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PROSPECTIVE ALTERNATIVE VEGETABLE PROTEIN FOR FISH FEED

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ABSTRACT

One of the key elements of feed that promotes the best possible growth of fish and cattle is protein. Protein can be obtained from two sources to meet the fish requirements: animal protein and plant protein (vegetable protein). Alternative sources, such as those from plants or other industrial processes, might be used as one of the protein sources for fish feed. Numerous aquatic and terrestrial plants are said to contain significant levels of protein, both naturally and as a result of modern farming operations, making them suitable to be utilized as feed components for fish feed that contains vegetable protein sources. Vegetable protein sources can be utilized to replace fish meal in feed formulations, making feed more cost-effective while still providing a complete dose of animal protein. This essay will discuss various plant-based sources of protein as well as agricultural industrial waste used as an element in fish feed. According to the literature review, it is clear that there are many different sources of vegetable protein, which have a wide range of varieties and a significant number of possibilities for application as sources of vegetable protein as fish and livestock feed.

1. INTRODUCTION

Protein is one of the main components in feed that supports optimal growth of fish and livestock. Fish feed requires more protein than terrestrial animal feed. This is related to the need for protein and the low ability of fish to digest carbohydrates so that they are more dominant in using protein in their feed. While in meeting its need, protein can be provided from two sources, namely protein derived from animals (animal protein) and from plants (vegetable protein).

Soybean meal is a by-product of soybean oil industry which is used as a source of vegetable protein in feed because it contains quite high protein (35-45%). Until now soybean meal is a component of feed ingredients that are still imported. This causes the price of commercial feed to be higher so that production and marketing costs also increase [1]. Therefore, substitute raw materials are needed to reduce production costs.

One of the protein sources for fish feed can use alternative sources such as those from plants or the rest of industrial processes. Various aquatic and terrestrial plants are reported to have high protein content, as well as from the remnants of agricultural-based industrial processes, hence that they can be used as feed ingredients for vegetable protein sources in fish feed. Utilization of vegetable protein sources cannot replace fish meal as a complete source of animal protein, but it can reduce the amount of fish meal used in feed formulations so that feed is more economical. Restrictions on the use of vegetable protein in fish feed are related to the nutritional content of forages. The quality of vegetable protein is almost close to the quality of animal protein, except for the lack of amino acids containing sulfur. [2] stated that, protein from plants contains the amino acid lysine which is high, but the amino acid content of methionine is very low. This paper will review several sources of vegetable protein from plants and the rest of the agricultural industry processing as a source of fish feed ingredients.

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2. FUNCTIONS AND CHEMICAL PROPERTIES OF PROTEINS

Proteins in nature are found in colloidal form with different protein solubility in water, from the insoluble (keratin) to the highly soluble (albumin). Proteins can be denatured by heat, strong acids, alkalis, alcohols, acetone, urea and salts of heavy metals. Denaturation is a process that changes the structure of a molecule without breaking the covalent bonds.

Denaturation is usually accompanied by loss of biological activity and significant changes in some physical properties and functions. If a protein is denatured, it will lose its unique structure and therefore its chemical, physical and biological properties will change. An example in this case is an enzyme that is inactivated by heat. Denaturation and coagulation of proteins are aspects of stability that can be related to the arrangement and sequence of amino acids in proteins.

Protein has several functions for fish, namely as a building material, to repair damaged or shrinking tissue (tissue repair and maintenance) and to build new tissue. Growth and formation of protein, can be catabolized as a source of energy or as a substrate for carbohydrate and fat tissue, and is needed in the body for the construction of hormones, enzymes and other important biological substances such as antibodies and hemoglobin.

3. ALTERNATIVE VEGETABLE PROTEIN SOURCES FOR FISH FEED

3.1. Papaya Leaf

Papaya plant classification is as follows:

Division : Magnoliophyta
Class :Magnoliopsida
Kingdom :Plantae
Sub Class :Dilleniidae
Order : Violales
Family :Caricaceae
Genus : Carica
Species : *Carica papaya* L.

Papaya is a plant that has a vertical and watery trunk. Papaya trees are generally unbranched or slightly branched, growing to a height of 5-10 m with leaves that form a spiral on the upper trunk. The surface of the papaya stem appears to have leaf attachment marks with the stem having no branches and the direction of the stem growing is perpendicular. According to [3], papaya leaves contain 17.00% crude protein, 7.2% crude fiber and 11.1% ash. While the active substances contained in papaya leaves include alkaloids, polyphenols, flavonoids, saponins, tannins, and papain enzymes.

