Fisheries Journal, 14(3), 1535-1545 (2024)
http://doi.org/10.29303/jp.v14i3.1034

AVOCADO LEAF AND FRUIT EXTRACT (*Persea Americana MILL*) AS A FEED ADDITIVE FOR NILE TILAPIA (*Oreochromis* sp.)

Ekstrak Daun Dan Buah Alpukat (*Persea Americana* Mill) Sebagai *Feed Additive* Pada Ikan Nila (*Oreochromis* sp.)

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(Received July 22th 2024; Accepted September 4th 2024)

ABSTRACT

Nile tilapia (Oreochromis sp.) is one of the freshwater fish highly favored by fish farmers in Indonesia. The use of feed additives in fish diets to accelerate growth and enhance immunity has been widely practiced. Avocado is a natural plant known for its beneficial chemical compounds. This study aims to investigate the potential of avocado fruit and leaf extracts as feed additives for Nile tilapia. The Nile tilapia, with an average weight of 2.0 g/fish, were reared in 21 aquariums at a density of 16 fish/aquarium for 30 days. Avocado leaf and fruit extracts were mixed into the feed before being given to the fish. The study included seven treatments: avocado leaf extract at 5%, 10%, and 20% (DA5, DA10, and DA20), avocado fruit extract at 5%, 10%, and 20% (BA5, BA10, and BA20), and a control group without treatment (C). The final fish weight, weight gain, specific growth rate, and survival rate of Nile tilapia with avocado leaf and fruit extract treatments were higher compared to the control group. Conversely, the condition factor of fish without treatment was higher compared to those with treatments. Avocado fruit extract showed a more beneficial effect compared to avocado leaf extract. The use of higher doses of extracts demonstrated a better positive impact on Nile tilapia. Avocado fruit extract at a dose of 20% showed the best results for application in aquaculture activities.

Keywords: Avocado fruit; Avocado leaf; Feed additive; Growth; Nile tilapia.

ABSTRAK

Ikan Nila (*Oreochromis* sp.) merupakan salah satu ikan air tawar yang menjadi primadona para pembudidaya ikan di Indonesia. Penggunaan *feed additive* pada pakan untuk mempercepat pertumbuhan dan meningkat imunitas ikan telah banyak dilakukan. Alpukat merupakan salah satu tumbuhan alami dengan kandungan senyawa kimia yang bermanfaat. Penelitian ini bertujuan untuk mengetahui potensi ekstrak buah dan daun alpukat sebagai *feed additive* pada ikan Nila. Ikan Nila dengan berat rata-rata 2,0 g/ekor, dipelihara pada 21 akuarium dengan kepadatan 16 ekor/akuarium selama 30 hari. Esktrak daun dan buah alpukat dicampurkan pada pakan sebelum diberikan pada ikan. Penelitian dilakukan dengan tujuh perlakuan yaitu ekstrak daun alpukat 5%, 10% dan 20 % (DA5, DA10, dan DA20), ekstrak buah alpukat 5%, 10% dan 20 % (BA5, BA10, dan BA20), serta tanpa perlakuan/kontrol (C). Berat akhir ikan, pertumbuhan berat dan rata-rata pertumbuhan spesifik serta tingkat kehidupan ikan Nila dengan perlakuan ekstrak daun dan buah alpukat lebih tinggi jika dibandingkan dengan tanpa perlakuan. Sebaliknya, faktor kondisi ikan tanpa perlakuan lebih tinggi jika dibandingkan dengan ikan dengan perlakuan. Ekstrak buah alpukat menunjukkan efek positif lebih baik daripada ekstrak daun alpukat. Penggunaan ekstrak dengan dosis lebih tinggi menunjukkan dampak positif yang lebih baik pada ikan Nila. Penggunaan ekstrak buah alpukat dengan dosis 20% menunjukkan hasil terbaik untuk diterapkan dalam kegiatan akuakultur.

Kata Kunci: Buah Alpukat; Daun Alpukat; *Feed additive*; Ikan Nila; Pertumbuhan.

INTRODUCTION

Population growth in the world increases every year. Based on data from the United Nations (UN), the global population is projected to reach 9.7 billion in 2050 (UN, 2017). Population growth results in an increase in food needs, including fish as a source of animal protein. As capture fisheries production declines, aquaculture has become one of the key sectors in global food production, providing a sustainable solution to meet the increasing demand for fish. According to the FAO report, aquaculture production has increased significantly in recent decades, now accounting for more than 50% of total global fish production. In 2022, aquaculture production will account for 59% of total world fisheries production (FAO, 2024).

