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Review of Fish Feed Forms, Processes, and Their Purpose

Tinjauan Bentuk Pakan Ikan, Proses, dan Tujuannya

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Abstract

Fish feed is critical to the success of aquaculture as it fulfills nutritional needs, promotes growth, and improves fish health. Several feed forms are used routinely, such as flake, pellet, and cake, each with its characteristics and applications, depending on the fish species and growth stage. Flake feed is a good choice for ornamental fish and small fish that consume on the surface or in the water column because it allows it to float longer on the water surface, making it easier for small fish to consume. Cake-shaped feed is soft, denser, and has a distinctive cake aroma. Cake-shaped feed is usually used for larval-stage fish species with small mouth openings. In addition, pelleted feed, available in various sizes and densities, is becoming more popular in consumer fish farming because it is easy to apply and can meet balanced nutritional needs, especially for sizeable juvenile fish. Pellets can be adjusted to match the water density for fish feeding at the water's top, column, or bottom. Therefore, it is crucial to know the forms of feed and their uses so that farmers can choose the optimal feed for their fish by understanding the characteristics and applications of each type of feed.

Keywords: Fish feeds, Pellet, Cake, Flake

Abstrak

Pakan ikan sangat penting bagi keberhasilan budidaya ikan karena memenuhi kebutuhan nutrisi, mendorong pertumbuhan, dan meningkatkan kesehatan ikan. Ada beberapa bentuk pakan yang digunakan secara rutin, seperti flake, pelet, dan cake, yang masing-masing memiliki karakteristik dan aplikasinya sendiri, tergantung pada spesies ikan dan tahap pertumbuhannya. Pakan berbentuk flake merupakan pilihan yang baik untuk ikan hias dan ikan-ikan kecil yang mengkonsumsi di permukaan atau di kolom air karena pakan berbentuk flake memungkinkan untuk mengapung lebih lama di permukaan air, sehingga lebih mudah dikonsumsi oleh ikan-ikan kecil. Pakan berbentuk kue memiliki karakteristik lembut, lebih padat dan memiliki aroma khas kue. Pakan berbentuk kue biasanya digunakan untuk spesies ikan pada stadia larva dengan bukaan mulut yang kecil. Selain itu, pakan pelet yang tersedia dalam berbagai ukuran dan kepadatan menjadi semakin populer dalam budidaya ikan konsumsi karena mudah diaplikasikan dan dapat memenuhi kebutuhan nutrisi yang seimbang, terutama untuk ikan-ikan remaja yang berukuran besar. Pelet dapat disesuaikan agar sesuai dengan kepadatan air untuk pemberian pakan ikan di bagian atas, kolom, atau dasar air. Oleh karena itu, penting untuk mengetahui bentuk-bentuk pakan dan kegunaannya agar para pembudidaya dapat memilih pakan yang optimal untuk ikan mereka dengan memahami karakteristik dan aplikasi dari setiap jenis pakan.

Kata kunci: Pakan Ikan, Pelet, Cake, Flake

1. Introduction

Artificial feed is one of the critical elements in fish farming. Feed is food given to fish or livestock to meet the nutritional needs of these organisms. According to Perius (2011), feed serves as a source of material and energy that supports fish growth and fish survival, but on the other hand, feed also accounts for the largest share in costs for production (50-70%).

The primary function of feed is to be the main source of energy that supports the life and growth of fish (Kholis et al., 2023). Furthermore, according to Rohma (2020), feed also plays a role in reproduction and activity. Therefore, the feed must meet fish's energy needs, such as protein, carbohydrates, and fat. Fish feed is divided into two types: natural and artificial. Natural feed is usually given in live conditions, and it is not easy to adjust its nutritional content. Meanwhile, artificial feed results from a formulation of various feed ingredients designed to meet the dietary needs of fish according to stadia and their eating style (Zaenuri et al., 2014).

