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THE EFFECT OF LOW-DOSE MOLASSES ADDITION ON WATER QUALITY AND BIOFLOCK FORMATION IN CATFISH *(Clarias gariepinus)* CULTURE

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ABSTRACT

Biofloc technology utilizes heterotrophic bacteria to control waste by adding organic carbon sources. The addition of organic carbon sources is based on the feed-to-carbon ratio. This study aims to evaluate the effect of adding low doses of molasses to a biofloc system on water quality and floc formation in catfish farming. The study used a Completely Randomized Design (CRD) with four treatments: no molasses (control), 5%, 10%, and 15% molasses, each with three replicates. The results showed that molasses addition had no significant ($P > 0.05$) effect on water quality and floc volume. Parameters such as temperature, pH, TSS, TAN, nitrite, and nitrate remained relatively stable across all treatments, while floc volume at 5%, 10%, and 15% molasses was relatively similar. Thus, the use of 5% molasses is recommended as the most efficient dose because it produces water quality and floc formation conditions equivalent to higher doses. The presence of plankton in the rearing medium and the fish intestines indicates that the flocs have the potential to be utilized as natural feed by catfish.

KEYWORDS: Biofloc; catfish; floc consumption; floc volume ;water quality

ABSTRAK

Teknologi bioflok memanfaatkan bakteri heterotrof untuk mengontrol limbah dengan menambahkan sumber karbon organik. Penambahan sumber karbon organik berdasarkan rasio pakan dan karbon. Penelitian ini bertujuan mengevaluasi pengaruh penambahan molase dosis rendah pada sistem bioflok terhadap kualitas air dan pembentukan flok pada budidaya ikan lele. Penelitian menggunakan Rancangan Acak Lengkap (RAL) dengan 4 perlakuan, yaitu tanpa molase (kontrol), molase 5%, 10%, dan 15%, masing-masing 3 ulangan. Hasil penelitian menunjukkan penambahan molase tidak memberikan pengaruh nyata terhadap kualitas air dan volume flok. Parameter suhu, pH, TSS, TAN, nitrit, dan nitrat relatif stabil pada seluruh perlakuan, sedangkan volume flok pada molase 5%, 10%, dan 15% relatif sama. Dengan demikian, penggunaan molase 5% direkomendasikan sebagai dosis paling efisien karena menghasilkan kondisi kualitas air dan pembentukan flok yang setara dengan dosis lebih tinggi. Keberadaan plankton dalam media pemeliharaan dan usus ikan menunjukkan flok berpotensi dimanfaatkan sebagai pakan alami oleh ikan lele.

KATA KUNCI : Bioflok; ikan lele; kualitas air; konsumsi flok; volume flok*(Footnotes)*

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INTRODUCTION

Catfish is a freshwater fish species with significant potential for development due to its high popularity among the public. Catfish accounted for approximately 15% of the total national aquaculture output in 2020, with a volume of 1.01 million tons (Subhan *et al.*, 2025). Catfish have relatively rapid growth and are highly tolerant of various water quality conditions and culture environments (Apriyani, 2017). Catfish production continues to be carried out and improved. Intensification through increased stocking density is one of the alternatives chosen to boost catfish production.

Intensification has negative impacts, such as an increase in the use of commercial feed. The accumulation of organic resulting from metabolic waste and uneaten feed residues causes pollution and degrades the quality of aquaculture water (Aziz & Oktaviana, 2021). If organic waste accumulation is not properly managed, it can become a serious problem for aquaculture farmers. Biofloc technology can serve as an alternative because it improves water quality, contributes to enhanced biosecurity, increases water use efficiency, and reduces aquaculture waste, making it suitable for supporting the development of sustainable intensive aquaculture (Aboseif *et al.,* 2022; Kumar *et al.,* 2022).

Biofloc technology is a sustainable aquaculture technology that works by utilizing the in situ mass production of microorganisms within the aquatic system (Ogello *et al.,* 2021). In this context, inorganic nitrogen concentrations in the water can be controlled, while the resulting microbial biomass may serve as an additional feed source for fish (Fujiana *et al.,* 2020). The addition of organic carbon sources such as molasses, wheat flour, and tapioca flour is carried out to balance the C/N ratio to stimulate the growth of heterotrophic bacteria in biofloc technology (Dauda, 2020; Li *et al.,* 2019). The optimal C/N ratio that must be achieved in biofloc technology ranges from 10:1 to 25:1 (Dauda *et al.,* 2018; Yu *et al.,* 2020).

