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UTILIZATION OF CORN AND ITS SUBSTANCES AS A SOURCE OF FISH FEED (ARTICLE REVIEW)

Pemanfaatan Jagung Dan Bahan Ikutanya Sebagai Sumber Pakan Ikan (Review Artikel)

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ABSTRACT

Fish farming is highly dependent on the use of feed, which can even account for up to 70% of the total cost of farming. Therefore, the availability of quality feed in sufficient quantities is a key factor in ensuring successful farming. However, feed with high protein content tends to be expensive. The solution to this problem is to use alternative feed raw materials that have good nutritional content, do not compete with human needs, and are easy to obtain. Organic waste from corn harvest residues has great potential because it is easy to obtain and cheap. Corn waste has the problem of low nutritional content, so a fermentation process is needed as an effort to increase its nutritional value. This study aims to examine the extent to which the utilization of fermented corn waste can be used as fish feed to support increased fish growth performance.

Keywords: Corn Waste, Fermentation, Fish Feed, Microbes, Nutrition

ABSTRAK

Budidaya perikanan sangat bergantung pada penggunaan pakan, bahkan dapat memakan hingga 70% total biaya budidaya. Oleh karena itu, ketersediaan pakan yang bermutu dan dalam jumlah yang cukup menjadi faktor kunci dalam menjamin keberhasilan budidaya. Akan tetapi, pakan dengan kandungan protein yang tinggi cenderung mahal. Solusi dari permasalahan tersebut adalah dengan menggunakan sumber bahan baku pakan alternatif yang memiliki kandungan gizi baik, tidak bersaing dengan kebutuhan manusia, dan mudah diperoleh. Limbah organik dari sisa panen jagung memiliki potensi yang besar karena mudah diperoleh dan murah. Limbah jagung memiliki kendala kandungan gizi yang rendah, sehingga diperlukan proses fermentasi sebagai upaya peningkatan nilai gizinya. Penelitian ini bertujuan untuk mengkaji sejauh mana pemanfaatan limbah jagung fermentasi dapat digunakan sebagai pakan ikan untuk mendukung peningkatan kinerja pertumbuhan ikan.

Kata Kunci: Fermentasi, Limbah Jagung, Mikroba, Nutrisi, Pakan Ikan

INTRODUCTION

Feed is an important component in fish farming, contributing around 60-70% of the total production cost (Afrianto & Liviawaty, 2005). Commercial fish feed, which is generally expensive, is a constraint for developing countries due to dependence on imported materials such as fish meal, squid meal, crustacean meal, soybean meal, vitamins, and minerals (Nasser *et al.,* 2018). Agricultural waste such as corn waste consisting of corn cobs, husks and corn silk can be an alternative source to overcome these problems.

One alternative feed source that is abundant, affordable, easy to obtain, and does not compete with human needs is corn waste. As agricultural waste, corn faces various challenges that require processing with the help of feed technology. Corn cobs have a high fiber content, reaching 46.52%, and a low protein value of only 2.67% (Suryani *et al.,* 2016). In addition, corn cobs contain 15% lignin, 45% cellulose, and 35% hemicellulose (Simanullang *et al.,* 2021). One technology that can be applied to process corn cobs as alternative feed is through the fermentation process.

Fermentation utilizes the activity of microorganisms to break down coarse fibrous materials into more easily digested parts. This process can also reduce crude fiber content and increase protein content (Hawusiwa, 2015; Wina, 2005). In this process, the microorganisms used can be probiotics, such as bacteria, fungi, yeast, or both, as well as fermentation products or extracts from the fermentation process. This process begins with the fermentation of protein from plant sources, with the aim of reducing the fiber content in the material (Arief *et al.,* 2014).

The use of technology in the utilization of agricultural waste as feed aims to improve the quality of the feed material. This includes increasing storage life, digestibility, removing anti-nutrients, and increasing the nutritional content of feed (Ariyanto & Slamet, 2014). The purpose of this study was to review the literature on research results to determine various corn waste processing technologies to increase the nutritional content of corn waste.

RESEARCH METHODS

This research was conducted at the Padjadjaran University Campus located in Jatinangor District, Sumedang Regency, West Java. The tools used in this study were only laptops and library source search tools. The approach taken involved systematic descriptive and exploratory study methods, by integrating several previous primary research results to obtain accurate and provable facts, taken from various literature in national and international journals such as Research Gate and Google Scholar. According to Sugiyono (2017), exploratory descriptive research is a method used to provide clear research results, but these results are not intended to make general conclusions or generalizations. The number of book sources used was eight, the number of journals used as sources was 31, and the number of proceedings sources used was 13. The keywords used to obtain information include fish feed, corn waste, fermentation methods, fermentation microbes, corn cob fermentation, corn skin fermentation, and yellow corn fermentation. This comprehensive search approach makes it easier to compile a theoretical framework that is in accordance with the main topics discussed in the literature.

