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EXTRUDED SHRIMP FEEDS IMPROVE PERFORMANCE, SO WHY ARE THEY NOT MORE POPULAR?

Extruded feeds are used by less than 10 percent of the shrimp-farming sector, but have considerable advantages over traditional, compression-based alternatives in terms of factors such as growth rates, environmental impacts and feed conversion ratios.

According to FAO FishStatJ, approximately 48.2 million tonnes of farmed fish and crustaceans were dependent upon the external supply of feed inputs in 2019, primarily in the form of commercially manufactured feeds estimated at 56.5 million tonnes in 2019 (Table 1). Fed aquaculture species production grew at an average annual rate of 6.7 percent per year from 2000 to 2019 (FAO, 2021).

Global farmed shrimp production was reported at 6.55 million tonnes in 2019 and valued at over USD 40.67 billion (the highest of all farmed fed species production; FAO, 2021). Feed usage for shrimp was estimated at 9 million tonnes (16 percent of the total estimated global aquafeed usage, with an estimated value of USD 7.2 billion, based on an average shrimp feed price of USD 0.8/kg).

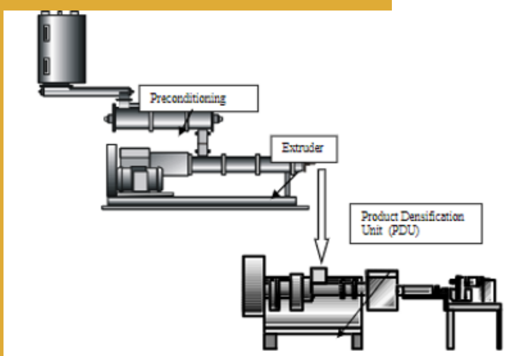
Notwithstanding the high economic value and global importance of the shrimp-farming sector, over 90 percent of shrimp feed production in Asia is still based on the use of lower-cost compression-based pelleting techniques (Merican, 2020). This necessitates additional fine grinding, the use of specific binders and/or high starch-based feed formulations, and the need for preconditioning and/or postconditioning of the feed mash/pellets to achieve 100 percent sinking feed with the desired water stability (Joseph, 2021; Lastein, 2019).

Table 1. Major fed aquaculture production and estimate of compound feed usage in 2019 and 2030

Top fed species	Species production (thousand tonnes)[1]	Feed use (%)	Economic FCR	Feed use (thousand tonnes)
Chinese carp	14 346/19 666	59/70	1.7/1.5	14 389/20 649
Shrimp	6 555/10 188	86/95	1.6/1.4	9 020/13 550
Catfishes	6 264/9 735	82/90	1.3/1.3	6 677/11 390
Tilapia	6 195/9 444	94/100	1.7/1.5	9 900/14 166
Freshwater crustaceans	3 475/9 208	59/70	1.8/1.6	3 690/10 313
Marine fish	3 194/4 964	84/95	1.6/1.4	4 293/6 602
Salmon	2 870/4 457	100	1.3/1.3	3 731/5 794
Other freshwater and diadromous fish	2 502/3 887	45/55	1.6/1.4	1 801/2 993
Milkfish	1 537/2 390	54/65	1.6/1.4	1 328/2 175
Trout	940/1 460	100	1.3/1.3	1 222/1 898
Eel	272/342	98/100	1.5/1.5	400/513
Total	48 150/75 741			56 451/90 043

Source: [1] FAO (2021)

Figure 1. A feed extruder with a product densification unit (PDU)



Source: Muñoz (2011)

Source: Muñoz (2011)

TECHNIQUE AND APPROACH USED

The main innovations in the production of extruded shrimp feeds have come from advances in the extruder barrel configuration, to increase feed density, so as to produce 100 percent sinking feeds (Figure 1). This is done either through: 1) the design and use of extruders with a pressure control chamber, 2) the use of extruders with a special densification cone, 3) the use of extruders with a product densification unit, and/or the use of special extruders with an oblique tube die (Muñoz, 2011).

SCOPE AND SCALE OF APPLICATION

Although the nutritional and economic superiority of using extruded shrimp feeds has been known for almost two decades (Chamberlain, 2004; Obaldo, Dominy and Ryu, 2000; Tacon, 2003), the shrimp-farming sector still depends on the use of compression-based pelleted shrimp feeds – only 5 percent to 10 percent of shrimp feeds are extruded.

However, with the entry of the major European salmon feed producers into the international shrimp feed market over the last decade, there has been a renewed interest in the development and use of a new generation of extruded sinking shrimp feeds produced using advanced shrimp-processing technologies (see Byrne, 2021; Kearns, 2011; Kumar and Engle, 2016; Ma *et al.*, 2013; Molina and Espinoza, 2020; Muñoz, 2011; Poveda and Ortega (2021); Riaz, 2014; Vijayagopal, 2004).

