3. Potential impact of nutrient substitutes in aquafeeds on fish health and on the food safety of aquaculture products

3.1 IMPACTS OF RISING AQUAFEED COSTS AND PRICE VOLATILITY ON THE HEALTH AND PRODUCTIVITY OF FISH

In most major aquafeed-based intensive aquaculture production systems there is a high reliance on nutritionally balanced complete aquafeeds. In situations where on-farm feeds are made, farmers attempt to produce a balanced feed using vitamin and mineral premixes. In all regions of the world, the increase in the cost of raw ingredients for commercially manufactured or on-farm aquafeeds resulted in an increase in aquafeed prices from 20 to 40 percent, thus forcing farmers to adopt alternative strategies to secure feeds. In the light of such price increases, farmers are increasingly looking for alternative sources of feeds such as trash fish, animal by-products and grain by-products, or are reverting to the use of single ingredient supplementary feeding regimes, reduced feeding frequency and ration. These types of interventions to mitigate against rising feed costs will compromise fish growth, health and welfare and could reduce fish productivity and production.

As prices of raw ingredients increase, farmers have to travel farther distances to obtain cheaper and alternative feedstuffs, incurring longer transport times under suboptimal conditions of heat and humidity, and store greater than normal quantities of ingredients under suboptimal storage conditions, resulting in spoilage, and fungal and bacterial contamination. These contaminants are pathogenic to fish as well as humans. The subsequent use of such ingredients or contaminated diets could reduce growth and reduce survival. Aquafeeds can serve as a carrier for a range of microbial contaminants such as moulds, mycotoxins and bacteria (Maciorowski *et al*., 2007).

Bacterial contamination of feed ingredients or diets with potential pathogens such as *Salmonella, E. coli, Staphylococcus, Streptococcus, Pasteurella, Pseudomonas,* and *Clostridia* will compromise fish and human health. Its impact may be relevant across the whole aquaculture sector, because the route of such contamination can be through both plant and rendered animal protein sources (Barakat, 2004; PDV, 2007).

3.1.1 Implications of fungal contamination in aquafeeds

The use of plant-based ingredients as substitutes for fish protein and oil in aquafeeds increases the risk of contamination by mycotoxins (fungal toxins produced by naturally occurring filamentous fungi or moulds). To date, several potent mycotoxins have been identified and those of serious concern, based on their toxicity and ubiquity, are aflatoxin, ochratoxin A, the trichothecenes (DON, T–2 toxin), zearalenone, fumonisin, and moniliformin (Bhatnagar *et al.*, 2004).

Mycotoxin producing moulds can infect agricultural crops, particularly cereals and oilseeds, during crop growth, harvest, storage, processing or during the storage of the manufactured compounded feed. Suitable conditions for fungal growth, in terms of warm temperature and moisture, promote mycotoxin contamination. Aflatoxin, a ubiquitious mycotoxin, which is produced primarily by the fungus *Aspergillus flavus* is

a major concern because of its carcinogenicity, especially in warm and humid climates. The production of aflatoxins increases at temperatures above 27°C, humidity levels above 62 percent and moisture levels above 14 percent in the feed. For the main aquaculture producing regions of the world, notably Asia, these climatic factors increase the risk of such contamination. The extent of contamination will further be affected by ingredient and feed storage practices and processing methods. Additionally, long duration of transport under poor conditions and improper storage are crucial factors favouring the growth of aflatoxin-producing moulds. Consequently, poorer aquafarmers in developing countries, where quality control of feeds may not be as high as in developed countries, are more likely to acquire contaminated feeds. Further, the recent increase in prices of feed ingredients is likely to drive poor farmers to look for cheaper sources and run the risk of purchasing rejected or contaminated ingredients and feeds.

Mycotoxins pose a serious threat to fish health and well-being. For example, aflatoxins are known to suppress the immune system and growth and increase mortality (Lim and Webster, 2001). Studies on Nile tilapia (*Oreochromis niloticus*) fed diets containing 1.8 mg of aflatoxin/kg of feed for 75 days showed reduced growth rates (Tuan *et al.*, 2002). Impaired immune function has been observed in Indian major carp (*Labeo rohita*) subjected to as low as 1.25 mg of aflatoxin B1/kg body weight in the feed (Sahoo and Mukherjee, 2001). Aflatoxin B1 concentrations of 75 ppb have been demonstrated to significantly reduce growth performance in pre-adult shrimp, Penaeus monodon (Bautista et al., 1994).

The condition, aflatoxicosis, caused by such contamination could be minimized by enforcing strict regulations for screening aquafeed ingredients, such as oilseeds, corn and other feed ingredients, for aflatoxins. As the principal route of such contamination is through ingredients of plant origin, the effects of such contamination on cultured warm-water fishes, such as tilapia, carps, milkfish and catfishes (*Pangasius* spp.), may be more significant because their diets contain more plant than animal ingredients. Effective methods of reducing the effects of mycotoxins using mycotoxin-adsorption agents such as Mycosorb® (Alltech, Inc.) are available, but such additives will increase feed costs further.

3.1.2 Implications of bacterial contamination in fish feeds

Contrary to fungal contamination, bacterial contamination is frequently overlooked but can have serious implication for fish and human health. Feed contaminated with bacteria, pathogenic to humans, can contribute to food borne human illness through the feed-animal-food-human chain.

Feed has been shown to be a major vector for transmission of *Salmonella* to farms and processing plants. Corry *et al*. (2002) compared the number of *Salmonella* serovars found in the feed mills of two integrated companies with those isolates found at their respective processing plants. The percentage of isolates found at the processing plants and feed mills were 56.3 and 54.5 percent, respectively. Hals *et al*. (2006) also found that out of 82 *Salmonella* serotypes found in both production animals and humans, 45 of these were isolated in feed.

