



*The following protocol is in a process of continual improvement and will be updated periodically.
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Ingredient Functionality

Feed manufacturers must consider the effect of a novel feed ingredient on the overall quality of the form factor in which the feed is given or on the pellet. Fish farmers have expectations of pellet quality:

- a. There should be little dust and oil coming off of pellets in the feed bag.
- b. The effect of ingredients on pellet quality need to be available in terms of pellet durability, expansion, oil absorption, and water stability (Glencross et al., 2007) and these need to be of high quality for commercialization of the ingredient.

Ingredient functionality is often measured during the production of diets for a digestibility study for novel ingredients. The FIN uses a design protocol in which test diets contain 30% of the test ingredient and 70% of the control diet. As a result, any differences in pellet quality between test and control diets are due to the test ingredient.

As background information for ingredient functionality tests, the settings that are used to produce ingredients into feeds should be specified: All extruder settings including feed rate, screw speed, moisture added in barrel, barrel pressure and temperature. The results of Digestibility and other tests should be annotated with feed production parameters, along with feed formulations so that any variation in feed production techniques that are used can be assessed, alongside ingredients.

Pellet durability: There are many different methods to determine pellet durability. Some are very aggressive resulting in low values of intact pellets (impeller driven). Some are very weak and do not identify differences among different feeds (swinging bucket).

A recommended method for calculating the Pellet Durability Index is the use of the Holmen NHP 100 that simulates pneumatic conveyance to determine pellet durability (Norfolk, United Kingdom). In this method, a 100 g sample of feed is put into a chamber that resembles a screen basket and the timer is set for one minute as a fan blows the pellets around the chamber. During this period, fine particles break off leaving the chamber. At the end of the period, the pellets are removed and weighed. The percent of remaining pellets ($(\text{final wt.}/\text{initial wt.}) \times 100$) is the pellet durability index (PDI).

The PDI should also be calculated for a control diet that is commercially available for comparison. Quadruplicate runs should be conducted for both the control and experimental diet. Comparisons should be made along many dimensions, noting where significant differences ($P < 0.05$) and no significant differences exist. If there are

significant negative differences, the dietary inclusion levels can be changed until a level exists that results in no significant difference ($P < 0.05$) in ingredient functionality. PDI should be measured with the dried pellets before they are coated with additional oil since oil causes the broken pieces to stick to the pellets and the basket.

Expansion: Extruded feeds need to expand upon cooking/processing so that the feeds will float and absorb oil for some types of diets. A pellet that can float in freshwater is considered to have an acceptable expansion. The expansion ratio is determined by comparing the size of the opening in the extruder (die) where the pellet comes out of to the size of the dried final pellet. For example if a 3 mm die opening is used in the extruder and the final pellet is 4.5 mm in diameter the expansion ratio would be 150%. Why do pellets expand? The expansion of the pellet is due to the amount of carbohydrates. High protein concentrated feeds without significant amounts of carbohydrate often do not expand enough.

The control diet should have enough carbohydrate, usually provided by a grain flour (ie. wheat) to allow the feed to float in freshwater. Proteins often contain significant amounts of lipid, with a negative effect on expansion. "Contamination" or coating carbohydrates with oil prior to hydration can occur during processing. If the ingredient negatively affects expansion, the level of ingredient should be varied to determine the maximum inclusion level of this ingredient in the diet that does not affect expansion.

Oil absorption and Water Stability sections are forthcoming.

References:

Glencross, B.D., Booth, M., Allan, G.L. A feed is only as good as its ingredients - a review of ingredient evaluation strategies for aquaculture feeds. *Aquaculture Nutrition* 13; 17-34. 2007