Replacement of Fish Meal with Fermented Soybean Meal in Fish Feed: A Review

ABSTRACT

Soybean meal is a source of vegetable protein to replace fish meal which is widely used because it has a high protein content (26.7 -65.5 %), balanced amino acids and easy to find compared to other plants. Besides being high in protein, soybean meal also contains anti-nutrients which can inhibit growth, feed effectiveness, and lower nutrient utilization in fish. So it is necessary to process feed ingredients to remove anti-nutritional content. Fermentation can be a solution for utilizing soybean meal by reducing the anti-nutrient content and crude fiber to produce components that can be utilized properly, such as protein, β-glucan, vitamins, mannan oligosaccharides, organic acids, and antibiotics. The type of fermented soybean meal that is widely used is *Bacillus* spp., *Aspergillus* spp., *Lactobacillus* spp., and yeast. The purpose of this literature review study was to determine the effect of replacing fish meal with fermented soybean meal in fish feed. Several types of fish that have been fed using fermented soybean meal include seabasses, green snapper, mud grouper, rainbow trout, pomfret star, tilapia, and turbot. Fermentation of soybean meal to fish can increase growth rate, gut morphology, gut microecology, feed digestibility, feed preferences, fish innate immunity and produce antimicrobial peptides. Soybean meal fermentation as a substitute for fish meal has been shown to have a good effect on fish so that it can continue to be developed to increase the utilization of soybean meal.

Keywords : Fish feed, fermentation, soybean meal, growth, digestibility

1. INTRODUCTION

Fish meal has a high protein content (around 44.2-58.87%) [1] so that it can be used as the main protein source in the manufacture of carnivore fish feed with additional ingredients such as a balanced amino acid content and other growth promoting factors [2]. However, reducing the use of fishmeal can be a challenge in promoting the development of a sustainable aquaculture industry due to increased feed prices stemming from large amounts of wild catch which can damage marine ecosystems [3]. Dwindling fishery resources and increasing fish prices are the main factors in urging nutritionists to replace fish meal without reducing the protein content and easy to find [4].

A feed ingredient that can be used as a protein source to replace fish meal is soybean meal, because the price is cheap, the availability is wide, the supply is stable and it does not compete with food ingredients compared to fish meal [4]. Soybean meal is a by-product of processed soybean oil with a high protein content (40-50%), high carbohydrates (57.15%) and balanced amino acids, so that it can be used as the main protein source in the manufacture of animal feed [5] [6]. The advantages of soybean meal are that it has high digestibility in fish and has a pleasant aroma when compared to fish meal. However, the drawback of soybean meal is that its use as an alternative raw material is still limited because there are anti-nutritional ingredients such as oligosaccharides, saponins, protease inhibitors and phytic acid [7] which

can inhibit growth, physiological conditions and feed utilization so that the nutrients in the feed are not absorbed completely [8].

Substituting fish meal with soybean meal often results in stunted growth and lower utilization of nutrients in feed [9] [10]. Previous research suggests reducing or even eliminating the antinutrient content in soybean meal using various techniques to increase the nutritional value content [11]. So it is necessary to process feed raw materials before being given to fish [12].

Fermentation is a process of chemical changes in certain materials with the help of enzyme activity originating from microorganisms [13]. The function of the fermentation process is to degrade the anti-nutritional content in soybean meal, fiber, oligosaccharides and protein, besides that it can also improve the quality of vegetable protein and make other beneficial components such as probiotics and prebiotics [14]. Making a review of this journal aims to determine the effect of replacing fish meal with fermented soybean meal in fish feed.