Feed additives are substances added in small amounts to feed as preservatives, binders, feed stimulants, food coloring with the aim of making the feed more attractive, tasty, easy to digest and as a digestive aid (Yadav et al., 2021) . The use of feed additives in feed is carried out with the aim of improving growth performance, manipulating gut microbiota, increasing immune status, resistance to disease and oxidative fish, controlling bacterial infections, feed utilization and life levels which will ultimately contribute to more sustainable aquaculture (Abdel- Warith et al., 2020; Mohammadiazarm et al., 2021; Eissa et al., 2024). The use of feed additives such as medicinal plants, herbal extracts, phytochemicals, plant secondary metabolites, immunostimulants and probiotics has been widely recommended by farmers (Yılmaz et al., 2022). Microalgae and herbal plants such as nipah leaves (Nypa fruticans Wurmb), neem leaves (Azadirachta indica Juss.), leaves and stems of Brazilian spinach (Althernathera sissoo Hort), leaves of senjaga bulu (Clidemia hhirta), and cherry leaves (Muntingia calabura) have been used. in fish and shrimp cultivation because they contain chemical compounds such as saponins and tannins which can be useful as antibacterial, anti-inflammatory and astringent compounds in the proliferation phase of the wound healing phase and can increase growth (Abdel-Warith et al., 2020; Mukti et al., 2020; Bahri, 2021; Guimarães et al., 2021; Kartina et al., 2024;).

Tilapia (Oreochromis niloticus) is a type of freshwater fish that has the prospect of being developed because this fish has several advantages, including being easy to breed, high survival rate, relatively fast growth with relatively large body size, a fairly high level of productivity, and resistance. to changes in environmental conditions. Apart from that, Tilapia has a distinctive meat taste, clean white flesh color and is not thorny with quite high nutritional content, so it has a wide market and high demand in society. Tilapia fish production in Indonesia increases every year, in 2022 production will reach 1.36 million tons, an increase of 15.8% compared to production in 2018, namely 1.17 million tons (KKP Statistics, 2024). The presence of disease infections and environmental conditions that often fluctuate resulting in stress in fish are problems that are often faced in Tilapia cultivation activities (Novianti et al., 2022). As an effort to prevent and treat these problems, the practice of using herbal ingredients such as the microalgae Nannochloropsis oculate, aloe vera (Aloe vera), mangrove leaves (Avicenia rumphiana), soursop leaves (Annona squamosa), and cumin or cumin (Cuminum cyminum) has been carried out. for antifungal, antibacterial, antioxidant and antiparasitic purposes as well as enhancing growth (Syed et al., 2022; Mamdouh et al., 2021; Wulansari et al., 2020; Almarri et al., 2023; Deng et al., 2023). The use of herbal feed additives for value fish has shown good results such as increasing growth and immunity in Tilapia (Pramono et al., 2023; Ta'dung et al., 2023; Yunus, 2023).

The leaves and skin of avocado (Persea americana Mill) contain compounds including flavonoids, saponins, alkaloids, tannins, terpenoids and phenols which are known to function as immunostimulants, antioxidants, anti-inflammatory and antimicrobial (Katja et al., 2019; Kirana et al., 2023; Hastuti et al., 2024). Apart from that, Utari (2023), said that avocado skin is known to contain secondary metabolite compounds which have the potential to act as antibacterials. Avocado leaves have been widely used as a natural ingredient in the prevention and treatment of disease (Muqowwiyah & Dewi, 2021). Apart from that, research conducted by Ayeni et al. (2022), shows that the use of avocado leaf extract does not have a bad effect on health status and increases the growth of broiler chickens. According to Kemit et al. (2016), avocado flesh has high nutritional content. Avocado juice has a strong inhibitory effect on bacterial growth, meaning that avocado flesh has anti-bacterial power (Muchyar et al., 2018). Based on the description above, this research was conducted to determine the potential of avocado leaves and fruit as feed additives by measuring their effect on the growth and survival of Tilapia fish.

METHODS

Tools and Materials

The research was conducted at the Fisheries Business Expert Polytechnic for 30 days starting. The tools and materials used were a blender, tray, filter, 21 aquariums (80 x 40 x 40 cm), knife, 100 ml measuring cup, 250 ml beaker glass, spoon, small plate, hose, scoop, dropper and scales. Meanwhile, the materials used are avocado fruit and leaves, tilapia fish seeds 3 - 5 cm long with an average weight of 2.0 grams/fish for 336 fish, fish feed, water, label paper.

Procedure

Research design

The research was carried out using 7 treatments and each treatment consisted of 3 replications. There were 21 aquarium containers used in this research equipped with irrigation in each aquarium. Aquariums are arranged on aquarium shelves randomly. Each aquarium is filled with fresh water with a volume of 96 liters. After the aquarium was prepared, 16 Tilapia

fish with an average weight of 2.0 grams were put into each aquarium so that the density of Tilapia fish used in this study was 50 fish/m2. The treatments used in this research are:

DA5 : Feed with the addition of avocado leaf extract 5%
DA10 : Feed with the addition of avocado leaf extract 10%
DA20 : Feed with the addition of avocado leaf extract 20%
BA5 : Feed with the addition of avocado extract 5%
BA10 : Feed with the addition of avocado extract 10%
BA20 : Feed with the addition of avocado extract 20%
Conrol : without treatment

Making extracts and enriching feed

Making avocado leaf and fruit extract is done by grinding the avocado leaves and fruit using a blender until they are smooth/homogeneous. The solvent used in making this extract is water. The number of avocado leaves and fruit used depends on the treatment. DA5 extract (5% avocado leaves) is made by grinding 5-gram avocado leaves and adding 100 ml of water. The refined extract is then filtered and ready to be mixed with feed. The feed that will be given to the fish during the research is mixed with avocado leaf or fruit extract according to the treatment. Feed enrichment is carried out by mixing 5 ml of extract with 100 grams until smooth and then the feed is aerated before being given to the fish.

