

Bioenrichment of Papaya Leaf Meal With Different Feed Formulations on Growth Performance of Tilapia (*Oreochromis niloticus*)

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Abstract. *The production and demand of tilapia (*O. niloticus*) in some countries continue to increase but are not matched by good growth quality. Several methods have been used to increase growth, such as the use of synthetic hormones and radiation, however, the methods require such a high cost. Thus it needs to be investigated the potential replacement with natural prooduct. Papaya leaf contains papain enzyme thought to be able to improve the growth performance of fish body weight through the conversion of proteins into amino acids. The purpose of this study was to investigate the growth performance of tilapia (*O. niloticus*) fish that were given papaya meal (*C. papaya*) treatments. The concentrations pellet with papaya meal respectively T1 (feed with 0 grams of papaya leaf meal), T2 (administration of papaya leaf meal with 1.25 g/kg feed), T3 (administration of papaya leaf meal with 1.75 g/kg feed), T4 (administration of papaya leaf meal with 2 g/kg feed), T5 (administration of papaya leaf meal with 2.25 g/kg feed). Parameters analyzed included: absolute length growth, absolute weight, specific growth rate, FCR survival rate and, water quality. The results showed that the highest weight growth of tilapia fed with the administration of papaya leaf meal was found at T4 of 21.23 grams. In the specific weight, the optimal treatment was found in T4 with a percentage of 20.97%. In the length growth of tilapia, it was known that the T1, T4 and T5 had highest lengths when compared to other treatments and the highest survival rate of tilapia (*O. niloticus*) was in the T2, T3, T5 treatments of 73%. The optimal FCR value was found in the T4 treatment of 1.14. Based on the results of the study, it can be concluded that the administration of papaya leaf flour can increase the growth performance of tilapia.*

Keywords: bioenrichment, growth, Nile tilapia, papaya meal

Citation

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INTRODUCTION

Tilapia (*Oreochromis niloticus*) is a fish that has high economic value and has become one of the commodities that play a major role in fishery production. This high economic value is directly proportional to the increasing

market demand so that the market potential for tilapia demand is quite high (East Java Provincial Fisheries and Marine Service, 2013). The increase in tilapia cultivation cannot be separated from its biological comparative advantage as an omnivorous fish that has a wide range of environmental and practical econom-

ic aspects, such as easy cultivation, preferred taste, and relatively high market price.

Among the comparative advantages of fish farming, there are obstacles, the limited growth of fish caused by the provision of feeds that contain high energy, but cannot be digested by fish (Riyanti et al., 2014; Simanjuntak et al., 2018). Currently, the use of synthetic enzymes formulated into feed has a high price and is quite dangerous. Therefore, to reduce the use of synthetic enzymes, it is necessary to add natural ingredients that help the process of absorption of feed of fish. One of the natural ingredients that can be used is papaya leaf. Papaya leaves as natural ingredients are rich in protein and enzymes, so the papaya leaf will be very important to support the growth of cultured fish (Rukisah et al., 2021)

Papaya leaf is part of the papaya plant that contains papain (Dongoran, 2004; Simanjuntak et al., 2021). Papain functions as a proteolytic enzyme that breaks down protein in the feed into amino acids. The amino acids will be more easily absorbed into the body of tilapia for growth. This is intended to make the digestive metabolic process easier, so that fish growth will increase (Simanjuntak et al., 2018; 2021). Research on the use of papaya leaves has been reported by Isnawati (2015), where the use of papaya leaf powder as much as 2% can increase feed utilization efficiency, protein efficiency ratio, and relative growth rate in tilapia with a size of 9-12 cm. However, based on these results, the growth rate was still not optimal when given papaya powder. The protein concentration in the feed is still 30%. Therefore, it is necessary to optimize the concentration of papaya leaf meal and increase the protein concentration of feed to 35%. Moreover, the use of papain enzymes is also able to increase the growth of eel (Sagita et al., 2017) and *Cyprinus carpio* (Sulasi

et al., 2018). Based on this research, it is necessary to optimize the formulation process and concentration of papaya leaf meal into feed to increase the growth of tilapia, and the purpose of this study was to investigate the growth performance of tilapia (*O. niloticus*) fish that were given papaya meal (*C. papaya*) treatments.