ACCESSIBILITY

The current dependence of the shrimp feed manufacturing sector on the use of compression-based sinking pelleted feeds is attributable to: 1) the absence of extrusion-based processing equipment during the early 1980s, when the shrimp-farming industry emerged and 2) the higher cost of extrusion-based processing equipment and the higher level of technical skill required to operate these more advanced feed manufacturing facilities compared to conventional compression-based feed milling operations (Chamberlain, 2004; Ma *et al.*, 2013).

Over 70 percent of global aquaculture feed production is extruded (Table 1, Delgado and Reyes-Jaquez, 2018; Joseph, 2021; Ma *et al.*, 2013; Riaz, 2014).

The main drivers for the shrimp-farming sector to transition from the use of conventional pelleted feeds to extruded shrimp feeds will be economics and farm profitability.

THE OUTCOME AND BENEFITS

Shrimp fed with sinking extruded feeds display higher growth and improved feed conversion efficiency compared to shrimp fed with conventional pelleted feeds (Chamberlain, 2004; Molina and Espinoza (2020); Poveda and Ortega (2021); Tacon, 2003).

Extrusion-based feed processing is currently the most advanced technology for the production of floating and slow-sinking fish feeds. Table 2 summarizes the major reported technological, nutritional and economic advantages and disadvantages of using compression-based pelleted shrimp feeds compared with extruded-based shrimp feeds.

Table 2. Comparison of the technological, nutritional and economic advantages and disadvantages of pelleted versus extruded shrimp feeds

Criteria	Pelleted shrimp feeds	Extruded shrimp feeds
Nutritional	• Low starch gelatinization (30% to 50%) and reduced carbohydrate digestibility. • Need for use of non-starch binders. • Limited fat addition (<12%). • Limited destruction of heat labile plant antinutritional factors (ANFs). • Reduced risk of denaturizing dietary proteins and heat labile vitamins. • Limited flexibility in feed formulation and potential higher formulation costs. • Limited ability to top dress feeds. • Increased leaching of water-soluble nutrients on prolonged water immersion. • Increased potential environmental impacts due to nutrient leaching and reduced water stability.	• High starch gelatinization (95% to 100%) and consequent carbohydrate digestibility. • Reduced need for non-starch binders. • Facilitate higher fat addition. • Improved destruction of heat labile ANFs and consequent improved gut health. • Increased risk of denaturizing dietary proteins and heat labile vitamins. • Increased flexibility in feed formulation and reduced feed ingredient costs. • Increased ability to top dress feeds. • Reduced leaching of water-soluble nutrients on prolonged water immersion. • Reduced environmental impacts due to nutrient leaching and increased water stability.
Processing	• Need for fine grinding. • Limited ability to top dress feeds. • Need for postconditioning to achieve desired feed water stability. • Limited ability to produce small-sized feeds and control pellet length. • Increased level of fines (feed dust) and potential feed wastage during feed processing. • Limited destruction of pathogens during processing and reduced feed biosecurity. • Limited ability to manipulate the feed density and feed shape/texture. • Limited ability to form amino acid–carbohydrate complexes during processing.	• Less need for fine grinding. • Increased ability to top dress feeds. • No need for postconditioning of feeds to achieve desired feed water stability. • Can produce a wide range of feed sizes down to 0.8 mm. • Reduced level of fines and feed wastage during feed processing. • Increased destruction of pathogens and improved feed biosecurity. • Increased ability to manipulate the feed density and feed shape/texture. • Increased ability to form amino acid–carbohydrate complexes during processing.
Economic	• Lower investment, equipment and processing costs. • Lower technical skill and expertise required to operate a pellet mill.	• Higher investment, equipment and processing costs. • Higher technical skill and expertise required to operate a shrimp extruder. • Although extrusion processing is 20% to 25% more expensive than pelleting (approximately USD 15/tonnes more costly), this difference can be made up in feed formulation savings or increased feed mill productivity (tonnes/hour) without affecting overall digestible nutrient levels. • Improved dietary nutrient digestibility and shrimp growth, and reduced feed conversion efficiency compared with pelleted feeds, and consequent increased profitability for the shrimp farmer, especially under indoor intensive culture conditions.

Source: Joseph (2021); Kearns (2011, 2013, 2014, 2015, 2017); Ma *et al.* (2013); Molina and Espinoza (2020); Muñoz (2011); Poveda and Ortega (2021); Riaz (2014); Vijayagopal (2004)

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