Figure 1. Papaya Trees

3.2 *Sente* Leaf (*Alocasia machrorhiza* (L) Schott)

The classification of sente plants is as follows:

Kingdom : Plantae
Super division : Spermatophyta
Division : Magnoliophyta
Class : Liliopsida
Order : Arales
Family : Araceae
Genus : Alocasia
Species : *Alocasia macrorrhiza* (L) Schott

The *Alocasia macrorrhiza* (L) Schott plant is known as *bira* or *sente* in Indonesia. Morphological characteristics of this plant include: including large herbaceous plants that can reach 3-4 meters in height, have stems above the ground that can reach 1 meter in height with a diameter of 20 cm, leaf length 0.8-1.0 meters. Types of *sente* plants that have green stems are usually not eaten by people because they cause itching, however the leaves can be used as carp feed.

Figure 2. *Sente* plant (*Alocasia macrorrhiza* (L) Schott)

Sente leaves are natural food for broods and baby gouramy fish, but should not be given directly to fish, it must be dried first because the sap can cause yellowpox. To increase the protein content and reduce the anti-nutrients in the leaves, a fermentation process is needed. The fermentation process has advantages such as a more pleasant aroma and taste due to the formation of acids, esters and other vitamin-forming compounds, especially vitamin B_{12} and increasing protein value.

3.3 *Sengon* Leaf (*Albazia falcataria* (L) Fosberg)

The classification of sengon plants is as follows:

Kingdom : Plantae
Subkingdom : Tracheobionta
Super division : Spermatophyta
Division : Magnoliophyta
Class : Magnoliopsida
Sub class : Rosidae
Order : Fabales
Family : Fabaceae
Genus : Albazia
Species : *Albazia falcataria* (L) Fosberg

Sengon or albasia, is a woody plant shaped like an umbrella with lush leaves that are not too dense. *Sengon* leaves are composed of double pinnate compound with small leaflets and fall off easily. *Sengon* leaves can be used as animal feed. According to [4], the results of proximate analysis of *sengon* leaves showed that this leaf contains 20.65% crude protein, 28.34% crude fiber, 5.13% crude fat, 1.48% Ca and 0.25% Phospor.

Figure 3. *Sengon* plant (*Albazia falcataria* (L) Fosberg)

3.4 *Apu-apu* Water Plants (*Pistia stratiotes*)

Apu-apu water plants are also known as water lettuce which means water cabbage or watercress. *Apu-apu* water plants are classified as follows [5]:

Kingdom : Plantae
Division : Magnoliopita
Class : Lilioptida
Order : Arales
Family : Araceae
Genus : Pistia
Species : *Pistia stratiotes*

Apu-apu water plants are also one of the floating plant groups that contain sufficient amounts of nutrients and are safe enough to be considered as potential animal feed (Table 1). Anti-nutritional ingredients contained in apu-apu water plants include polyphenols with a total content of 2.2%, 1.6% free polyphenols, 0.6% bound polyphenols and 1.3% nitrate. The content of polyphenols bound to aquatic plants used as animal feed can inhibit the rate of performance of proteolytic enzymes resulting in low digestibility, but the nitrate content of less than 1.5% in aquatic plants is included in the safe category for use as animal feed ingredients [6].

Table 1. Proximate composition of *Apu-apu* water plants

Pistia stratiotes	Average Composition (% Weight)							
	H_2O	CP	CF	NFE	Ash	Lipids	P	Ca
Wet based weight	93.6	1.2	1.0	2.3	1.6	0.3	-	-
Wet based weight (Thailand)	91.9	1.2	1.8	2.9	-	0.4	-	-
Dry based weight	0	15.9	20.8	36.1	23.0	4.2	0.30	2.35
Dry based weight (India)	5.3	20.5	19.1	39.6	17.0	3.8	-	-
Dry based weight (India)	4.9	19.5	11.7	37.0	25.6	1.3	-	-

* CP = Crude protein; CF = Crude Fiber; NFE = Nitrogen-free extract; P = Phospor; Ca = Calcium.

Figure 4. *Apu-apu* water plant (*Pistia stratiotes*)

3.5 Peanut Meal

Peanut is a food plant in the form of a bush originating from South America, precisely from Brazil. The classification of peanut plants according to [7] can be seen as follows:

Kingdom : Plantae
Division : Spermatophyta
Subdivision : Agiosperms
Class : Dicotyledoneae
Order : Legumminales
Family : Papilionaceae
Genus : Arachis
Species : *Arachis hypogaea* L.

The composition of peanuts is influenced by variety, geographical location and growing conditions. Generally, peanuts contain 20-30% protein and fat content ranges from 40-50%. Peanuts are also a good source of fiber and minerals. Mineral content between 2.0 – 5.0% varies according to the type and variety of peanuts. Peanuts are also rich in calcium, iron and water-soluble vitamins such as thiamine, riboflavin and nicotinic acid [8]. The protein content of peanut meal varies depending on the process of extracting the oil. The nutritional content of peanut meal is shown in Table 2.

