Feed Quality Problems and Management Strategies

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Abstract

Feed is the single most important input in increasing aquaculture production and profits. Success or failure in augmenting yield with feeding depends, to a large extent, on the quality of the diet. Feed quality, generally perceived as the responsibility of the feed manufacturer, is affected by factors outside of the plant such as handling, storage, and use. Thus, the maintenance of feed quality becomes partly the responsibility of the farmer. Every fish farmer must be familiar with the nature and occurrence of major feed quality problems and able to prevent and control them. This paper is based on a farmer's viewpoint. Valuable insights are provided for the feed manufacturer.

Introduction

Market prices of fish in the Philippines have increased considerably in the last few years compared with those of other meat commodities. This is due to lack of supply caused largely by overfishing of wild stocks and the government regulation against overexpansion of fish farms in mangrove and inland areas. The increase in fish prices has brought about widespread interest in increasing yields with the use of feeds. Although the technology of feeding has been practised for over 20 years, it is only recently that its application for fish has become commercially attractive. Traditional fish farmers throughout the country are now able to double pond productivity with feeding. Where life support systems are provided, five- to ten-fold increase in yields is commonly attained. At present, the annual local market for commercial fish and shrimp feeds is at least 35,000 and 30,000 metric tons, respectively.

Since feed accounts for about 50-60% of the variable costs of production, feed quality is crucial to the success of fish farming operations. Major problems that may result from low quality feeds are poor appetite, slow growth, high feed conversion ratio, and low survival. These usually develop as a result of problems on quality of raw materials, feed formulation, processing technology, storage, and feed manage-

merit. The management and control of the first three parameters are within the jurisdiction of the feed manufacturer. The fourth involves the farmers, while the fifth is fully a farmer's responsibility.

This paper focuses on feed quality and management on the farm level. Discussions are based on the author's experience on commercial pelleted diets for black tiger shrimp (*Penaeus monodon*), milkfish (*Chanos chanos*), and Nile tilapia (*Oreochromis niloticus*).

Important Problems on Feed Quality

Typical indicators of feed quality problems include:

1. gradual development of the disease, initially affecting fish growth and health, and eventually, feed efficiency and survival;

2. disease that is neither infectious nor contagious and is confined to a compartment or group of compartments;

3. absence of pathogenic bacteria or viruses;

4. minimal or no improvement after drug or antibiotic treatment;

5. signs of rancidity or aflatoxin contamination resembling vitamin deficiency symptoms but not ameliorated with vitamin supplementation;

6. occurrence of disease associated with the use of a particular feed batch.

Other than feed formulation which is beyond the control of the farmer, the most serious problems on feed quality are those involving rancidity, aflatoxin contamination, and nutrient loss.

Rancidity

The primary cause of rancidity in feeds is the peroxidation of lipids, particularly the unsaturated form. Feed ingredients that are prone to rancidity include fish meal, shrimp head meal, copra meal, rice bran, and marine oils. Rancid lipids reduce feed attractability, palatability, nutritional value, and produce toxic by-products. The overall effect is a reduction in appetite, growth, and feed efficiency. Prolonged exposure to rancid feeds weakens the animal, eventually leading to secondary diseases and mortality.

High temperature is one of the most important factors promoting rancidity (Chow 1980). Because of the inherently warm conditions in the Philippines, rancidity is a common problem both in raw materials and processed feeds.

Lipid peroxidation levels of up to 828 mg malonaldehyde/kg feed is tolerated by *P. monodon* juveniles for at least 2 months under laboratory conditions (Bautista and Subosa, in press). No toxicity data are available to date for milkfish and tilapia.

Aflatoxin contamination

Aflatoxins are the most toxic natural contaminants in artificial diets. They are produced mainly by strains of *Aspergillus flavus* and to a lesser extent by *A. parasiticus* (Smith and Moss 1985). There are more than a dozen types of anatoxins although most of its toxicity is attributed to aflatoxin B_1. The presence of molds in feeds suggests aflatoxin contamination, but absence of spoilage signs does not guarantee a low aflatoxin level since the toxin can originate from the raw ingredients.

Anatogenic strains of fungi are most common in the tropics. High temperature and humidity favor growth of molds especially on substrates with high C/N ratio such as copra, peanut, corn, cottonseed, and cassava (Smith and Moss 1985). All feedstuffs and feeds when stored for prolonged periods under adverse conditions are open to fungal attack.