Bacterial contamination of feed ingredients affects protein sources of both animal and plant origin. Recent studies have shown that vegetable protein sources, e.g. grains and their by-products, have incidences of Salmonella similar to rendered animal proteins (Barakat, 2004; PDV, 2007). Many bacteria associated with environmental contamination of feed ingredients are of the family Enterobacteriacea and their abundance in ingredients such as unprocessed soybean can be as high as 106–108/g of ingredient (Veldman *et al.*, 1995).

Bacterial contamination of feed can affect animal performance especially through its impact on the form and functioning of the gastrointestinal tract and, hence, growth performance.

Under conditions of increasing feed ingredient prices, farmers and small feed producers may compromise standards and inadvertently acquire contaminated feed ingredients in order to lower costs and in doing so, compromise fish and human health.

3.1.3 Trash fish as aquafeed

In many Asian countries using cheap trash fish as aquafeed is a common practice. As prices for formulated feeds increase, there will be a tendency for farmers elsewhere also to revert to using such sources of feed. In addition to the significant quantities of trash fish required, compared with pelleted diets, the increased frequency of use of trash fish will exasperate water quality problems and compromise fish growth and survival. The direct infection of cultured fish through the consumption of trash fish containing high bacterial loads, particularly of the streptococcal types, are well documented (Austin, 1997; Muroga, 2001; Ghittino *et al*. 2003).

In addition, the procurement of increased quantities of trash fish will require increased capacity to refrigerate and to store feed. For example, in Viet Nam, 3 tonnes of feed are required per day to maintain just two ponds (see Box 5).

3.1.4 Rise in fishmeal replacement with plant ingredients and anti-nutritional factors

The greater pressure on inclusion of proteins and oils of plant origin, will increase the overall negative impacts of anti-nutritional factors present in such ingredients. Greater details on the influence of anti-nutritional factors on diet performance are given in Section 2.5. While these effects may be reduced through processing or through the addition of enzymes, which will increase costs, the use of unprocessed ingredients, which may be cheaper, will compromise fish growth, suppress immune response and reduce survivability.

In addition, reverting to the use of single ingredient supplementary diets, e.g. soybean meal, may also result in the use of nutritionally unbalanced diets. The amino acid in soybean protein, for example, is well known to be limiting in total sulphur amino acids (methionine plus cysteine). Soybeans are characterized by a high content of non-starch polysaccharides (NSPs), which provide marginal energy for the fish and may negatively affect nutrient utilization and reduce feed efficiency (Gatlin *et al*., 2007). The oligosaccharide component of soybean meal (SBM) also has been linked with reduced growth performance (Refstie, Storebakken and Roem, 1998) and the occurrence of SBM-induced enteritis in several salmonid fish species (van den Ingh *et al.*, 1991; van den Ingh, Olli and Krogdahl, 1996; Bureau, Harris and Cho, 1998). Proteins in plant seeds and seed products often contain anti-nutritional factors such as antigenic compounds, protease inhibitors and lecithin. Lecithin can cause alteration in the intestinal structure and changes in the immune function of fish, while protease inhibitors cease protease enzyme activity. In addition, protease inhibitors, present in many seed meals, can also affect gut health and fish performance. Enzymes of fish seem to be particularly sensitive to these protease inhibitors (Krogdahl and Holm, 1983), but heat treatment will inactivate protease inhibitors if applied correctly.

Approximately two-thirds of the total phosphorus in oilseed meals or grains and their by-product meals is present as phytic acid (phytate), which prevents or lowers the bioavailability of phytate-phosphorus to fish (Gatlin *et al.*, 2007). Further, phytic acid lowers the availability of certain divalent cations, notably zinc, to carnivorous species of fish (trout and salmon) and to omnivorous species (catfish), and also has been reported in some studies to reduce the apparent digestibility of protein. Heat treatment associated with extrusion pelleting does not improve the availability of phytate-phosphorus in oilseed meals or grains (Gatlin *et al*., 2007).

Greater details on influence of anti-nutritional factors on diet performance is given in Section 2.5.

3.1.5 Adulteration of fishmeal and implication for fish and human health

The rise in costs of fishmeal and the shortage of supply has resulted in the addition by several companies in China of the toxic chemical melamine to fish and animal feeds to artificially inflate protein content (see Box 4). These toxic chemicals entered the human food chain resulting in fatalities and illness (www.naturalnews.com/025836.html).

3.1.6 Contaminants in lower quality fishmeal

As regulations on screening standards for fishmeal form part of enforcement, there is a probability that substandard fishmeal will be disposed at discounted prices and could be acquired by farmers for on-farm feed production and by smaller feed manufactures. In such circumstances, using such contaminated ingredients by farmers, especially those operating on a small scale, will result in bioaccumulation in farmed fish (see Box 4).

BOX 4
Contamination of fishmeal with melamine

According to Chinese media reports, melamine is routinely added to animal feed because it mimics protein in quality tests.

"The feed industry seems to have acquiesced to agree on using the chemical to reduce production costs while maintaining the protein count for quality inspections," the *China Daily* said in an editorial. "We cannot say for sure if the same chemical has made its way into other types of food."

Because the news media in China are state controlled, analysts interpreted the recent reports as a tacit government admission that melamine has widely contaminated animal food products across the country.

In one of the biggest food safety operations in years, 369 000 government agents inspected animal feed operations across the country at the beginning of November, destroying 3 600 tonnes of feed and shutting down 238 producers.

The agriculture ministry reported that a nationwide inspection of the country's quarter of a million animal-feed makers has found at least 500 suspected producers of deliberately adding melamine to their products or of engaging in other questionable practices.

Source: www.naturalnews.com/025836.html