Isnawati et al. (2015) state that artificial feed is designed through a unique formulation that considers the nutrients fish need. Yanti et al. (2013) revealed that the nutritional content in feed that fish need is generally formulated from animal and vegetable sources at the same time to get a balanced nutritional content. From a physiological point of view, feed affects growth, motor activity, energy sources, and reproduction. Feed is one of the critical elements in fish farming. Feed is food given to fish or livestock to meet the nutritional needs of

One way to study fish food habits is to understand the type of feed consumed by each fish species (Anisa et al., 2015). Food habits refer to the amount and type of food consumed by fish, while feeding habits are related to the time, location, and method of obtaining food. Each fish life stadia also needs feed with different nutritional content and properties from the starter, grower, and finisher phases. Therefore, artificial feed is also provided in various forms to suit the needs of the fish. Types of artificial feed based on their shape include cakes, emulsions, crumbles, flake pellets, long pellets (spaghetti pellets), and porous pellets. These feeds have characteristics, so farmers must choose feeds suitable for fish (Apul et al., 2023).

This paper is the result of a review of various literature studies that aim to find out the forms of fish feed, the process of feeding, and its designation for multiple types of fish. This paper is expected to be helpful for the development of efficient and sustainable fish farming.

2. Material and Method

The method used is descriptive, as it involves conducting literature review studies using various libraries from the ScienceDirect, Google Scholar, and Dimensions AI portals using the keywords fish feed, flakes, pellets, and cake. The type of journal or literature studied is research on various feed forms such as flakes, cakes, and pellets. The animal subjects tested were different types of fish. The results of journal reviews are grouped according to the topics obtained from the journals and analyzed according to the topic.

3. Result and Discussion

3.1. Form and Flake Feed

The fish feed has various shapes and characteristics; below is an explanation of several feed forms, including flake, cake, and pellet. Flake feed is available in the form of flakes or thin fragments. This type of feed is made by drying the flattened, moist feed dough to form thin fractions (Figure 1).

Figure 1. Flake feed (aliexpress.com)

This process is called flaking. Flake consists of various raw materials adjusted to the needs of the fish, which are then made into an emulsion, spread on a mat, dried, and squeezed. Flake feed functions as a feed that can support the growth and development of the fish's body because it has a balanced protein and low water content. This feed is suitable for fish with small mouth openings, such as ornamental fish (guppies and koi). According to Azizah (2023), flake feed is made by adding golden snail flour to flake feed, as shown in Figure 2.

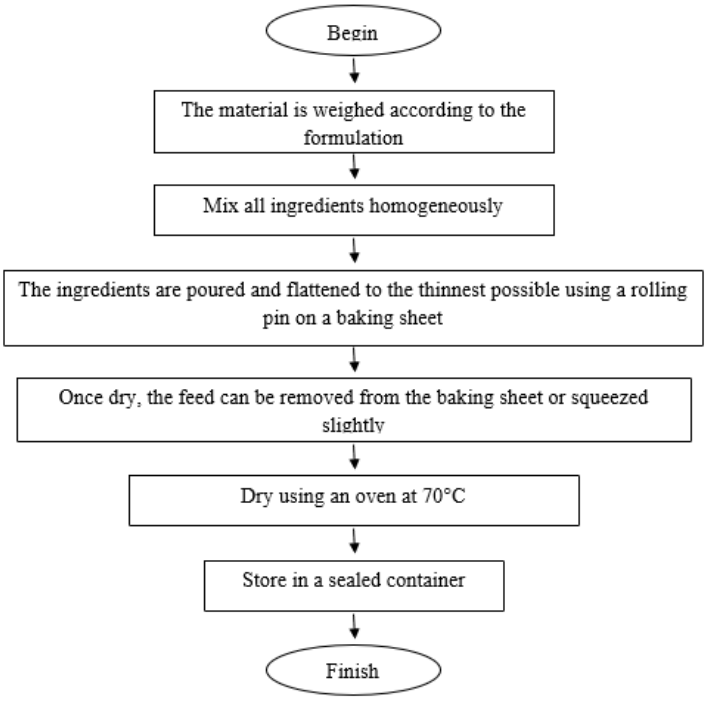

Figure 2. The process of making flake form feed

This feed will float in the upper water column when it is first spread, and then the feed will sink after <20 minutes to the bottom of the water. Fish need more effort to consume flake feed because they need to bite into floating feed. This process takes a long time (two to three times longer than powdered feed) and causes the nutrients in the feed to be dissolved in water before entering the fish's body (Harpaz et al., 2005).