Current laboratory studies on juvenile *P. monodon fed* continuously for at least two months showed that between 50-75 ppb aflatoxin B_1 in feed reduced growth and 100-150 ppb decreased survival (Bautista et al. 1994). At very high levels, aflatoxin has been demonstrated to cause reddish discoloration of the shell (de la Cruz *et al* 1989). Reddening which results from a damaged hepatopancreas causing the release, distribution, and deposition of stored carotenoids into tissues, is not a specific symptom but can also be induced by *vibriosis.*

The toxicity of aflatoxins in general may be categorized as acute or chronic. Acute anatoxicosis causes marked signs of disease or death. The liver is usually pale, atrophied or necrotic. Symptoms include loss of appetite and lethargy leading to death. Chronic aflatoxicosis are not readily discernible in affected animals. Visible symptoms may include reduced growth, appetite, and feed efficiency. The liver may appear normal but histological examination will likely reveal abnormalities (Bautista *et al* 1994).

Vitamin loss

In general, vitamin depletion in feeds is accelerated by heat, moisture, light, high pH, presence of certain minerals, and lipid oxidation (Tacon 1991).

Destruction of vitamins by heat and oxidation during feed processing and storage is well documented. In the case of ascorbic acid, for example, studies on fish and shrimp feeds have shown that as much as 50-95% of the vitamin activity can be destroyed (Akiyama 1991; Tacon 1991). Vitamins are also affected during transport especially under tropical conditions. Feeds which are shipped by sea in

containers are subject to elevated temperatures at day and cool temperatures at night. In the Philippines, it takes three to six months from the time the feed is processed up to its use.

A compounding problem in aquaculture diets particularly shrimp diets is the leaching of water-soluble vitamins (e.g., vitamin C and B complex). To compensate for processing, storage, and leaching losses, shrimp feeds are usually fortified with vitamins. Feed binders also play a major role in minimizing vitamin losses. The inevitable peroxidation of lipids has detrimental effect on the vitamin integrity. Typical symptoms of vitamin deficiency are poor growth, lethargy, low resistance to stress and diseases, and low feed efficiency. Because vitamins are costly to analyze, levels in feeds are rarely checked. However, a growing number of shrimp farmers recognize vitamin deficiency as a contributory factor to crop failures as evidenced by the increasing practice of vitamin supplementation.

Feed Quality Control Areas

A farmer has four control points over feed quality. These are through acquisition, quality evaluation, storage, and use. These control areas play an important role in the prevention and management of feed problems.

Feed acquisition

During feed acquisition, farmers are encouraged to exercise all possible precautionary measures in avoiding low quality feeds.

Feed should be procured only from reputable sources and supplies withdrawn good only for two weeks. Ideally, stocks should only be 1-2 months old from the date of production; the newer the feed, the better. Feed bags should be clear, intact, with the proper weight, and with appropriate tags.

In high density culture, it is good practice to have a "major" and a "minor" feed brand (used separately). The minor brand provides a basis for checking the performance of the major brand which is supposedly the more economical choice. It also provides an alternative source in case the major brand runs out of supply. If a minor brand is not available, an inventory of two production batches at any time should be prepared. This allows comparison when production problems are suspected on a feed batch.

Storage

Upon arrival in the farm, feeds should be segregated according to production batches and labeled with the date of storage. The inventory should be arranged in such a way that older feeds could be withdrawn first.

Feeds undergo rapid deterioration if not stored and handled properly. The following practices are recommended:

1. Use a store room that is cool, dry, well ventilated, and protected from rain and direct sunlight.

2. Keep the storage area away from sources of fungal or insect contamination.

3. Use wooden pallets; do not stack directly over soil or concrete floor.

4. Stack feeds no more than five bags and provide adequate spacing between pallets to promote air circulation; this can also rupture the packaging material.

5. Avoid rough handling. Do not throw or step on feed bags as this breaks the pellets and produces fines; this can also rupture the packaging material.

6. Protect the storage area from insects and rodents; conduct regular pest eradication.

7. Do not leave feed bags open and use opened or broken bags immediately.

8. Keep the storage area clean. Do not allow eating, sleeping or smoking in the vicinity.

Quality evaluation

Quality differences between production batches are common. These are due mainly to differences in ingredients used, batch of raw materials, processing settings, and storage conditions. Feed quality can also vary within the same feed batch due to inadequate mixing of ingredients and fluctuations in the processing condition. The routine evaluation of quality is integral in feed management.

