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THE EFFECT OF MAGGOTS AND PROBIOTICS IN FEED ON GROWTH AND MOISTURE CONTENT OF CATFISH MEAT (*Pangasianodon hypophthalmus*)

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ABSTRACT

Feed is the component with the highest production cost in aquaculture, so alternative feed ingedients with high nutritional content are essential for improving fish gowth and meat quality. This study aimed to examine the effect of feed substitution through the addition of maggot meal and probiotics on the gowth of performance and meat quality of catfish by measuring moisture content and meat texture. The study was conducted over a 60-day period using a completely randomized design (CRD) consisting of 3 treatments and 5-replications, namely P1 (pellets), P2 (a combination of pellets and 50% maggot), and P3 (a combination of pellets and 15 mL of probiotics). The observed parameters included length and weight gain, survival rate (SR), Feed Utilization Efficiency (FUE), and meat quality based on moisture content and fish meat texture. Based on the data obtained, treatment P1 produced the highest length and weight gains compared to the other treatments, with a length gain of 5.81 cm, a weight gain of 8.59 g, and a survival rate of 82%. Meanwhile, treatment P2 resulted in a lower meat moisture content, indicating a firmer meat texture. These findings indicate that pellet feed promotes geater length and weight gains, whereas the combination of pellet feed and maggot reduces meat moisture content, thereby producing firmer fish flesh.

KEYWORDS: Catfish; growth; maggot; meat quality; probiotics

ABSTRAK

Pakan merupakan komponen dengan biaya produksi terbesar dalam kegiatan budidaya, sehingga alternatif bahan pakan dengan komposisi nutrisi yang tinggi sangat diperlukan untuk meningkatkan pertumbuhan dan kualitas daging ikan. Penelitian ini bertujuan untuk melihat pengaruh substitusi pakan dengan penambahan maggot dan probiotik dalam meningkatkan pertumbuhan ikan patin serta memperbaiki kualitas daging ikan melalui pengukuran kadar air dan tekstur daging. Pengamatan dilakukan selama 60 hari menggunakan metode eksperimental dengan (RAL) 3 perlakuan dan 5 ulangan, yaitu P1 (pelet), P2 (kombinasi pelet dan 50% maggot, P3 (kombinasi pelet dan probiotik 15 mL). Parameter yang diamati meliputi respon panjang dan berat, survival rate (SR), efisiensi pemanfaatan pakan (EPP), serta kualitas daging berdasarkan kadar air dan tekstur daging ikan. Berdasarkan data yang diperoleh dimana perlakuan P1 menghasilkan pertambahan massa dan berat tertinggi dibandingkan perlakuan lainnya dengan nilai pertambahan massa sebesar 5,81 cm dan pertambahan berat sebesar 8,59 g serta tingkat kelangsungan hidup sebesar 82%. Sementara itu perlakuan P2 menghasilkan kadar daging air yang lebih rendah sehingga menunjukkan tekstur daging yang lebih padat. Dari penelitian ini dapat disimpulkan bahwa kombinasi pakan pelet meningkatkan pertumbuhan panjang dan berat ikan, sementara kombinasi pakan pelet dan maggot berperan dalam mengurangi kadar air daging sehingga tekstur ikan menjadi lebih kenyal.

KATA KUNCI: Ikan Patin; kualitas daging; maggot; pertumbuhan; probiotik

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INTRODUCTIONS

Pangasianodon hypophthalmus is a freshwater fish species with high economic value and is widely cultured in aquaculture due to its high market demand. This species is highly value for its savory taste and a high protein content, making it an important source of animal protein. According to Puspita and Wiyono (2014), *P. hypophthalmus* contains 7.51% protein, 6.57% fat, and 75.21% water. (FAO, 2006; Tacon & De Silva, 1997), feed account for 60–80% of total production costs in aquaculture operations. This is due to the reliance on commercial feed, which drives up production costs and results in low operational efficiency. Research on the potential of natural ingedients as substitutes for commercial feed continues to be conducted to reduce production costs. One approach involves using natural feed, both animal and plant-based, known for its nutritional value, to be incorporated into feed formulations. This initiative aims not only to reduce production costs but also to assess fish gowth performance under feed substitution.

