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Pengaruh Variasi Komposisi Tepung Tongkol Jagung dengan Campuran Ikan Cere (*Gambusia affinis*) dan Vitamin Mix untuk Pembuatan Pakan Ikan Lele

The Effect of Variations in Corn Cob Flour Composition with a Mixture of *Gambusia affinis* and Vitamin Mix for Making Catfish Feed

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ABSTRACT

This study aims to determine the optimal nutritional quality of fish feed from corn cob waste flour mixed with *Gambusia affinis* and vitamin mix, especially in terms of protein, fat, carbohydrates, and minerals, and to determine the effect of composition variations for making fish feed. The process of making fish feed in the form of pellets includes preparation of ingredients, mixing, steaming, molding, and drying. The study was conducted experimentally with four formulation variations, namely: P1 (100% corn cob flour), P2 (75% corn cob flour + 25% *Gambusia affinis*), P3 (75% corn cob flour + 25% vitamin mix), and P4 (50% corn cob flour + 25% *Gambusia affinis* + 25% vitamin mix). Each sample was tested for nutritional quality through proximate analysis, including moisture content, ash content, fat content, and protein content. The results showed that the protein content of the feed ranged from 7–9%, fat content 1–4%, ash content 5.63% - 22%, and moisture content 10.35–12.81%. The best formulation was obtained in a combination of P2 (75% corn cob flour and 25% *Gambusia affinis*), but all formulations still did not meet the SNI 01-4087-2006 standard for catfish feed, especially in protein and fat content. The addition of vitamin mix was proven to be effective in reducing moisture content, thereby increasing the shelf life of the feed. This study concluded that corn cob flour has the potential as an alternative raw material for fish feed, but reformulation is needed with an increased in protein and fat sources so that the nutritional quality of the feed can meet the standards required by fish.

Key words: corn cobs, fish feed, gambusia affinis, proximate analysis, vitamin mix.

ABSTRAK

Penelitian ini bertujuan untuk mengetahui kualitas nutrien yang optimal untuk pakan ikan dari tepung limbah tongkol jagung dengan campuran ikan cere dan vitamin mix, khususnya protein, lemak, karbohidrat, dan mineral, serta mengetahui pengaruh variasi komposisi terhadap pembuatan pakan ikan. Proses pembuatan pakan ikan berbentuk pelet meliputi persiapan bahan, pencampuran, pengukusan, pencetakan, dan pengeringan. Penelitian dilakukan secara eksperimental dengan empat variasi formulasi, yaitu: 100% tepung tongkol jagung (P1), 75% tepung tongkol jagung + 25% ikan cere (P2), 75% tepung tongkol jagung + 25% vitamin mix (P3), dan 50% tepung tongkol jagung + 25% ikan cere + 25% vitamin mix (P4). Setiap sampel diuji kualitas nutrisinya melalui analisis proksimat, meliputi kadar air, abu, lemak kasar, dan protein kasar. Hasil penelitian menunjukkan kadar protein pakan berkisar antara 7%–9%, kadar lemak 1%–4%, kadar abu 5,63%–22,44%, dan kadar air 10,35%–12,81%. Formulasi terbaik diperoleh pada kombinasi 75% tepung tongkol jagung dan 25% ikan cere, namun seluruh formulasi masih belum memenuhi standar SNI 01-4087-2006 untuk pakan ikan lele, terutama pada kandungan protein dan lemak. Penambahan vitamin mix terbukti efektif menurunkan kadar air, sehingga meningkatkan daya simpan pakan. Penelitian ini menyimpulkan bahwa tepung tongkol jagung berpotensi menjadi bahan baku alternatif pakan ikan, namun diperlukan reformulasi dengan peningkatan kandungan protein dan lemak agar kualitas nutrien pakan dapat memenuhi standar yang dibutuhkan ikan.

Kata kunci: analisis proksimat, ikan cere, pakan ikan, tongkol jagung, vitamin mix.

INTRODUCTION

Feed represents the largest cost component in aquaculture, accounting for approximately 60–70% of total production costs, making feed efficiency a key factor in improving farming profitability (Zaenuri *et al*. 2017). One strategy to reduce feed costs is the utilization of locally available agricultural by-products, such as rice bran, palm kernel meal, palm oil sludge, coconut meal, and corn cob waste, which are relatively inexpensive and continuously available throughout the year (Hatta & Sugiarto 2015). Feed in the form of pellets is widely used because it is easy to handle, store, and distribute while improving feed density and palatability (Nugroho 2016; Retnani 2015). Among freshwater aquaculture species, Catfish (*Clarias gariepinus*) is one of the most important commodities due to its rapid growth, high adaptability, and omnivorous feeding habit, allowing the use of various plant- and animal-based feed ingredients (Tesfahun 2018).

