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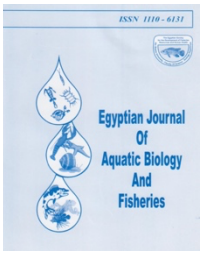

Evaluation of Mandarin Orange Peel (*Citrus reticulata*) as Feed Additive for Catfish (*Pangasianodon hypophthalmus*)

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ABSTRACT

Mandarin orange peel (*Citrus reticulata*) contains nutrients that are beneficial for fish and has the potential as a feed additive. This study aimed to evaluate the effect of adding mandarin orange peel flour with different doses on hematological parameters, including the number of lactic acid bacteria in the intestine, growth performance, feed utilization and survival rate of the catfish (*Pangasianodon hypophthalmus*) seeds. This study consisted of four treatments and three replications, namely the dose of orange peel flour of 0, 2.5, 5.0, and 7.5g kg^{-1} diet. A total of 180 catfish, measuring 9.08 ± 0.31g, 15 of them each were reared in plastic containers with a volume of 40L for 30 days and fed twice a day *ad satiation* according to treatment. The results showed that the addition of mandarin orange peel flour in the diet had an effect on hematological parameters, the number of lactic acid bacteria, growth performance and feed utilization of catfish (P<0.05). Several hematological parameters such as hemoglobin, leukocytes, monocytes and neutrophils were higher with the addition of orange peel flour in the diet compared to the control. The highest number of lactic acid bacteria, weight gain, length growth, and specific growth rate were shown by T1, 3.95 log CFU mL^{-1}, 6.69g, 12.57cm, 1.79% day^{-1}, respectively (P<0.05). The same thing was also shown in the efficiency of feed utilization and protein conversion ratio, 74.67% and 2.02%, respectively (P<0.05), while the survival rate of all treatments were 100%. Based on these results, it can be concluded that mandarin orange peel flour with a dose of 2.5g kg^{-1} diet is the best dose as a feed additive for the catfish seeds.

INTRODUCTION

Catfish (*Pangasianodon hypophthalmus*) is a type of freshwater fish that is widely favored because of its savory and delicious meat and high protein content. Catfish

cultivation has been carried out by the community and is a freshwater cultivation commodity that is quite in demand. In Indonesia, according to the **Ministry of Marine Affairs and Fisheries of the Republic of Indonesia (2022)**, the catfish production in 2022 was 340,444 tons, an increase compared to 2021 which was recorded at 332,022 tons. This increase in production is in line with the increasing need for feed for catfish cultivation activities. The costs incurred to meet feed needs during fish cultivation activities, especially in intensive cultivation, can reach 70% of the total production costs **(Kari *et al*., 2022)**. This is remarkably an obstacle that must be faced by fish farmers.

Feed additives are additional ingredients in feed that are useful for increasing fish growth and health. The use of feed additives in fish cultivation is an alternative in producing good quality feed by utilizing cheaper and more easily obtained raw materials. Organic waste in the form of fruit peels shows potential as feed additives for fish, including apple peels **(Qiang *et al*., 2019)**, bananas peels **(Susanto & Agustina, 2023; Agustina *et al*., 2024)** and dragon fruit peels **(Xuan *et al*., 2024)**. The effectiveness of these fruit peels in increasing fish growth and health is shown by the increased effectiveness of feed digestion and stimulation of the immune system.

Mandarin orange (*Citrus reticulata*) is one of the types of sweet orange that is widely cultivated. According to **AbdEl-ghfar *et al*. (2016)**, orange peel reaches around 50-65% of the fruit weight and is a source of natural antioxidants at a low price. The peel of this sweet orange fruit is rich in bioactive compounds, among the main bioactive compounds are pectin, phenolics, alkaloids, tannins, and flavonoids **(Anwar *et al*., 2008)**, where these active compounds are functional in influencing growth and as immunostimulants **(Van Doan *et al*., 2018)**. **Attala *et al*. (2021)** found that a mixture of flour and oil extract from orange peel as much as 2% in feed can increase growth, feed utilization and immune response of tilapia (*Oreochromis niloticus*). Meanwhile, **Fadda *et al*. (2021)** recommend dry orange peel powder for use in tilapia feed in order to achieve the best fish performance and to save around 30% of yellow corn costs. Growth performance, feed utilization, ability to cope with oxidative stress, and hematological parameters of the rohu fish (*Labeo rohita*) increased with 30% orange peel supplementation in the diet **(Virk *et al*., 2023)**.