Flake feed is a product that can absorb moisture in the air. If the moisture content in the flake is high, it will cause the flake to have a low shelf life. Water greatly affects the quality of the flour. High moisture content will cause the flour to be easily damaged by mold growth and cause a sour aroma, such as a musty smell. When the moisture content is low, flake feed can last quite a long time with a good and correct packaging process (Susanti et al., 2017).

The constituent ingredients influence the nutritional content of flake feed in its formulation. Each ingredient certainly has a different nutritional content. Therefore, it is crucial to determine the type of ingredients and their amount when making a feed. For example, it can be seen from the nutritional content of flake feed with the addition of different amounts of golden snail flour based on Azizah's (2023) research. Various levels of golden snail flour addition are shown through the following treatments: Treatment A uses feed with 70% golden snail flour and 5% fish meal, Treatment B uses 65% golden snail flour and 10% fish meal, Treatment C uses 60% golden snail flour and 15% fish meal, and Treatment D as a control using commercial feed (Table 1).

Table 1. Nutrient content of flake feed

Test Parameters	Treatment			
	A (70%)	B (65%)	C (60%)	D (Control)
Protein (%)	45.11	45.12	45.13	30.00
Fat (%)	9.78	9.46	9.14	5.00
Ash (%)	5.62	5.62	5.62	12.00
Crude Fiber (%)	4.18	4.01	3.85	7.00

The difference in the nutritional content of flake feed is due to the difference in the application of golden snail flour in each treatment. However, from the three treatments (A, B, and C), it was known that there was a decrease in the amount of protein. The denaturation process can cause a decrease in protein during drying. According to Ghozali et al. (2004), a material heated to a temperature of 50°C or more will cause the proteins in the material to undergo denature. In a frying pan, the protein will be damaged by very high heat temperatures. The higher the heat or temperature, the lower the protein level (Winarno, 1993). Denaturation is a process in which a stable double-chain structure is transformed into a looser, more open form so digestive enzymes can efficiently hydrolyze it into amino acids.

Similarly, Kumar et al. (2019) conducted research regarding the formulation of flake feed using the addition of Artemia (cysts, nauplii, and biomass) to guppy fish. His study shows that adding Artemia to various stadia and biomass produces different nutritional content, as seen in Table 2.

Table 2. Nutritional content of flake feed

Nutritional Analysis	Feed Flake with Artemia Cysts	Feed Flake with Nauplii Artemia	Flake Feed with Artemia Biomass
Protein (%)	42	44	46
Fat (%)	4	6	8
Fiber (%)	3	3	3
Water (%)	10	10	10

Based on the study, it is known that flake feed with the addition of artemia biomass has an excellent effect on the growth of guppy fish. The resulting feed has a good taste and texture, so the fish respond to the feed, and the guppy shows good pigmentation and color development.

3.2. Feed Cake

The cake is fish feed made from dough and then made into a cake. This feed is given to fish still in the seed stadia or larvae by cutting (peeling) into small pieces. It has characteristics like wet cakes commonly made by humans, namely soft and the typical aroma of cakes, as shown in Figure 3.

Figure 3. Feed cake

The manufacturing process includes mixing ingredients, steaming, and storage. According to Sutarjo (2018), the cake feed-making process is presented in Figure 4.

