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The Role and Function of Fatty Acids in Feed on Fish Growth

Peran dan Fungsi Asam Lemak dalam Pakan Terhadap Pertumbuhan Ikan

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Abstract

Essential fatty acids play a crucial role in fish growth and health. A quality feed containing the right amount of fats can promote fish growth and support metabolic functions. Fatty acid requirements vary depending on the fish species and habitat, with freshwater fish tending to require more n-6 fatty acids, while marine fish require more n-3 fatty acids. The use of fat in feed should be well regulated, as too high levels can interfere with the digestive and metabolic processes of the fish. The use of fish oil mixed in feed as much as 1.5% can help improve the growth performance of carp. Magot oil mixed into the feed as much as 15%/100 g gives the best growth performance in carp. Soybean oil used as much as 10% in feed can increase the content of omega 3, EPA, and DHA in catfish meat. Coconut oil used in feed at 6% proved to have a good impact on the DHA content of tilapia. The purpose of this paper is to review the literature on the role and function of fatty acids in fish growth.

Keywords: Fish feed, Fatty acids, Fat utilization, Fish growth

Abstrak

Asam lemak esensial, memiliki peran yang sangat penting dalam pertumbuhan dan kesehatan ikan. Pakan yang berkualitas, yang mengandung lemak dalam jumlah yang tepat, dapat meningkatkan pertumbuhan ikan dan mendukung fungsi metabolisme. Kebutuhan asam lemak bervariasi tergantung pada spesies ikan dan habitatnya, dengan ikan air tawar cenderung memerlukan lebih banyak asam lemak n-6, sementara ikan laut lebih membutuhkan asam lemak n-3. Penggunaan lemak dalam pakan harus diatur dengan baik, karena kadar yang terlalu tinggi dapat mengganggu proses pencernaan dan metabolisme ikan. Penggunaan minyak ikan yang dicampurkan dalam pakan sebanyak 1,5% dapat membantu meningkatkan performa pertumbuhan ikan mas. Minyak magot yang dicampurkan kedalam pakan sebanyak 15%/100 g pakan memberikan performa pertumbuhan terbaik pada ikan mas. Minyak kedelai yang digunakan sebanyak 10% dalam pakan dapat meningkatkan kandungan omega 3, EPA, dan DHA dalam daging ikan lele. Minyak kelapa yang digunakan dalam pakan sebanyak 6% terbukti mampu memberikan dampak yang baik terhadap kandungan DHA ikan nila. Tujuan penulisan ini adalah telaah pustaka tentang peran dan fungsi asam lemak untuk pertumbuhan ikan.

Kata kunci: Pakan ikan, Asam lemak, Pemanfaatan lemak, Pertumbuhan ikan

1. Introduction

Feed is the most vital element in fish farming because it greatly affects fish growth. Feed plays a crucial role in fish farming activities. Synthesized feed is a type of feed designed with specific formulations based on the nutritional needs of fish (Isnawati et al., 2015). The quality of feed given to fish can be evaluated by its constituent components and how much these components can be digested, absorbed, and utilized by fish (Megawati et al., 2012). Feed digested by fish provides the energy needed to perform various activities. However, not all energy obtained from feed will be fully utilized by fish to meet their energy needs. Before being digested in the fish body, the feed will pass through several process stages (Rahmatia, 2016). The growth and quality of cultured fish meat are strongly influenced by the quality of feed and cultivars, which include macronutrients and micronutrients (Shofura et al., 2017). Macronutrients such as protein, carbohydrates, fat, and crude fiber are important in determining fish quality.

Fat is one of the primary nutrients needed to support fish growth and is also one of the macronutrients with the highest energy content compared to protein and carbohydrates (Subandiyono & Hastuti, 2011). Fish use fat for daily activities, such as swimming, searching for food, avoiding predators, supporting growth, and increasing endurance. Fats and oils belong to the lipid group and are essential food components for living organisms. They are significant because they contain the necessary essential fatty acids. In addition, fats dissolve vitamins A, D, E, and K, important to fulfill the body's needs (Sutantyo, 2011).

