Feed only a maintenance *ration* to prevent the fish from losing weight. Therefore, at *carrying capacity* a feed *ration* of about 0.5 to 1% body weight (depending on the fish size) is recommended. Feed the smaller *ration* (0.5% body weight) to adult fish above 600g. Remember, when the pond's *carrying capacity* has been reached, fish will not grow regardless of how much you feed them. Feeding more at this time is wasteful. One would rather stop feeding all together if you are sure you will harvest or reduce densities by at least 30% of the pond total *biomass* within a week. After reducing pond *biomass*, and water quality conditions improve in the pond, then start giving the full *ration* once again.

### 6.2.4. Administering the Feed

The way feed is administered to the fish affects their access to the feed and subsequently plays a great role in influencing growth rates,

uniformity in size and *FCR*s. When administering the feed, one must therefore aim at ensuring:

1. **Rapid and Positive Consumption of Feed by the Fish.** This is to increase ingestion rates and ensure that pellets do not remain for a long time in the water before they are consumed. Otherwise the pellets will fall apart, and nutrients will leach from the pellet into the water resulting into wastage, and reduced water quality.

2. **Minimal Metabolic Energy Expenditure Associated with Feeding.** Feed the fish the largest particle size it can consume. For example, do not feed adult fish with powdered feed but rather with larger sized pellets. This allows the fish utilise most of the energy they derive from the feed for growth, rather than for obtaining the feed. When fish are feed particles that are too small they end up spending a significant proportion of their energy trying to get enough food. Therefore, a 300 g fish should be fed a 5 mm pellet not a 1 mm pellet. Imagine yourself being asked to pick and eat all the rice for your lunch a grain at a time. It would be easier and more satisfying to consume the rice on the plate within a short time using a spoon.

3. **Ensure all the Fish have Equal Access to the Feed.** When all fish have equal access to feed of good nutritional quality, uniform growth rates are achieved and better *FCR*s are obtained. It is important to prevent a situation, whereby, only a few fish dominate the access to the feeding area. When only a few fish dominate the feeding area, the fish that can get to the feed grow much larger and start predating upon the smaller fish. In such a case, there will be a few *jumper* fish plus several small fish. Consequently overall survival rates and *FCR*s at harvest become negatively affected.

Feed can be offered to fish in ponds by one of the several ways:

a. By broadcasting (floating and sinking pellets). Slow broadcasting of pellets is the recommended way for administering pellets to catfish grow-out ponds (See **Plate 6.2a** and for details see section 4.2.5 below).
b. Via feeders (floating and sinking pellets).
c. Applied within feeding rings (floating feeds – especially for juveniles in ponds)

When deciding what feeding technique to adopt, the following should be taken into account:

1. How much feed should be fed per day per fish (*ration* size)?
2. How many times a day the fish should be fed (i.e. the feeding *frequency*)?
3. When the feeding times should be? The amount of feed consumed and the rate at which fish can metabolise it depends on water quality. Therefore, avoid feeding early in the morning when water temperatures and oxygen levels are usually at their lowest.
4. How you intend to administer the feed (i.e., the feeding technique)?
5. Labour availability and costs.

### 6.2.5. Feeding *Frequency*

The *feeding frequency* is the number of times fish in a pond are fed in a day. The feeding *frequency* affects the efficiency of feed utilisation (i.e. the *FCR*) so it is important to establish the optimal *frequency* of feeding so as to attain the best possible (optimal) *FCR* and uniform sizes of fish.