Feeding and Observation

The research was carried out for 30 days. Fish are given feed that has been given extracts according to the treatment. The amount of feed given is 5% of the total weight of the fish. Feeding was carried out twice, namely at 08:00 and 16:00. Observation of fish growth was carried out by sampling every 10 days by measuring the weight of the fish. Observations of fish deaths are carried out every day. The amount of feed given to fish is adjusted to the weight of the sampling results and fish mortality. At the end of the research, the weight and length of the fish were measured in each aquarium.

Data Analysis

The data obtained was analyzed using descriptive analysis and presented in the form of tables, diagrams and graphs using Microsoft Office Excel. The data used in this research include initial body weight (IBW), final body weight (FBW), weight gain (WG), average specific growth rate (specific growth rate, SGR), condition factor (CF), level of life (survival rate, SR) and average daily growth (ADG). Calculations are carried out using the formula below:

Weight gain (WG, %) = (FBW – IBW) / IBW × 100
Specific growth rate (SGR, %/day) = [ln (FBW - ln (IBW)] / duration of feeding × 100
Survival rate (SR, %) = [(total number of fish – number of dead fish)] / total number of fish × 100
Condition factor (CF) = (FBW / total length^3) × 100
Average daily growth (ADG, g/day) = (FBW – IBW)/ duration of feeding
Where the units for weight and length are grams and centimeters respectively.

RESULT

Fish growth during the study is presented in Table 1. The final fish weight, weight growth and average specific growth of Tilapia fish treated with avocado leaf and fruit extract were higher when compared to those without treatment. Apart from that, the life rate of fish without treatment showed a lower value, namely only 81.3%, while fish with treatment was 100% until

the end of the study. On the other hand, the condition factor for fish without treatment was higher (1.10) when compared to fish with treatment, namely 0.85 – 1.08 (average 0.93). Fish growth data during the research can be presented in Table 1.

Table 1. Data on fish growth during the research

Treatment	Parameters[1]					
	IBW (g)	FBW (g)	WG (%)	SGR (%/hari)	CF	SR (%)
DA5	2,0	15,2	660	6,76	1,08	100
DA10	2,0	15,4	670	6,80	0,99	100
DA20	2,0	15,9	695	6,91	0,88	100
BA5	2,0	15,8	690	6,89	0,89	100
BA10	2,0	16,4	720	7,01	0,88	100
BA20	2,0	17,5	775	7,23	0,85	100
Control	2,0	15,1	655	6,74	1,10	81,3

The final weight of fish without treatment with avocado leaf and fruit extract was 15.1 g/fish, while the average weight of fish treated was 16.0 (15.2 – 17.5 g/fish). This shows that the weight of fish without treatment with avocado leaf and fruit extract is lower than the weight of fish treated with avocado leaf and fruit extract. Fish treated with avocado fruit extract showed a higher average final fish weight (16.6 g/fish) compared to those treated with avocado leaves (15.5 g/fish). The higher the extract of avocado leaves and fruit used, the higher the final weight of the fish. Fish treated with avocado leaf and fruit extract at a dose of 20% showed a higher final fish weight compared to fish treated with 5% or 10% extract.

Fish treated with avocado leaf and fruit extract had a weight growth of 701.7% (660 – 775%), this value was higher compared to fish without treatment, namely only 655.0%. The use of avocado fruit extract showed a higher average weight growth (728.3%) compared to fish treated with avocado leaf extract (675.0%). The use of avocado leaf and fruit extracts at doses of 5% and 10% showed lower weight growth compared to the use of 20% extract. So use of higher doses will result in higher weight growth.

The average specific growth of fish with the use of avocado leaf and fruit extracts showed a higher value, namely 6.93%/day when compared to without the use of extracts, namely only 6.74%/day). As with the final weight and weight growth of fish, the average specific growth rate for fish treated with avocado leaf extract (6.83%/day) showed a lower value when compared to the avocado fruit extract treatment (7.04%). In addition, fish treated with avocado leaf and fruit extract at a dose of 20% showed a higher average specific growth compared to the 5% and 10% treatments.

