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SIGNIFICANT ASPECTS OF FEED PREPARATION FOR FEEDING CATFISH

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SIGNIFICANT ASPECTS OF FEED PREPARATION FOR FEEDING CATFISH

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Few, if any, agricultural or aquacultural enterprises rival the rate of grwoth of commercial freshwater catfish culture. The U. S. Bureau of Commercial Fisheries has presented the following statistics and production estimates which illustrate the increasing rate of production of catfish for food and sport fishing in this country (Jones, 1969): production in 1962, 1967, and 1968 was estimated at 1.1, 16.5 and 27.5 million pounds, respectively; projected production in 1969 was 42.0 million pounds and by 1975 it was predicted to be over 100 million pounds. Major factors, perhaps the most important, in the expansion of commercial catfish culture have been the adaptability of the fish to the supplemental feeding of dry, pelleted formulations plus advancements in the feeding and nutrition of catfish.

The science and art of commercial catfish feeding is still a few years behind livestock feeding, which has had the support of at least 100 years of research plus the convenience of making generalizations by analogy between different types of feedlot species; however, the progress made in the last decade by the relatively few persons working this area is meritorious. Most of the research has been conducted by the Southeastern Fish Cultural Laboratory of the U. S. Bureau of Sport Fisheries and Wildlife at Marion, Alabama; the Fish Farming Experimental Station, U. S. Bureau of Sport Fisheries and Wildlife at Stuttgart, Arkansas; Kansas State University; and Auburn University. However, within the last year or so a number of projects have been initiated at other state, federal and private research sites.

Most of the research in catfish nutrition has involved the nutrient requirements and practical feed formulation, with considerably less emphasis on methods of feed preparation. The research areas which have taken priority are justly qualified; however, the physical properties of a feed, as distinguished from nutritional and economic, are probably of greater importance for fish than for livestock or poultry. The following discussion will present some of the reasons in support of this. Considering the fact that there is such a dearth of printed information on catfish feed preparation, this report will rely heavily on unpublished observations and analogies from other animal feeds.

Catfish are not filter feeders, as are many fishes such as tilapia and some carps which can remove small suspended particulate matter from water, hence, their ingesta must be of relatively large particle size to be efficiently consumed. This means that the supplemental feed for catfish must be in a pellet, or large particle form, and stable in water for a reasonable period of time. Swingle (1958) fed the Auburn No. 1 mixture to channel catfish in ponds in the meal and in the pelleted forms. Feed conversion and weight gain were markedly superior for the pelleted ration as shown in Table 1. Fish could consume more of the feed in pelleted form and water pollution was less.

Table 1. Weight gain and feed conversion for channel catfish fed Auburn No. 1 feed mixture in pelleted and meal forms.

Feed preparation	Stocking rate, fish/acre	Feeding period, days	Yield, lb per acre	Conversion, lb feed/lb gain
Pelleted	3,000	252	2,363	1.6
Meal	3,000	252	1,113	3.3

Stability in water is the most important physical aspect of pellet quality. The pellet should be resistant to water penetration and subsequent disintegration, to erosion, and to leaching of nutrients. Pellets which degrade quickly in water are not consumed efficiently by the fish. This not only results in poor feed conversion but also in poor water quality. Uneaten organic matter increases the oxygen demand in the water, and inorganic material not absorbed by the fish contributes to more profuse growth of algae in the pond. The pellet should remain relatively intact in the water for at least 10 minutes. Catfish are rapid feeders and, according to Hastings (1969), usually consume all they want within 15 minutes. Hastings (1968) developed a test for measuring water stability of hard pellets. A weighed amount of the pellets is placed into still water on a No. 10 Tyler mesh aluminum screen for 10 minutes, removed and dried, and reweighed. A loss of not more than 10 per cent of the dry weight characterizes a good pellet.

Hastings has recommended a minimum of 8 per cent crude fiber in the ration and emphasizes that finely ground fibrous materials are important for compressibility and binding of the pellet (1967b). He stressed the importance of regrinding feedstuffs when necessary and suggested that fibrous feeds such as rice hulls should pass a U. S. No. 80 sieve before being pelleted. Israeli workers (Hepher, 1968) also emphasized the importance of fine grinding of the feed ingredients. This is to increase surface area of the particles to improve binding, and to allow better compressibility to prevent water penetration.