According to Almatsier (2006), fatty acids are organic acids with a straight hydrocarbon chain structure, which has a carboxyl group (COOH) at one end and a methyl group (CH_3) at the other end. Fatty acids are divided into two, namely saturated and unsaturated fatty acids. Based on the source, unsaturated fatty acids are divided into non-essential and essential. Based on the chemical structure, it is divided into two, namely Mono Unsaturated Fatty Acid (MUFA) and Poly Unsaturated Fatty Acid (PUFA) (Ajiningrum et al., 2022).

Fats and oils that can be consumed come from nature and can be sourced from plant and animal materials. In animals, this oil serves as an energy reserve. The fatty acid composition and the physicochemical properties of each type of oil vary, influenced by factors such as source material, climatic conditions, growing location, and processing methods. Animal fats contain cholesterol, while vegetable fats contain phytosterols. The content of unsaturated fatty acids in animal fats is lower than in vegetable fats. In addition, animal fats have higher Reichert-Meissl values and lower Polenske values than vegetable oils (Destiana & Nurul, 2021).

2. Material and Method

The approach involved a systematic descriptive and exploratory review method, integrating previous primary research results to obtain accurate and demonstrable facts from various kinds of literature in national and international journals such as Researchgate and Google Scholar. The keywords used to get this information included fish feed, fatty acids, fat utilization, and growth. This comprehensive search approach facilitated the development of a theoretical framework that matched the main topics in the literature.

3. Result and Discussion

3.1. Role and Function of Fatty Acids in Fish Growth

Fatty acids, particularly essential fatty acids, are vital to fish growth and health. Fatty acids are carboxylic acids with long aliphatic chains, either saturated or unsaturated. Almost all natural fatty acids have unbranched chains with an even number of carbon atoms ranging from 4 to 28 (Figure 1). Fatty acids are usually derived from triglycerides or phospholipids. Fatty acids are an essential source of fuel nutrition for animals because, when metabolized, they produce large amounts of ATP. Essential fatty acids are lipid components that fish cannot synthesize in sufficient quantities and must be obtained through feed. They serve as energy sources, cell membrane components, and precursors for various bioactive compounds important in fish metabolism. Lipids are important as a source of essential fatty acids, contributing significantly to fish's expected growth, development, and reproduction (Leaver et al., 2008).

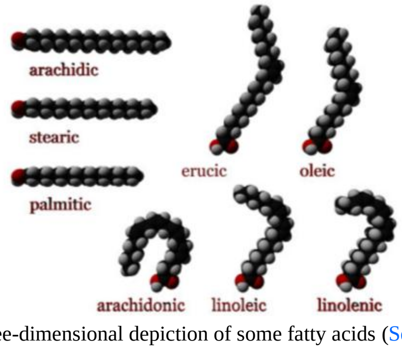

Figure 1. Three-dimensional depiction of some fatty acids (Selvaraj, 2017)

Fat acts as a long-term energy source, aids movement and serves as an energy reserve during periods of food shortage. In the body, fat produces twice as much energy as protein (Sargent et al., 2002). Fats and oils are the most concentrated energy source, where 1 gram of fat can produce nine kcalories, 2½ times more energy than carbohydrates and protein (Almatsier, 2010). Fat reserves in the body come from excessive consumption of fat or in combination with other nutrients, such as carbohydrates and protein. Phospholipids, a combination of fatty acid esters and phosphatidic acid, are the main component of cell membranes. Phospholipids play a role in maintaining the hydrophobic or hydrophilic nature of the membrane surface. Sphingomyelin, a fatty acid ester of sphingosine, is found in the brain and nerve tissue. Waxes, esters of fatty acids and long-chain alcohols, are commonly found in egg tissue, liver, and muscle. Sterols, which are long-chain alcohols with a polycyclic structure, are important components in several hormones that support the gonadal maturation process (Pangkey, 2011).

3.2. Types of Fatty Acids and Sources

Fatty acids can be categorized into two main types. The human body can synthesize saturated fatty acids, which are non-essential fatty acids. Generally, saturated fatty acids, such as butter derived from animal fat, are solid at room temperature. Unsaturated fatty acids are essential as the human body cannot synthesize them. Unsaturated fatty acids are usually liquid at room temperature, such as cooking oil derived from vegetable fats (Santika, 2016).