Chemical analyses are ideal indicators of feed quality. Important chemical measurements include: proximate composition, aflatoxin B_1 level, peroxide value or thiobarbituric acid value, and bacterial and fungal counts. Application of these tests, unfortunately, has serious constraints. Since a new feed batch is used in the farm every few days or weeks, monitoring chemical quality for every batch becomes costly. Chemical tests are also not readily available and it takes time to obtain results. For economic and practical reasons, an average farmer cannot depend on chemical tests to routinely monitor feed quality. However, these tests are a must for the feed manufacturer.

There are alternative methods for evaluating the quality of feeds without the use of laboratory equipment. These are through sensory evaluation, physical examination, water stability test and palatability test.

Feed use

The inventory should be managed according to production batches where quality differences can be significant. Feed stocks should be consumed preferably within two weeks from acquisition. The shorter the storage period, the better will be the quality of the stock. The pond compartment where each feed batch is used should be identified. This will be needed when evaluating production performance and troubleshooting any problem that may occur. After a crop, if possible, remaining stocks which could not be immediately used should be returned or traded for newer feeds. Although feed quality evaluation should be assigned only to a specific person, all farm personnel should be familiar with and vigilant to feed quality problems.

Different culture systems require different feed formulations for cost-effective operation. In high density culture, nutrient-rich complete diets are necessary. In low density culture, lower quality supplementary feeds are the economical choice. The use of the right feed promotes maximal production at the lowest cost. In recent years, local feed manufacturers introduced low-cost shrimp diets for low density culture. Unfortunately, these products were used for high densities. As expected, there were many production failures which led to the negative impression of the industry on low-cost feeds.

Feed use need not necessarily be exacting. There are sound ways to manage certain quality problems. For example, in shrimp culture, when feeds are of different water stabilities, the regular feeding protocol using the monitoring trays should be modified to maintain the necessary feeding level by adjusting the monitoring time and/or the tray allocation. An increase in stability may cause underfeeding whereas a decrease may lead to overfeeding (Cruz 1991). Another problem on feed use arises when stocks approach their expiration date but are still in good condition. It is neither wise to continue using the feed as it is nor dispose of it. Instead, the feed can be mixed with a new batch, supplemented with vitamins, or used for low density culture. In problem management, close monitoring and supervision are of particular importance.

Practical Methods for Feed Quality Evaluation

Changes on the regular characteristics of a feed usually forewarn problems on quality. Below are practical and inexpensive tests recommended for routine feed examination. These methods have proven reliable not only for identifying feeds unfit for use, but also for detecting critical changes between and within production batches.

Routine random sampling for quality control should be conducted on at least 10% of the stocks (i.e., bags) for each production batch. If possible, each batch sample should be examined separately. For the next 60 days, 100 g of a pooled sample for each production batch should be stored in a sealed plastic bag for future reference.

Sensory evaluation

Smell and taste. Through experience, it is possible to detect major changes on the formulation just by the smell and taste. Fresh feeds have an agreeable odor. High protein diets (> 30%) in particular possess a strong odor of animal meal (e.g., fish, squid, shrimp). A faint odor is typical of old feeds. Spoiled feeds have a characteristic stale and musty smell due to fat rancidity and fungal growth, or putrid or ammoniacal smell due to bacterial decomposition. Spoiled feeds taste bitter, sour or rancid (off-flavor, as in spoiled peanut butter).

Temperature. Normal feed temperature should be about the same as that of the store room. Growth of mold in feeds is caused by a rise in temperature. Feed bags will feel warm to the touch and will tend to "sweat". Under favorable conditions, fungi can raise the temperature in their immediate environment up to 55°C (Chow, 1980) which destroys the heat-sensitive nutrients.

Physical examination

Moisture and hardness. Moisture promotes fungal and bacterial growth; thus feed manufacturers target moisture content below 12%. Feeds exposed to high humidity tend to increase moisture content. Moist feeds are relatively soft and easily compressed. When placed inside a bottle and shaken vigorously, the sound is muffled. Moist pellets do not flow freely inside the bag. Dampness in a sealed bag can be detected by pressing and feeling the feeds along the edges.

Amount of fines. Fines are too small to be consumed causing feed wastage and water pollution. Fines come from three sources: feed processing (poor pelleting quality), transport and handling damage (low durability), and prolonged storage (spoilage). Fines from mechanical damage usually concentrate at the bottom of the bag while those resulting from spoilage tend to be more evenly distributed. The content of the entire feed bag should be seived through a mesh size < 1mm. Fines should be below 3%. The smaller the pellet size, the higher will be the amount of fines.