MATERIALS AND METHODS

This research was carried out at the Laboratory for Fisheries Products, Technology, Mini-hatchery and Water Quality, Universitas Borneo Tarakan from May 2020 to January 2021. The total juvenile tilapia used was seventy-five fish with rearing treatment. The average tilapia initial length of 10-12 cm/fish and the average tilapia initial length was 2-3 cm/fish. The fish used in this study were obtained from traditional nurseries in Tarakan City, North Kalimantan. The rearing container in this study was a fifteen aquarium with 20 liters and five tilapia stocking density in each aquarium. During treatment we used the aerator as an aeration source without lighting and control the temperature between 25-33°C (Salsabila & Suprpto, 2018). Total experiment for tilapia with administration of papaya leaf meal was 30 days.

Papaya Leaf Meal

The raw material used was papaya leaf obtained from traditional farmers in Tarakan City. Fresh papaya leaf, then sun-dried for 2 weeks. Dried papaya leaf was grinded and sifted (60 mesh) until it becomes a meal (Simanjuntak & Ridwansyah, 2020). Papaya leaf meal was then dissolved in 50 ml of water and sprayed into commercial feed.

Feed Formulation

The commercial feed contains 35%

crude protein, 2% crude fat, 3% crude fiber, 13% crude ash, and 12% of water content. Commercial feed was mixed with a solution of papaya leaf meal using the spray method. Tilapia was given commercial feed 2 times a day as much as 5% of the total body weight of the fish.

This research used a completely randomized design in five treatments with three replications:

T1: commercial feed with 0 grams of papaya leaf meal

T2: administration of papaya leaf meal 1.25 g with commercial feed

T3: administration of papaya leaf meal 1.7 g with commercial feed

T4: administration of papaya leaf meal 2 g with commercial feed

T5: administration of papaya leaf meal 2.25 g with commercial feed

Content Absolute Length of Tilapia

The measurement of absolute length growth was carried out by calculating the difference between the initial length and the final length, using the formula proposed by Effendi (2002).

$$L = Lt - Lo$$

Description:

L = absolute length growth (cm)

Lt = body length at the end of the study (cm)

Lo = body length at the early of the study (cm)

Absolute Weight Growth

Measurement of absolute weight growth was carried out by calculating the difference between the initial weight and final weight using the formula proposed by Effendi (2002), as follows:

$$W = Wt - Wo$$

Description:

W = absolute weight

Wt = body weight at the end of the study (g) \

Wo = body weight at the early of the study (g)

Specific Growth Rate (SGR)

Specific growth rate is defined as the weight gain of fish over a period of time. The specific growth rate was measured using the formula (De Silva & Anderson, 1995):

$$SGR = 100 (\ln Wt - Wo) / t$$

Description :

SGR = Specific Growth Rate (%/days)

Wt = Weight of fish at the end of the study (g)

Wo = Weight of fish at the early of the study (g)

t = Times (days)

Survival Rate

The survival rate is the ratio between the number of individuals living at the end of the period and the number of individuals living at the beginning period in the same population (Awaludin et al, 2020). The survival rate was calculated by the Effendie (2002):

$$S = \frac{Nt}{No} \times 100\%$$

Description :

SR = Survival Rate (%)

Nt = Number of fish at the end of the study

No = Number of fish at the early of the study

Feed Conversion Rate (FCR)

Feed conversion rate (FCR) is the ratio between the amount of feed and the weight of the biomass produced. Feed conversion during the rearing period was calculated using the formula Zonneveld et al. (1991):

$$FCR = \frac{F}{Bt + Bm - B0}$$

Description

FCR= Feed Conversion Ratio

F = Feed Biomass

Bt = Final Weight

Bm = Fish weight mortality

Bo = Initial Weight

Water Quality

Water quality measurements were carried out every 5 days to determine the temperature, pH, dissolved oxygen, and ammonia levels in the water. Temperature and pH were tested by in situ method while dissolved oxygen and ammonia were tested by ex situ method by titration.