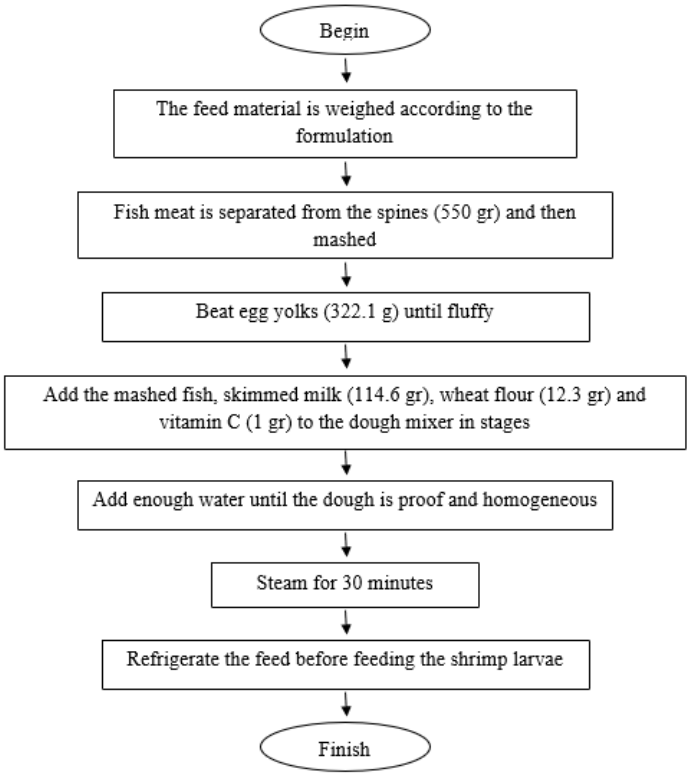

Figure 4. The process of making cake feed

Cake feed has the advantage of low production costs because the ingredients used are relatively economical. Then, the feed size can be adjusted to the opening of the fish's mouth because the feeding process is done in a cuil-cuil. However, the disadvantage is that cake feed is easily soluble in water, so the feeding frequency must be according to the dosage and not excessive. The larval-rearing water will become cloudy if much leftover feed is not eaten. Another disadvantage is the short-lived shelf life because this feed is classified as a feed with a lot of water content, and spoilage microbes quickly develop (Mahardika, 2017).

Table 3 shows the results of the proximate cake feed analysis and its comparison with tubifex worm flour, according to Sutarjo (2018).

Table 3. Nutritional content of cake feed

Sample Name	Proximate Results								
	BB (g)	BK (g)	Water (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	BETN (%)	GE (%)
Cake	99,22	41,47	61,41	5,42	38,70	26,28	2,36	27,24	494,88
Tubifex sp			87,7	87,7	36,57	13,3	2,04		

Sutarjo (2018) conducted a study with the following five treatments: Treatment 1 used 100% *Tubifex* sp without cake feed, Treatment 2 used 25% *Tubifex* sp and 75% cake feed, Treatment 3 used 50% *Tubifex* sp and 50% cake feed, Treatment 4 used 75% *Tubifex* sp and 25% cake feed, and Treatment 5 used 0% *Tubifex* sp with 100% cake feed. The results showed that the combination of *Tubifex* sp and cake-shaped feed affected the growth rate (SGR), feed conversion ratio (FCR), and survival rate of shrimp larvae (Table 4).

Table 4. Effect of the use of Tubifex sp feed and cake feed on specific growth rate (SGR), survival, and feed conversion ratio (FCR)

Treatment	Growth Rate (%)	Survival (%)	FCR
P1	94	99,4	3,5
P2	247	98,1	2,5
P3	213	99,4	2,7
P4	198	100	2,8
P5	146	99,4	3,7

Based on this study, a good feed combination for shrimp larval growth is P2 with 25% worm flour and 75% cake feed. This treatment resulted in shrimp larvae's highest specific growth rate (247) and the lowest survival rate (98.1).

3.3. Pellet Feed

According to Nilasari (2012), pellets are fed raw materials that have gone through mixing, pressing, and printing mechanically before being removed from the mold (Figure 5).

(A) (B) (C)

Figure 5. (A) Pellet *Starter* (B) Pellet *Grower* (C) Pellet *Finisher* (dkpp.bulelengkab.go.id)

Pellet feed can be the right choice because the benefits are very diverse, including 1) increasing feed density, which can reduce lethargy, save storage space, make handling and serving more effortless, and reduce transportation costs; 2) high density can increase feed consumption while reducing waste feed; and 3) prevent "de-mixing" or re-separation of pellet components, so that feed consumption is by the set standards (Anggraini, 2018). Pellets are feed that has been crushed and compacted mechanically. Pellets of varying diameters, lengths, and strengths can be formed into small clumps and cylinders (Ensminger et al., 1990). The disadvantage of using pellet feed is that it is more susceptible to damage during storage and transportation due to its weaker structure. Figure 6 shows the process of making pellet feed, which is based on the research of Syaubari et al. (2024).