Color. The type of raw material used influences the overall color of the feed. For example, formulations using white fish meal (in contrast to brown fish meal) or large amounts of soybean will produce lighter color feeds. When ingredients are not well mixed or when cooking temperature fluctuates, feed color will not be uniform. The degree of cooking also reflects on the color; undercooked feeds tend to be light while overcooked feeds appear dark. Furthermore, undercooking lowers water stability and probably lowers digestibility while overcooking feeds destroys heat labile vitamins. Feed deterioration also affects the color. Feed pellets that start to spoil become dull and eventually turn whitish.

Pellet size and uniformity. Variable pellet sizes result in feed wastage and show poor quality control on the part of the feed manufacturer. Variable size can result from transport and handling damage due to poor pellet integrity. Such feeds have low water stability and high amount of fines.

Ingredient size. Feed pellets should not show large ingredient particles. The presence of large particles indicates poor manufacturing practice. As a result, the feed will have a low water stability. Digestibility may also be low.

Presence of insects and foreign matter. Feeds should be free from insects. The presence of insects such as beetles or larvae indicates either poor storage condition or old feeds. Insect-infested feeds have low nutrient value and are susceptible to growth of molds. Inclusion of foreign matter such as plastic, paper, rope and insect dung reflects the plant practices on cleanliness and hygiene.

Water stability

Good water stability of feeds reduces wastage from physical disintegration, leaching of attractants and water soluble ingredients, and pollution of the environment. Feed stability is determined mainly by the kind of binder, type of raw material, particle size of ingredients, and degree of cooking. Different species have different requirements for feed stability. Shrimps, because of their slow feeding behavior, require highly water stable feeds (> 4 hours). On the other hand, milkfish and tilapia, which consume their rations quickly, can utilize less water stable feeds (< 1 hour).

Water stability can be measured upon immersion by: (a) qualifying the extent of pellet disintegration after a given time, (b) measuring the percentage of pellets that break under a fixed weight (i.e., suspended to the center of the pellet with a wire hook), and (c) measuring the time it takes for the pellet to lose its core. The first test is the simplest but has some degree of subjectivity. The second test is more difficult but provides greater consistency and reliability. The third method is not recommended since certain binders allow pellets to remain intact for long periods despite the loss of its core.

Palatability test

Consumption of feed within a short period is desired as this minimizes physical losses and leaching of soluble nutrients. Appetite is enhanced by the proper use of natural and chemical attractants, and is depressed by spoilage and use of inferior formulation.

Feed palatability can be tested by comparing its consumption in trays with that of a known good feed.

Crisis Management

When the feed is suspected to be causing a problem, other compartments that were given the same feed batch for the last four weeks should be identified and the health condition and production data of the animals compared. If there are indications that the problem is feed related, the feed should be changed to lower feed type (e.g., from grower to starter) or to another brand. If changing feeds is not immediately possible, enrichment with critical nutrients (i.e., vitamins, minerals and essential lipids) is recommended. In shrimps, supplementation with vitamin C (up to 2,000 mg/kg) and feeding of raw meat (e.g., oyster, mussel, trash fish) is frequently observed to improve health condition.

General observations on the occurrence of feed-related problems:

1. high density culture systems are more sensitive to feed quality problems

2. production problems involving feed quality mostly occur during the use of grower and finisher feeds

3. problems on feed spoilage are more common during the rainy months due to high relative humidity

4. smaller feed markets and minor feed brands tend to experience more quality problems due to longer storage time and fewer batches produced

Problems on growth, feed conversion, and survival can be caused by other factors such as unsuitable environmental conditions or presence of pathogenic organisms. Most often, it will be difficult to establish the specific cause of a problem with so many factors involved During periods of crisis, a "shotgun" approach is usually the best approach. Improve the diet, water quality, and health condition of the animals, and avoid all possible sources of stress.

Conclusion

The management of feed quality on the farm level is vital in the success of feeding operations. This encompasses the areas of acquisition, storage, quality evaluation, and feed use. Feed problems will sometimes occur inspite of the strict quality control measures undertaken by the manufacturer. For a farmer, what is important is to be able to prevent or immediately contain sporadic feed quality problems through sound management practices and decisions in order to avoid crop failures and economic losses.

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