Data Analysis

The weight and length growth data were then analyzed with Analysis of Variance using SPSS 23.0. This analysis is needed to determine the effect of treatment and control on fish growth with a 95% confidence level.

RESULTS AND DISCUSSION

Absolute Growth Weight

Based on the experiment (Figure 1), it is known that the highest absolute weight growth value for tilapia that was fed with the addition of papaya leaf flour was found in T4 when compared to other treatments. The optimal growth value at T4 was thought to have more optimal proteolytic and facilitate the absorption of amino acids that have been converted by papain enzyme. We suspect that there are similarities between the converted amino acids and the amino acids present in the fish's body, thus facilitating absorption and containing high nutrition. Isnawati et al. (2015), a protein with the same amino acid composition Simanjuntak et al.

as the fish's body has a high nutritional value so that the absorption of the feed into the fish's body can be more optimal.

The high level of digestibility is thought to be due to the papain enzyme factor contained in papaya leaves. The metabolic process of feeding with high protein content will then be broken down into amino acids and their derivatives so that they are easily absorbed into the body. Amino acids are simple forms of protein that can improve the growth process of fish. This excess energy can be used for growth. Isnawati et al, (2015) stated that the addition of papaya leaf meal containing the enzyme papain in artificial feed can help and accelerate the digestive process so that sufficient nutrients are available for growth and survival of fish. In another study, Simanjuntak et al, (2018) reported that bioenrichment of papaya meal may enhance tilapia growth during treatment.

Specific Growth Rate

Based on Figure 2, the optimal specific growth was obtained in the T4 when compared to other treatments. We suspect that the optimum value is the result of optimization of the papain enzyme role in converting feed protein during the study period. because the protease enzyme will work optimally if the ratio between the protein to be converted to the presence of proteases is balanced. The papain enzyme in papaya leaf meal can be a stimulator as a protease enzyme to increase specific growth. The increase in specific growth is an effective concentration of tilapia that can be optimized for feed.

Bioenrichment of feed with papaya leaf meal which contains papain enzymes helps produce more optimal amino acids so that the feed consumed can be utilized for growth. Simanjuntak et al, (2018) said the increase in specific growth of tilapia (*O. niloticus*) occurred after the addition of papaya fruit meal

containing papain in artificial feed. Thus, it is suspected that papaya fruit meal containing papain can increase protein availability by

proteolytic activity, where papaya fruit meal contributes to growth.

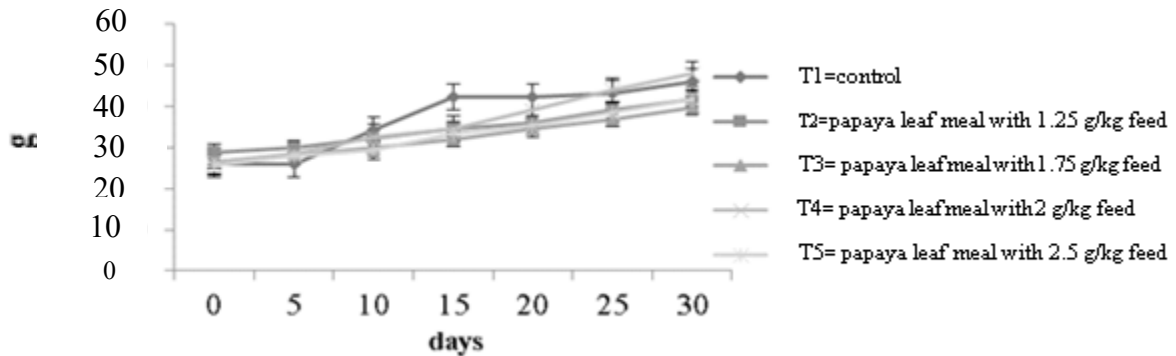


Figure 1. Alteration in the color of the outer skin of the shallot bulbs at the 9-week shelf life