The following should be taken into account, when deciding how frequently fish should be fed each day:

1. For optimum growth and feed conversion, each feeding should be about 1% body weight. However, it is expensive in terms of labour to feed 4 or 5 times per day. In grow-out ponds, feeding 2 or 3 times a day is adequate.
2. Proper feeding *frequencies* reduce starvation and result into more uniform sizes.
3. Juvenile catfish need to be fed more frequently than adults, because they have higher metabolic rates and their stomachs are too small to hold all the feed they require for a day (see feeding chart in appendix 5).
4. Catfish from 400 g can be fed once a day, because at this size the stomach can hold enough food for the day. At this stage, feeding all the fish at the same time once a day, results into more uniform growth rates because the greedy ones will still be full when there is still food around in the pond. This provides a good chance for the smaller fish to come and feed, hence, they also grow.
5. The feed administered at a meal should be consumed within the first 15 minutes of the feeding if you are using floating feed. If it is not, reduce the amount given to match how much can actually be consumed. This is a bit tricky with sinking feed but it is possible.

## 6.2.6. Feeding Response

It is extremely important to feed fish in ponds by response, because:

1. It enables the farmer to feed the fish based on their actual needs at each meal. Therefore, the likelihood of overfeeding or underfeeding is reduced to a minimum.
2. It enables the farmer visually assess the number of fish in the pond, and their growth on a daily basis without actually having to physically handle the fish. The only time a farmer can see most of the fish in the pond in one mass, is during the course of feeding (see **Plate 6.2b**). Hence, feeding by response also provides another avenue for inventory control.
3. When water quality conditions in the pond are poor, or fish are sick, their first response is to go off feed. When fish are fed by response, it becomes easy to detect when they have lost their *appetite*. Therefore problems can be detected sooner, and remedial measures effected promptly before it is too late. The fishes feeding response, is therefore, the first indicator of the fishes well being.

The fish's feeding response depends on the:

1. **Suitability of the Feed.** The feed's appearance, smell, texture/feel and taste also influence the fish's *appetite*. The more palatable the feed is, the better the feed response should be.
2. **Culture (Water) Environment**. The most important water quality parameters that affect feeding response in ponds are water temperature and dissolved oxygen. The warmer the water and more dissolved oxygen it has, the more active fish will be and the better their feed consumption and *FCR*.
3. **Other Stressors,** such as pollutants in water, other water quality variables (notably of ammonia and pH), handling and social interactions also affect the fish's *appetite*. When fish are *stressed*, their *appetite* drops quickly.

### 6.2.6.1. Assessing Feeding Response

The attention paid by the farmer or person feeding is *extremely important* in assessing how much the fish actually need to be fed at each meal, or that day. In order to make this assessment, the following should be noted by the farmer during feeding:

1. How fast the fish moved towards the feed and how this reaction/behaviour compares with that at previous feedings?
2. Whether or not the fish are interested in the feed?
3. What the colour of the pond water is prior to feeding?

4. What proportion of the fish comes to the feed?
5. What the weather was a few days before, and on that day? Is (was) it rainy, cold or hot?

Therefore, the farmer must **always** stay around during feeding to watch how the fish feed every single day. Simply calculating and feeding the amount prescribed by the feeding chart results into wastage, high *FCR*s and poorer water quality. Feeding based on calculations only, is therefore "*dumping*" the feed, or "*feeding the pond*"; not feeding the fish.

### 6.2.6.2. Criteria for Judging Feeding Response

The following is a description of the criteria used to judge the fishes feeding response:

**E – Excellent** – Fish are very active and come to feed immediately. The feed administered is all consumed by the fish within 5 to at most 10 minutes of feeding.

**G – Good** – Fish are less active and come to feed over a longer duration. Feed gets consumed in about 15 to 20 minutes.

**F – Fair** – Fish are sluggish but do consume about three quarters of the feed. However, they do so in over more than 30 minutes.

**P – Poor** – When feed is applied, fish do not come to feed. More than three quarters of the feed administered is left over.

**NOTE:** The grading criteria listed above are subjective. Therefore, it is upon each farmer or the person feeding, to study the fish and their feeding behaviour. As much as possible, the same person should feed the fish on a daily basis. Likewise, the person who feeds the fish should be the one who keeps the daily feeding records, not someone else.