The nutritional quality of pellet feed, particularly its protein, fat, carbohydrate, and mineral contents, greatly influences fish growth and feed performance (Manik and Arleston 2021). Corn cob waste is a promising alternative feed ingredient because it is abundant yet underutilized. It contains approximately 90% dry matter, 11.38% crude protein, 5.39% crude fat, 21.09% crude fiber, and 8.30% ash, making it a potential energy source in fish feed formulations (Hatta & Sugiarto 2015; Novrianto *et al.* 2019). To compensate for its relatively low protein content, *Gambusia affinis* (ikan cere), which is rich in protein and amino acids, can be incorporated as an alternative protein source to partially replace commercial fish meal (Sinthiya *et al*. 2023). In addition, vitamin premixes containing vitamins A, D, E, K, and B complex are commonly added to improve nutritional quality, fish growth, and survival (Hasri *et al*. 2023).

Proximate analysis is widely used to evaluate the nutritional quality of fish feed by determining moisture, ash, fat, and protein contents (Gunawan & Khalil 2015). Previous studies have demonstrated the potential of corn cob waste as a feed ingredient. Novrianto *et al*. (2019) reported that the inclusion of 157 g corn cob meal produced the best performance in tawes fish feed, while Zaenuri *et al.* (2017) successfully formulated fish feed using corn cobs, sludge, fish meal, and rice bran in different proportions with each treatment having a total composition of 200 g. However, studies combining corn cob flour with *Gambusia affinis* and vitamin mix as a complete feed formulation for Catfish remain limited.

Therefore, this study developed pellet feed formulated from corn cob flour, *Gambusia affinis*, and vitamin mix as an alternative low-cost feed ingredient. The novelty of this study lies in the combination of these three materials and the evaluation of their effects on the proximate composition of catfish feed. This study aimed to determine the effect of different proportions of corn cob flour, *Gambusia affinis*, and vitamin mix on the moisture, ash, protein, and fat contents of artificial feed for Catfish (*Clarias gariepinus*), providing an economical and sustainable alternative feed formulation.

METHOD

Materials and Equipment

The tools used in this research included; an analytical balance, a mixer that functions as a tool for mixing ingredients, a pan that is used to steam fish feed mixture, an extruder/pellet molding machine for molding the fish feed mixture into uniform pellets, an oven for drying the molded pellets, and sealed plastic packaging for storing the dried fish pellets, as well as silica gel was used to maintain the quality of the feed and prevent moisture damage.

The materials used in this research included; corn cob flour, used as a vegetable raw material in fish feed production, fresh fish (*Gambusia affinis)* used as an animal raw material to replace fish meal, and vitamin mix with the *Supermix* brand formulated by Otsuda Japan which is used as an additional vitamin ingredient in making fish feed, as well as water was used to help maintain the ingredients and facilitate the molding process.

Experimental Procedure

Feed preparation

The method used in this study was an experimental method to determine the effect of ingredients on the nutritional content of corn cob flour formulated into pellet feed using additional ingredients such as fresh fish (*Gambusia affinis)* and vitamin mix. Feed formulation was prepared based on the weight of the ingredients on an as-fed basis, so the proportion of each ingredient was calculated according to the actual weight of the ingredients without considering differences in moisture content. The feed was formulated using raw materials based on the design shown in Table 1.

The research procedure began with the procurement of the main ingredients: corn cob flour, *Gambusia affinis*, and vitamin mix. The fresh fish (*Gambusia affinis)* were first steamed at 80°C for 15 minutes until softened, then mashed. After that, all ingredients were mixed according to the predetermined composition using a mixer, and 250 mL of water was added to each treatment (200 g total feed ingredients). The water served as a solvent and binder to facilitate dough formation and obtain a homogeneous mixture during pellet preparation, and it was not considered part of the nutritional composition of the feed.