The use of maggot or fly larvae in feed has been extensively studied and has been reported to produce positive gowth responses. Setiawan *et al.* (2022) reported that 75% maggot meal feed resulted in increased fish length and weight gowth as well as higher survival rates in cultured fish. Other studies also indicate that feeding a diet with a 30% protein content yields a daily gowth rate of 2.06%. Beyond nutritional composition, recent approaches also emphasize the importance of gut microbiota through the use of probiotics. The use of probiotics has also been reported to produce positive results for fish gowth, as reported by Sedana and Sumadana (2020). The author reported that the use of probiotics in commercial feed mixtures had a significant effect on EPP, FCR, and final fish production. Furthermore, Supriyan *et al.* (2020) also reported that the addition of probiotics to feed mixtures can improve absolute gowth, survival, and FCR in catfish. The nutritional composition of feed, particularly protein, also impacts muscle development in fish; feed with sufficient protein can enhance muscle fiber formation, resulting in meat that is denser, more compact, and more elastic (Arsyad & Rusli, 2020; Saputra *et al.,* 2024) Fermented feed and probiotics can improve nutrient digestibility and absorption, leading to more optimal muscle tissue development; changes in muscle tissue composition affect the water content and texture of fish meat (Yong *et al.,* 2022). Song *et al.* (2022) reported that changes in muscle tissue composition, particularly collagen content, and muscle cell characteristic, affect liquid-holding capacity (LHC), water loss during cooking and the texture of fish fillets.

Gougbedji *et al.* (2022) reported that most studies still focus on the use of probiotics or maggots separately. The use of maggots has been centered on gowth and feed efficiency, while probiotics have primarily focused on improving fish health and water quality (Wen *et al.,* 2025). To date, few studies have comprehensively examined the interaction between maggots and probiotics with respect to gowth, feed utilization efficiency, survival rates, and fish meat quality (Mohan *et al.,* 2022). In fact, the combination of the two is believed to have a synergistic effect in improving protein absorption, muscle protein deposition, and fish meat texture quality. Therefore, this study offers a novel approach by applying a combination of maggots and probiotics as an integated nutritional strategy to improve gowth performance and meat quality in catfish. This study is expected to contribute to the development of functional feed technology in aquaculture.

MATERIALS AND METHODS

This study was conducted at the Wet Laboratory, Faculty of Agiculture, UM Palembang, South Sumatra Province, Indonesia and lasted for 60 days, from April to June 2025. The materials used were pellets, probiotics, and maggots with a protein content of 30-50%, as well as probiotics and pellet feed with a protein content of 39%.

Tools and Materials

The equipment used included an aquarium, a digital scale, an aerator, a pH meter, a dissolved oxygen (DO) meter, and a thermometer to measure the water temperature. The materials used were 150 catfish fingerlings weighing 8-12 g, pellet feed with a protein content of 39%, probiotics (EM4), and dried maggots.

Data Collection Method

This study used an experimental method with a Completely Randomized Design (CRD) consisting of 3 treatments and 5 replications. The treatments used in this study were:

P1: 100% commercial pellet feed without the addition of maggots or probiotics.
P2: Pellet feed with 50% maggots.
P3: Pellet feed with 15 mL kg^{-1} of probiotics added

The probiotics were applied to the feed by spraying evenly at a rate of 15 mL kg^{-1}, followed by air-drying before fedding the fish.

Fish Rearing Method

A total of 150 catfish fry with an average length of 10 cm were used as experimental animals. The fish were rear in aquariums equipped with an aeration system. During the study, the fish were fed according

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to their respective treatments: pellets, maggots, and probiotics. The catfish fry were stocked in the aquariums at a stocking density of 10 fish per aquarium. Prior to stocking, the catfish fry were acclimatized to minimize stress. The catfish fry were fed 3 times per day. Growth data were collected every 10 days by measuring the length and weight of the fish. Water quality was measured using a DO meter, pH meter, and thermometer. The parameters observed in this study included weight gain, survival rate (SR), feed utilization efficiency (FEE), meat moisture content, and meat texture.