The pellets' properties must be by the SNI 2006 fish feed standard, which requires a protein content of 20-35%, a fat content of 2-10%, an ash content of less than 12%, and a moisture content of less than 12%. In addition, for the fish to easily reach high-quality pellet feed, the fish must have sufficient buoyancy. The size of the pellets, which usually vary from 1-2 cm, makes them easier for different types of fish to eat, and their buoyancy also helps prevent feed waste in the water. According to Jahan et al. (2006), the type of material components used, the size of the pellet printing machine, the amount of pressure, the amount of water used, and the use of binding materials to produce pellet feed that is strong and compact and difficult to break, all affect the quality of the pellets.

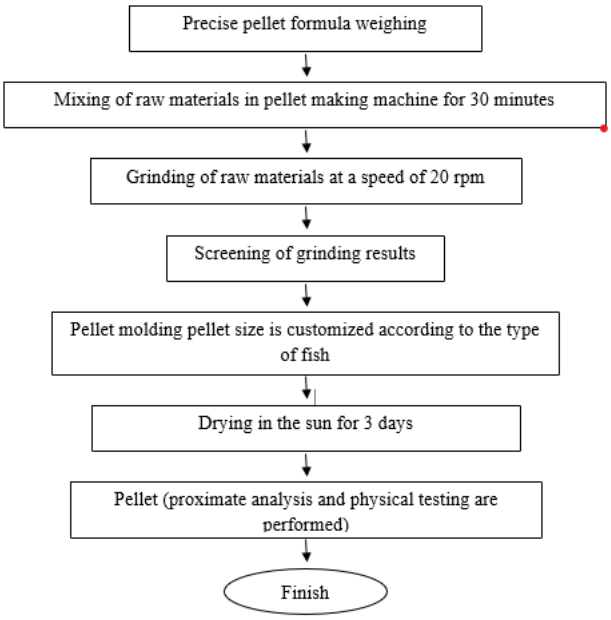

Figure 6. Pellet-shaped feed making process

To maintain the strength and cohesiveness of the structure, the components in the form of feed pellets are bonded by adhesives. Tapioca flour, cassava flour, molasses, and seaweed are some food ingredients that have been put together using natural adhesives (Sari et al., 2016). According to Akhadiarto (2010), converting feed into pellets has several advantages, including reducing the consumption of selective livestock rations, facilitating feed distribution, increasing ration density, and ensuring that livestock can absorb nutrients from the feed because each pellet contains all the nutrients needed. Pellet feed significantly impacts aquaculture operations due to its benefits, which include modifying nutrient content based on the development and survival of cultivated biota. According to Gunawan & Khalil (2015), the raw materials used in pellet feed formulations must be economical, by the nutritional needs of fish, and adequate for the growth of cultivated fish.

Pellet-shaped feeds tend to dissolve or disintegrate quickly in water, especially if the pellets are of poor quality, which can pollute the water and degrade the quality of the aquatic environment (Faisal, 2018). Specific pellets have poor buoyancy, which can cause the feed to sink instantly and make it difficult for shrimp or fish not at the bottom of the water to access it. In addition, fish or shrimp may not get the maximum nutritional value from pellet feed because they are susceptible to nutrient breakdown, especially if stored in humid conditions or for long periods. Pellet raw materials often come from outside sources, including fishmeal or soybean meal, whose prices fluctuate and can impact feed production costs, affecting aquaculture's operational costs (Sitompul et al., 2016).

The following are the results of the analysis of the nutritional content of pellet feed and its comparison with the addition of different animal raw materials based on the research of Khalil et al. (2015), as shown in Table 5.

Table 5. Nutritional content of pellet feed

Material	Protein (%)	Carbohydrates (%)	Fat (%)	Water (%)	Ash (%)
A (T. Earthworm)	38,46	31,29	12,40	9,29	8,56
B (T. Snaccot)	33,53	36,20	17,47	11,14	1,67
C (T. Keong Mas)	37,49	45,27	8,20	8,64	0,40
D (T. Fish)	30,41	49,96	8,10	11,10	0,57

Based on the research of Khalil et al. (2015), the nutritional content in feed differs. However, the highest protein content was found in treatment A. Namely, feed formulations that used additional feed ingredients derived from earthworms with a value of 38.46% then, followed by C treatment with a protein content of 37.49%; after that, treatment B was continued with a score of 33.52%; and the last one is treatment D, which is with a value of 30.41%. Based on the value of the protein content contained in the four feeds, the feed is excellent and suitable for fish growth. This is because protein plays a vital role in the development of fish, where many amino acids are contained, both essential and non-essential. The same thing was also expressed by Rostika (1997), that fish need high protein content in their growth aspect to make fish grow and develop properly and optimally.