The average daily growth of Tilapia fish without treatment with avocado leaf and fruit extract showed a higher value when compared to fish without treatment with avocado leaf and fruit extract except for fish treated with avocado leaves at a dose of 5%. Fish treated with avocado fruit extract at a dose of 20% showed the highest average daily growth, namely 0.52 g/day. Fish treated with 20% avocado leaf extract showed the same average daily growth as fish treated with 5% avocado fruit.

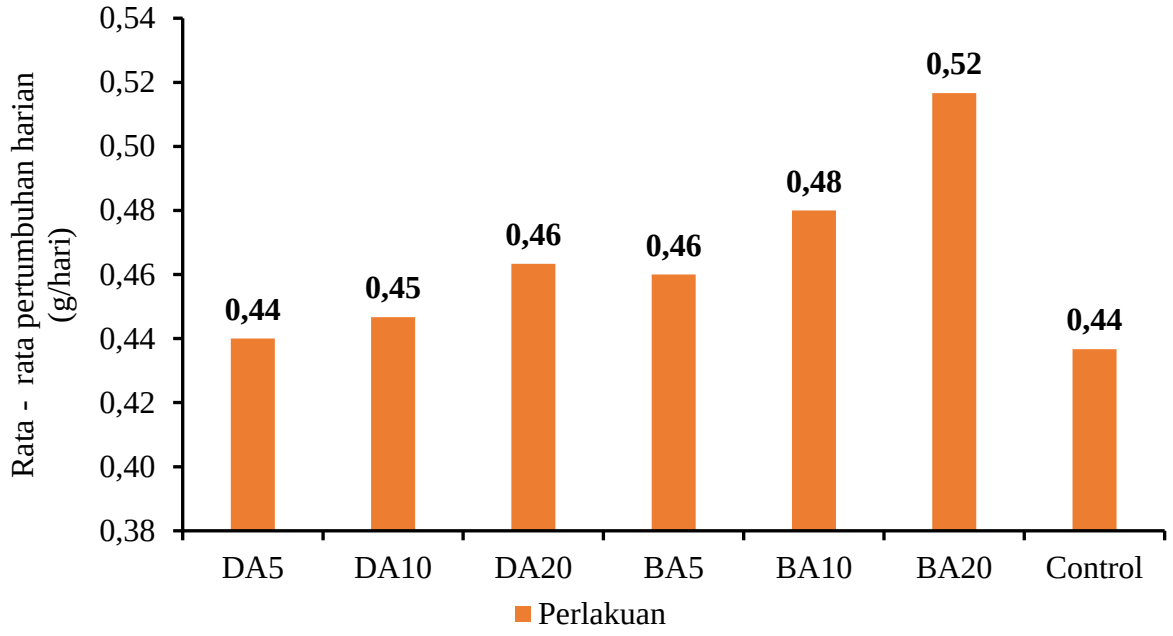

Fig 1. Average daily growth of fish

DISCUSSION

The use of avocado leaf and fruit extracts in this research had a positive impact on the growth of Tilapia fish. This can be seen from the growth of Tilapia fish including the final weight parameters of the fish, weight growth and the average specific growth given the avocado treatment which is higher when compared to without treatment. These results are in line with the results of research conducted by Chaves et al. (2015), avocado can support the growth and weight gain of Tilapia (Oreochromis niloticus L.) and goldfish (Cyprinus carpio L.) fry. The use of avocado as feed has also been reported in male mice (Mus musculus), avocado as daily food has an effect on increasing the body weight of mice (Hanizar, 2023). Ayeni et al. (2022), reported that feeding a mixture of avocado leaf composites in feed did not have an adverse effect on the health status of broiler chickens but increased the growth and total welfare of broiler chickens. The increase in growth of Tilapia fish treated with avocado leaf and fruit extract is thought to be due to the nutritional content they contain.

Condition factor (CF) is an index that reflects the interaction between biotic and abiotic factors on the physiological condition of fish. The CF value results indicate good health and better environmental conditions for the fish. Several factors can cause variations in CF values such as water quality and food availability. A CF greater than one indicates the well-being of fish fed with a particular diet (Datta et al., 2013; Rossi et al., 2020; ÇIÇEK et al., 2022). In this study, the CF value of untreated fish showed a value greater than 1 (>1), while fish treated with avocado leaf and fruit extract showed a CF of less than 1 (CF<1), except for fish treated with avocado leaf extract 5 %. However, the level of life and growth of fish treated with avocado leaf and fruit extract was better than without treatment. For this reason, further research is needed on other factors such as water quality.

The life level of tilapia fish that were fed with extracts of avocado leaves and fruit showed higher levels of tilapia when compared to fish that were fed without treatment. Previous research has reported that the use of avocado leaf extract can increase survival rates, disease

resistance and anti-bacterial properties in catfish (Clarias gariepinus) infected with diseases such as Klebsiella pneumonia and Pseudomonas aeruginosa. These researchers suspect that this is due to the presence of phenols, flavonoids, carotenoids, steroids and other alkaloids contained in avocado leaves which have the potential to act as antibacterials, anti-inflammatories and immunostimulants (Ukwe and Abu, 2021; Ukwe and Etire, 2021; Ukwe and Deekae, 2022). Most recently, it was reported that avocado leaves have the potential to improve the innate immune system of Tilapia, especially in hematocrit and leukocrit as well as phagocytic activity (Hastuti et al., 2024).