The use of molasses in tilapia (Oreochromis niloticus) aquaculture using biofloc technology, as conducted by (Pérez-Fuentes *et al.,* 2016), indicates that a C/N ratio of 10:1 is optimal, research on catfish conducted by Saha *et al.* (2022) indicates that a C/N ratio of 15:1 is the best, while Imron *et al.* (2014) reported that a C/N ratio of 24:1 yields the best results. Based on these studies, the optimal C/N ratio for biofloc technology shows varying results. Research examining the use of low-dose molasses without reducing the effectiveness of biofloc formation remains limited. Furthermore, there are few studies on the extent to which reducing the molasses dose can still maintain water quality and aquaculture performance; therefore, research is needed on strategies for using molasses that are more economical, efficient, and easy for aquaculturists to implement.

The addition of low-dose molasses is believed to be capable of maintaining water quality and efficiently enhancing floc formation. Therefore, this study was conducted by adding molasses at low doses, with the administration procedure based on the percentage ratio of feed to carbon source. The carbon source was adding while maintaining the optimal C/N ratio for floc formation, with a minimum C/N ratio of 10:1 (Ahmad *et al.,* 2017; Terkula *et al.,* 2025). This study was conducted to analyze the effect of administering low doses of molasses in varying amounts on water quality as well as floc volume and consumption.

MATERIALS AND METHODS

This study was conducted over a period of 49 days from December 2023 to February 2024 at the Indoor Hatchery of the Bogor Campus of the Polytechnic of Fisheries Business, located at Jl. Cikaret No. 2, South Bogor District, Bogor City, West Java Province. The study employed a completely randomized design (CRD) with three treatments and one control, each with three replicates. The control treatment was without molasses (TM), the M5 treatment (5% molasses of the daily feed amount), the M10 treatment (10% molasses of the daily feed amount), and the M15 treatment (15% molasses of the daily feed amount). The ponds sed in this study were concrete tanks measuring 1.5×1.0 m^2 with a water depth of 55 cm. Each experimental ponds was aerated at a single point. The African catfish used measured 7.67 ± 0.08 cm in length and weighed 6.24 ± 0.14 g. A total of 206 fingerlings were stocked in each tank at a stocking density of 250 fingerlings/m^3. The fish were fed a commercial feed containing 31% protein, 5% fat, 8% fiber, 13% ash, and 12% moisture, at a feeding rate of 4% of biomass per day. Feeding frequency was twice daily. Molasses (100 mL/L) and probiotics (20 g/m^3) were added at the start of the rearing period. The probiotic used was Pro Flok Probiotic Powder, containing a mix of *Lactobacillus* sp., *Nitrobacter* sp., *Bacillus* sp., *Bacillus megaterium*, *Bacillus polymyxa*, and *Rhodobacter*. Subsequently, molasses is added to the rearing medium every 5 days. Sampling is conducted every 10 days on 10% of the stocked fingerlings. Water changes in the molasses-free ponds are performed every 7 days, replacing 50% of the total water volume to maintain stable water quality and ensure fish survival.

Water Quality and Floc Volume

Temperature and pH are measured directly every day using a 7-in-1 digital water quality meter *(pen-type)*, and dissolved oxygen is measured using a DO-

9100 *Backlight* Digital *Dissolved Oxygen* Meter. Total Suspended Solids (TSS), Total Ammonia Nitrogen (TAN), nitrite, and nitrate were measured at the Aquaculture Environmental Laboratory of the Department of Aquaculture, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB) at the beginning and end of the rearing period. The TSS measurement method was based on APHA, ed. 21, 2005, 2540-D, TAN based on APHA, 21st ed., 2005, 4500-NH3-F, nitrite based on APHA, 21st ed., 2005, 4500-NO2-B, and nitrate based on APHA, 21st ed., 2005, 4500-NO3-E.

Floc volume is measured every 10 days using an *Imhoff* cone. The measurement is performed by allowing 1 liter of the water sample to settle for 20 minutes in an *Imhoff* cone. The floc sedimentation value can be observed in the *Imhoff* cone used (Avnimelech, 2015).