The fiber in the pellet provides mechanical strength and surface area upon which the bonding agents can adhere. Excessive fiber in the formulation may reduce the quality of the pellet as was demonstrated in a feeding experiment at the Auburn Fisheries Laboratory. Experimental rations were prepared which contained, as the major ingredients, corn starch and reground soybean and fish meals, with various levels of finely pulverized cellulose ranging from 2 to 22 per cent. As illustrated in the slide the pellets containing the higher levels of cellulose disintegrated more quickly than those containing the lower levels of cellulose.

Starch is an extremely important ingredient in pellet manufacture. At approximately 180°F in the presence of moisture, corn starch, and perhaps most other cereal starches, gelatinizes. This gelatinized starch plus the more water soluble protein in the feed ingredients form hydrocolloidal bonds in the pellet. Israeli workers (Hepher, 1968) strongly recommend wheat gluten meal or other wheat products in pellet formulae because of the excellent binding properties of wheat gluten. Not only is gluten a good bonding agent, it is a valuable nutrient. Both Hastings (1964) and Hepher of Israel (1968) contend that good pellets can be produced without the addition of nonnutritive bonding agents to the formula provided the manufacturer uses finely ground ingredients, a gelatinizable starch, or, perhaps, gluten, and good steam processing technique.

Hastings (1968) described the process of hard-pellet manufacture as the conditioning of a finely-ground feed with dry steam which increases moisture by 5 to 6 percent and raises the temperature to about 185°F; compression of the moist feed by rolling through holes in a die ring; cutting the extruded material into pellets; and, drying and cooling of the pellets. Several precautions should be taken to insure good pellet quality. Too much moisture added in the manufacturing process can cause plugging of equipment and excessive drying time. Not enough moisture will reduce the quality of the pellet. Insufficient drying may result in moldy pellets. Frequently moldy fish feeds are found. This may be the fault of the feeder due to improper storage. Since fish feeds are often stored near water where the relative humidity is high, the use of bags with polyethylene liners to reduce moisture penetration would be advantageous. Moldy feeds could contain mycotoxins (mold poisons) which are toxic to catfish.

Several companies are manufacturing low-density, non-sinking pelleted foeds for catfish. The advantages of the non-sinking or slow-sinking pellet are: feed consumption can be observed easier, particularly by the untrained feeder, which will help prevent over- or underfeeding; off-feed or disease can be detected easier when fish feed on the surface of the water; and, some fish culturists claim that fish feeding on the surface may be less likely to contact diseases than bottom feeders. Several fish culturists and commercial feeders have pointed out that it is important for catfish to be exposed to floating pellets as small fingerlings and early in the growing season because catfish are inherently not surface feeders and require gradual adaptation to the surface feed. Our experiences at Auburn have shown that channel catfish adapt readily to floating feeds but white catfish do not feed well on floating feed in cages.

Hastings (1969) fed blue and channel catfish a ration in a hard-pellet form and in a floating-pellet form and found that the blues performed slightly better on the floating pellet while the channels did essentially as well on one as the other. Survival was approximately equal for the two pellet forms. Hastings fed the floating pellets at a rate of 3 per cent body weight through June and 2.5 per cent for the remainder of the growing season and observed that the fish consumed this amount in about 15 minutes which was about all they would eat at one feeding per day.

Hastings (1969) has described the manufacturing process for the low-density pellets as, first, conditioning the finely ground mixture with steam under pressure; exposing the material to extremely high pressure (440 to 520 x $10^4 kg/m^2$) at a temperature of 107° to 127^oC, and suddenly releasing the pressure to allow the water vapor to expand the material, which, when dried will have the texture of "puffed" cereal.

In 1969 the low-density pellets were priced from 20 to 40 per cent above the conventional-type pellets (Simonton, private communication). The advantages of the non-sinking feed may be worth the price differential to the novice feeder; however, as the industry becomes more competitive and profit margins narrow and feed costs become more critical, it is doubtful that a feeder can afford to pay this magnitude of difference in price for the benefit of an expanded pellet.

