Aquafeeds

Density control of extruded marine fish feeds

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Tools can help manufacturers control product density based on desired product characteristics

Aquaculture of an ever-increasing variety of aquatic species requires flexible feed manufacturing processes. Aquatic feeds can be broadly categorized based on their total fat content requirements as:

- low-fat diets (less than 12 percent fat)
- medium-fat diets (12 to 24 percent fat)
- high-fat diets (greater than 24 percent fat).

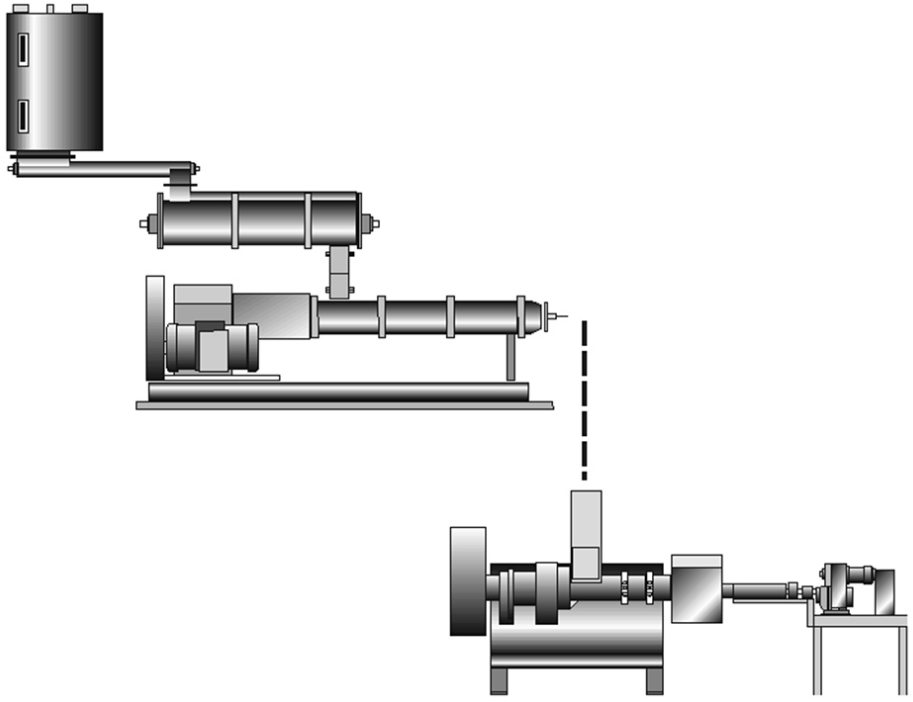
The diets in each category require different expansion ratios (bulk densities) to achieve the desired level of fat absorption and the desired floating/sinking characteristics.

Controlling feed density

Several process tools are available to control the feed density of extruded marine fish feeds, including:

- internal/external fat levels
- specific mechanical and thermal energy inputs
- extrusion moisture
- vented extruder barrel (with or without vacuum assist)
- extruder die value
- separate cooking and forming extruders.

Internal/external fat levels



One way to produce dense, well-cooked feeds is to use separate extruders for cooking and forming.

Nutritional requirements dictate the levels of fat required in aquatic feeds. The total levels can vary from 3 to 40 percent in diets. As the fat level increases, there is an expected increase in bulk density of the feed. For example, a diet containing 60 percent fishmeal, 24 percent soybean and 16 percent wheat grain was extruded at six internal fat levels. The internal fat level was adjusted by continuously injecting fish oil into the preconditioning phase of extrusion system at 0, 0.9, 1.8, 3.6, 7.2 and 14.4 percent levels. As the internal fat addition increased from 0 to 14.4 percent, bulk density of the extruded product increased and external fat absorption decreased (Fig. 1).