Consumable fats and oils come from nature and can be sourced from plant and animal materials. In animals, these oils serve as energy reserves. The fatty acid composition and the physicochemical properties of each type of oil vary, influenced by factors such as source material, climatic conditions, growing location, and processing methods. Animal fats contain cholesterol, while vegetable fats contain phytosterols. The content of unsaturated fatty acids in animal fats is lower than in vegetable fats. In addition, animal fats have higher Reichert-Meissl values and lower Polenske values than vegetable oils (Destiana & Nurul, 2021).

3.3. Fatty Acid Metabolism Flow in Fish

In aquatic organisms, fat is a component of feed that serves as a source of energy. Fat in feed also contains fat-soluble vitamins and fatty acids. In many species, the enzyme lipase is mainly produced by the pancreas and is also found in the mucosa. Fats in feed are not digested in the oral cavity due to the absence of enzymes that break them down. Although the lipase enzyme is present in the gaster, the amount is very small, and the pH conditions in the gaster do not support the enzyme's activity (Mainisa, 2019).

The process of fat digestion occurs when food reaches the intestines. It involves the action of lipase enzymes from the gut, stomach, and pancreas. Lipases function to hydrolyze lipids and triglycerides into monosaccharides, glycerol, and free fatty acids. Pancreatic lipase enzymes are more effective in digesting triglycerides with long carbon chains, with optimal activity at pH 7-9. Fat digestibility is influenced by several factors, including the amount of fat in the feed, fat type, water temperature, fat saturation level, and carbon chain length (Mainisa, 2019).

3.4. Fish Needs Fatty Acids for Growth

Essential fatty acids that are important for fish include eicosapentaenoic acid (EPA) (20:4n-6), docosahexaenoic acid (DHA) (22:6n-3), and arachidonic acid (AA) (20:4n-6). Unsaturated fatty acids are generally synthesized from C-18 fatty acids (linoleate). EPA and DHA play a role in supporting cell membrane function, while DHA has a vital role in the cell membrane of nerve tissue and is a precursor of eicosanoids, a group of hormones (Tocher, 2003).

Fatty acid requirements vary for each type of fish, depending on their habitat and environment. Freshwater fish generally require more n-6 (linoleic) fatty acids than n-3 (linolenic) fatty acids or a combination of both. In contrast, marine fish require more n-3 (linolenic) fatty acids. In general, the range of n-3 (linolenic) and n-6 (linoleic) fatty acid requirements ranges from 0.5% to 2.5% (Utomo et al., 2009).

The fish body cannot synthesize unsaturated fatty acids, so they must be obtained from feed. With the help of enzymes, linolenic acid is converted into long hydrocarbon chains. The double bond formation process produces HUFA, EPA, and DHA, which are essential for metabolic functions and as components of cell membranes (Lall et al., 2002).

A quality feed usually contains fat in the range of 4-18%. Carnivorous fish require about 8% fat, while herbivorous fish require no more than 3% fat. In shrimp, fat requirements vary according to the growth stage: larvae require 12-15% fat, shrimp weighing more than 1 gram require 3-8%, and juvenile shrimp require about 8-12%. For fish, fat requirements vary by species, with milkfish requiring 7-10%, tilapia 6-10%, carp 6-8%, and snapper around 10% (Mainisa, 2019). Carnivorous fish generally have limitations when using carbohydrates as an energy source, so fat and protein play an important role in meeting the metabolic energy needs of fish (Pei et al., 2004).

Based on Table 1, adding fatty acids to feed provides diverse results from various uses of fat in feed. The use of vegetable and animal fat sources has a positive impact on fish growth. Subandiyono & Hastuti (2011) stated that in feed formulations for aquatic animals, lecithin provides phospholipids and gives the feed the right physical properties. Lecithin has several advantages, such as increasing growth, improving fat and cholesterol digestion, increasing the absorption of vitamin A and carotene, and preventing the dissolution of various water-soluble components.