### 6.2.6.3. Training Fish to Feed by Response

Fish should be trained to come up, and get their feed at the water surface. In order to do this, the following steps should be followed when fish are fed by the slow broadcasting technique:

a. Administer the feed at the **same place in the pond and at about the same time every day.** This gets the fish into the habit of being in a certain area of the pond at feeding time. If the fish do not come to the area to feed initially, do not add any more feed until they learn to come to the assigned feeding area. It may take

up to a week to train fish to come and feed from the same area and learn their feeding times. Do not worry if in the mean time they do not get much. One may stomp at the edge of the pond, to call the fish at feeding time before administering the feed to them.

b. Broadcast a handful or plate full of the feed once most of the fish have collected at the feeding area. If the fish come out to get the feed and immediately consume the '*tester*', then the rest of the feed may be added. However, **do not trickle** the rest of the feed into the pond bit-by-bit. Rather, slowly broadcast large scoopfuls or bucketfuls at a time, until the fish's response starts to slow and the fish show no more interest in coming back for more feed. Weigh any leftover feed and keep it for the next meal.

By training fish to feed in this way, one is deliberately creating competition for food. The fish soon realise that if they do not come to feed at meal times, then they will not have food until the next meal time. Therefore, the fish actively compete to get to the feed at meal times and eat as much as they can, as fast as they can. Because all the fish eat at the same time, growth rates become more uniform and *FCR*s consequently improve. The effect is similar to that obtained when several children are made to sit around, and eat from the same plate.

### 6.2.7. When <u>Not</u> to Feed Fish

1. **The Feeding Response is Poor.** When the fish show a poor feeding response, it is normally for a reason. The water quality may have changed. For example, on a cold wet day, the pond water temperature may have dropped. Therefore, do not add more food than the fish are interested in consuming. Rather, find out the cause of the poor response and if it is due to something you can address, then correct it.

2. **They are Feeling Unwell.** When fish are sick, they go off feed. If you insist on feeding them, they still will not eat. The feed administered will instead accumulate at the bottom of the pond, and cause the water quality to drop. No positive returns accrue from wasted feed. Instead losses accrue due to reduced water quality, higher *FCR*s and the lost income from the wasted feed.

3. **At least Two Days before Harvest and Transportation.** This is to allow them to empty their guts before harvest and

transportation. In so doing, water quality in transport containers can be better maintained and *stress* levels during transportation reduced. The other objective is to improve quality of the harvested product for the market.

4. **The Afternoon before *Sampling* and on the *Sampling* Day before *Sampling*.** Fish should not be fed the afternoon before *sampling* for the same reason as above. Also, do not feed them on the actual day of *sampling* especially before they are *sampled*. This is because they will be subjected a lot to *stress* from physical handling during seining, weighing and counting. In addition, the act of passing a seine through the pond has a temporal negative effect on water quality because of the mixing of the top and bottom pond water. The bottom water is often of poorer quality.

   Young fish still being fed more than once a day, may be fed that day after *sampling* at their normal feeding time. Adults fed once a day should be fed next the day after. Because of the stressors the fish will have been exposed to at *sampling*, their feeding response is likely to be poorer for up to two days after *sampling* or partial harvests. The fish will still be recovering from the handling *stress*. Therefore, do not insist on giving the fish their full *ration*, if they show no interest in feeding after *sampling* or partial harvests. Only give the full *ration* when their response picks up.

5. **When Treatments are applied to the Pond.** When some treatments like formalin are applied to the pond, the fish get *stressed* because the water quality within the pond will have temporarily been altered. Their *appetite* subsequently drops. It is best to allow the water quality to improve and when it does, so will the fishes feeding response.

6. **When Water Temperatures are Low on Rainy Days.** After a series of rainy days if the water temperatures drop below 22 °C, the fish are unlikely to be interested in feeding. Therefore, do not feed.