Until now there is no information regarding the use of mandarin orange peel in catfish feed. Evaluation of the effect of mandarin orange peel as a feed additive for the catfish needs to be done in an effort to increase its production by improving feed quality in addition to reducing organic waste entering the environment. Hematological parameters related to fish health status, the number of lactic acid bacteria in the intestine, growth performance, feed utilization rate and survival of catfish seeds are the scope of this study.

MATERIALS AND METHODS

Preparation of fish and containers

Catfish seeds were obtained from the community seeding unit in Samarinda City in healthy condition. The fish were then adapted in a round plastic tub with a diameter of 1m, which contained water that had previously been settled and aerated. Adaptation was carried out for 5 days and the fish were given commercial feed till *satiation*, twice a day at 7.00–8.00 AM and at 5.00–6.00 PM. The rearing container was in the form of a rectangular plastic tub and filled with water with a volume of 40L in a recirculation system. The water that was entered had been settled for about 5 days, and each container was then aerated.

Preparation of mandarin orange peel flour and experimental feed

Mandarin orange peel flour was made from mandarin orange peel purchased in dry condition. The orange peel was ground into flour and was then mixed into the feed according to the treatment. The feed formulation is listed in Table (1). The mixture of feed ingredients and orange peel flour was then printed with a feed and pellet printing machine and was then dried in an oven at a temperature of 50^{o}C for about 3 hours. The dried feed was then stored in a closed plastic container.

Table 1. Diet ingredients and chemical composition of experimental diets

Ingredient (g 100 g^{-1})	Treatment			
	T0	T1	T2	T3
Fish meal	32.00	32.00	32.00	32.00
Soybean flour	25.70	25.70	25.70	25.70
Wheat flour	14.50	14.50	14.50	14.50
Bran Flour	10.00	10.00	10.00	10.00
Fish oil	2.00	2.00	2.00	2.00
Corn oil	2.00	2.00	2.00	2.00
Vitamin and mineral mix	6.00	6.00	6.00	6.00
Mandarin orange peel flour	0.00	0.25	0.05	0.75
Coline chlorida	2.00	2.00	2.00	2.00
Carboxymethyl cellulose	2.00	2.00	2.00	2.00
Organic chromium	0.18	0.18	0.18	0.18
Cellulose	3.62	3.37	3.57	2.87
Proximate analysis (%)				
Moisture	4.91	5.82	5.46	5.05
Ash	16.07	14.76	15.28	17.34
Crude protein	32.79	33.79	34.33	35.43
Crude fats	4.68	4.26	4.20	5.26
Crude fiber	5.75	5.87	5.26	4.20
Carbohydrates	35.80	35.50	35.07	32.73
Energy (Cal)	242,17	241,52	241,85	248,44
C/P	7,39	7,15	7,04	7,01

T0: 0; T1: 2.5; T2: 5.0 T3: 7.5g orange peel flour kg^{-1} diet. This feed formulation is based on calculations for 100g of diet.

Experimental design

This study was an experimental laboratory study using a completely randomized design, consisting of 4 treatments and 3 replications. The treatments used included different doses of mandarin orange peel flour in the feed, namely: 0.0 (T0/control), 2.5 (T1), 5.0 (T2), and 7.5g kg^{-1} diet (T3).