2. SOYBEAN MEAL AS A SUBSTITUTE FOR FISH MEAL

Soybean meal is a source of vegetable protein which is often considered as a substitute for fish meal. Soybean meal has a fairly high effective content such as protein (40-50%) , amino acids which are relatively balanced and easy to find compared to other plants [15]. The effect of using soybean meal as a substitute for fish meal on the growth and health of fish depends on the species and feeding habits of the fish [16]. In general, the use of soybean meal is well received by herbivorous and omnivorous fish compared to carnivore fish. Soybean meal can replace part or all of fish meal without inhibiting the growth and health of herbivorous and omnivorous fish [17]. The replacement of 75% fish meal with soybean meal showed no significant difference in the growth of digestive enzyme activity and the antioxidant status of tilapia (*Oreochromis niloticus*) [18]. However, the use of soybean meal in food for carnivore fish such as orange spotted grouper (30%) [19], Eur operatic seabass (25%), and turbot (30%) [20] requires a benchmark in feeding soybean meal because it can inhibit performance. growth of the carnivore fish.

The high amount of soybean meal used in feed can have an adverse effect on growth, feed utilization and fish health status [21]. Substitution of 24% fish meal with soybean meal in carnivore fish has an adverse impact on feed efficiency, lipids, protein, metabolism, growth and health of Japanese flounder (*Paralichthys olivaceus*) [22]. The use of soybean meal as a substitute for fish meal which exceeds 49% will show an adverse effect on the growth, feed conversion and digestibility of the Chinese sucker (*Myxocyprinus asiaticus*) [23]. Several studies have stated that feeding fish fermented with soybean meal in aquaculture ponds can affect immune function, adverse inflation responses and stress in fish [3]. The anti-nutrient content in soybean meal raw materials can inhibit the efficiency of feeding so that the nutritional content is disturbed, such as the content of phytic acid [24]. In general, plant-type feed ingredients contain anti-nutrients which are the main source of phosphate and cause low feed solubility in monogastric animals. The strategy that can be used to remove anti-nutritional content in soybean meal is by utilizing the fermentation process by microorganisms which has many benefits such as increasing the nutrient content and increasing the solubility of vegetable protein sources by fish [25].

FERMENTATION FUNCTION

Fermentation is a method of breaking down organic compounds into simpler compounds by utilizing microorganisms. Fermented products are usually biodegradable easily and their nutritional value increases from the original material. Besides being able to break down complex compounds into simpler ones, the fermentation process can also synthesize several complex vitamins. The fermentation process has the benefit of converting complex organic materials such as carbohydrates, proteins and fats into easily digestible molecules. In addition, fermentation can also change the aroma and taste to be easily liked by organisms and can synthesize protein. Another benefit of the fermentation process is that it can reduce toxic compounds, and the shelf life becomes longer, so that the basic ingredients produced have better economic value [12]. The advantages of the fermentation process are increasing protein content, feed digestibility and reducing crude fiber so that the nutrients in the feed can be absorbed perfectly [26]. Additionally, it ferments with *Bacillus subtilis* can reduce the trypsin content in soybean meal from 3.38 to 1.65 mg/g [27].

This method is widely used in increasing the utilization of fish meal substitutes for soybean meal [28]. Previous studies have established fermentation as an effective method for improving the quality of soybean meal by producing probiotics or prebiotics. So that it can improve nutrient digestibility, fish immune system and palatability by eliminating anti-nutrients, oligosaccharides, and fiber [29]. In the soybean meal fermentation process, the microorganisms that are widely used are *Bacillus* spp., *Aspergillus* spp., and *Lactobacillus* spp. [30] [31]. Several studies also explain that the use of fermented soybean meal with *Bacillus* spp. can increase protein content, thioxidative activity, total amino acids, fish digestibility and can reduce anti-nutritional content and immunoreactivity [10]. So that fermentation is highly recommended to increase the utilization of soybean meal [25].