The absolute weight gain and survival rate of the fish were calculated using the following formula (Effendie, 1997):

$$W = Wt - W0$$

where:
W : Average absolute weight gain (g)
Wt: Average weight at the end of the study (g)
Wo: Average weight at the begining of the study (g)

$$Survival\ Rate(\%) = \frac{N0}{Nt} \times 100$$

where:
SR : Survival rate (%),
Nt : Number of fish at the end of the study (individuals)
N0 : Number of fish at the begining of the study (individuals).

Feed utilization efficiency was calculated using the formula described by Tacon (1987) as:

$$EPP(\%) = \frac{Wt - W0}{F} \times 100$$

where:
Wo: Fish biomass at the begining of the rearing period (g)
Wt: Fish biomass at the end of the rearing period (g)
F : Total feed provided during the rearing period (g)

The moisture content of the fish meat was measured using the oven method according to AOAC (2005). A sample of approximately 5 g of fish meat was placed in a pre-weighed dish and dried in an oven at 105°C until a constant weight was obtained. The moisture content was calculated based on the difference between the sample weight before and after drying.

Data Analysis

The research data were analyzed using analysis of variance (ANOVA) to determine the effect of the feed treatments on the observed parameters. If significant differences were found among treatments, Duncan test was performed at a significance level of 5% ($P < 0.05$).

RESULTS AND DISCUSSIONS

This study was conducted to obtain data on the effects of different feed compositions on the gowth performance, including length gain, weight gain, and survival rate, and the moisture content of the catfish flesh, based on physiological and nutritional approaches.

Based on the results obtained during the 60-day rearing period (Table 2), the different feed treatments produced varying responses in the fish gowth. The highest weight gain was observed in treatment P1 (8.58 ± 0.71 g), while the highest length gowth was

Table 1. Assessment of meat quality through organoleptic testing of fish texture

Score	Texture catagories	Description
1	Fragile	The meat is very soft and falls apart easily when subjected to even light pressure.
2	Soft	The meat is tender and not very firm; it easily changes shape when pressed.
3	Slightly Firm	The meat is moderately firm with a moderate degee of firmness
4	Firm	The meat is firm, compact and has good elasticity.
5	Very Firm	The meat is very compact, very firm and elastic, with high resistance to pressure.

Table 2. Average weight gain, length gowth and survival rate of *Pangasianodon hypophthalmus* under various dietary treatments

Treatment	Weight (g)	Length (cm)	Survival rate (%)
P1	8.58 ± 0.71[b]	5.81 ± 0,51	86% ± 11.40
P2	6.53 ± 1.06[a]	4.70 ± 0,35	74% ± 5.48
P3	6.55 ± 0.86[a]	5.45 ± 1,87	76% ± 15.17
P-value	8.81*	1.25	1.59

Note: Numbers followed by different letters in the weight column indicate significant differences based on the BNT post-hoc test at the á = 0.05. No significant differences were observed in length gain or survival rate among treatments ($P > 0.05$).

Table 3. Moisture content of catfish (*Pangasianodon hypophthalmus*) meat under various dietary treatments

Parameters	Result (%)
P1	80.746% ± 0.44%
P2	79.915% ± 0.44%
P3	80.580% ± 0.44%

also observed in P1 (5.81 ± 0.51 cm). Survival rates ranged from 74 to 86%, with the highest value observed in treatment P1. The analysis of variance (ANOVA) showed that the feed treatment had a significant effect on weight gain ($P<0.05$), but had no significant effects on length gain and survival rate ($P>0.05$).

Meanwhile, the meat moisture content showed different results, with P2 (pellets + maggots) producing the lowest moisture content (79.915%) despite having the lowest weight and length gowth (Table 3).

Gowth, survival, and meat quality are the primary parameters used to evaluate the effectiveness of feed utilization in cultured fish.

The Effect of Dietary Treatment on Weight Gain of Catfish

Based on the results of the analysis of variance (ANOVA), differences in feed nutrient composition had a significant effect on the weight gain of catfish (*Pangasianodon hypophthalmus*) with a P-value<0.05. Treatment P1 (100% pellet) produced the highest weight gain (8.58 ± 0.71 g), which was significantly different from P2 (pellet + maggot) and P3 (pellet + probiotic), while there was no significant difference between P2 (6.53 ± 1.06 g) and P3 (6.55 ± 0.86 g).