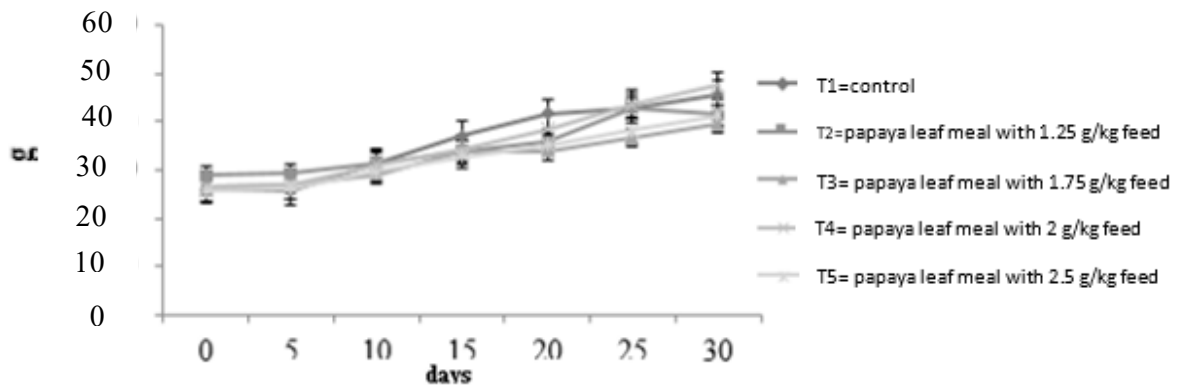


Figure 2. Specific growth weight of Nile tilapia with administration of papaya leaf meal during

Absolute Growth Length

Based on the observation of the length growth of tilapia in Figure 3, it is known that the T1, T4, and T5 have optimal length growth when compared to treatments T2 and T3. We suggest that the resulting growth is part of the role of papain from papaya leaf meal that was enriched in fish feed. The absolute growth length was linear with the weight gain of tilapia during the study. Hasan et al., (2000) stated that the percentage of artificial feed used in this study was different and the texture of the feed fed with papaya leaf solution changed in size.

The more protein that can be hydrolyzed into amino acids, the more amino acids that can be absorbed and used by the body. Sagita et al, (2017) stated that the feed added to the enzyme papain is easy for the fish to digest, meaning that the feed has good quality. In addition, Mareta et al., (2016), explained that the papain enzyme was able to increase the digestibility and absorption of feed protein, thereby increasing fish growth. Based on the results of the Anova test, absolute length growth showed insignificant results during the study. However, based on the growth pattern, the control treatments T4 and T5 had optimal

digestibility and absorption of amino acids resulting from hydrolysis due to the effect of

enrichment of the papaya leaf.

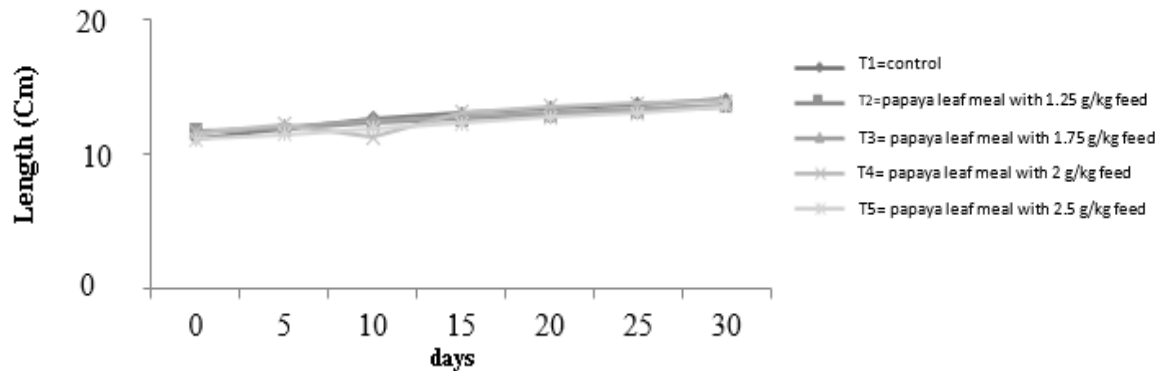


Figure 3. Absolute growth length of Nile tilapia with administration of papaya leaf meal during treatment.