The adapted catfish were then put into a rearing container as many as 15 fish per container with an initial weight of 9.08± 0.31g. The fish were kept for 30 days and fed *ad satiation* with the treatment feed twice a day at 7.00–8.00 AM and at 5.00–6.00 PM. During rearing, siphoning was carried out every two days and adding new water according to that released during siphoning. The water quality parameters during this study were as follows: temperature around 27.6−27.8^{o}C; water pH around 6.2−6.5; dissolved oxygen ranged from 5.4−5.8ppm. These three parameters were measured using the Horiba U-10 Water Quality Checker. Total ammonia nitrogen was 0.01−0.02ppm, measured based on the spectrophotometric method using a UV-Vis Spectrophotometer, B-ONE brand, model UV-Vis 100 DA-X.

Measurement of hematological parameters and the number of lactic acid bacteria

The hematological parameters observed in this study included: hemoglobin levels, hematocrit levels, total erythrocytes, total leukocytes and leukocyte differentials (lymphocytes, monocytes and neutrophils). These parameters were observed at the beginning and end of fish rearing (days 0 and 30). The first step was to take blood samples from the caudal vein using a syringe. The Sahli method with a haemometer was used to assess hemoglobin levels based on the method of **Wedemeyer and Yasutake (1977)**. Hematocrit levels and leukocyte differentials were assessed according to the method of **Anderson and Siwicki (1995)**. The procedure of **Blaxhall and Daisley (1973)** was used in assessing the number of erythrocytes and leukocytes in fish. Meanwhile, the number of lactic acid bacteria in the catfish intestines was also observed at the beginning and end of rearing, referring to the pour plate method **(Mousavi *et al*., 2019)** with modifications using MRSA media.

Measurement of growth performance, feed utilization rate and fish survival

The parameters of growth performance and feed utilization include final weight parameters, weight gain (WG), specific growth rate (SGR), feed utilization efficiency (FE), and protein efficiency ratio (PER) which were measured by referring to the following methods:

WG (g) = final weight − initial weight **(Nasr *et al*., 2021)**.

SGR (% day^{-1}) = [(Ln final weight − Ln initial weight)/60 days] x 100 **(Nasr *et al*., 2021)**.

FE (%) = [(final weight + dead weight) − initial weight]/feed intake x 100% **(Aisyah *et al.*, 2021)**.

Protein efficiency ratio (%) = Fish weight gain / Protein intake **(Salem & Abdel-Ghany, 2018)**.

Survival rate (%)=100 x (Final fish number/Initial fish number) **(Salem & Abdel-Ghany, 2018)**.

Data analysis

The data obtained in this study were analyzed statistically using analysis of variance (ANOVA) and continued with Duncan's test at a 95% confidence level, with SPSS 12.0 program.

RESULTS

Hematological parameters of catfish reared for 30 days with the addition of several doses of mandarin orange peel flour in the feed are presented in Table (2). The initial hemoglobin level of the catfish was 4.70g dL^{-1} and increased on the 30th day, ranging from 5.87−12.47g dL^{-1}. The highest hemoglobin level of the catfish was shown by T3 and the lowest was in T0 or control. The hematocrit level of the catfish increased during rearing, if at the beginning of rearing it was 18.5%, then at the end of rearing it reached 26.67%. The highest hematocrit level was shown for T1 and the lowest was in T0, 26.67% and 15.33%, respectively. The erythrocyte cells of catfish at the beginning of rearing were 1.28 x 10^6 cells $mm^{3\ -1}$ and increased at the end of rearing in all treatments, except for T0, which decreased to 1.25 x 10^6 cells $mm^{3\ -1}$. The erythrocyte cells in T1 were the highest compared to other treatments, which was 1.59 x 10^6 cells $mm^{3\ -1}$. On the 30th day of observation, the highest total leukocytes were shown by catfish on T3 at 2.86 x 10^4 cells $mm^{3\ -1}$ and the lowest was shown by T0 at 1.90 x 10^4 cells $mm^{3\ -1}$. In this study, the total leukocytes of catfish tended to increase compared to the beginning of rearing which was only 1.25 x 10^4 cells $mm^{3\ -1}$. The lymphocyte levels of catfish in the last observation were highest at T0 at 93.56% and lowest at T2 at 91.73%. The highest monocyte levels were shown by T3 at 5.87% while the lowest were shown by T0 at 4.53%. Meanwhile, the neutrophil levels of catfish on the 30th day of observation were at their highest values at T1 and the lowest at T0, at 3.11% and 1.90%, respectively.