A feed manufacturer in Alabama has developed a floating gel-type feed which is reportedly a good feed for newly-hatched fry. A liquid formulation containing fish protein solubles, molasses, ethanol, and vitamin and mineral additives is mixed with a jelling agent to form a stable, floating gel. One hatchery which has used the formulation for newly-hatched fry reports good palatability, good growth and very little unconsumed feed.

The effect of pelleting, primarily the moist heat, on the nutritional value of the feed has been considered. Hastings (1968) warns that heat labile vitamins are partially destroyed in the expanded pellet process which provides a more intensive heat treatment than in conventional pelleting. He suggests that the vitamin premix may be solubilized and sprayed onto the finished pellets. If this is not done overfortification of some of the vitamins is obviously necessary. The heat stability of the various vitamins during the expanded pelleting process has not been investigated. Generally, fat soluble vitamins are not destroyed to a great degree by heat, providing the exposure to oxygen is minimized (Davidson et al, 1962). Several of the water-soluble vitamins used in catfish feeds are heat sensitive, thiamine being the most sensitive (Cain, 1967). On the average approximately 50 per cent of the thiamine is lost in thermally processed foods receiving intensive heat treatment. Perhaps thiamine activity could be used as an index of vitamin stability in fish feeds receiving high heat treatment in their manufacture.

Steam processing, on the other hand, may improve nutritional values for fish feeds. Summers et al (1968) found that steam pelleting increased the metabolizable energy values of corn and wheat bran for poultry. This is apparently due to improvement in availability of carbohydrates to the birds. Summers et al (1968) also found that phosphorus availability from plant sources was increased for poultry by steam pelleting. Bayley et al (1968) pelleted poultry rations at temperatures of 70° to 90°C and found that all improved the value of the feeds and 90°C caused no more apparent damage than did lower temperatures.

Pellet size is important. If the pellets are very small for the size of the fish, more are likely to be uneaten; also, small pellets have more surface area exposed to the water which will allow relatively more leaching and erosion of material from the pellets and greater penetration of water into the pellets which weakens their structure. Moreover, pellets too large for the catfish to consume will disintegrate in the water and a substantial amount will not be eaten by the fish. The optimum pellet size is the maximum size that the fish will readily consume. Uneaten feed is a serious hazard to water quality. The inorganic material that is not absorbed by the fish will enhance the growth of algae and other aquatic plants, not only for the current year, but because it is accumulative, this problem will be accentuated in ensuing years. Unabsorbed organic matter must be oxidized by lower organisms, namely bacteria, which utilize more oxygen per unit mass of organic matter consumed than do the fish. In ponds with deep areas, namely old ponds which were not designed for catfish culture, unabsorbed organic matter may accumulate on the bottom in deep water where the oxygen is extremely low, then, when the pond "turns over" large amounts of the organic matter are brought to the surface and biological oxygen demand of the water becomes dangerously high.

A situation was observed during the 1970 growing season where a catfish farmer had fed a large, nonfloating pellet, which was 3/8-inches in diameter and up to 1-inch long, for the entire growing season. His feed conversion was not highly impressive, his pond bottoms had deep deposits of unconsumed organic matter, and his water had extremely intense plankton blooms. It appeared that at least during a part of the growing season his fish had been unable to utilize all of their feed allowance, probably because of the large pellet size when the fish were small.

Kansas researchers (1967) have recommended that newly hatched fry be offered the fines, which pass through a 3/16-inch screen, from crumbled pellets as soon as they will eat. As the fish grow, they should be fed somewhat larger crumbles and when they are 5- to 8-inches long, they may receive 3/16-inch diameter pellets until harvest. A 3/16-inch diameter pellet, approximately 1/4-inches long, appears to be the most popular size recommended by fish culturists when only one size pellet is used for feeding year-old fingerlings to harvest weight. A slightly larger diameter of 1/4- to perhaps 3/8-inch may be satisfactory for fish during the advanced stages of feedout periods.