Table 2. Nutrient Content of Peanut Meal

Nutrients	Percentage (%)
Water	8.98
Ash	7.64
Protein	42.43
Crude Fiber	8.59
Crude Fat	10.32
Nitrogen-free Extract	31.02
Gross Energy (Kcal/kg)	4281

a b

Figure 5. (a) Whole Peanut and (b) Peanut Meal

Peanut meal has a weakness that is low in the content of essential amino acids in the form of lysine and methionine. Lysine is the limiting amino acid in plant proteins. The lysine requirement for fish ranges from 4-6% in feed protein [9]. The amino acid methionine is one of the building blocks of body proteins, while the protein in each body tissue has different amino acid content, so that amino acids determine the shape and function of body tissues. Peanut meal has a limiting use in the form of anti-nutritional anti-trypsin if it is not stored properly.

3.6 *Lamtoro* Leaves (*Leucaena leucocephala*)

Lamtoro is a type of shrub from the family Fabaceae (Leguminosae, legumes), which is often used in reforestation of land or preventing erosion. Based on the literature, the following is a general classification of *lamtoro* plants:

Kingdom : Plantae
Division : Magnoliophyta
Class : Magnoliopsida
Order : Fabales
Family : Fabaceae
Genus : Leucaena
Species : *Leucaena leucocephala* (Lamk.) de Wit

Figure 6. *Lamtoro* leaves (*Leucaena leucocephala*)

Lamtoro leaf flour is a potential local biological source to be used as a source of vegetable protein in fish feed because it contains about 25-30% protein [10] or 24.2% . This value is high compared to other vegetable protein sources after soybeans. The results of the proximate test on unfermented and fermented *lamtoro* leaf flour can be seen in Table 3.

Table 3. Proximate Test Results for LLF (Lamtoro Leaf Flour) and FLLF (Fermented Lamtoro Leaf Flour)

Material	Ash	Fat	Crude Fiber	Protein	NFE
LLF	7.53	4.48	46.31	30.56	54.76
FLLF	8.19	5.25	34.14	31.82	57.13

Source: [11]

The use of *lamtoro* raw materials for fish is limited by the high content of Neutral Detergent Fiber (NDF) of 39.5% and Acid Detergent Fiber (ADF) of 35.10%. Crude fiber is a carbohydrate component rich in lignin and cellulose which is difficult to digest. Cellulose is the frame of plant cells consisting of p-D-glucose chains with a degree of polymerization of approximately 14,000 [12]. The use of *lamtoro* leaf flour in feed is also limited by the presence of mimosin which is a heterocyclic amino acid, which is an amino acid that has circular carbon chains with different groups. Mimosin is often called leucine with the molecular formula $C_8H_{10}O_4N_2$. This compound seen from its structure is a derivative of protein which is characterized by the presence of the element N in its structure. In addition to mimosin, other nutrient ingredients contained in lamtoro leaf flour are myoinositol hexakiphosphate ($C_6H_{18}O_{24}P_6$) which are commonly called phytic acid and tannins.

4. UTILIZATION OF ALTERNATIVE VEGETABLE PROTEIN FOR FISH FEED

Several research results have been carried out and show good results regarding the use of waste as a source of vegetable protein in fish feed. The results of these studies are presented in Table 4

Table 4. Production of Fish Farming Based on Alternative Vegetable Protein Sources

Prospective Protein	Treatment	Result	Reference
Cabbage Waste	Substitution of cabbage waste with tofu dregs, bamboo shoots and bran on the growth of pearl catfish (Clarias gariepinus) seeds	The results showed that the growth of pearl catfish fed with cabbage waste substitution with tofu, rebon and bran can increase the growth of pearl catfish seeds with feed efficiency of 59.74%. The nutritional content of the feed is protein (33.31%), fat (3.48%) and carbohydrates (21.63%)	[13]
Moringa leaf (*Moringa oleifera*)	Moringa leaf meal supplementation and probiotics into fish feed	The results showed that the addition of Moringa leaf flour combined with probiotics in feed gave a significant effect on absolute weight of 4.673 g, absolute length of 2.607 cm, specific weight of 2.25%, specific length of 1.07%, feed conversion 1.84%.	[14]
Indigofera zollingeriana leaf	Substitution of *I. zollingeriana* leaf meal plus soybean meal for fish feed	The results showed that the absolute weight growth of carp fry given 50% *I. zollingeriana* flour plus 50% soybean flour resulted in better growth than other treatments with protein retention and high protein digestibility.	[15]
Papaya leaf (*Carica papaya L.*)	Addition of papaya leaf flour and pineapple peel in commercial fish feed	The results showed that the increase in the growth of tilapia (*Oreochromis niloticus*) with the addition of 25% papaya leaf flour and 75% pineapple peel was able to increase the growth of absolute length, absolute weight, SGR, FCR and obtain the best SR results.	(Rudiansyah 2022)

Conclusion

Based on the literature study, it can be seen that various sources of vegetable protein have high abundance and diversity and have great potential to be used as sources of vegetable protein to be utilized as fish and livestock feed.

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