The use of leaf and avocado extracts on animals other than fish has also been reported to increase the level of life. Seixas Filho et al. (2022) reported that tadpoles (Lithobates catesbeianus) given peeled avocados had a higher level of survival when compared to those without peeled avocados. Other studies report that avocado juice has strong inhibitory (antibacterial) power against the growth of S. aureus, Bacillus cereus bacteria (Muchyar et al., 2018; Utari, 2024). Apart from being antibacterial, the flavonoid content in avocados also has the potential to act as an anti-inflammatory in male white rats of the Wistar strain (Lutfiah and Lestari, 2023). In line with this research, Pamungkas et al. (2022) reported that ethanol extract of avocado leaves had an effect on healing burns in rabbits (Oryctolagus cunicullus).

CONCLUSSION

The use of avocado leaf and fruit extracts showed a positive impact on the growth and survival of Tilapia including final fish weight, weight growth and average specific growth. Avocado leaf and fruit extracts influence the condition of Tilapia fish. Avocado fruit extract shows better positive effects than avocado leaf extract. The use of extracts at higher doses showed a better positive impact on Tilapia fish. The use of avocado fruit extract at a dose of 20% shows the best results for application in aquaculture activities.

ACKNOWLEDGEMENT

The author would like to thank the Polytechnic Academic Community of Fisheries Business Experts who have supported the implementation of this research.

REFERENCES

Abdel-Warith, A. W. A., El-Bab, A. F. F., Younis, E. S. M., Al-Asgah, N. A., Allam, H. Y., Abd-Elghany, M. F., ... & Shamlol, F. S. (2020). Using of Chitosan Nanoparticles (Csnps), Spirulina as a Feed Additives Under Intensive Culture System for Black Tiger Shrimp (*Penaeus monodon*). *Journal of King Saud University-Science*, *32*(8), 3359-3363. https://doi.org/10.1016/j.jksus.2020.09.022

Almarri, S. H., Khalil, A. A., Mansour, A. T., & El-Houseiny, W. (2023). Antioxidant, Immunostimulant, and Growth-Promoting Effects of Dietary Annona Squamosa Leaf Extract on Nile Tilapia, *Oreochromis niloticus*, and its Tolerance to Thermal Stress and *Aeromonas sobria* Infection. *Animals*, *13*(4), 746. https://doi.org/ 10.3390/ani13040746

Aryasa, N. A. G. (2024). Pengaruh Pemberian Pelet Berbasis Ekstrak Daun dan Batang Bayam Brasil *(Althernathera sissoo* Hort.*)* terhadap Pertumbuhan dan Status Imunitas Ikan Nila *(Oreochromis niloticus* L.) (*Doctoral dissertation*, Universitas Kristen Duta Wacana).

Aulia, D., Rivero, C. J., Choi, W., Hamidoghli, A., Bae, J., Hwang, S., ... & Bai, S. C. (2024). Microalgae Feed Additives Improve Growth, Immunity, and Resistance to *Vibrio Anguillarum* Infection in Juvenile Rainbow Trout, *Oncorhynchus mykiss*. *Iranian Journal of Fisheries Sciences*, *23*(4), 537-557.

Ayeni, A. O., Adegbenro, M., Dick, O. E., Oyedokun, E. S., Olasehinde, I. O., & Agbede, J. O. (2022). Performance, Haemato-Biochemical Indices and Antioxidants Status of Broiler Chickens Fed Diets Supplemented with Avocado-Bamboo Composite Leaf mix. *Nigerian Journal of Animal Production*, *49*(1), 293-303. DOI: https://doi.org/10.51791/njap.v49i1.3428

Bae, J., Hamidoghli, A., Won, S., Choi, W., Lim, S. G., Kim, K. W., ... & Bai, S. C. (2020). Evaluation of Seven Different Functional Feed Additives in a Low Fish Meal Diet for Olive Flounder, *Paralichthys olivaceus*. *Aquaculture*, *525*, 735333. https://doi.org/10.1016/j.aquaculture.2020.735333

Bahri, A. (2021). Pengaruh Perendaman Ekstrak Etanol Daun Kersen (*Muntingia calabura*) untuk Pengobatan Infeksi Jamur *Saprolegnia* sp pada Benih Ikan Lele *(Clarias gariepinus)* (*Doctoral dissertation*, Universitas Islam Riau).