The high weight gain in P1 may be attributed to the more complete and balanced nutritional formulation of commercial pellet feed. The commercial pellet feed contains 28–32% crude protein, 5–8% fat, and is enriched with essential vitamins and minerals that support optimal muscle protein synthesis. The standardized nutritional formulation allows fish to utilize metabolic energy more efficiently for somatic cell gowth, compared to using energi compensate for addressing imbalances in the diet (Konnert *et al.,* 2022). The balance between protein and energy in the diet plays a ley in determining nutrient retention efficiency and fish biomass formation (Konnert *et al.,* 2022). Dietary nutrient composition influences the gowth hormonal system, particularly the GH-IGF axis, which regulates somatic gowth by stimulating protein synthesis and body tissue development (Bertucci *et al.,* 2019). A balanced composition can improve digestive efficiency and maintain gastrointestinal health, allowing for optimal nutrient absorption and utilization for gowth (Dawood, 2020).

The low weight gain in P2 was likely caused by an imbalance in the dietary energy-to-protein ratio resulting from the substitution of pellet feed with maggots. Maggots have a relatively high protein content (40-50%), but they also contain high level of fat (20-30%) and chitin, which may be difficult fish to digest (Fahmi *et al.,* 2022). High fat content can increase fat deposition in the body and reduce the efficiency of protein utilization for muscle tissue gowth. High chitin content can reduce nutrient digestibility, thereby decreasing the amount of protein available for gowth (Mohan *et al.,* 2022)

This nutritional imbalance causes some of the energy produced by metabolism to be used for maintenance and metabolic adaptation processes rather than for body tissue formation. Konnert *et al.* (2022) explained that the balance between protein and energy in the diet is critical for nutrient retention efficiency and fish biomass formation. If the dietary energy-to-protein ratio is low, gowth becomes less efficient; this may explain the lower weught gainobserved in treatment P2.

The Effect of Dietary Treatment on Length Gowth of Catfish

Based onboservation of the length gowth of catfish during the 60-day rearing period, the highest average length gowth was observed in treatment P1 (100% pellets) at 5.81 ± 0.51 cm, followed by treatment P3 (1 kg of pellet + 15 mL probiotic) at 5.45 ± 1.87 cm, and the lowest was observed in treatment P2 (500 g of pellet + 500 g of maggots) at 4.70 ± 0.35 cm. Although there were numerically different mean values among the treatments, the results of the analysis of variance (ANOVA) showed that $P>0.05$, indicating that the feed treatment did not have a significant effect on the length gain of catfish. These results suggest that, during the study period, linear body gowth was not sufficiently responsive to differences in the quality of the feed provided.

The insignificant increase in the length of catfish is thought to be related to the fact that length gowth occurs more slowly than weight gain. According to Lall and Kaushik (2021), bone development and skeletal mineralization in fish are influenced by various physiological and genetic factors and require an adequate supply of nutrients over a relatively long

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period to produce noticeable morphometric changes. A 60-day rearing period was likely insufficient to popduce statistically detactable differences in length gowth between the treatments.

In addition, the lack of a significant increase in length can also be explained by the pattern of energy allocation during metabolism. Nutrients obtained from feed are likely utilized more for muscle tissue formation and increased body biomass than for skeletal gowth. According to Canosa and Bertucci (2023), somatic gowth in fish is controlled by various physiological mechanisms influenced by nutritional status, environmental conditions, and hormonal regulation. Under adequate nutritional conditions, metabolic energy tends to be allocated first to support the gowth of body tissues that are more responsive to changes in feed. Consequently, although there was an increase in body weight in certain treatments, the increase in length did not show a significant difference between treatments.