RESULT

Characteristics of Corn Waste

Since corn waste is easy to find and cheap (Figure 1), it has great potential. According to Dirgantara *et al*., (2013), corn husks or klobot can be obtained easily, are affordable, and can decompose naturally. According to Haluti (2016), 65% of the corn harvest comes from corn (yield), and the last 35% comes from waste (stalks, leaves, husks, and corn cobs). Although corn waste is very abundant, its utilization is still not optimal.

Figure 1. Corn Waste
(Sumber: https://komunita.id/2019/01/22/beberapa-cara-pemanfaatan-limbah-jagung-agar-bernilai-ekonomi/)

Essential fatty acids, isoflavones, fiber, minerals (such as Ca, K, Na, P, and Fe), anthocyanins, beta-carotene (provitamin A), and other essential amino acid compositions can be found in corn (Suarni & Yasin, 2011). Corn contains protein (8%-11%), linoleic fatty acids (omega-6), vitamin A, vitamin E, and several other important minerals. The main nutritional content of corn is starch, which reaches 72% to 73%, with amylose and amylopectin ratios of 25% to 30% and 70% to 75%, respectively. With a water content of 7.53%, corn cobs have an energy potential of 0.27 (with a calorific value of 4,451 kcal/kg), while corn waste consisting of dry stems and leaves has an energy potential of up to 66.35 GJ. Meanwhile, the energy from corn cobs reaches 0.27 (with a water content of 7.53%) and a calorific value of 4,451 kcal/kg, so that its energy potential reaches 55.75 GJ.

Lignocellulosic waste is corn plant waste consisting of three main components: lignin, cellulose, and hemicellulose (Muhadjir, 2008). In addition to the three main components, lignocellulose also contains minor components such as ash, protein, and pectin, with varying levels depending on the source of the lignocellulose. Containing 15% lignin, 45% cellulose, and 35% hemicellulose, this corn plant waste can produce 0.24 liters of bioethanol per kilogram of corn biomass (Koswara, 2011). Lignin coats the microfibrils in a hydrophobic matrix covalently bonded to hemicellulose. The purpose of this lignin-carbohydrate relationship is to prevent cellulose from being hydrolyzed (Steffen, 2003). In feed, lignin can inhibit nutrient absorption due to its resistance to enzymatic hydrolysis (Hattaka, 2000).

Definition of Fermentation

Chemical on organic substrates carried out by enzymes made by microorganisms. Enzymes made by *microorganisme* help change complex compounds into simpler ones (Suprihatin, 2010; Jay *et al.,* 2005). Bacteria, yeast, and mold are microorganisms that are usually involved in food fermentation. Activating certain microbes to change the properties of materials so that useful fermentation products are produced is the main principle of fermentation.

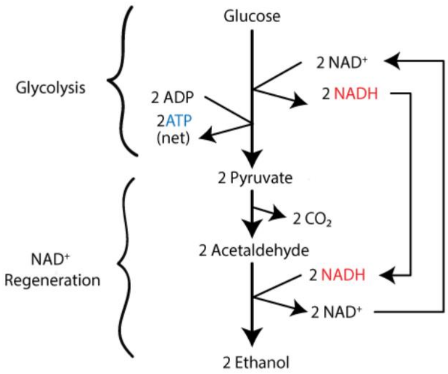

Figure 2. Fermentation Process

Solid substrate fermentation, also known as solid-state fermentation (SSF), is a type of fermentation in which microorganisms grow on solid materials without the presence of free water (Ningrum, 2015). With fungi, this process produces high-quality products. Fungi, unlike other microorganisms, naturally grow on solid media such as wood, seeds, stems, roots, and dry body parts such as skin and bones. The purpose of SSF is to allow microorganisms or fungi that have been cultured to interact with water-insoluble substrates in the most effective way and also to maximize the concentration of nutrients that can be obtained from the substrate (Ningrum 2015). In short, fermentation converts simple sugar glucose ($C_6H_{12}O_6$) into ethanol ($2C_2H_5OH$) (Figure 2). The chemical reactions that occur can be written as follows:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO2 + 2\ ATP$$

Factors Affecting the Fermentation Process

Microorganisms, substrate (media), acidity level (pH), temperature, oxygen, and water activity affect the fermentation process (Afrianti, 2013). According to Buckle *et al*., (1985), time, water, pH, temperature, oxygen, and other nutritional factors contribute to fermentation. Variables related to the microbial growth phase during the fermentation process are referred to as fermentation time. This will affect the fermentation results in the end. The type of organism involved in the fermentation process determines the ideal fermentation process (Sulistyaningrum, 2008).