Survival Rate

The survival rate of tilapia (*O. niloticus*) during the treatment period showed the highest value in T2, T3, and T5 treatments at 73% and the lowest was T1 at 53% and T4 at 60%. Figure 4 shows that the highest average survival is 73%, while the lowest is at P3 53%. Murjani (2011) stated that fish survival

depends on the adaptability of fish for food and the environment, fish health status, stocking density, and water quality that is sufficient to support fish growth. Mulyani (2014), stated that the survival rate of 50% was good. Survival of 30-50% is moderate and less than 30% is not good

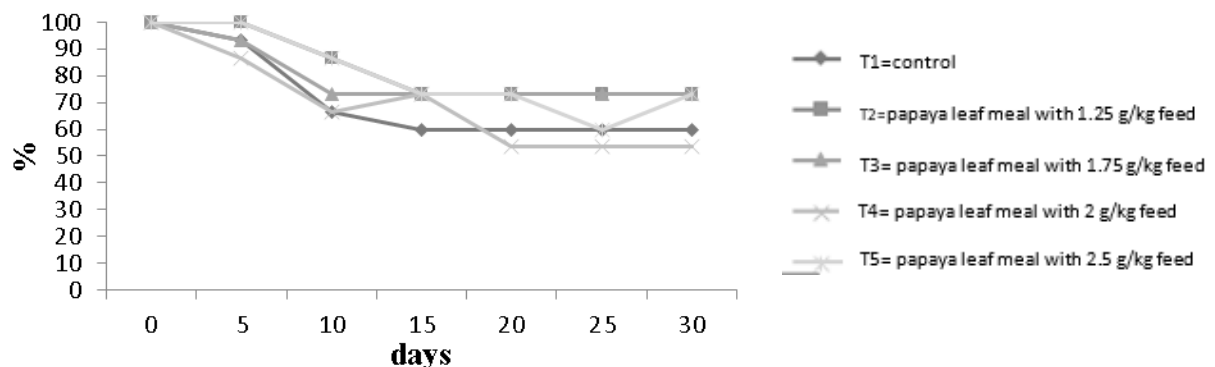


Figure 4. Survival rate of Nile tilapia with administration of papaya leaf meal during treatment

Feed Conversion Ratio (FCR)

Based on the results of the FCR calculation in Figure 5, revealed that the optimal value is in the T4 treatment. We suspect that amino acids have been converted in accord-

ance with the amino acids possessed in the digestive system of tilapia. The quality of the converted amino acids facilitates the absorption process thereby increasing the FCR. The smaller the feed conversion value, the better

the efficiency of feed utilization. However, if the feed conversion value is high, the efficiency level of feed utilization is not good. Thus feed conversion describes the efficiency level of feed utilization with the resulting body biomass.

The feed conversion value is also influenced by the amount of feed given, the less

feed given, the more efficient the feeding. Therefore, energy metabolism derived from food is one of the important processes in feed conversion. Haetami et al., (2005) stated that the high and low value of feed conversion can be influenced by the travel rate of food in the digestive tract and the content of food substances contained in the ration.

