NUTRITIONAL AND PHYSICAL QUALITY OF AQUA FEEDS

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NUTRITIVNA I FIZIČKA SVOJSTVA HRANE ZA RIBE

Abstrakt

Ishrana čini najveći deo troškova u intenzivnoj i polu-intenzivnoj proizvodnji u akvakulturi. Zbog toga hrana mora imati visok kvalitet, kako bi bili sigurni da će se dobro iskoristiti, obezbedi visok dnevni prirast, dobro zdravlje i proizvode visokog kvaliteta. Nutritivni kvalitet se obično definiše kao sposobnost hraniva da obezbedi ribama hranljive materije kako bi se postigao dobar porast. Fizički kvalitet se obično ne vezuje da nutritivni kvalitet ali se definiše kao sposobnost obrađenih hraniva da podnesu rukovanje bez stvaranja većih količina prašine. Postoji više metoda da se oceni kvalitet hrane za ribe. Oni koji se najviše koriste opisani su i diskutovani u ovom radu.

Ključne reči: *hrana za ribe, kvalitet*

INTRODUCTION

Feed comprises the biggest cost in intensive and semi-intensive aquaculture production. From an economical and environmental perspective it is important to ensure that feed is well utilized, providing high growth rate, good health and finally ensures a high quality product. Fish feed is formulated in order to meet the target species needs for nutrients and energy. Ingredients from various sources are combined by least cost formulation software to satisfy nutritional requirement of targeted spices. Knowing that feed cost comprises 40-60% of the variable cost in aquaculture worldwide (M e y e r s, 1999) price is a very important aspect of feed formulation. However, bioavailability of the nutrients and the physical quality of the feed, which can be affected by processing technology, are the most important factors in order to maximize feed utilization. Moreover the feed should ensure good health and high quality on the end product. Whereas nutrient requirement is well established for many aquatic species (N R C, 1993), other quality attributes such as physical quality of feed is less standardized.

Production of fish feed

Extrusion processing technology has become of major importance in the production of modern feeds used in intensive aquaculture. Extrusion is a process where the feed is subject to mixing, shearing and heating under high pressure before the extrudate finally is forced through a die. The feed constituents undergo transformations that affect nutritional (S ø r e n s e n et al., 2005; B a r r o w s et al., 2007) and physical quality of the feed (A a r s e t h et al., 2006). Physical quality is affected by several variables, among which formulation (R e f s t i e, et al., 2007; Ø v e r l a n d et al., 2007) and extruder parameters are recognized as having great influence. The transformations can be beneficial if the nutritional value is improved, but detrimental if nutrients are destroyed or become resistant to digestion. In this context, bioavailability of the nutrients and the physical quality of the feed both are of great importance.

Definition of feed quality

Feed quality is an imprecise term used to describe several aspects of feed quality such as nutritional, physical, hygienic- and sensorial quality. Physical quality is usually defined as the ability of processed feed, either pelleted or granulated to withstand handling without creating excessive amount of fines. Nutritional quality can be defined as the ability of the feed to meet nutritional requirement of the target animal. Hygienic quality refers to the content of mycotoxins, microorganism or mould in the feed at the point it is fed the animal. Sensorial quality can be defined as how the look, smell and taste of the feed appear to the animal. To some fish spices shape is important to stimulate feeding, however the most important criteria are not to exceed the capacity of the oral cavity. Palatability is important to stimulate feeding and diets often contain attractants in order to enhance feeding activity.

Physical quality of extruded fish feed

High technical quality of the feed pellet is necessary in order to minimize feed wastage and thereby maximizing feed intake and utilization of the feed. Feed is subjected to different stresses that may induce fines during transportation in the processing line during manufacturing, thereby during transportation to the fish farmer and finally in the feeding devices. Undersized particles are not wanted in any pelleted animal feed because it results in increased feed conversion ratio. Furthermore fines may cause water pollution that can affect fish health in a negative manner. Suspended solids may harm fish by clogging of the gills or by mechanical irritation that permits disease organisms to gain entrance. Moreover, oxygen is removed from the water during bacterial decomposition of the fines. Thus, durability index of the feed should be high to avoid induction of fine particles during transportation and feeding.

Equipment used for measuring pellet durability, hardness and sinking velocity

Some of the most important physical characteristics of feeds for salmonids are measured as: breaking strength, durability, bulk density, size (length and diameter) and sinking velocity.

Force at rupture

Force at rupture, or hardness or breaking strength, should be high in order to make the pellet withstand a certain amount of force without cracking for instance when feed is stored in bins. However, hardness might affect voluntarily feed intake. C l a r k et al. (1995) concluded that soft pellets were more acceptable to juvenile Atlantic salmon than hard pellets. Besides, salmonids do not physically disrupt the feed in the oral cavity but gulp the pray whole (S t e f f e n s, 1989). If the feed is too hard, the utilization of nutrients might be lower because the pellet stay intact through the gastrointestinal tract and the nutrients are not available for enzymatic degradation. On the other hand, too soft pellets may cause problems associated with the logistics. The pellet must be durable and remain in one piece until eaten by the fish. Dust and small fractures of the feed is not ingested by the fish and will therefore cause an increase in feed conversion ratio.