Table 2. Average hematological parameter values of catfish (*P. hypophthalmus*) during observation

Parameter	Day	Treatment			
		T0	**T1**	**T2**	**T3**
Hemoglobin (g dL^{-1})	0	4.70±0.99	4.70±0.99	4.70±0.99	4.70±0.99
	30	5.87±0.04^{a}	9.00±0.23^{a}	7.47±2.55^{a}	12.47±1.65^{b}
Hematocrit (%)	0	18.50±4.95	18.50±4.95	18.50±4.95	18.50±4.95
	30	15.33±1.02^{a}	26.67±0.69^{b}	17.67±3.66^{a}	18.33±4.67^{a}
Erythrocytes (x10^{6} cell $mm^{3\ -1}$)	0	1.28±0.42	1.28±0.42	1.28±0.42	1.28±0.42
	30	1.25±0.07^{ab}	1.59±0.15^{ab}	1.40±0.19^{b}	1.31±0.03^{a}
Leukocytes (x10^{4} cell $mm^{3\ -1}$)	0	1.88±0.24	1.88±0.24	1.88±0.24	1.88±0.24
	30	1.90±0.49^{a}	1.97±0.19^{a}	1.96±0.33^{a}	2.86±0.72^{b}
Lymphocytes (%)	0	92.33±2.01	92.33±2.01	92.33±2.01	92.33±2.01
	30	93.56±1.88^{a}	92.00±0.97^{a}	91.73±1.67^{a}	91.94±1.11^{a}
Monocytes (%)	0	5.12±1.34	5.12±1.34	5.12±1.34	5.12±1.34
	30	4.53±1.48^{a}	4.90±0.96^{a}	5.43±1.22^{a}	5.87±0.91^{a}
Neutrophils (%)	0	2.56±0.67	2.56±0.67	2.56±0.67	2.56±0.67
	30	1.90±0.41^{a}	3.11±0.18^{b}	2.84±0.46^{ab}	2.19±0.48^{ab}

T0: 0; T1: 2.5; T2: 5.0 T3: 7.5g orange peel flour kg^{-1} diet. Mean values followed by the same letter in the same row are not significantly different (P>0.05).

At the beginning of rearing, namely on day 0, the number of lactic acid bacteria in the intestines of catfish was 3.36 log CFU mL^{-1}. This number increased at the end of rearing T1 and T2, conversely it decreased at T0 and T3 to 3.20 log CFU mL^{-1} and 3.22 log CFU mL^{-1}, respectively, while at T1 the highest number of lactic acid bacteria was 3.95 log CFU mL^{-1}. Analysis of variance showed that the treatment of adding orange peel flour with different doses in catfish feed had a significant effect on the number of lactic acid bacteria in the intestines (P<0.05). Further tests showed that the number of lactic acid bacteria in the intestines of the catfish at T1 was significantly different from T0, T2 and T3 (Fig. 1).