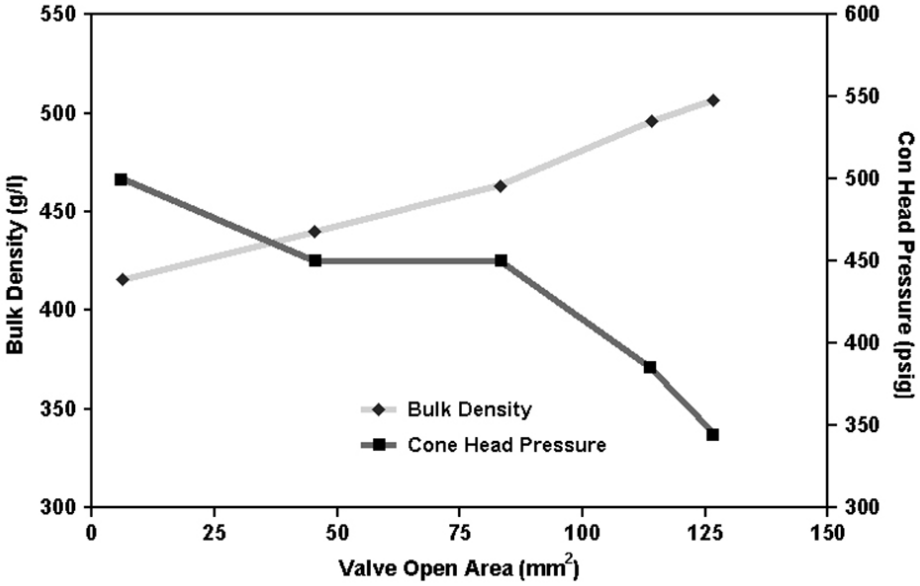


Fig. 1: Effect of added internal fat and bulk density on external fat absorption.

Specific mechanical, thermal energy inputs

Energy management is essential in controlling bulk density of extruded marine diets. A correlation exists between an extruder's specific mechanical energy inputs and the bulk density of uncoated diet. As these energy inputs are increased, density will generally decrease.

Extrusion moisture

Extrusion moisture is an important process variable for controlling final product characteristics, including bulk density. Extruded product bulk density first decreases and then increases as extrusion moisture decreases. (Fig. 2).

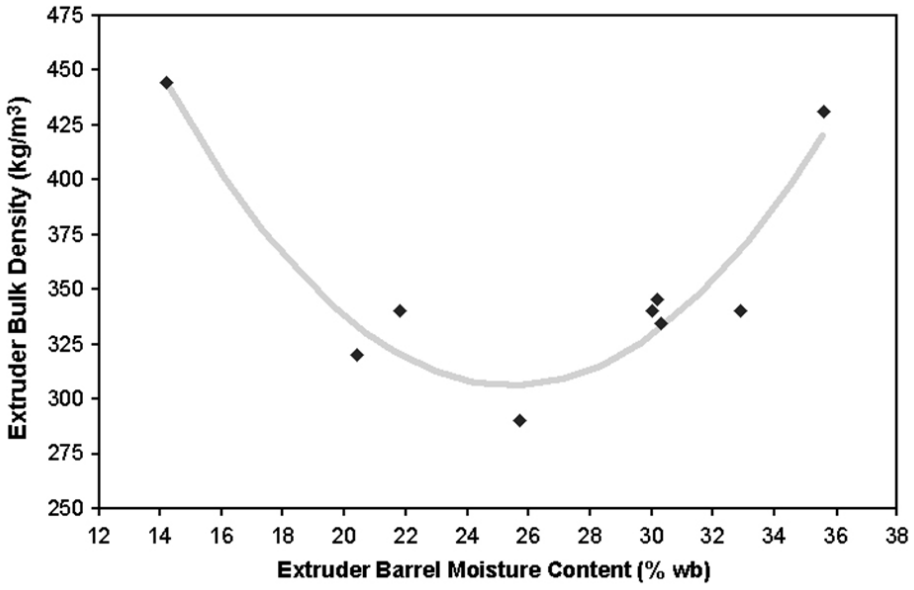


Fig. 2: Effect of extrusion moisture on bulk density.

Vented extruder barrel

Extruder barrels can be configured to include an atmospheric vent to permit reduction in extrusion pressures to cool and densify the extrudate. Extruded feeds can be further densified by coupling a vacuum system to the vented barrel (Table 1). Vacuum levels of up to 50 kPa (15 inches of mercury) are employed to assist densification.

Rokey, Effect of vacuum-assisted extruder venting on pellet density, Table 1

Pellet Size (mm)	Piece Density (g/ml) Without Vacuum	Piece Density (g/ml) With Vacuum
6	0.87	1.23
20	0.92	1.14
25	1.12	1.19

Table 1. Effect of vacuum-assisted extruder venting on pellet density.

Extruder die valve

Extrusion pressure can be varied by adjusting the opening size of die flow-control valves. As the die valve open area is increased, extrusion pressures decrease and final product densities increase (Fig. 3).

Fig. 3: Effect of die valve open area on extrusion pressure and bulk density.

Individual cooking, forming extruders

Very high density aquatic feeds can be manufactured by processing diets through a cooking extruder followed by a separate forming extruder. This processing method requires extensive equipment installation, but the separate, secondary forming extruder cools and densifies the feed to a high degree (Table 2).

Rokey, Effectiveness of densification tools, Table 2

Process Tool	Product Density Range (g)
Vented Barrel	480-600
Vented Barrel With Vacuum Assist	480-720
Cooking Extruder/Forming Extruder	560-720

Table 2. Effectiveness of densification tools.

Conclusion

Various process tools are available to the manufacturers of marine fish feeds to control product density. The choice of which tool(s) to use depends upon the density required to achieve the desired product characteristics (floating/-sinking, fat absorption, pellet durability and others).

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