## 6.3. Evaluating Feed Performance

Feed, is the input with the greatest influence on water quality during production. Feed is also the input whose expenditure line is the largest during the course of production. Feed performance alone, can therefore single handily make or break one's business. Therefore, it is extremely

important to closely monitor the performance of feeding during the course of production, in feed-based systems.

### 6.3.1. Feed Records

Records about feed usage should indicate:

1. the type of feed(s) administered,
2. the amount of feed given each day,
3. the feeding response at each feeding,

Records will help assess cost-effectiveness of the feeding program.

Figure 9.3 in section 9.2.1. explains how to fill the daily feed sheet while figure 9.4 in the same section gives examples of two different ways of filling the feed record sheet.

### 6.3.2. Feed Conversion Ratio (*FCR*)

The *Feed Conversion Ratio* (*FCR*) is the amount of food required to produce a unit of fish (see equation 6 below). It is an indicator of the:

i. performance of a feed,
ii. performance of the person feeding the fish and the fishes *health*
iii. cost-effectiveness of using a particular feed.

$$FCR = \frac{\text{total amount of food given } (\text{kg})}{\text{total amount of fish produced } (\text{kg})} \qquad \textbf{Equation 6}$$

**Box 5: Example on How to Calculate *FCR* and use *FCR* to Assess Returns to Feed**

i) **If at the end of a *production cycle*, a total of 150 kg of fish are harvested from a pond and a total of 200 kg of feed was fed to the fish during production, how much feed was required (used) to produce each kilogram of fish harvested?**
The *FCR* will be:

$$= \frac{\text{200 kg (total amount of feed fed during production)}}{\text{( 150 kg fish harvested- 10 kgfish stocked)}}$$
$$= 1.4$$

This means a total of **1.4 kg** of feed was used to produce each kilogram of fish.

**ii) If each kilogram of feed cost USh.500/=, how much did it cost to produce 1 kg of fish?**

= Amount of feed required to produce 1 kg of fish (*FCR*) x Unit Cost of feed (USh.s.)

= 1.4 kg X USh.s. 500/ = USh.s 700/=

**USh.700/= was spent on the feed to produce each kg of fish.**

In grow-out operations, a good *FCR* should be between 1.5 and 2 when using the pellets currently available on the market. The *FCR* should never be above 2. Having it equal to 2 means 2 kg of feed is used to produce a kilogram of fish. A feed conversion above 2 is poor and arises when:

i) Poor quality feed is fed. This occurs when feed is of poor nutritional value or the pellet is of poor physical quality.
ii) The feed (size or nutritional quality) given is not suitable for the age of fish being grown. For example, the pellet may either be too big or too small, contain nutrients in the wrong proportions, etc.
iii) The culture conditions are stressful to the fish. For example, if dissolved oxygen levels are continuously below 1 mg/l and/or ammonia levels are high (>20 mg/l), as commonly occurs when ponds have attained their *carrying capacity*.
iv) Fish are 'over-fed'.
v) Survival rates at harvest are low. Low survival rates may arise as a result of *stocking* small sizes, poor handling at *stocking*, predation, etc.
vi) Feeding for growth when the pond is at its *carrying capacity*.

### 6.3.3. How to Assess the Cost-Effectiveness of a Feed

When evaluating the cost-effectiveness of a particular feed, the *FCR* of that feed and its unit cost should be taken into account simultaneously and not independently of each other. Using the cheapest feed available, more often than not, does not translate into the lowest cost to produce a kilogram of fish (see table 6.2 below).