The importance of fine grinding of the ingredients on pellet stability has been discussed. Particle size is also important in the digestibility of feeds by catfish. Catfish have a short, simple digestive tract with no grinding organs. This is in sharp contrast to some fish, such as carps, which have pharyngeal teeth, an elongated digestive tract, and, as some researchers have suggested, accessory organisms in the gut which aid in degrading herbivorous material. Consequently, for feeds containing large amounts of plant cell wall material, such as cereal grain by-products, particle size should be of significant importance to the digestibility of these feeds by catfish. For protein supplements such as animal and fish byproducts or low-fiber oilseed meals which contain little cellulosic material, particle size has less effect upon digestibility. Dupree (1967) fed casein and several other high protein feedstuffs of plant and animal

origin of various particle sizes to channel catfish fingerlings. The particles were sized by sifting the natural materials through screens of 40- to 100-mesh per inch. These particle sizes had no effect on the utilization of these protein sources by catfish fingerlings.

Another important characteristic of catfish feeds, which probably will not be discussed by other speakers on the program, is the amount of fiber in the ration. Catfish probably are unable to utilize cellulose of other plant cell wall materials for energy, judging from the design of their digestive system. Digestibility studies with catfish conducted in our laboratories (unpublished) showed that essentially all of the ingested cellulose cleared the digestive tract. However, Dupree and Sneed (1966) found that cellulose was beneficial in purified diets for fingerling catfish. They fed from 0 to 51% cellulose flour in nutritionally adequate experimental diets and found that the highest weight gains were by fish receiving 21% cellulose. Apparently fiber or nonnutritive bulk has a function in the digestibility of ingested nutrients, perhaps by reducing their rate of movement through the alimentary tract, thereby increasing absorption of the solubilized nutrients. On the other hand, too much fiber, whatever this quantity may be, is likely to depress digestibility due to a "nutrient dilution and envelopment effect" as has been demonstrated in livestock nutrition. Also, fiber in the ration proportionately reduces the amounts of absorbable nutrients the fish consumes per unit of dry matter intake. Moreover, fiber level is usually a reliable index of digestibility of natural feedstuffs by catfish, as was demonstrated by Hastings (1967a).

A study was conducted at Auburn in 1970 (unpublished) to compare the effect of fiber level in the diet on performance of catfish grown under intensive culture conditions from fingerlings to harvest size. Fish were fed rations containing equal levels of protein, energy, and growth factors but variable levels of cellulose ranging from approximately 4 to 28 per cent. As shown in table 2 the fish on the lowest fiber ration performed slightly better than the other fish on the higher fiber diets.

Table 2. Average percentage weight gains for catfish rations containing various levels of fiber.

Per cent fiber in ration: as cellulose	as crude fiber	Stocking rate fish per acre	Feeding period days	Weight gain lb/acre
3.4	2.0	6,000	205	3,807
11.8	8.3	6,000	205	2,881
20.0	15.1	6,000	205	2,759
27.9	21.5	6,000	205	2,779

As catfish culture is orienting toward more intensification and more artificial environments, feeds with maximum digestibility and maximum nutrient concentrations, as defined by physiological and economic parameters, will be favored because any material, organic or inorganic, not absorbed by the fish will be a burden to the system.

Fortunately, perishability of feed is a minor problem for catfish producers. There are a number of trout diets which consist of a combination of ground, wet meat and dry meal. Such moist or semi-moist feeds are obviously perishable and require low temperature storage. Catfish will readily accept a variety of feedstuffs in dry-pellet form and grow quite well. For this the catfish farmer must be eternally grateful. The importance of preventing mold in catfish feeds has been mentioned previously.

In summary, a good fish feed is one which provides for maximum feed conversion. Feed preparation plays a vital role. Most important in this respect is the manufacture of a pellet that has good water stability. Pellet size is important. Also, the use of highly digestible feed ingredients which do not have a surplus of nonnutritive material is desirable. In feeding fish, as in feeding other feedlot species, unconsumed feed is expensive; on the other hand, unlike in the feeding of terrestrial animals, unabsorbed feed is detrimental to water quality and is a threat to the survival of the fish.