Various factors, including substrate, temperature, pH, oxygen, and the microbes used, can affect the fermentation time, both directly and indirectly (Nasrun *et al.,* 2015). Substrates that contain the necessary macro and micronutrients and temperatures that suit the needs of microorganisms can grow well (Pasaribu, 2007).

Microbes Used in the Fermentation Process

In general, lactic acid bacteria (LAB) function to produce lactic acid to lower the pH of the product. In addition, LAB also has the ability to produce antimicrobial compounds, such as organic acids called bacteriocins (Reli *et al.,* 2017). Lactic acid bacteria can also produce Bacteroides bacteria such as Lactobacillus, Streptococcus, Lactococcus, Pediococcus, Enterococcus, Leuconostoc, Bifidobacterium, and Corinebacterium (Shah *et al.,* 2014).

Rhizopus is a type of mold that can produce many enzymes, such as lipase, pectinase, amylase, and protease. This mold can also be used for bacterial fermentation such as Rhizopus oligosporus, R. oryzae, R. stolonifer (also known as bread mold), and R. arrhizus (Wipradnyadewi *et al.,* 2010). According to Hilakore *et al.,* (2015), fermentation of sago pulp with Aspergillus niger and urea has been shown to increase protein and fat content while reducing crude fiber levels. This makes livestock feed easier to digest. This is because Aspergillus niger can produce decomposing enzymes such as amyloglucosidase, cellulase, and amylase.

Through the activity of the cellulase enzyme made by microbes in the rumen, the rumen participates in the fermentation process which reduces the amount of crude fiber in the feed. This process is expected to increase nutritional value by reducing the levels of Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF). According to Anam *et al.* (2012), livestock have difficulty digesting lignocellulose bonds of NDF and ADF. However, processing using a fermentation method involving rumen fluid allows the separation of lignocellulose bonds, which makes straw easier to digest.

Cellulose bacteria are microorganisms that have the ability to decompose cellulose into glucose and produce cellulase enzymes (Murtiyaningsih & Hazmi, 2017). Certain cellulase enzyme complexes are used in this enzymatic breakdown process. These include endo-1,4-β-D-glucanase (known as endocellulase or carboxymethylcellulase/CMCase), exo-1,4-β-D-glucanase (known as cellobiohydrolase), and β-glucosidase (known as cellobiase) (Haq, 2005). These bacteria can stop the growth of pathogenic bacteria through the production of lactic acid and acetic acid. They can also decompose materials rich in cellulose and lignin (Adawiyah *et al.,* 2017).

Amylase, protease, and lipase are enzymes that play a role in fermentation. These enzymes hydrolyze polysaccharides, proteins, and fats in food into simple substances such as amino acids, fatty acids, alcohols, carbon dioxide, peptides, and other components. The breakdown of these substances affects the aroma, texture, and taste, so that the resulting product is different from the original material (Jay *et al.,* 2005)

Both glucoamylase and amylase enzymes have the ability to hydrolyze starch. The function of the amylase enzyme is to convert starch into glucose by breaking the glycosidic bond, which is the bond between glucose molecules and starch polymers (Wu *et al.,* 2011). During metabolism, the product of the amylase enzyme, which breaks down glucose, will be used. Converting glucose to pyruvic acid is the first step in metabolism. This is done through anaerobic fermentation, which produces other products.

Increasing the Nutritional Value of Corn Waste Through Fermentation

Some research results on corn waste processing with satisfactory results, especially increasing protein content and reducing fiber content. Some methods and types of microbes used with fermentation as presented in Table 1.