Table 1 Feed formulation for each treatment (%)

Treatment	Ingredients (%)		
	Corn cob flour	*Gambusia affinis*	Vitamin mix
P1	100	0	0
P2	75	25	0
P3	75	0	25
P4	50	25	25

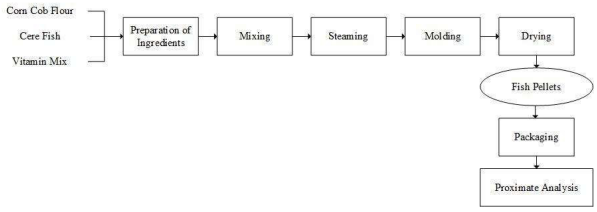

Figure 1 Research Flow

The resulting mixture was steamed again at 80°C for 3 minutes to improve homogeneity and texture. The steamed mixture was molded into pellets and dried in an oven at 110°C for 1 hour until the moisture content was reduced and the pellets became hard. The drying temperature of 110°C was selected because it is commonly used for feed drying, being sufficiently high to effectively reduce moisture content while remaining below the combustion point of organic materials. The drying duration of 1 hour was intended to ensure a significant reduction in moisture content, thereby improving pellet hardness and minimizing the risk of mold growth during storage. The dried pellets were then packed in tightly sealed plastic packaging with the addition of silica gel to maintain low humidity. The final stage of the process was proximate analysis, including the determination of moisture, ash, fat, and protein contents to evaluate the nutritional quality of the fish feed produced (Zaenuri *et al.* 2017). The research flow can be seen in Figure 1.

Analytical Methods

The pelleted fish feed was then subjected to proximate analysis. This test was conducted to determine the nutritional content of the fish feed to ensure it meets the national standards for catfish (*Clarias gariepinus)* feed based on SNI 01-4087-2006 (Standar Nasional Indonesia 2006a). The nutrients tested included: water content, ash content, fat content, and protein content.

Moisture content. Moisture content was determined using the oven-drying (thermogravimetric) method by measuring the weight loss of the sample after drying at 105–110°C. The moisture content was calculated using Equation (1) according to SNI 2354.2:2015 (Standar Nasional Indonesia 2015).

$$Moisture\ content\ (\%) = \frac{B - C}{B - A} \times 100\% \quad (1)$$

where: A = weight of empty cups (g), B = cup weight + initial sample (g), and C = cup weight + dry sample (g)

Ash content. Ash content was determined using the gravimetric method by incinerating the sample at high temperature until all organic matter was removed, leaving inorganic residue (ash). Ash content was calculated using Equation (2) according to SNI 01-2354.1-2006 (Standar Nasional Indonesia 2006b).

$$Ash\ (\%) = \frac{B - A}{Sample\ weight\ (g)} \times 100\% \quad (2)$$

where: A = weight of empty porcelain dish (g), and B = weight of dish with ash (g)

Crude Fat content. Crude fat content was determined using the Soxhlet extraction method with an organic solvent. Fat content was calculated using Equation (3) according to SNI 01-2354.3-2006 (Standar Nasional Indonesia 2006c).

$$Crude\ Fat\ (\%) = \frac{(C - A)}{B} 100\%$$

where: A = weight of empty bottom flask (g), B = weight of sample (g), C = weight of round bottom flask and extracted fat (g)

Crude Protein content. Crude protein content was determined using the Kjeldahl method based on total nitrogen determination, and protein content was calculated using Equation (4) according to SNI 01-2354.4-2006 (Standar Nasional Indonesia 2006d).

$$Crude\ Protein\ (\%) = \frac{(V_A - V_B)\ HCl\ x\ N\ HCl\ x\ 14{,}007\ x\ 6.25\ x\ 100\%}{W\ x\ 1000} \quad (4)$$

Where: V_A= ml HCl for sample titration, V_B = ml HCl for blank titration, N = Normality of the standard HCl used, 14.007 = Atomic weight of nitrogen, 6.25 = Protein conversion factor for fish, and W = Sample weight (g). Protein content is expressed in units of g/100 g sample (%).

RESULTS AND DISCUSSION

Nutritional Quality of Fish Feed and the Influence of Variations in Ingredient Composition on Nutritional Quality

Moisture content. From the results of testing the moisture content of pellet-shaped fish feed using the SNI 2354.2:2015 test method (Standar Nasional Indonesia 2015), the results are presented in Table 2. Moisture content is one of the important parameters in the proximate analysis of fish feed, as it affects the stability and shelf life of the feed. In this study, based on Table 2. The results of the analysis of moisture content in fish feed based on corn cob waste ranged from 10.35% to 12.81%. The moisture content of the P1 formulation (100% corn cob flour) is 12.81% and the P2 formulation (75% corn cob flour + 25% *Gambusia affinis*) is 12.77%, slightly exceeding the maximum limit set by SNI 01-4087-2006 (Standar Nasional Indonesia 2006a) which is a maximum of 12%. This shows that both formulations have a fairly high humidity, which can affect the shelf life and overall feed quality. This excess moisture content is due to the natural hygroscopic properties of corn cobs, which tend to absorb moisture from the surrounding environment.