Fish are divided into three categories: starter, grower, and finisher, each with characteristics. The feed that will be used must also be adjusted to the characteristics of the existing fish. Research results from Tobuku (2022) and Muskita et al. (2022) mention the difference in each feed based on the life phase of the fish, as shown in Table 6.

Table 6 contains information about the type of fish, feed designation, fish size, and nutritional content of fish feed. Starter fish, or larval and seed fish, require a feed size of 0.5 - 1 mm. Feed for starter fish contains 30 - 45% protein, 5 - 10% fat, and 15 - 20% carbohydrates. Grower fish, or growing juvenile fish, need feed with a size of

1 - 2 mm. Feed for fish growers contains 30 - 40% protein, 5 - 10% fat, and 20 - 25% carbohydrates. Meanwhile, finishers and adult fish near harvest time need feed larger than 2 mm. Feed for finisher fish contains 20-30% protein, 10-15% fat, and 30-35% carbohydrates.

Table 6. Comparison of starter and finisher pellet types

Types of Pellet Feed	Designation	Feed Size (mm)	Nutritional Content		
			Protein (%)	Fat (%)	Carbohydrates (%)
Starter	Larval fish and fry	0.5 – 1	30 - 45	5 - 10	15 – 20
Grower	Growing young fish	1 – 2	30 - 40	5 - 10	20 – 25
Finisher	Adult fish ahead of harvest	≥ 2	20 - 30	10 - 15	30 – 35

The nutritional content of fish feed pellets varies according to the stage of fish development. This is to meet the dietary needs of fish at every stage of growth. The feed protein level is 30 - 45% greater for starter fish in the larval and seed phases. This is because fish in the early stages of life require a high protein intake to support their rapid growth and development (Sutikno, 2011). Furthermore, at the grower stage, when the fish begin to mature, the protein content of the feed decreases to 30 - 40%, while the carbohydrate content increases to 20 - 25%. The goal is to provide enough energy for the fish to perform heavier activities (Sogandi et al., 2019). At the finisher stage, after the fish is dehydrated, the protein content of the fish is increased to 20 - 30%, while the carbohydrate content is increased to 30 - 35%. This is because fish at this stage need more energy for tubule maintenance and harvest production (Muller-Feuga, 2013).

Based on the description of the types of artificial feed forms, The following is a comparison between the feed forms: feed flake, cake, pellets sink, and float, as shown in Table 7.

Table 7. Comparison between flake feed, cake, floating pellets, and submersible pellets

Types of Feed	Characteristic	Buoyancy	Durability	Storage
Flake	Thin flakes (0.1 - 1.0 cm), easily crushed, generally for ornamental fish	Floating (< 20 minutes)	2 - 15 minutes (depending on size)	3 - 4 months
Cake	Solid shape (1.0 - 5.0 cm), soft generally for larval stadia fish	Sink	10-15 minutes	3 days in the refrigerator
Floating pellets	Small round (0.2 - 1.5 cm), designed for all fish commodities	Floating (30 - 60 minutes)	30 - 120 minutes (depending on quality)	3 - 6 months
Submersible pellets	Small round (0.5 - 2.0 cm), suitable for heavy water and basic fish farming systems	Sink	10 – 30 minutes	3 - 6 months

4. Conclusions

The shape and process of making feed will affect the characteristics of the feed produced. Flake feed is generally used for ornamental fish with thin characteristics and is easily destroyed. Cake feed has a soft but dense texture and is the typical flavor of cakes, generally used for fish on larval stadia. Pellet feed is divided into two types: floating pellets suitable for surface fish such as tilapia and carp and sinking pellets suitable for essential fish such as catfish and vannamei shrimp. Floating pellets have lightweight and hollow characteristics, while submersible pellets are designed with a higher density, so they fall directly to the bottom. Each feed will have its advantages and disadvantages. Therefore, it is vital to determine the type of feed to be given to suit the nature of the fish's food and feeding habits.

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