Table 1. Increase in Nutritional Value of Corn Waste After Fermentation Process

No	Microbes Used	Purpose	Methods	Result	Author
1	*Trichoderma* sp	Knowing the characteristics, protein content and crude fiber of corn cobs with different fermentation times (*Trichoderma* sp).	Soaking corn cobs, *Trichoderma* sp, rice bran, and rumen, with different times (0, 5, 10, 15, 20 days).	The best corn cob fermentation was for 10 days in terms of crude fiber content (25.73%) and crude protein (7.54%).	Rostini *et al.*, 2022

2	Buffalo Rumen	Analyzing the crude protein and crude fiber content of corn cobs fermented with different levels of buffalo rumen fluid.	Using corn cob powder (1000 gr and 50 gr bran) with a mixture of buffalo rumen with different percentages (20%, 40%, 60%, and 80%) fermented for 21 days	The use of 80% rumen fluid produced the highest crude protein (28.38%) and decreased crude fiber (8.22%)	Widaningsi *et al.*, 2018
3	Probiotics	Creating new feed sources by making corn husk silage using fish probiotics	Corn husk silage (banana stalks, bran, goat manure, rice husk ash, probiotics) (corn husk silage: A 140g, B 210 g, C 280 g)	The use of 280 g fermented feed was the best formulation with a protein content of 4.15%, a fat content of 0.56%, a fiber content of 3%, and a carbohydrate content of 3.30%.	Hilma *et al.*, 2017
4	*Rhyzopus oligosporus*	Increasing the nutritional value of corn by fermentation with mold	Corn is fermented using mold by steaming and sprinkling with mold which is then dried and made into flour. The fermentation process was carried out for four days with a dose of 9 mL (*Rhizopus oligosporus*, *Rhizopus oryzae*, and *Aspergilus niger*) per 100 g (corn flour) and incubated at room temperature (30°C).	The use of mold resulted in an increase in protein from 6.25% to 13.85%	Saloko *et al.*, 2019

5	*Rhizopus oligosporus*, *Rhizopus oryzae*, Aspergilus *niger*	Knowing the type and level of the right inoculant in the corn flour fermentation process.	Soaking corn cobs, *Trichoderma* sp, rice bran, and rumen, with different times (0, 5, 10, 15, 20 days).	The best treatment for protein and fat content was corn fermented with R. oligosporus (100 g) which increased from 9.49% to 17.68% and from 3.95% to 6.04% respectively and crude fiber 15.3%.	Samsudin *et al*., 2011

Based on Table 1. fermentation using buffalo rumen, *Trichoderma* sp., probiotics, and *Rhyzopus* sp. has been proven to increase the nutritional value of corn waste. The use of buffalo rumen produces the best increase in nutritional value because the number of microbes is greater when compared to the use of other inoculants which only play a role in one microbe. The real difference is in the increase in protein content and the best decrease in fiber is in the use of buffalo rumen with 28.38% crude protein and 8.22% crude fiber.

Corn cob fermentation is very different from buffalo rumen fermentation. Treatment with 80% buffalo rumen fluid produces an average crude protein of 3.89%, not 3.03%. Bacteria hydrolyze feed into amino acids and polypeptides. Short chain peptides are then formed from these polypeptides. Then deamination occurs, which is usually slower than proteolysis (Ismail, 2001). The initial stage of the ensilase process is the hydrolysis of ammonia protein by the protease enzyme. Proteins are converted into amino acids, which are then converted into ammonia and amines. The rate of protein breakdown is greatly influenced by the decrease in pH. According to Slottner and Bertilsson (2006), depending on the type of material used, protease activity peaks at pH 4-7.

To maximize microbial growth and microbial protein production, the use of buffalo rumen requires an ammonia concentration of at least 5 mg NNH_3 per 100 milliliters of rumen fluid. According to Oosting *et al.,* (1989) to maximize microbial fermentation activity, a higher ammonia concentration is required than that required for the highest microbial protein production. The value of 80% buffalo ammonia in rumen fluid is less than 5 mg-NH_3 per 100 g of fermented material, but the crude protein value is higher than other methods. Cellulolytic bacteria such as *Ruminococcus flavefaciens, R. albus, Butyrivibrio fibrisolvens, Bacteroides succinogenes, C. lochheadii*, and *C. longisporum* can be found in buffalo rumen fluid (Thalib, 2002).

According to Hernawati *et al.,* (2010), the number of cellulolytic bacteria that is in accordance with the availability of nutrient sources causes a decrease in the level of crude fiber in feed fermented by cellulolytic bacteria. This prevents competition between microbes and allows optimal microbial growth. This supports the activity of degrading cellulose in feed ingredients more effectively. Sandi *et al*., (2010), stated that the rate of crude fiber reduction is highly dependent on the components of crude fiber, especially lignin content. Bacteria or microorganisms that have lignin content may not be able to break down the material. As a result, the reduction in crude fiber is low. The lignin content in corn cobs reaches 6% (Murni *et al.,* 2008). Harman (2004), said that the fermentation process carried out by the fungus Trichoderma sp. causes an increase in this crude protein. *Trichoderma* sp. has the ability to increase or improve the nutritional value of protein content.