Table 2 Data on yield on water content, ash content, fat content, and protein content in fish feed

Fish Feed Specification	Test method (SNI)	SNI standard	Sample formulation			
			P1	P2	P3	P4
Moisture (%)	SNI 2354.2:2015	Max. 12%	12,81	12,77	11,03	10,35
Ash (%)	SNI 01-2354.1-2006	Max. 13%	5,63	5,86	17,81	22,44
Crude fat (%)	SNI 01-2354.3-2006	Min. 5%	3,04	4,09	1,10	2,16
Crude protein (%)	SNI 01-2354.4-2006	Min. 35%	7,39	9,63	6,24	7,62

(Source: Test Results Report of UPT Lab. Integrated, Undip)

High moisture content can lead to a decrease in feed quality and reduce shelf life, so it is necessary to carry out proper drying after the molding process. In the feed manufacturing process, suboptimal drying can lead to high water retention.

The high moisture content in fish feed can lead to fungal growth, as fungi thrive well in high air humidity conditions (Zaenuri *et al.* 2017). Therefore, to prevent fish feed from being overgrown with mold, it is necessary to use appropriate packaging that is able to maintain the moisture of the product. In this study, plastic packaging with a tight seal and the addition of silica gel as a drying agent were used to keep fish feed dry and protected from air moisture, thereby extending the shelf life of the feed (Klahan *et al*. 2016).

Instead, based on Table 2, the P3 formulation (75% corn cob flour + 25% vitamin mix) is 11.03% and the P4 formulation (50% corn cob flour + 25% *Gambusia affinis* + 25% vitamin mix) which is 10.35% successfully meets the SNI 01-4087-2006 (Standar Nasional Indonesia 2006a), indicating that the addition of vitamin mix in both formulations has the potential to reduce water content through limited hydroscopic mineral interactions. Vitamin mixes often contain minerals that can act as water-binding agents, thereby improving feed stability. According to researchers Zaenuri *et al.* (2017), the appropriate moisture content will cause fish feed to not be easily overgrown with fungi, so that the shelf life and shelf life of the feed are maximum. Drying using the oven at the right temperature can reduce the moisture content to below 12%, making feed more durable and safe to use (Klahan *et al.* 2016).

Ash content. From the results of testing the ash content in pellet-shaped fish feed using the SNI 01-2354.1-2006 test method (Standar Nasional Indonesia 2006b), the results are presented in Table 2. The ash content in fish feed reflects the mineral content present in the substance. In this study, based on Table 2 the results of the analysis of ash content in corn cob-based fish feed ranged from 5.63% to 22.44%. The ash content in the P1 formulation (100% corn cob flour) is 5.63% and the P2 formulation (75% corn cob flour + 25% *Gambusia affinis*) which is 5.86% is still within the safe range and meets SNI 01-4087-2006 which is a maximum of 13%. Meanwhile, based on Table 2 the P3 formulation (75% corn cob flour + 25% vitamin mix) which is 17.81% and the P4 formulation (50% corn cob flour + 25% *Gambusia affinis* + 25% vitamin mix) which is 22.44% far exceeds the maximum limit set by SNI 01-4087-2006 (Standar Nasional Indonesia 2006a).

The high ash content in P3 and P4 formulations is due to the addition of vitamin mixes that contain inorganic minerals, such as calcium and phosphorus, in high concentrations. According to research by Mutia *et al*. (2019), the addition of vitamin mix by 3% of the amount of feed provides the best results for the growth and survival of Tilapia seeds. In the book written by Manik and Arleston (2021) it is also stated that vitamin and mineral ingredients must be used, usually around 3-5% of the entire feed ingredients. These additives often contain various minerals such as calcium carbonate and magnesium sulfate which function to increase the nutritional value of feed. In contrast, raw corn cobs contain only about 8.30% ash (Novrianto et al. 2019), so the dominance of this ingredient in P1 and P2 formulations results in lower ash content. Excess ash content in P3 and P4 can interfere with catfish metabolism if not properly regulated, as excess minerals can cause health problems in fish.