**Table 6.2:** Example showing what it Actually Costs to Produce a Kilogram of Fish using Different Feeds

| | **Maize bran** | **Farm mixed fish feed[a]** | **Complete diet/pellets** |
|---|---|---|---|
| **Unit Cost of feed/kg** | 400/= | 515/= | 920/= |
| ***FCR* of the feed** | 9 | 5 | 1.8 |
| **Amount of feed required to produce 1 kg of fish** | 9 kg | 5 kg | 1.8 kg |
| **Total Cost (USh.) of feed used to produce a kilo of fish** | = 9 kg bran x USh. 400/= = **3,600/=** | 5 kg feed x USh. 600/= = **2,575/=** | = 1.8 kg pellets x USh. 920/= = **1,656/=** |

**Note:** *(i)* Costs of all feeds based on actual market prices at the end of November, 2008
*(ii)* ªFarmer's feed mixture – 60% maize bran, 15% fish meal, 15% sunflower cake and 10% cassava flour.

The lower the *FCR*, the lower the amount of feed used to produce a kilogram of fish. Therefore, the feed which gives the lowest *FCR*, even though it might be more costly, is often the one that gives the lowest cost of production.

## 6.4. Managing *FCR*s

Ensuring that your *FCR* remains within an economic range (i.e. of not more than 2 at harvest), is extremely important when raising fish using 'feed-based' technologies. An *FCR* greater than 2, more often than not results in losses. This is because about 70% of one's operational costs are spent on buying feed for the fish. So any slight drop in the *FCR*, results in a significant increase of one's profit margins,(Table6.3).

The *FCR* obtained is simultaneously influenced by the quality of feed given, the fish themselves, pond water quality and feeding management. These factors act together and determine the fish's *appetite*, as well as how much of the feed eaten is actually digested and used for growth. Hence, they collectively determine what the *FCR* shall be at any given time (see figure 6.1 below). All four factors must perform optimally to get an optimum *FCR*. A lapse in any one of four results in higher *FCR*s.

**Table 6.3:** Proportionate Change in Cost Structure for Major Production Inputs over the Course of Production from a Catfish Mono-Culture Pond – *Static Water* Pond Management, Fed Nutritionally Complete Pellets. Data from Samarieza Fish Farm, Mukono.

| Time (days) | % Total Variable Costs | | |
|---|---|---|---|
| | Fingerlings | Feed | Labor |
| **0** | 98.7 | 0.0 | 1.3 |
| **18** | 91.5 | 6.7 | 1.8 |
| **28** | 81.4 | 16.1 | 2.5 |
| **48** | 66.7 | 29.8 | 3.5 |
| **61** | 55.1 | 41.2 | 3.7 |
| **83** | 46.1 | 49.7 | 4.2 |
| **117** | 38.1 | 57.0 | 4.9 |
| **175** | 32.0 | 61.9 | 6.1 |
| **208** | 28.9 | 64.5 | 6.5 |
| **283** | 23.6 | 69.1 | 7.3 |
| **311** | 22.8 | 69.5 | 7.7 |

Table 6.3 illustrates how, by harvest time, expenses on feed shall be about 70% of Total Variable Costs. It is therefore important to use feed as efficiently as possible in order to optimize returns.

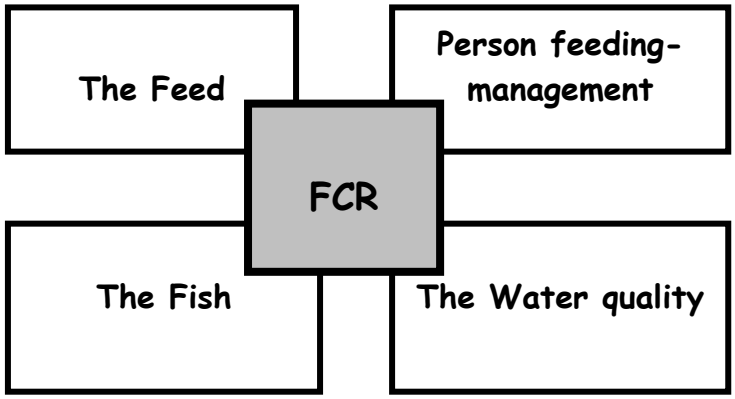


**Figure 6.1**: Factors Affecting the *FCR*

Therefore:

1. **The Person Feeding** is the most important person on the farm. He or she must be in position to:
   a. Train fish to the fish feed based on response.
   b. Keep track of and evaluate fish feeding response as well as fish performance through actual observation and keeping of records (i.e., with quantitative as well as qualitative information).
   c. Keep track of fish numbers and sizes in the various production units during the course of production.
   d. Deduce correctly from the pond and feeding records as well as the fish's feeding behaviour, what the next course of action should be *(e.g. what type of feed to give, how much feed to give, whether or not to adjust or withhold feeding, how best to administer the feed, what pond/water management details need adjusting, etc.*).

If the person feeding cannot do this, then it is not worth spending money on commercial feeds as you will end up losing money instead.

2. **The Feed**
   a. **Quality** (both physical and nutritional). Having a well made pellet of the correct size and of the right nutrient value for the size of fish being raised, is extremely important. Pellet integrity is also important.
   b. **Quantity.** It is important that the right amounts are fed.

3. **The Fish**
    a. **The species being raised.** For example, tilapia *fingerlings* will perform better than catfish *fingerlings* in an earthen pond receiving only fertiliser as an input.
    b. **The size of fish.** Fry require a higher protein level in their feed as well as a smaller feed pellet compared to adult fish.
    c. **Quality of seed *stocked*.** For example, was the fish *stressed* at *stocking*? Was it of the correct *stocking* size for the unit and intention for which it is being raised? For example, catfish grow-out ponds should be *stocked* with fish of not less than 5 g but preferably with fish of 10 g and above. *Nursery pond*s on the other hand, are managed to ensure survival young fry and can therefore be *stocked* with fish of 1-5 g. .

4. **The Water Quality within the Production Pond**, notably;
    a. the water temperature,
    b. levels of oxygen,
    c. levels of ammonia, pH and other pollutants in water.

## 6.5. On-Farm Feed Handling and Storage

The quality of a feed begins to deteriorate steadily after manufacture. The rate and magnitude of decline can significantly be slowed, through proper feed handling and storage at the farm. The following are recommended guidelines for handling and storing dry pelleted fish feed from time of purchase.

1. Check the labels and buy the freshest feed in the store. Feed pelleted within the past 4 weeks often meets the nutritional and physical standards stated on the label. Feed degradation can include loss of vitamins, especially vitamin C, and an increase in mold, etc.
2. Purchase only the quantity of feed that will be consumed within 4 to 6 weeks. Remember, the longer the feed is in storage, the lower its nutritional quality will be with time.
3. During transportation and handling, protect the feed from moisture, heat and direct sunlight. Heat and sunlight directly destroy feed nutrients like vitamins.
4. Store the feed in a cool, shaded, dry and well ventilated room. White, wooden buildings with reflective metal roofs are excellent for storing feed. Warm, moist and stagnant air enhances mold growth and attracts insects.

5. Do not stack bags on feed directly against a wall or on a concrete floor. Stack them on top of pallets off the walls of the building to prevent moisture coming in contact with the bags (see **Plate 6.3a**).
6. Protect the feed from rodents, bats, chickens and other animals. The feed can be stored in cages made of coffee wire mesh to keep off such animals (See **Plate 6.3b**).
7. Try to minimize insect contact and infestation.
8. Do not use pesticides or other toxic materials near the feeds.
9. Do not keep feed that has been molded or spoiled. Learn what the normal colour, smell and taste of the feed you use is. If the feed looks gray, blue or green in color; has a sour, musty or mildew odour (smell); or has been wet and has clusters of fused pellets - **do not use it** (**Plate 6.4b**).

**NOTE:** If you are feeding during the rain and the feed gets wet, feed all that wet feed that day or as soon as possible. Do not store wet feed, as it will get moldy.