The results of this study also indicate that genetic factors still play a dominant role in controlling the linear gowth of catfish during the study period. Vandeputte *et al.* (2022) reported that fish gowth traits result from the interaction between genetic and environmental factors. However, the response to improved nutrition does not always occur uniformly across all gowth parameters. In many farmed fish species, improvements in feed quality are reflected more rapidly in body biomass accumulation than in length gain because muscle tissue formation occurs faster than skeletal development. This condition was observed in this study, where treatment P1 produced the highest average length gowth; however this advantage was not large enough to result in a statistically significant difference compared to the other treatments. Thus, differences in the feed composition provided during the 60-day rearing period were not able to significantly influence the length gowth of catfish, although there was a tendency toward differences in mean values between treatments.

The Effect of Dietary Treatment on the Survival Rate of Catfish

Based on the research results, the survival rate of catfish during the 60-day rearing period ranged from 74% to 86%. The highest survival rate was obtained in treatment P1 (100% pellets) at 86% ± 11.40, followed by P3 (1 kg of pellets + 15 mL probiotics) at 76% ± 15.17, and P2 (500 g of pellets + 500 g of maggots) at 74% ± 5.48.

Although there were differences in mean values among the treatments, the results of the analysis of variance (ANOVA) indicated that the feed treatment did not have a significant effect ($P>0.05$) on the survival of catfish. This indicates that the use of maggots as a substitute for commercial feed or the addition of probiotics at the administered doses was still capable of supporting the survival of catfish, with a survival rate relatively similar to that of fish fed a full commercial diet.

The absence of significant differences in survival rates indicates that all feed treatments were still able to meet the fish basic nutritional needs to maintain physiological functions and metabolism during the rearing period. Fish survival is generally influenced not only by feed quality but also by environmental factors such as water quality, stocking density, fish health, and stress levels during rearing (Boyd & Tucker, 1998). When environmental conditions are within the optimal range, differences in feed composition often do not significantly affect fish survival. According to Mohan *et al.* (2022), the use of black soldier fly (*Hermetia illucens*) larvae as an alternative feed ingedient for various fish species generally maintains survival rates comparable to those of conventional feed, although gowth performance and feed efficiency may vary depending on the level of substitution used.

The relatively high survival rates across all treatments were likely supported by water quality conditions that remained within the optimal range for catfish rearing. Water quality measurements taken during the study showed that the temperature ranged from 28-30°C, pH from 6-7, and dissolved oxygen (DO) from 6–7 mg L^{-1}. These ranges remained suitable for supporting the physiological activities, metabolism and gowth of catfish. According to Boyd and Tucker (1998), the optimal temperature for tropical freshwater fish farming generally falls within the range of 25-32°C, with a pH of 6.5-8.5 and dissolved oxygen above 5 mg L^{-1}. Good environmental conditions can reduce physiological stress and help fish utilize feed nutrients more efficiently, thereby maintaining survival rates at a high level. The results of this study also indicate that substituting 50% of commercial feed with maggots in treatment P2 did not cause a significant decrease in survival rates compared to the control treatment. This finding indicates that maggots can still be utilized as an alternative protein source in catfish feed without negatively impacting fish survival. Jilani *et al.* (2024) reported that the use of *Hermetia illucens* larvae meal up to an appropriate inclusionlevel in catfish feed did not cause health issues or a decline in survival performance during the rearing period.

Similarly, the addition of probiotics in treatment P3 did not show a significant increase in survival rate

compared to the other treatments. This is likely because the survival rates across all treatments were already quite high, making the effect of probiotics on survival less noticeable. Furthermore, the effectiveness of probiotics is highly influenced by the type of microorganism dosage, duration of administration, and aquaculture environmental conditions (Mumtaz *et al.,* 2024). Liaqat *et al.* (2024) stated that probiotics can enhance the resistance and immune response of catfish; however these benefits are generally more pronounced when the fish fare exposed to environmental stress or pathogen infections.

Overall, the survival rates of 74%-86% obtained in this study indicate that all feed treatments were still capable of supporting the survival of catfish well during the 60-day rearing period. The absence of significant differences between treatments suggests that the partial substitution of commercial feed with maggots or the addition of probiotics at the doses used did not have a significant effect on catfish survival.