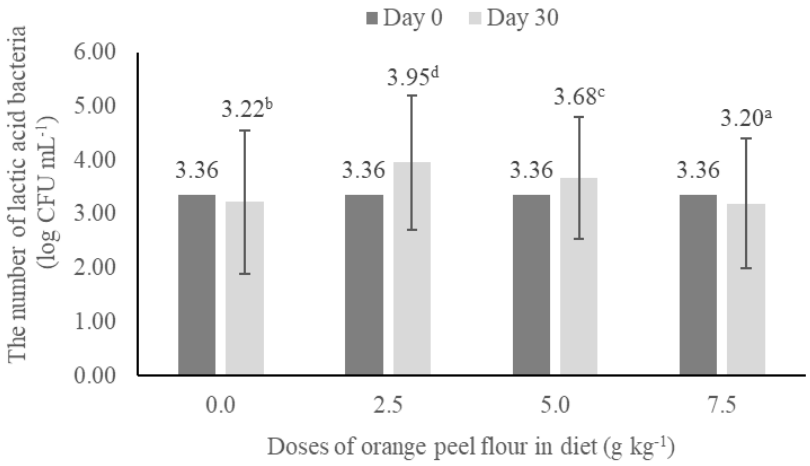

Fig. 1. The number of lactic acid bacteria in the intestines of catfish (*P. hypophthalmus*) during observation

Table (3) shows the growth performance of catfish during 30 days of rearing, where the highest weight growth was shown in T1, followed by T3, T0 and T2, respectively, at 6.69, 4.23, 4.18 and 4.16g. Analysis of variance showed that the addition of mandarin orange peel flour with different doses in the feed significantly affected the weight growth of catfish (P<0.05). Further tests showed that the weight growth of catfish at T1 was significantly different from T0, T2 and T3 (P<0.05). The highest specific growth rate was shown by T1 at 1.79% day^{-1} and the lowest was shown in T3 at 1.05% day^{-1}. The addition of orange peel flour with different doses significantly affected the specific growth rate of catfish in the analysis of variance (P<0.05). Meanwhile, further tests showed that the specific growth rate of catfish in T1 was significantly different from T0, T2 and T3 (P<0.05).

Table (3) also shows that the highest feed utilization efficiency of catfish at the end of rearing was at T1, which was 74.67%, followed by T3, T0 and T2, respectively, at 47.31, 46.47, and 43.32%. Analysis of variance showed a significant effect on the feed utilization efficiency of catfish with the addition of orange peel flour with different doses in the feed (P<0.05). Meanwhile, further tests showed that the feed utilization efficiency of catfish at T1 was significantly different from T0, T2 and T3 (P<0.05). This is in line with the protein efficiency ratio of catfish, where the highest value was shown by T1 at 2.02% and the lowest at T2 at 1.11%. Analysis of variance showed that the addition of orange peel flour with different doses in the feed had a significant effect on the protein efficiency ratio of catfish. The protein efficiency ratio at T1 was significantly different from T0, T2 and T3 in the further test (P<0.05). In contrast to the previous parameters, the survival rate of catfish was the same in all treatments, namely 100% and the addition of orange peel flour with different doses did not affect the survival rate of catfish in this study (P>0.05).

Table 3. Average growth performance, feed utilization and survival rate of catfish (*P. hypophthalmus*) during observation

Parameter	Treatment			
	T0	**T1**	**T2**	**T3**
Initial weight (g)	8.74±0.40^{a}	9.08±0.71^{a}	8.99±0.56^{a}	9.49±0.31^{a}
Final weight (g)	12.68±0.61^{a}	16.02±2.33^{b}	13.90±2.18^{ab}	15.72±0.12^{a}
Weight gain (g)	4.18±0.75^{a}	6.69±1.74^{b}	4.16±0.79^{a}	4.23±0.36^{a}
Initial length (cm)	10.51±0.33^{a}	10.66±0.43^{ab}	10.93±0.65^{ab}	11.34±0.18^{b}
Final length (cm)	11.93±0.44^{a}	12.57±0.55^{a}	12.32±1.12^{a}	12.56±0.32^{a}
Length growth (cm)	1.67±0.50^{ab}	1.91±0.15^{b}	1.39±0.50^{ab}	1.22±0.18^{a}
Specific growth rate (% day^{-1})	1.24±0.25^{a}	1.79±0.29^{b}	1.18±0.07^{a}	1.05±0.10^{a}
Feed consumption rate (g)	135.40±4.02^{a}	132.98±14.83^{a}	143.75±5.39^{a}	133.95±2.95^{a}
Feed utilization efficiency (%)	46.47±9.01^{a}	74.67±11.36^{b}	43.32±7.10^{a}	47.31±3.10^{a}
Protein efficiency ratio (%)	1.24±0.25^{a}	2.02±0.31^{b}	1.11±0.18^{a}	1.21±0.08^{a}
Survival rate (%)	100±0.00	100±0.00	100±0.00	100±0.00