Beltrán, J. M. G., & Esteban, M. Á. (2022). Nature-Identical Compounds as Feed Additives in Aquaculture. *Fish & Shellfish Immunology*, *123*, 409-416. https://doi.org/10.1016/j.fsi.2022.03.010

Chaves, R. C., de Paula, R. Q., Gücker, B., Marriel, I. E., Teixeira, A. O., & Boëchat, I. G. (2015). An Alternative Fish Feed Based on Earthworm and Fruit Meals for Tilapia and Carp Postlarvae. *Revista Brasileira de Biociências*, *13*(1).

Çiçek, E., Seçer, B., Eagderi, S., & Sungur, S. (2022). Length–Weight Relations and Condition Factors of 34 *Oxynoemacheilus* Species (Actinopterygii: Cypriniformes: Nemacheilidae) from Turkish Inland waters. *Acta Ichthyologica et Piscatoria*, *52*(1), 29-34. DOI 10.3897/aiep.52.81211

Datta, S. N., Kaur, V. I., Dhawan, A., & Jassal, G. (2013). Estimation of Length-Weight Relationship and Condition Factor of Spotted Snakehead *Channa punctata* (Bloch) Under Different Feeding Regimes. *SpringerPlus*, *2*, 1-5.

Deng, H., Tian, Z., Zhou, H., Zhang, Y., Chen, X., Cui, Y., ... & Huang, L. (2023). Elucidating the Effects of Cumin (*Cuminum cyminum*) Fruit and Stem as Feed Additives on Growth, Antioxidant Capacity, Liver and Intestinal Health, and Gut Microbiome of Nile tilapia (*Oreochromis niloticus*). *Aquaculture Reports*, *31*, 101687. https://doi.org/10.1016/j.aqrep.2023.101687

Eissa, E. S. H., Aljarari, R. M., Elfeky, A., Abd El-Aziz, Y. M., Munir, M. B., Jastaniah, S. D., ... & ElBanna, N. I. (2024). Protective Effects of *Chlorella vulgaris* as a Feed Additive on Growth Performance, Immunity, Histopathology, and Disease Resistance Against *Vibrio parahaemolyticus* in the Pacific white shrimp. *Aquaculture International*, *32*(3), 2821-2840. https://doi.org/10.1007/s10499-023-01298-y

FAO. 2024. The State of World Fisheries and Aquaculture. Blue Transformation in action. *Rome*. https://doi.org/10.4060/cd0683en

Guimarães, A. M., Guertler, C., do Vale Pereira, G., da Rosa Coelho, J., Costa Rezende, P., Nóbrega, R. O., & do Nascimento Vieira, F. (2021). N*annochloropsis* spp. as Feed Additive for the Pacific White Shrimp: Effect on Midgut Microbiology, Thermal Shock Resistance and Immunology. *Animals*, *11*(1), 150. https://doi.org/10.3390/ani11010150

Hanizar, E. (2023). Pengaruh Konsumsi Buah Alpukat (*Persea americana*) dan Lemon pada Berat Badan Mencit Jantan (*Mus musculus*). *BIO-CONS: Jurnal Biologi dan Konservasi*, *5*(1), 260-268.DOI: https://doi.org/10.31537/biocons.v5i1.1144

Hastuti, S. D., Zubaidah, A., & Fatimah, S. (2024). Respons Kekebalan Bawaan Ikan Nila (*Oreochromis niloticus*) yang diberi Pakan dengan Suplementasi Daun Alpukat (*Parsea americana* Mill). *Jurnal Riset Akuakultur*, *19*(1), 15-29. doi:http://doi.org/10.15578/jra.19.1.2024.15-29

Kartina, K., Ramli, R., Awaludin, A., & Nurasmi, N. (2024). Pengaruh Penambahan Ekstrak Daun Katuk (*Sauropus androgynus*) pada Pakan terhadap Performa Ikan Bandeng (*Chanos chanos*). *Al-Kauniyah: Jurnal Biologi*, *17*(1), 70-80. DOI: https://doi.org/10.15408/kauniyah.v16i2.1.27374

Katja, D. G., Suryanto, E., & Wehantouw, F. (2019). Potensi Daun Alpukat (*Persea americana* mill) sebagai Sumber Antioksidan Alami. *Chemistry Progress*, *2*(1), 58-64.

Kemit, N., Widarta, I. W. R., & Nocianitri, K. A. (2016). Pengaruh Jenis Pelarut dan Waktu Maserasi terhadap Kandungan Senyawa Flavonoid dan Aktivitas Antioksidan Ekstrak Daun Alpukat (*Persea Americana* Mill). *Jurnal Ilmu Teknologi Pangan*, *5*(2), 130-141.