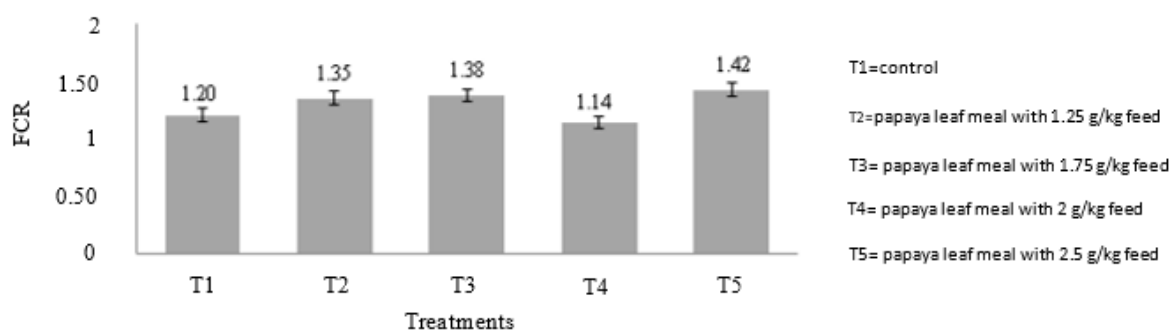


Figure 5. Feed conversion rate of Nile tilapia with administration of papaya leaf meal during treatment

Water Quality

Water quality has a very important role as a medium for rearing tilapia. Feeding in large quantities will affect tilapia rearing. This can result in changes in the value of water quality parameters, such as increased waste from fish metabolism. In this study, there are differences of parameter values in each research aquarium which can be seen in Table 1.

Temperature is one of the important factors in aquaculture activities. The higher the water temperature, the more active the fish's metabolism. At low temperatures, fish will lose their appetite and become more susceptible to disease. Conversely, if the temperature is too high, the fish will experience respiratory stress and can even cause permanent gill damage (Suriansyah, 2014). The temperature in this study was in the range of 27-28 °C (Table 1). This shows that the temperature in the aquarium is still in optimal conditions. Sal-

sabila & Suprpto (2018) stated that the most ideal growing environment for tilapia cultivation is freshwater which has a temperature between of 25-33°C.

Prakoso (2014), stated that most aquatic organisms are sensitive to changes in pH, and prefer a neutral pH, which is between 7-8.5. In this study, the results of pH measurements in the rearing container ranged from 6.5 to 7.5 (Table 1). These conditions indicate that the pH in the aquarium is still relatively safe for the life of the tilapia. Prakoso (2014) stated that water biochemical processes, such as nitrification, are strongly influenced by pH. Boyd (1982) stated that the pH values that caused death for fish were less than 4 and more than 11.

The results of the oxygen content measurement in this study were categorized as good and were in the range of 4.22–7.5 mg/l (Table 1). Tilapia is a type of fish that can with-

stand conditions of lack of oxygen. If there is a lack of oxygen, the tilapia will take oxygen directly from the free air. In fact, tilapia can survive for some time on land without water. The range of dissolved oxygen is still feasible for tilapia cultivation, > 3 (SNI, 2009). Dissolved oxygen is needed for respiration and metabolism as well as for the survival of organisms (Effendi, 2003). In other case, good oxygen content of tilapia is at least 4 mg/liter (Amri & Khairuman, 2013).

The results of ammonia in the rearing container were quite high from 0.48-0.72 mg/l

(Table 1). The high value of ammonia was caused by the residual feed that was uneaten by tilapia during the research period. However, the range of ammonia is still suitable for tilapia cultivation, < 1 (Robinette, 1976). Sucipto and Prihartono (2007) stated that ammonia is the end result of the decomposition process by protein to the rest of the feed and the metabolic products of fish that settle in the waters. Jobling (1994) suggested that the ammonia excretion of fish fed daily was higher than that of fasted fish, the increase could even be up to 2 times higher.