T0: 0; T1: 2.5; T2: 5.0 T3: 7.5g orange peel flour kg^{-1} diet. Mean values followed by the same letter in the same row are not significantly different (P>0.05).

DISCUSSION

The addition of mandarin orange peel flour up to a dose of 7.5g kg^{-1} diet did not cause health problems to catfish. This is indicated by the hematological parameter values which are generally still within the normal range. The hemoglobin levels of catfish range from 4.70−12.47g dL^{-1}, and the normal range of hemoglobin according to **Fazio *et al.* (2019)** is between 4.70−16.6g dL^{-1}. The hematocrit value of catfish reared for 30 days was classified as good, ranging from 30.6−39.7% **(Phu *et al.*, 2016)**. The range of hematocrit levels of catfish in this study was lower, namely 15.33−26.67%. According to **Fazio *et al.* (2019)**, erythrocytes in fish species ranged from 0.81−3.73 x 10^{6} mm$^{3\ -1}$, indicating that erythrocytes of catfish in this study were still classified as normal at 1.25−1.29 x 10^{6} cells mm$^{3\ -1}$. Catfish leukocytes for 30 days of rearing with feed given mandarin orange peel flour at a dose of 0−7.5g kg^{-1} of feed ranged from 1.88−2.86 x10^{4} cells mm$^{3-1}$, in accordance with the normal range of 0.94−82.93 x 10^{4} cells mm$^{3\ -1}$ **(Fazio *et al.*, 2019)**. The increase in total catfish leukocytes accompanied by an increase in monocyte and neutrophil levels was greater than the control, indicating the ability of mandarin orange peel flour to stimulate the immune system of catfish, especially phagocytosis. These results are in line with **Abdel-Rahman *et al.* (2019)** and **Mohamed**

***et al*. (2021)**, who found that lysozyme activity, phagocytic activity, and leukocyte count of tilapia increased significantly when fed with orange peel powder (1−2%) and bitter orange peel (0.75−1%). In rohu fish, the addition of 30% orange peel in the feed was also able to increase hematological parameters compared to the control **(Virk *et al*., 2023)**.

The number of lactic acid bacteria (LAB) in the intestines of catfish fluctuated from day 0 to day 30. The control treatment and mandarin orange peel flour with a dose of 7.5g kg^{-1} diet experienced a decrease in the number of LAB. This is different from the treatment of mandarin orange peel flour 2.5 and 5.0g kg^{-1} diet which experienced an increase. The number of LAB in the intestines of catfish increased in these two treatments associated with the content of fiber such as pectin with a concentration of around 12.27–18.43% in mandarin orange peel **(Yun & Liu, 2024)**, which functions as nutrition for LAB. In addition, the antibacterial components in orange peel can also improve the health of intestinal microbiota and reduce harmful microorganisms, thereby improving the digestive system **(Salem *et al*., 2019)**. *In vitro* tests showed that the fiber contained in mandarin orange peel was able to increase the growth of two strains of bacteria *Lactiplantibacillus plantarum*, and *Levilactobacillus brevis*, which showed the capacity of mandarin orange peel as a prebiotic **(Razola-Díaz *et al*., 2024)**. The results of this study are also supported by **Ricci *et al*. (2019)**, who grew LAB using orange peel as a substrate. On the other hand, the treatment of orange peel flour at a dose of 7.5g kg^{-1} diet showed a decrease in the number of LAB in the intestines of catfish, it is suspected that this condition is due to an increase in phenol compounds as the dose of mandarin orange peel flour in the feed increases. According to **Razola-Díaz *et al*. (2024)**, phenol compounds are toxic to LAB. Although several previous studies have shown the ability to adapt and metabolize several LAB species to phenol compounds in plants, phenol compounds can change the composition of the fatty acid membrane of these bacterial cells. When phenol compounds are released during the incubation period in in vitro tests, these compounds show antibacterial properties against LAB growth.

