Effect of different sources of starch and guar gum on aqua stability of shrimp feed pellets

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ABSTRACT

A shrimp feed formulation, consisting of fishmeal, squid meal, prawn head meal, soybean meal, cereal flour (different sources), fish oil, lecithin and other feed additives was selected for evaluating aqua-stability of different sources of starch namely, corn flour, maida flour, rice flour, tapioca flour and wheat flour as binders at 15.3% each in combination with guar gum at three levels of 1, 2 and 3%. The feed pellets were prepared (3-5 mm length, 3mm diameter) by adding 40 ml water for 100g dry powdered feed mix followed by steaming, pelleting in hand pelletizer and drying at 70 o C. The aqua-stability of feed pellets was determined by measuring the loss in weight of pellets soaked in water and the turbidity of water as Nephlometer reading (NMR). Among the starch sources tested, maida flour in combination with 2% guar gum in the feed imparted better aqua-stability to pellets followed by tapioca flour, rice flour, wheat flour and corn flour. Further increase in the level of guar gum in feed had no beneficial effect. It was observed that pellets containing guar gum rapidly swelled and developed cracks and these effects were higher with increase in guar gum level.

Feed pellets containing wheat flour and tapioca flour showed highest Nephlometer reading (water turbidity), while pellets with maida flour showed the least NMR followed by corn flour and rice flour. While addition of 1% guar gum considerably reduced the NMR of tapioca flour and wheat flour, incorporation of 2% guar gum resulted in the least NMR reading of pellets with wheat flour and maida flour. However, further increase in guar gum (3%) has no beneficial effect. But raising guar gum level to 3% decreased the NMR reading in the case of tapioca flour and increased the NMR of rice flour and corn flour. Feed pellets of the same shrimp feed formulation containing wheat flour along with 2% guar gum and processed in a commercial scale ring-die pellet mill having three stage conditioners and steam injection facility, showed good water stability up to 4 hours (79.5 % stability).

Introduction

Formulated feeds which are generally presented as dry pellets to shrimp should not disintegrate in water. They should absorb water, become soft but retain their shape for at least two hours till shrimp consumes them. This requirement of shrimp feed pellets is known as aqua-stability of pellets. Feeds with poor or inadequate water stability may disintegrate fast and pollute water causing mortality of shrimp and
economic loss. The aqua-stability of feed pellets is achieved mainly through use of appropriate binding material coupled with suitable processing technology. There are different types of materials, which can be used as binders (Meyers et al., 1972; Hertrampf, 1992). Forster (1972) examined the effect of different binders on the assimilation of prawn feeds. Starch can act as a binder in aqua feeds when appropriate processing technology is adopted and it can also serve as source of energy nutrient (carbohydrate) in the feed. In the present study five different sources of starch were evaluated as binders in a multi-ingredient feed formulation.

Materials and methods

A shrimp feed containing fishmeal, squid meal, prawn head meal, soybean meal, cereal flour (different sources), fish oil, lecithin and other feed additives was selected for evaluating different sources of starch as binders in combination with guar gum. The starch sources selected for evaluation were corn flour, maida flour (derived from polished wheat grain devoid of husk/bran), rice flour, tapioca flour and wheat flour. Three levels of guar gum 1, 2 and 3% were evaluated in combination with 15.3% of each of the starch source. A diet without guar gum served as control in each case. The solid ingredients of the diet were finely powdered and passed through a 0.5 mm sieve. The diets after mixing as per the formulation were thoroughly homogenized along with guar gum and starch source. For 100 g of dry diet mix, 40 ml of water was added and mixed into a hard dough. It was steamed at atmospheric pressure for ten minutes and cooled. The dough was patted in 3mm die hand pelletizer and dried at 70°C overnight. The dry feed pellets were manually broken into pieces of 3-5mm length and used in the experiment.

Since wheat flour is extensively used in commercial shrimp feeds, the same shrimp feed formulation used in this study with wheat flour and 2% guar gum, was taken and feed pellets were produced in a commercial scale ring-die pellet mill having three stage conditioners and steam injection facility. These pellets were also subjected to water stability test by determining the weight loss of pellets in water.

Determination of water stability of pellets

The water stability of feed pellets was determined by the standard method of keeping a weighed quantity (around 5g) of feed pellets in a beaker containing 500 ml tap water. The physical shape of the pellets was visually monitored with time while gently stirring the water with a glass rod every one hour. At the end of one hour a sample of water in each beaker was taken and the turbidity was measured in a Nephelometer. The water was filtered through a bolting cloth and the pellets were collected, dried and weighed. This process was repeated at the end of 1, 3, 5 and 6 hours. The water stability test was conducted in duplicate for all the treatments and for all the time intervals simultaneously.