Table 1. Water quality parameter during treatment

Parameters	Treatments					Optimum Value
	T1	T2	T3	T4	T5	
Temperature (°C)	27-28	27-28	27-28	27-28	27-28	25-33 *
DO (mg/L)	4.49-4.49	5.02-3.70	6.07-5.81	4.22-4.22	5.02-5.54	>3**
pH	6.5-7.44	6.5-7.5	6.5-7.5	6.5-7.44	6.5-7.44	7-8***
Ammonia (mg/L)	0.48-0.43	0.68-0.30	0.72-0.40	0.48-0.39	0.67-0.35	<1****

*Effendi (2003), Salsabila & Suprpto (2018)

**SNI 7550-2009 (2009)

***Prakoso (2014)

**** Robinette (1976)

CONCLUSION

Based on the results of the study, it can be concluded that the administration of papaya leaf meal in T4 increased the growth of tilapia include: absolute growth weight, specific growth rate, absolute growth length, survival rate, and FCR. However, based on the statistical analysis of all treatments did not show a significant difference

AUTHOR CONTRIBUTION

R.F.S. and I.R.A designed and supervised all the research, P., R...S. collected sample from wet and dry laboratory
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CONFLICT OF INTEREST

We do not have any conflict of interest. In accordance with that, we as an author have disclosed those interests fully to the journal, and I have in place an approved plan for managing any potential conflicts arising from (that involvement).

REFERENCES

- Al-Nemrawi, N. K., Alsharif, S. S. M. & Dave, R. H. (2018). Preparation of Chitosan-TPP Nanoparticles: The Influence of Chitosan Polymeric Properties and Formulation Variables. *International Journal of Applied Pharmaceutics*, 10(5), 60–65.
- Awaludin., Simanjuntak, R. F. & Jumsan. (2020). Modifikasi Pakan Buatan untuk Meningkatkan Pertumbuhan dan Kelangsungan Hidup Udang Windu (*Penaeus monodon*). *Majalah Ilmiah Biosfera*, 37 (3). 168-174
- Amri, K. & Khairuman. (2003). *Membuat Pakan Ikan Konsumsi*. Agromedia Pustaka. Tangerang.
- Boyd, C. E. (1982). *Water Quality Management for Pond Fish Culture*. Amsterdam: Elsevier Scientific Publishing Company.
- De Silva, S. S. & Anderson, T. A. (1995). *Fish Nutrition In Aquaculture*. Aquaculture Series 1. London, Chapman and Hall.
- Dongoran, D. S. (2004). Pengaruh Activator Sistein dan Natrium Klorida Terhadap Aktivitas Papain. *Jurnal Sains Kimia*, 8 (1). 26-28
- Effendi, M. I. (2002). *Biologi Perikanan*. Cetakan Kedua. Yayasan Pustaka Nusantara, Yogyakarta:
- Effendi, M. I. (2003). *Telaah Kualitas Air*. Kanisius: Yogyakarta. '
- Haetami, K., Junianto. & Andriani, Y. (2005). Tingkat Penggunaan Gulma Air *Azolla pinnata* dalam Ransum Terhadap Pertumbuhan dan Konversi Pakan Ikan Bawal Air Tawar. *Laporan Penelitian*. Universitas Padjadjaran, Jatinangor
- Handajani, H. & W. Widodo. (2010). *Nutrisi Ikan*. Malang: UMM Press.
- Irawati, D., Rachmawati, D. & Pinandoyo. (2015). Performa Pertumbuhan Benih Ikan Nila Hitam (*Oreochromis niloticus bleeker*) Melalui Penambahan Enzim Papain dalam Pakan Buatan. *Journal of Aquaculture Management Technology*, 4 (1). 1-9.
- Isnawati, N., Sidik, R. & Mahasri, G. (2015). Potensi Serbuk Daun Pepaya untuk Meningkatkan Efisiensi Pemanfaatan Pakan, Rasio Efisiensi Protein Dan Laju Pertumbuhan Pada Budidaya Ikan Nila (*Oreochromis niloticus*). *Jurnal Ilmiah Perikanan dan Kelautan*, 7(2).
- Mareta, E. R., Subandiyono, & Hastuti, S. (2016). Pengaruh Enzim Papain dan Probiotik dalam Pakan Terhadap Tingkat Efisiensi Pemanfaatan Pakan dan Pertumbuhan Ikan Gurami (*Osphronemus gouramy*). *Jurnal Sains Akuakultur Tropis*, 1 (1):21-30.
- Murjani, A. (2011). Budidaya Beberapa Varietas Ikan Sepat Rawa (*Trichogaster Trichopterus* Pall) Dengan Pemberian Pakan Komersial. *Jurnal Fish Scientiae*, 1 (2): 214-133.
- Prakoso, T. (2014). Pengaruh Suhu yang Berbeda Terhadap Laju Pertumbuhan Benih Ikan Gurami (*Osphronemus gouramy lac*) didalam Akuarium. *Skripsi*. Program Studi Budidaya Perairan, Fakultas Pertanian, Universitas Antakusuma.
- Riyanti, A., Susanto, A. & Sukarti, K. (2014). Penambahan Tepung Buah Pepaya (*Carica papaya*). Dalam Pakan Terhadap Pertumbuhan dan Efisiensi Pakan Pada Ikan Nila Gift (*Oreochromis sp*) Ukuran 3-5 cm. *Jurnal Ilmu Perikanan Tropis*, 30 (1). 60-67
- Robinette, H. R. (1976). Effect of Sublethal of Ammonia on the Growth of Channel Catfish (*Ictalurus punctatus* R). *Frog. Journal Fish Culture*, 38 (1). 26-29
- Rukisah., Simanjuntak, R. F. & Anugrah, W.