NUTRIENTS IN FERMENTATION OF SOYBEAN MEAL IN FISH FEED

Feed ingredients processed by the fermentation process will experience an increase in nutrients such as an increase in protein (38.25% to 44.82%) and increase the digestibility of the feed by reducing the levels of crude fiber and fat [32] . Several studies have stated that fermentation can be used to improve the quality of soybean meal. One of them is the increased content of amino acids in *Bacillus subtilis* fermented soybean meal such as asparagine (10.89%), threonine (3.71%), serine (4%), glucogenic (16.35%), glycine (4.15%) , alanine (4.70%), cysteine (1.40%), leucine (8.08%), tyrosine (4.60%), valine (5.83%), and methionine (2.49%). The increase in amino acid content in soybean meal fermentation can be influenced by the type of bacteria used. In addition, the content of phenols and flavonoids in fermented soybean meal also increased significantly from 3.0 to 14.7 mg/g [27] . The nutritional content in fermented soybean meal can improve fish growth performance, physiological conditions of digestion and coefficient of digesting nutrients. The type of fermentation that is widely used is the bacterium *Bacillus subtilis* and *Lactobacillus* spp. [8] . A list of nutrient content and types of fermentation in several studies can be seen in (Table 1.).

Table 1: Nutrient content of fermented soybean meal

Fermentation Type	Crude protein (%)	Carbohydrates (%)	Ash Content (%)	Lipids Rough (%)	References
Bacillus pumillus	42	-	-	10	[4]

SE5					
Aspergillus awabor	60,58	-	-	2,7	[21]
Bacillus subtilis E20	48,82	-	11.85	7.50	[19]
Bacillus subtilis , *Lactobacillus,* ragi	65.5	-	-	-	[7]
Lactobacillus spp.	50	-	-	-	[8]
Saccharomyces cerevisiae	29,7	57,15	5.91	-	[33]
Bacillus spp .	49,9	21,3	-	-	[34]
Bacillus subtilis	44,82	-	-	-	[27]

3. FERMENTATION OF SOYBEAN MEAL AS FISH FEED

Fermented soybean meal using microorganisms has been widely used in several types of fish and produces soybean meal with a higher preference as a vegetable protein [35]. Fermented soybean meal has been widely used as feed for seabasses [4] , green snapper [36] , mud grouper [19], rainbow trout [7], pomfret star [8], tilapia [33], and turbot [21], Other research mentions the use of fermented soybean meal using *Bacillus* spp. can produce antibiotics [23] and does not cause any morphological changes in the gut of fish, especially in ranbow trout [35]. Soybean meal fermentation using lactic acid bacteria can increase the acidity of the feed, increase the preferences of the feed, and can produce antimicrobial peptides [37]. Fermented soybean meal using yeast can produce useful components such as mannan oligosaccharides, organic acids, vitamins, antibiotics, β-glucans, and chitin [38]. Components produced from soybean meal fermentation using microbes can increase growth rate, intestinal morphology, intestinal microecology and innate immunity of fish [39] [40]. The use of fermented soybean meal in fish has different optimum dose levels and growth (Table 2). This occurs because the types of fish fed with fermented soybean meal are different and the bacteria used are also different. The highest growth was in *Epinephelus coioides* fed soybean meal fermented *Bacillus subtilis* E20 with an optimum dose of 29.32 % .

Table 2: Growth and optimum dose of fermented soybean meal

Species	*Results (WG %)*	*Optimum Dose*	*Reference*
Lateolabrax maculatus	12.3	26.9-37.1%	[4]
Micropterus salmonides	14.71	30%	[36]
Epinephelus coioides	34.81	29.32%	[19]
Oncorhynchus mykiss	5.5	40%	[7]
Trachinotus blochii	25.3	35%	[8]
Oreochromis niloticus	21.87	37.4%	[33]
Scophthalmus maximus L.	N/A	45%	[21]

* WG : Weight Gain

6. CONCLUSION

The use of fermented soybean meal as a substitute for fish meal is an alternative that can be used because the protein content of fermented soybean meal (29.7 -65.5 %) is not much different from fish meal (44.2-58.87%). The best type of fermentation used is fermentation by

Bacillus *subtilis and Lactobacillus* sp. which produces the highest protein (65.5 %). The increase in protein in the fermentation process is influenced by the quality of the feed ingredients and the bacteria used. The highest increase in growth was in *Epinephelus coioides* (34.81 %) with an optimum dose of 29.32% fermented soybean meal. The type of fish fed fermented soybean meal greatly influences the increase in fish growth.

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