Kesselring, J., Gruber, C., Standen, B., & Wein, S. (2021). Effect of a Phytogenic Feed Additive on the Growth Performance and Immunity of Pacific White Leg Shrimp, *Litopenaeus vannamei*, Fed a Low Fishmeal Diet. *Journal of the World Aquaculture Society*, *52*(2), 303-315. DOI:10.1111/jwas.12739

Kirana, B. C., Imawati, M. F., & Aprilia, A. E. (2023). Perbandingan Kadar Flavonoid Ekstrak Etanol Daun dan Kulit Buah Alpukat (*Persea Americana* Mill). *JUKEJ: Jurnal Kesehatan Jompa*, *2*(2), 235-239. DOI: https://doi.org/10.57218/jkj.Vol2.Iss2.915

Lutfiah, I. W., & Lestari, T. (2023). Uji Aktivitas Anti-Inflamasi Ekstrak Etanol Daun Alpukat (*Persea americana* Mill) Terhadap Tikus Putih Jantan Galur Wistar. In *Prosiding Seminar Nasional Diseminasi Penelitian Volume 3* (Vol. 3, No. 1).

Ma, M., & Hu, Q. (2024). Microalgae as Feed Sources and Feed Additives for Sustainable Aquaculture: Prospects and Challenges. *Reviews in Aquaculture*, *16*(2), 818-835. DOI:10.1111/raq.12869

Mamdouh, A. Z., Zahran, E., Mohamed, F., & Zaki, V. (2021). *Nannochloropsis oculata* Feed Additive Alleviates Mercuric Chloride-Induced Toxicity in Nile tilapia (*Oreochromis niloticus*). *Aquatic Toxicology*, *238*, 105936. https://doi.org/10.1016/j.aquatox.2021.105936

Mohammadiazarm, H., Maniat, M., Ghorbanijezeh, K., & Ghotbeddin, N. (2021). Effects of Spirulina Powder (*Spirulina platensis*) as a Dietary Additive on Oscar Fish, *Astronotus ocellatus*: Assessing Growth Performance, Body Composition, Digestive Enzyme Activity, Immune-Biochemical Parameters, Blood Indices and Total Pigmentation. *Aquaculture nutrition*, *27*(1), 252-260. DOI: 10.1111/anu.13182

Morante, V. H. P., Copatti, C. E., Souza, A. R. L., da Costa, M. M., Braga, L. G. T., Souza, A. M., ... & Melo, J. F. B. (2021). Assessment the Crude Grape Extract as Feed Additive for Tambaqui (*Colossoma macropomum*), an Omnivorous Fish. *Aquaculture*, *544*, 737068. https://doi.org/10.1016/j.aquaculture.2021.737068

Muchyar, D. S., Pangemanan, D. H., & Supit, A. S. (2018). Uji Daya Hambat Perasan Daging Buah Alpukat (*Persea americana* Mill.) terhadap Pertumbuhan Bakteri *Staphylococcus aureus*. *e-GiGi*, *6*(1). DOI: https://doi.org/10.35790/eg.6.1.2018.19653

Mukti, R. C., Amin, M., & Sari, M. I. (2020). Kandungan Nutrisi dan Aktivitas Antioksidan Daun Nipah (*Nypa Fruticans* Wurmb) sebagai Bahan Pakan Ikan Nutrition Conten and Antioxidant Activities ff Nipah Leaves (*Nypa Fruticans* Wurmb) As Aquafeed.

Muqowwiyah, L. Z., & Dewi, R. K. (2021). Potensi Ekstrak Daun Alpukat Sebagai Anti Kolesterol. *Jurnal Tadris IPA Indonesia*, *1*(3), 403-412. DOI: https://doi.org/10.21154/jtii.v1i3.397

Novianti, N., Umar, N. A., & Budi, S. (2022). Pengaruh Berbagai Konsentrasi Anggur Laut *Caulerfa Lentillirea* pada Pakan Terhadap Pertumbuhan Ikan Nila. *Journal of Aquaculture and Environment*, *4*(2), 45-49. DOI: 10.35965/jae.v4i2.1523

Novianty, N. U. (2021). Pengaruh Pemberian Daun Mimba (*Azadirachta indica* Juss.) Tumbuk Terhadap Pengerutan Luka Ikan Zebra.

Pamungkas, W. T., & Wahyuningsih, S. S. (2022). Efek Pemberian Ekstrak Etanol Daun Alpukat (*Persea americana* Mill) Terhadap Penyembuhan Luka Bakar Pada Kelinci (*Oryctolagus Cunicullus*). *Indonesian Journal On Medical Science*, *9*(1), 33-39. https://doi.org/10.55181/ijms.v9i1.348

Pramono, T. B., Marnani, S., Junaidi, T., Setyawan, A. C., Nasikhah, A. L., & Wulan, T. S. (2023). Ramuan Jamu Herbal pada pakan Terhadap Performa Pertumbuhan Ikan Nila (*Oreochromis* sp). *Lempuk: Jurnal Ilmu Kelautan dan Perikanan*, *2*(2), 11-15.