Corn cobs fermented with *Trichoderma* sp. for ten days showed the best characteristics with an aroma value of 3.90, texture of 3.35, and color of 2.85 as a result of the fermentation process. According to Rostini (2014), ideal fermentation produces a yellowish green color, a non-lumpy texture, and a distinctive fermented sour aroma.

Use of Fermented Corn Waste in Fish Feed

Several studies have shown that fermented corn waste can be used in fish feed. The use of fermented corn waste in fish feed is presented in Table 2 below.

Table 2. Fish Performance in Fermented Corn Waste Feeding

No	Mikroba yang Digunakan	Purpose	Methods	Result	Author
1	*Rhyzopus oligosporus*	Knowing the best dosage of fermented yellow corn in artificial feed with different doses.	Corn fermented with mold (Rhyzopus oligosporus) at different doses A (0%), B (10%), C (20%), D (30%), E (40%) mixed into artificial feed.	In the eel, the highest daily weight growth rate (3.108%), the highest daily length growth rate (1.239%), and the highest feed efficiency (59.427%) were obtained using 40% fermented corn waste in the feed.	Saloko *et al.*, 2019
2	*Rhizopus oligosporus*	Knowing the best dosage of fermented corn (R. Oligosporus) in fish feed mixtures	Artificial feed contains fermented corn flour with different doses: 0%, 5%, 10%, 15%, and 20%. The fish used in the test were carp	The best growth rate of carp was obtained using 20% fermented corn with a growth rate of 1.96%, feed conversion (2.38), and fat retention of 42.98%.	Samsudin *et al.*, 2011
3	*Trichoderma viridae, Trichoderma reesei, Aspergillus oryzae, Rhizopus oligosporus*	Knowing the best formulation of fermented corn cobs to increase the growth rate of tawes fish.	Artificial feed was formulated with different amounts of composition R0 (0%), R0 (5%), R0 (10%), R0 (15%), R0 (20%), R0 (25%),	Tawes fish seeds containing fermented corn cob flour (R1, R2, R3, R4 and R5) were much better in terms of growth (sequential values 2.01; 1.86; 1.80; 1.92; 1.84) compared to the control feed (R0) which was 1.24.	Rostika dan Ratu, 2012

4	Local Microorganism Bioactivator (MOL) Tempe and Eco Enzyme (EE)	Knowing the effect of tilapia growth fed with fermented corn cob and coconut meal waste	Treatment using commercial feed (K0), feed from corn cob waste (T4), feed from palm kernel meal waste (B4), and feed from a combination of both wastes (TB4).	Feed from a combination of corn cob waste and coconut meal (TB4) had the highest average growth and specific growth rate of 5.54 ± 0.22 grams, 6.9 ± 0.13 and 0.52%.	Jannah, 2024

The results of research on the utilization of corn waste with a fermentation process have proven to have a positive impact on fish growth. In its utilization in fish, fermentation with 40% Rhizopus oligsporus produced the best results in the highest daily growth rate of 1.239%, the highest daily weight growth rate of 3.108%, and the highest feed efficiency of 59.427%.

According to Howard *et al.,* (2003), the decomposition of fiber components by fungi can cause a decrease in crude fiber content. According to Islamiyati (2013), along with more even fungal growth, the mycelium will increase and spread on the substrate particles. As a result, the enzymes produced also increase and are more active in changing the complex lignocellulose structure into a simpler form that is easier for fish to digest.

The increase in protein levels is closely related to the growth of fungal cells, the more fertile the fungi grow in the substrate, the higher the protein levels measured. This is because the mass of fungal cells consists mostly of protein. An increase in protein levels can occur during the fermentation process due to the growth of fungal cell mass. According to Wang *et al.,* (2012), the fungus Rhizopus oligosporus can be used for fermentation to increase protein digestibility in soybean and wheat cereals.

CONCLUSION

Based on a comprehensive analysis of various studies, it is clear that improving the quality of corn waste through fermentation, especially by utilizing bacteria, buffalo rumen, and molds can increase nutritional value and produce fish feed products characterized by high protein content and low fiber content, thus affecting fish growth performance. In the fermentation of corn cobs with buffalo rumen, it was proven to increase protein value and reduce fiber content by 28.38% and 8.22%, respectively. Feed with a mixture of fermented yellow corn with *Rhyzpus oligosporus* with a content of 40% produced the highest daily growth rate of length of 1.239%, the highest daily weight growth rate of 3.108%, and the highest feed efficiency of 59.427%.

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