**Summary Guidelines for Feeding Formulated Pellets to Catfish**

Besides the quality of the fish *stocked*, feed is the most important input in commercial catfish pond production because:

1. Feed is the highest proportion of operational costs and, therefore, the profitability of the operation depends largely on the performance of a feed (i.e. *FCR*). Remember, the aim is to convert the feed into fish to sell.
2. Pond production performance is attributable to the feed quality and the feeding technique.
3. Using a feeding technique based on feeding response is the *best* way a farmer can keep track of the:
   i. number and size of fish in the pond between samplings and at harvest
   ii. *health* status of the fish

In order to get the best out of a feed, one must:

1. Construct and prepare ponds for *stocking* as recommended in **Chapter 3**.
2. *Stock* the ponds based on their pond's *carrying capacity* in relation to targeted harvest size (see **Chapter 4)**.
3. Ensure best water quality (see **Chapter 5)**.
4. Feed the best quality feed available and aim for an *FCR* less than 2 as follows:
   a. Feed the right feed correctly based on the fish's feeding requirements and response.
   b. Be conservative when using feed because it costs money.
   c. The feed used must match the ponds inventory. Know the numbers and sizes of fish in the pond. Adopting a single batch system of management (*stock* one size and harvest all before restocking pond) allows better knowledge of what is actually in the pond and the population's size distribution. This is extremely important in catfish production because the larger fish will predate upon the small fish.
   d. Avoid overfeeding. One would rather keep fish slightly hungry than overfed.
   e. Avoid swings in feed input i.e. impromptu or haphazard feeding. Other than increasing *FCR*s such feeding results in increased size variation within the population which in turn results into increased cannibalism and lower survival rates. Catfish lose weight fast when not fed for a while.
   f. Base your feeding rate on the fish's feeding response using the feeding chart only as a guide. Feeding by response means the person feeding MUST take time to feed and observe how the fish are feeding.
5. Keep and regularly evaluate pond and feeding records. The person responsible for feeding should keep the daily feeding records. Adjust pond management and feeding based on the information derived from the records.
6. Harvest the production ponds **before** they reach *carrying capacity*. In the event that it is not possible to harvest the pond or reduce the fish density,
   i. 'flush' water through the pond before it gets to *carrying capacity* when there are signs of water quality deterioration, and
   ii. feed only a maintenance *ration*: about 0.5% to 1% body weight per day.


Good fish feed pellets maintain their integrity in water for several hours. This is what is referred to as the feed's '**water stability**'. A poor quality pellet disintegrates rapidly in water.

If you were feeding small catfish, you would want all of the pieces of feed to be small so the fish would not have to wait for them to dissolve before eating. Many feed companies have trouble adjusting their cutters on the pellet mill and do not make uniform-sized pellets. This will result in wasted feed.

**Plate 6.1: Pellet Quality - Water Stability and Uniformity**

**a. A Farmer Feeding by Slow Broadcasting of Pellets.**
Slow broadcasting is the recommended way for administering pellets to catfish grow-out ponds. **Do not** trickle the feed in.

**b. A Good Feeding Response.**
Note that one can see the fish as they come up to feed, if they have been properly trained. You do not have to be seated.

**Plate 6.2: Feeding Fish by Response**

**a. Bags of Feed in Store.**
On top of pallets and off the walls of the building to prevent moisture coming in contact with the bags. This provides protection against rodents.

**b. Feed Cage.**
A simple cage made of timber and coffee wire mesh all around to keep out vermin.

**Plate 6.3: Alternatives for Proper Storage of Feed**

**a. Good Pellets.**
Note the uniform colour and with no powdery substance

**b. Moldy Pellets.**
Note (i) the colour of pellets is not uniform, (ii) the powdery substance that remains on the hand and (iii) the holes in the pellets. The whitish tinge and powdery substance that remains on the hand are due to mold. The holes are due to insects.

**Plate 6.4: Pellet Quality: Identifying Moldy Pellets**