Crude fat content. From the results of testing fat content in pellet-shaped fish feed using the SNI 01-2354.3-2006 test method (Standar Nasional Indonesia 2006c), the results are presented in Table 2. The fat content in fish feed serves as a source of energy and essential fatty acids that are essential for fish growth. In this study, based on Table 2 the results of the analysis of fat content in corn cob-based fish feed varied from 1.10% to a maximum of 4.09%, all feed formulations did not meet the SNI 01-4087-2006 (Standar Nasional Indonesia 2006a) for fat content which was at least 5%. The highest fat content in the formulation only reached 4.09% in the P2 formulation (75% corn cob flour + 25% *Gambusia affinis*).

The low fat content in the P1 formulation (100% corn cob flour) is 3.04%, the P2 formulation (75% corn cob flour + 25% *Gambusia affinis*) is 4.09%, the P3 formulation (75% corn cob flour + 25% vitamin mix) is 1.10% and the P4 formulation (50% corn cob flour + 25% *Gambusia affinis* + 25% vitamin mix) is 2.16% due to the dominance of corn cob which contains only 5.39% crude fat [6]. The addition of 25% to the P2 formulation contributes to an increase in fat content because *Gambusia affinis* is known to have an excellent content of omega-3 and omega-6 fatty acids for fish growth. However, the proportion of *Gambusia affinis* in this formulation is still too small to reach the minimum fat

level required by catfish. The crude fat content in fish meal reportedly ranges from 8-12%, which makes it an important source of energy in fish feed formulations (Herdina *et al.* 2024). Therefore, it is necessary to add more fishmeal to achieve the desired fat level. Another alternative is to add 5% fish oil based on a study by Mukti *et al*. (2014), which showed that adding 5% fish oil to commercial feed can increase the fat content to 13% so that it reaches the set standard. Sufficient fat in the feed also contributes to digestion and absorption of other nutrients, thereby increasing the efficiency of feed use by fish. Therefore, feed formulations must consider the addition of high-quality fat sources in order to optimally meet the energy needs of fish.

Crude protein content. From the results of testing protein content in pellet-shaped fish feed using the SNI 01-2354.4-2006 test method (Standar Nasional Indonesia 2006d), the results are presented in Table 2. Protein content is a critical parameter in determining the nutritional quality of fish feed, especially for catfish farming which requires high protein for optimal growth. In this study, based on Table 2 the results of the analysis of protein content in corn cob-based fish feed ranged from 6.24% to 9.63%, all feed formulations did not meet the SNI 01-4087-2006 [10] for protein content which is at least 35%. The highest protein content in the formulation was only 9.63% in the P2 formulation (75% corn cob flour + 25% *Gambusia affinis*), which is well below the minimum limit set by SNI 01-4087-2006 (Standar Nasional Indonesia 2006a).

If there is less protein in the feed, it will cause fish growth to slow, if the protein in the feed is excessive, it will be excreted as nitrogen in the form of ammonia (Putri and Yusra 2024). This low protein content is due to the dominance of corn cobs in feed formulations; corn cobs are known to contain only about 11.8% crude protein (Novrianto *et al.* 2019). Although the addition of 25% *Gambusia affinis* to the P2 formulation can increase protein levels because *Gambusia affinis* meal generally has a fairly high crude protein content, ranging from 50-60% depending on the processing method and the source of the *Gambusia affinis* itself (Herdina *et al*. 2024). This proportion is still not enough to meet the daily protein needs of catfish optimally. Research by Zaenuri *et al*. (2017), shows that substituting 35% fish meal in corn waste and rice bran-based feed can increase protein levels by around 20%. Furthermore, research by Gunawan and Khalil (2015), show that substituting 60% fish meal in a mixture of rice bran and other additives can increase protein levels by around 30%. Therefore, it is necessary to reformulate by increasing the proportion of high-quality protein sources to meet nutritional standards for catfish.

CONCLUSION

The variation in the composition of corn cob flour, *Gambusia affinis*, and vitamin mix affected the proximate composition of the fish feed, particularly the moisture, ash, protein, and fat contents. Among the tested formulations, P2 (75% corn cob flour and 25% *Gambusia affinis* meal) produced the highest protein and fat contents. However, the protein and fat levels of all formulations remained below the Indonesian National Standard (SNI) requirements for catfish feed, indicating that further formulation improvement is needed.

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