Hardness can be determined by using a texture analyser (TA-XT2®, Model 1000 R; SMS Stable Micro Systems, Blackdown Rural Industries, Surrey, UK), fitted with a 25 kg load cell and a PC-operated remote control. The pellets are broken individually between a flat-ended cylindrical probe and the bottom plate at a speed of 1 mm sec^{-1}. The force used to break the pellets is presented as the function of force and time by a computer and analysed using the Texture Expert for Windows (version 1.15, Stable Micro Systems). The peak force, i.e. the force at the major break of the pellet, is calculated from the height of the first peak and presented as Newtons (N). Hardness was recorded on 30 pellets from each feed sample and reported as the average of 10×3 pellets.

Pellet size

Another characteristic of the feed is the pellet size. Smith et al. (1995) showed that Atlantic salmon need less time to capture larger pellets, however, the probability of rejecting the feed after having been grasped was lower for smaller pellet sizes. The pellet, on the other hand, should not be too large, limited by the size of the fish (Thorpe and Wankowski, 1979).

Length and diameter is usually measured by use of an electronic calliper. Expansion ratio (%) is calculated by the equation ((pellet width – die diameter) × die $diameter^{-1}$) × 100.

Sinking velocity

Sinking velocity is one of the most important features of feeds for aquatic organisms. However, different sinking speeds are required for different fish spices. For instance, catfish does not have a demand for but is usually fed floating pellet in order to monitor feeding activity. Salmonids should be fed slow sinking feed, while bottom feeders or 'slow eaters' such as shrimp and sea urchin, require sinking feed that stays intact for hours or days.

Sinking velocity is commonly measured in a transparent pipe with a sealed bottom. The tube is filled up with tap water of drinking quality, or tap water mixed with salt to simulate sea water. The water column has a uniform temperature during the experiments. A stopwatch is used to measure the time it takes for one pellet to sink between the fixed positions, and is reported as cm s−1.

Bulk density

Sinking velocity is associated with bulk density of the pellets. R o k e y (1994) suggested a bulk density of 320-400 g l^{-1} for floating feed and 450-550 g l^{-1} for sinking feed. Bulk density is measured by loose pouring feed into a measuring cylinder with a known volume (e.g. approximately 1 kg of feed poured into a modified 1000 ml measuring cylinder). The content of the measuring cylinder is weighed on the Mettler Toledo scale and the experiment is repeated three times.

Pellet durability index

Durability tester simulates the stress to which pellets are exposed when conveyed pneumatically through tubes. Different methods and equipment are used to measure durability of pellets.

Holmen durability index is measured using a Holmen durability tester (Borregaard Lignotech, Hull, UK). Sifted pellets (100 g) is loaded in the Holmen tester and conveyed around in the closed circuit at an air velocity of 21 m s^{-1} for either: 30, 60, 90 or 120 sec. Sample collected in the collector is sieved. The mash size of the sieves is determined by the pellet size according to standard procedures. The Holmen tester is repeated three times in order to get 3 replicates from each feed sample. Holmen durability index (HDI), is calculated as the percentage of pellets remaining on a screen with a mesh size that is adapted to the pellet size (P a y n e et al., 2001).

Ligno durability simulates a combination of mechanical and pneumatical stress. Sifted pellets (100 g) is loaded in the closed chamber of the lingo tester. Pellets are bounced against a perforated surface like a sieve with high velocity of pressure air. The openings of the sieve are constant for all pellet diameters. One test period takes 30s. The remaining whole pellets are sifted and reported. Three replicate samples are commonly analysed.

Tumbling box tester (Seedburo, Chicago IL, USA) is simulating stresses to the feed under mechanical conveying. The device has four tumbling boxes rotating about an axis. Moreover, a 230 mm long baffle mounted symmetrical to a diagonal of one 300 x 300 mm side of each box in order to increase the strain on the pellets when feeds are tumbled in the boxes. The procedure for analyzing feed samples is described in detail by ASAE standard S269.4 DEC01 (2006).

Samples of 500 g of pellets (left from the sieving test) are placed in each of the four boxes. Five iron nuts are in addition added to each of two boxes in order to enhance the pellet attrition during tumbling. The feed samples are tumbled for 10 minutes at a speed of 50 rpm. After testing, the feed samples are sieved to remove dust following standard sieve sizes. PDI is defined as the weight of pellets remaining on the sieve divided by the total weight of pellets before tumbling and multiplied by 100:

DORIS is a new testing procedure and the equipment is developed aiming at simulating stresses that extruded high energy feed is exposed to during pneumatic feeding devices used in the aquaculture industry. Doris tester manufactured by AKVAsmart (Bryne, Norway) is used to measure the Doris value (DV). A sample of sifted pellets (100 g) is loaded into the Doris tester. The pellets are conveyed in a screw conveyor to a rotating fan that picks up the pellets and convey them to the outlet. Impact when the pellet is picked up by the fan, and when the pellets hits the wall is generating cracks and fines. Pellets, dust and fracture is collected. The content in the collector is moreover sieved using a set of sieves with varying diameter (according to existing guidelines), and sifted for 60 sec at amplitude of 0.5 with a Retsch AS 200 Control sieving machine. The procedure is repeated three times in order to get 3 replicates. DORIS value is reported as the sum of dust and small fractions collected from the sieves. In contradiction to the Holmen tester, which measures the amount of whole pellets left on the screen, the data obtained by using the Doris tester is reported as the amount (g) of dust and fractured pellets generated during testing.

CONCLUSIONS

Although fish farmers using extruded fish feed is expecting a high quality of the pellets, there is no good standardization of methods to analyze physical quality of feed. Various methods used to analyze physical quality was presented and discussed. More research is needed to standardize analytical tools used to analyze technical quality of feed, as well as to understand how the physical and nutritional characteristics of the feed are correlated.

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