The highest growth of catfish was shown in the treatment of mandarin orange peel flour with a dose of 2.5g kg^{-1} diet (Table 2). Catfish are omnivorous fish that tend to be carnivorous so that the ability of their digestive system to utilize fiber is limited. When compared to tilapia which showed the best growth performance with a dose of 2% lemon peel and Ningu fish (*Labeo victorianus*) which showed the best growth performance after being fed more than 5% lemon peel in the feed **(Ngugi *et al*., 2017; Toutou *et al*., 2018)**. **Fadda *et al*. (2021)** also found that the best growth performance of tilapia was at the level of 20% orange peel in the feed. The addition of mandarin orange peel flour in catfish feed affects its growth associated with the fermentation activity by LAB on the fiber contained in mandarin orange peel. This is associated with an increase in the number of LAB in the intestines of catfish (Fig. 1), where LAB plays an active role in the digestion process through the production of enzymes such as protease, lipase, and carbohydrolase which can support growth **(Biliavska *et al*., 2019)**. In tilapia, the addition

of mandarin orange peel flour at a dose of 15−20% in feed can increase the activity of amylase and protease enzymes **(Reda *et al*., 2024)**. The protein content in mandarin orange peel is around 4.17−7.90% and fat is around 7.73−13.58% **(Yun & Liu, 2024)**, so it has the potential to support the growth of catfish. Based on research by **Fadda *et al*. (2021)**, 20% mandarin orange peel flour added to tilapia feed can reduce the use of corn flour in supporting its growth. This means that the mechanism of mandarin orange peel flour in influencing growth indirectly is through its role as a prebiotic with fermentation in the intestine, in addition to the presence of macronutrients such as protein which helps improve the quality of feed given to fish.

The level of catfish feed utilization with the addition of mandarin orange peel flour in the feed at a dose of 2.5g kg^{-1} diet was higher than other treatments (Table 2). At this dose, catfish digestion works optimally in absorbing nutrients so that it can ultimately produce the best growth. In other words, this dose is effective in supporting feed utilization and catfish growth. Feed utilization is closely related to the digestive system including intestinal morphology and colonizing microbiota and digestive enzyme activity. Previous studies have shown that the addition of orange peel flour and extract can increase the surface area of fish intestinal villi **(Muhamed *et al*., 2021; Reda *et al*., 2024)**. These structural changes play a role in improving enzymatic function and intestinal health, because studies have shown that changes in the shape of the villi increase nutrient absorption and encourage better growth performance **(Amin *et al*., 2019)**. **Salem and Abdel-Ghany (2018)** found that 2% orange peel flour in tilapia diet can improve digestion and absorption of nutrients. While **Fadda *et al*. (2021)** stated that the best dose of mandarin orange peel flour in increasing the utilization of tilapia feed is 20%. When compared with catfish in this study, tilapia required less mandarin orange peel flour to increase feed utilization and growth.

Nutritional factors and water quality greatly affect the survival rate of fish. In this study, all treatments showed a survival rate of 100%. Based on the hematological parameters of catfish reared for 30 days in this study, it showed a normal range, meaning that the fish were in healthy condition. Water quality parameters during the study showed a range that was suitable for fish cultivation based on the **Government Regulation of the Republic of Indonesia (2021)**, so that it was able to support the survival and growth of catfish.

CONCLUSION

Based on the results of this study, it can be concluded that mandarin orange peel flour with a dose of 2.5g kg^{-1} diet is the best dose as a feed additive for catfish (*P. hypophthalmus*) seeds,as evidenced by the improved health, growth performance and feed utilization.

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