- (2021). Pengaruh Pemberian Pakan Buatan dari Kombinasi Tepung Cacing Tanah (*Lumbricus rubellus*) dan Tepung Daun Pepaya Terhadap Pertumbuhan Ikan Nila. *Jurnal Harpodon Borneo*, 14 (1). 39-46
- Rukmana, H. R. (1997). *Ikan Nila Budidaya dan Prospek Agribisnis*. Yogyakarta: Kanisius.
- Sagita, F., Rachmawati, D. & Suminto. (2017). Pengaruh Penambahan Enzim Papain Pada Pakan Komersial Terhadap Efisiensi Pemanfaatan Pakan, Laju Pertumbuhan, Kelulushidupan Ikan Sidat (*Anguilla bicolor*). *Journal of Aquaculture Management and Technology*, 6(4). 77-84.
- Salsabila, M. & Suprpto, H. (2018). Teknik Pembesaran Ikan nila (*Oreochromis niloticus*) di Instalasi Budidaya Air Tawar Pandaan, Jawa Timus. *Journal of Aquaculture and Fish Health*, 7(3). 118-123
- Simanjuntak, R. F., Abdiani, I. M. & Verawati. (2018). Bioenrichment Tepung Pepaya (*Carica Papaya*) dengan Formula si Pakan yang Berbeda pada Performa Pertumbuhan Ikan Nila (*Oreochromis niloticus*). *Jurnal Harpodon Borneo*, 11 (2). 59-68.
- Simanjuntak, R. F. & Ridwansyah. (2020). Membangun Keterampilan Mahasiswa Perbatasan Kaltara Melalui teknologi dan Manajemen Pembuatan Pakan Ikan Pada Masa Pancemi dan Pasca Covid-19. *Jurnal Pengabdian Masyarakat Borneo*, 4 (2). 143-150
- SNI 7550.2009. (2009). Produksi Ikan Nila (*Oreochromis niloticus* Bleeker) Kelas Pembesaran di Kolam Air Tenang. Badan Standardisasi nasional. Jakarta
- Sulasi, S., Hastuti, S. & Subandiyono, S. (2018). Pengaruh Enzim Papain dan Probiotik pada Pakan Buatan terhadap Pemanfaatan Protein Pakan dan Pertumbuhan Ikan Mas (*Cyprinus Carpio*). *Sains Akuakultur Tropis : Indonesian Journal of Tropical Aquaculture*, 2 (1),
- Zonneveld, N., Huisman E. A. & Boon, J. H. (1991). Prinsip-Prinsip Budidaya Ikan. Jakarta: Gramedia Pustaka Utama.