Results and discussion

The weight loss of feed pellets in water is shown in Table 1. Among the starch sources maida flour in combination with 2% guar gum seems to impart better aqua-stability to pellets followed by tapioca flour, rice flour, wheat flour and corn flour in the decreasing order. Addition of guar gum improved the pellet stability and helped in reducing weight loss in water. The improvement could be seen only up to 2% inclusion of guar gum. Increasing its level to 3% had no beneficial effect in
TABLE 1: Loss in weight of feed pellets prepared with different starch sources along with guar gum (at different levels) in water at the end of six hours

<table>
<thead>
<tr>
<th>Guar gum (%)</th>
<th>0.0</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch source</td>
<td>Loss in weight (%) of pellets in water with different binders</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn flour</td>
<td>58.5</td>
<td>46.8</td>
<td>32.3</td>
<td>35.4</td>
</tr>
<tr>
<td>Maida flour</td>
<td>36.5</td>
<td>26.2</td>
<td>16.5</td>
<td>20.0</td>
</tr>
<tr>
<td>Rice flour</td>
<td>45.3</td>
<td>38.5</td>
<td>26.6</td>
<td>23.5</td>
</tr>
<tr>
<td>Tapioca flour</td>
<td>34.5</td>
<td>26.8</td>
<td>24.8</td>
<td>25.1</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>48.7</td>
<td>39.0</td>
<td>28.8</td>
<td>22.3</td>
</tr>
</tbody>
</table>

most of the cases. It was observed that pellets containing guar gum rapidly swelled and developed cracks and these changes were higher with increase in guar gum level.

The turbidity of water in which the pellets were soaked and measured as Nephelometer reading (NMR) is shown in Fig.1. In the control (0% guar gum), the NMR was the highest in pellets containing wheat flour and tapioca flour. Maida flour showed the least NMR followed by corn flour and rice flour. Addition of 1% guar gum considerably reduced the NMR of tapioca flour and wheat flour; there was practically no difference in other cases. Addition of 2% guar gum further minimized the NMR of wheat flour and maida flour, while it marginally increased in others. Further increase in guar gum up to 3% level led to the increase of NMR of rice flour and corn flour, while it decreased in the case of tapioca flour, The NMR remained practically unchanged in the case of wheat flour and maida flour.

Pellets containing wheat flour and 2% guar gum showed good water stability (Fig.2). The loss in weight of pellets occurred in the first one hour (19.6%) remained practically stable (20.5%) up to 4 hours with only a marginal fluctuation of 21.3% (difference of 1.7%).

Aquastability of shrimp feed pellets
Feed pellets should be sufficiently stable in water as the shrimps have to be fed under the water. Moreover, shrimps are slow feeders and carry feed pellets with them and nibble on at leisure. Unless the feed pellets have good stability it disintegrates faster causing water quality deterioration. Hence, water stability of pellet feeds is one of the quality criteria essential for shrimp feeds. It is desirable if the shrimp feed pellets are stable for 4-6 hours. Too hard pellets are also not desirable as they are difficult to be consumed by the shrimp.

The water stability of aqua feed pellets has been evaluated by different ways like physical shape (disintegration) and loss in weight of pellets when suspended in water (Ahamad Ali, 1988; Rani and Ahamad Ali, 1991) and turbiditymetry of water in which the pellets are soaked (Lowe and Apelt, 1985). In the present study a combination of both weight loss and turbiditymetry of water measured by nephelometer reading (NMR) along with observation on physical state of pellets was adopted and the approach gave fairly useful data for assessing the aqua-stability of the feed pellets.

Feeds having rough and water-soluble ingredients disintegrate faster (Meyers and Zein-Eldin, 1972). The grinding and the particle size of the ingredients also influence the water stability of feed pellets (Rani and Ahamad Ali, 1991). Shrimp feed formulations generally incorporate 15-20% of cereal flour. The starch present in these ingredients can act as binder if it is gelatinized by adequate moisture and heat treatment (steam cooking). Extrusion of feed pellets with steam injection works out well for achieving complete gelatinization of starch and provides good binding effect to the resultant pellets. However, shrimp feeds are generally processed in ring-die pellet mills, which work at low moisture (12-15%) and low temperature (>90°C). These conditions do not adequately gelatinize starch in feed. Hence, additional binders are used in shrimp feed formulations for achieving the desired water stability.

While studying the water stability of shrimp feed pellets using different binders, Ahamad Ali (1988) reported that the feed binding capacity of tapioca flour was comparable to that of agar agar, polyvinyl alcohol and sodium alginate at 2% level. However, pure water-soluble starch even at 40% was not as effective as other binders. In the present study when the formulations contained only starch source as binder, the loss in weight of pellets was high. Goswami and Goswami (1979) made similar observations with regard to starch as binder in prawn feeds. Addition of guar gum at 1-2% level in the formulation improved the binding capacity and lowered the loss in weight of pellets. Among the starch sources tested, maida flour in combination with guar gum seems to be the binder of choice. This is followed by tapioca flour, rice flour and wheat flour without any significant difference in the performance among them. Wheat flour and maida flour have additional advantage of gluten present in it, which also contributes to the binding. Hertrampf (1992) reviewed the water durability of aquaculture feeds. Meyers (1991) categorized binders into natural and synthetic. Huang (1989) subdivided the binders into natural minerals, botanic glues and synthetic binders. The botanic glues are more appropriately classified as plant products with pellet binding properties. Starch and guar gum come under this category. The pellet binding capacity of starch
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depends upon the nature and its gelatinization characteristics. Sufficient moisture and heat are essential for achieving this.

The NMRs of pellets with starch alone as binder were higher suggesting larger material from pellets was passing into water. Addition of guar gum decreased the NMRs. At higher levels of guar gum (2-3%) the NMR of rice flour and corn flour increased while that of tapioca decreased. The bulging and cracking of pellets observed in these cases must be responsible for this, which might have increased the surface area facilitating more materials from pellets to pass into water. However, NMR of maida flour, wheat flour and tapioca flour were comparatively low suggesting their superior binding properties. Trials of processing feed pellets in a commercial ring-die pellet mill indicated wheat flour and guar gum could be successfully employed as binders in shrimp feed.

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