Table 1. Results of adding fatty acids in feed on fish growth

No	Source of Fatty Acids	Objective	Method	Results	Author
1	Maggot Oil	Effect of adding maggot oil (*H. illucens*) on the growth of carp seeds	Treatment A (0%), B (10%), C (15%), D (20%)/100 g of feed, carp length 3.59±0.06 cm	Treatment C (15%): TKP 10.57±0.26 g, FCR 1.52±0.03, EPP 65.43±1.54%, SGR 1.57±0.04%/day, SR 95.56±3.85%	Jayanti (2022)
2	Coconut Oil	Effect of palm oil on the growth and body composition of O. *niloticus*	Feed with crude protein 32%, palm oil content 0%, 2%, 4%, 6%, and 8%, weight of tilapia 11.02 g	Best treatment at a dose of 6% with the highest DHA content	Ayisi et al. (2017)
3	Fish Oil	Effect of fish oil and lecithin on feed utilization and growth of goldfish	Treatment A (0.0:0.0%), B (0.30:0.0%), C (0.60: 0.30%), D (0.90:0.60%), weight of carp 1.62 g	Treatment D (0.90:0.60%): RGR 2.41 ±0.07%/day, EPP 59.09± 1.36%, PER 1.97±0.05%	Subandiyono & Pinandoyo (2015)
4	Fat and Energy Content	Effect of fat and energy content in feed on the growth of catfish (*P. pangasius*)	Treatment A (8%, 281.98 kcal), B (9%, 286.74 kcal), C (10%, 289.45 kcal), D (11%, 296.21 kcal)	Treatment D (11%): TKP 25.27±0.06g, EPP 54.62 ±0.93%, PER 1.82 ±0.03%, RGR 0.75 ±0.02%/day	Munisa et al. (2015)
5	Fish Oil	Impact of fish oil dosage on the growth and development of goldfish	Treatment A (fish oil 0.90 %), B (1.2%), C (1.5 %), D control	The best treatment at dosage C is with fish oil at 1.5%.	Khalil et al. (2022)
6	Soybean Oil	Determining the optimal level of soybean oil in feed to increase omega-3 (EPA and DHA) in catfish oil.	Treatment (linolenic acid in feed) A = 0%, B = 5%, C = 10%, D = 15%, and E = 20%.	Treatment B (10%) produced the best results, with omega-3 fatty acids at 8.33%, EPA at 5.05%, and DHA at 1.14%.	Salasah et al. (2016)

According to Haetami (2012), if the level of protein energy in the feed is below the optimal DE/P (digestible energy and protein) value (8-9 kcal/g), then the energy sources in the feed, especially fat and carbohydrates, will not meet the body's needs. Fat in feed has a variety of essential roles in fish nutrition, including as a source of energy, phospholipids, and steroid components vital for crucial organs. In addition, fat also plays a role in helping fish maintain balance in the water (buoyancy). In addition, fat in the diet provides essential fatty acids (EPA) necessary for growth and normal development and aids in absorbing various fat-soluble vitamins.

Sanjayasari et al. (2010) argue that the protein-sparing effect produced by carbohydrates and fats can balance most metabolic and maintenance activities of the body so that it is not completely dependent on protein. Thus, protein in feed can be allocated for growth. Growth occurs when there is excess free energy after the energy is used for body maintenance, metabolism, and activity. If energy from oil or fat is sufficient, then energy from protein can be used to build new tissue, which supports growth (Lante, 2010).

For optimal growth in organisms, the use of oil in feed must be adjusted accordingly. Excessive amounts of oil can inhibit growth, reduce production levels, and cause fatty acid buildup in the body. This fatty acid buildup usually occurs in the liver and can cause swelling of the liver, even risking death (Soerjodibroto, 2005).

In this case, the dose of fat used in feed should be limited, according to Wang et al. (2005), because higher lipid levels can jeopardize the fish's ability to digest and absorb food and also interfere with metabolic activity. This can lead to significant digestive and metabolic system disorders, ultimately having a negative effect on the overall health condition of the fish.

4. Conclusions

Based on a comprehensive analysis of various studies, the use of fatty acids such as maggot oil, fish oil, coconut oil, and soybean oil in feed can affect fish's growth and overall health. The addition of fatty acids in fish feed shows varying results and positively impacts fish growth. Maggot oil at a dose of 15% gave the best results for carp fry, while palm oil at 6% was optimal for tilapia growth with the highest DHA levels. The use of fish oil at a dose of 1.5% also showed significant improvement in carp growth. Feed with 11% fat content proved most effective for striped catfish growth, and the addition of 10% soybean oil resulted in optimal omega-3 levels, improving the quality of catfish feed. Properly selecting fatty acid sources is essential to support fish growth and health.

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