Rossi, A. S., Fantón, N., Michlig, M. P., Repetti, M. R., & Cazenave, J. (2020). Fish Inhabiting Rice Fields: Bioaccumulation, Oxidative Stress and Neurotoxic Effects After Pesticides Application. *Ecological Indicators*, *113*, 106186. https://doi.org/10.1016/j.ecolind.2020.106186

Seixas Filho, J. T., Mello, D. D. S., Mello, S. C. R. P., Dias, G. E. A., Pinto, E. D. C., Silva, W. N., & Pereira, M. M. (2022). Performance of Bullfrog Tadpoles (*Lithobates Catesbeianus*) Fed Balanced Diets Using Alternative Energy Ingredients Containing Vegetable Mesocarp. *Revista Brasileira de Saúde e Produção Animal*, *23*, e2122312021. http://dx.doi.org/10.1590/S1519-99402122312022

Statiatik KKP (2024, online). Data Volume Produksi Perikanan Tangkap dan Perikanan Budidaya Menurut Komoditas Utama.

Sufliarmi, S. (2022). Pengaruh Perendaman Ekstrak Etanol Daun Senduduk Bulu *(Clidemia hirta)* untuk Pengobatan Infeksi Jamur *Saprolegnia* sp. pada Benih Ikan Gurami *(Osphronemus Gouramy)* (*Doctoral dissertation*, Universitas Islam Riau).

Syed, R., Masood, Z., Hassan, H. U., Khan, W., Mushtaq, S., Ali, A., ... & Ullah, A. (2022). Growth Performance, Haematological Assessment and Chemical Composition of Nile Tilapia, *Oreochromis niloticus* (Linnaeus, 1758) Fed Different Levels of *Aloe Vera* Extract as Feed Additives in A Closed Aquaculture System. *Saudi journal of biological sciences*, *29*(1), 296-303. https://doi.org/10.1016/j.sjbs.2021.08.098

Ta'dung, R., Tumbol, R. A., Mudeng, J. D., Sinjal, H. J., & Lumenta, C. (2023). Pemanfaatan Ekstrak Daun Miana (*Coleus atropurpureus* L.(Bent)) untuk Meningkatkan Respon Imun Benih Ikan Nila (*Oreochromis niloticus*). *e-Journal Budidaya Perairan*, *11*(2), 90-97. DOI: https://doi.org/10.35800/bdp.v11i2.47719

Ukwe, I. O. K., & Abu, O. M. G. (2021). Effect of Dietary *Persea americana* on the Organosomatic Indices, Diseases Resistance and Liver Histopathlology of *Clarias gariepinus* Expose to *Klebsiella pneumoniae*. *Asian Journal of Fisheries and Aquatic Research*, *15*(6), 148-156. DOI: 10.9734/AJFAR/2021/v15i630360

Ukwe, I. O., & Etire, D. I. (2021). The Effects of *Persea americana* Leaves on the Enzymes and Organosomatic Indices of *Pseudomonas aeruginosa* Infect *Clarias gariepinus*. *Journal of Medical Care Research and Review*, *4*(07), 1067-1078.

Ukwe, I. O. K., & Deekae, S. N. (2022). Phytochemcial Assessment of *Persea americana* Powdered Leaves and Its Potency in Protecting *Clarias gariepinus* Against *Klebsiella pneumonia*. DOI: 10.9734/AJFAR/2022/v16i630387

United Nations (UN), Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP/248

Utari, U. (2023). Aktivitas Antibakteri Ekstrak Etanol Kulit Buah Alpukat *(Persea americana* Mill*)* Terhadap Bakteri *Bacillus cereus* (*Doctoral dissertation*, Universitas Islam Negeri Ar-Raniry).

Wulansari, D., Sulmartiwi, L., & Alamsjah, M. A. (2020, February). The use of Mangrove Leaves Flour *Avicenia rumphiana* as Antioxidant Feed Additive in Commercial Feed

Towards Growth and Survival Rate of Nile tilapia Fry *Oreochromis niloticus*. In *IOP Conference Series: Earth and Environmental Science* (Vol. 441, No. 1, p. 012048). IOP Publishing. DOI 10.1088/1755-1315/441/1/012048

Yadav, M., Khati, A., Chauhan, R., Arya, P., & Semwal, A. (2021). A Review on Feed Additives Used in Fish Diet. *Int. J. Environ. Agric. Biotechnol*, *6*(2), 184-190. https://dx.doi.org/10.22161/ijeab.62.21

Yılmaz, S., Ergün, S., Yiğit, M., & Yılmaz, E. (2022). An Extensive Review on The Use of Feed Additives Against Fish Diseases and Improvement of Health Status of Fish in Turkish Aquaculture Sector. *Aquaculture Studies*, *22*(3). http://doi.org/10.4194/AQUAST710

Yunus, Y. E. (2023). Respon Pertumbuhan dan Glukosa Darah Ikan Nila yang Diberi Pakan dengan Penambahan Tepung Daun Pepaya (*Carica papaya* L.). *Techno-Fish*, *7*(2), 142-155. https://doi.org/10.25139/tf.v7i2.6774