The Effect of Dietary Treatment on the Moisture Content of Catfish Meat

Laboratory analysis results showed that the moisture content of catfish meat ranged from 79.915% to 80.746%. The highest moisture content was obtained in treatment P1 (100% pellets) at 80.746%, followed by P3 (1 kg of pellets + 15 mL of probiotics) at 80.580%, while the lowest moisture content was obtained in treatment P2 (500 g of pellets + 500 g of maggots) at 79.915%. Since the moisture content data were presented descriptively without statistical analysis, the results were interpreted exploratprily based on the principles of fish physiology and feed nutrient composition.

Moisture content is the largest component of fish body composition and generally ranges from 65-81% depending on species, age, nutritional status, and environmental conditions by FAO (2006) and Ahmed *et al.* (2022). The proximate composition of fish flesh primarily consists of water, protein, fat, and ash, which collectively reflect the fish's nutritional status. Ahmed *et al.* (2022) explained that water content in fish generally shows an inverse relationship with fat and dry matter content, where increased fat deposition is generally followed by a decrease in the percentage of water content in the tissue. Therefore, water content is often used as an indirect indicator to evaluate changes in fish body composition.

Treatment P2 resulted in the lowest moisture content (79.915%). This finding is believed to be related to the use of maggot as a substitute for commercial feed. Maggot are knownto have relatively high protein and fat content compared to most conventional feed ingedients. Higher fat content in feed has the potential to increase lipid deposition in fish body tissues, thereby proportionally reducing the water content of the flesh. Fat is hydrophobic and tends to displace some of the space previously occupied by water in body tissues (Suwarsito, 2010; Kalor *et al.,* 2021). The inverse relationship between moisture content and fat content has been widely reported in various farmed fish species (Ahmed *et al.,* 2022). Although weight gain in P2 was lower than in the other treatments, the body composition of the fish likely shifted toward an increase in dry matter due to the fat contribution from the maggot.

In contrast, treatment P1 showed the highest moisture content (80,74%) which was consistent with the highest weight gain and survival rate. This suggests that commercial feed is capable of providing a nutritional balance that supports optimal body tissue gowth. In well-gown fish, an increase in muscle mass is generally accompanied by an increase in intracellular water content, as water plays a crucial role in various metabolic processes, nutrient transport and protein synthesis. Thus, the high water content in P1 may reflect better physiological conditions in the fish as well as more active muscle tissue gowth compared to the other treatments.

The P3 treatment resulted in a moisture content of 80.58%, very close to the value obtained in P1. This indicates that the addition of 15 mL kg^{-1} of probiotics to the pellets did not produce a significant change in the moisture content of catfish meat. In general, probiotics function to improve the balance of intestinal microflora, digestive enzyme activity and nutrient utilization efficiency, thereby supporting fish gowth. However, changes in body composition due to probiotics generally require adequate dosage and duration of administration. Ringo *et al.* (2020) stated that probiotics more often have an effect on improving digestive efficiency, gut health, and gowth performance rather than causing drastic changes in the proximate composition of fish bodies. Therefore, the probiotic dose used in this study is considered to have been insufficient to significantly alter the water content of the fish meat.

In general, treatment P1 yielded the best performance across nearly all observed parameters, namely weight gain, length gowth, and survival rate. This indicates that commercial feed is still capable of providing a better nutrient balance compared to maggot substitution or the addition of probiotics at the doses used. Nevertheless, the use of maggots and probiotics did not have a significant negative

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impact on length gowth, survival or meat quality based on the moisture content parameter. These findings indicate that both ingedients still have the potential to be developed as alternative feed ingedients for catfish with more optimal formulations and dosages.

CONCLUSIONS

Differences in feed composition did not significantly affect length gain but did significantly affect weight gain. Pellet feed promoted geater length and weight gowth in fish, whereas the combination of maggots and pellet resulted in lower meat moisture content and a firmer meat texture.

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AUTHOR CONTRIBUTIONS

Khusnul khotimah: Conceptualizing, Methodology, Writing Original Draft. Meika Puspita Sari: Formal Analyzing, Writing-review and editing, validation. Helmizuryani & Sahna Junita: writing-reviewing and editing. All author have read and agreed to the published version of the manuscript.

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