Floc Consumption

Floc consumption was assessed by identifying plankton species in the rearing water and fish intestines using a method based on Sachlan (1982). Plankton identification in the rearing water was conducted at the end of the rearing period by collecting 10 L of water samples from each experimental tank, which were then filtered using a 25 μm mesh plankton net until a final volume of 50 mL was obtained. The samples were then examined at the Fisheries Technology Laboratory of the AUP Polytechnic, Bogor Campus.

Plankton identification in the fish digestive tract was conducted at the end of the study through gut content analysis. The test fish were dissected at the abdominal region; the intestines were then removed in their entirety, washed, and placed in a petri dish. The intestinal samples were subsequently homogenized, then collected using a pipette and observed using an Optilab digital microscope. The observation results were displayed directly on a computer monitor for the plankton species identification process.

Data Analysis

The data obtained in this study were processed using SPSS 25 software. The analysis used was analysis of variance (ANOVA) at a 95% confidence level. If the analysis results indicated significant differences between treatments, Duncan's test was performed to determine the best treatment.

RESULTS AND DISCUSSIONS

Water Quality

The average results of the water quality measurements conducted in this study are presented in Table 1.

The temperature and pH values for all treatments in this study did not differ significantly ($P > 0.05$) and remained within the tolerance limits for the survival and growth of catfish. According to SNI 6848-5:2022, the optimal temperature for catfish cultivation to grow and develop well is 20–30°C, with a pH of 6.5–8. Temperature is one of the environmental factors influencing metabolism and the stability of the microbial community in the biofloc system. The relatively stable temperature range in this study, 25.66 ± 0.60 – 25.72 ± 0.61°C, supports the activity of floc-forming bacteria and maintains the efficiency of the biofloc system (Ahmad *et al.,* 2017; Emerenciano *et al.,* 2023). The relatively stable pH range of the study, namely 6.96 ± 0.06 – 6.99 ± 0.10, supports the maintenance of ammonia stability and facilitates nitrogen degradation by microorganisms (Emerenciano *et al.,* 2023). The use of 5% molasses proved to be the most efficient dose because it was able to produce water quality and natural feed formation comparable to higher doses but with a lower risk of environmental imbalance

The dissolved oxygen levels in this study differed significantly ($P < 0.05$) among treatments, with each remaining within the optimal range. According to SNI 6848-5:2022, a minimum dissolved oxygen level of 2 mg/L is the optimal threshold for supporting the survival of catfish. The results showed that the control treatment (TM) had the highest dissolved oxygen level, at 4.66 ± 0.14 mg/L was the best and significantly different ($P < 0.05$) compared to all biofloc treatments (M5, M10, and M15). The decrease in DO levels in ponds with molasses addition was caused by high oxygen consumption by heterotrophic bacteria for metabolism and nitrogen assimilation (Emerenciano *et al.,* 2023). These results are consistent with Kaya *et al.* (2019), which reported that the biofloc system has a higher respiration rate compared to the control pond due to microbial activity in the accumulation of suspended solids.

Treatment M5 showed the highest dissolved oxygen value among the treatments with molasses addition, namely 4.08 ± 0.10 mg/L. Increasing the molasses dose to 10% and 15% caused DO levels to decrease, with the lowest value observed in treatment M15 at 3.95 ± 0.10 mg/L. This indicates that adding higher amounts of molasses increases the activity and respiration of heterotrophic bacteria, thereby increasing oxygen consumption in the culture medium. However, this increase in dosage did not provide significant additional benefits for other water quality parameters. Therefore, the use of 5% molasses is considered more optimal and efficient because it supports the formation of bioflocs with adequate

Table1 . Water quality parameters during catfish (Clarias gariepinus) cultivation in the biofloc system

Parameter	Treatment				Optimal Standard	References
	TM	M5	M10	M15		
Temperature (°C)	25.66 ± 0.60[a]	25.66 ± 0.60[a]	25.72 ± 0.61[a]	25.67 ± 0.60[a]	20 – 30	(SNI 6848-5:2022)
pH	6.97 ± 0.05[a]	6.96 ± 0.06[a]	6.99 ± 0.1[a]	6.99 ± 0.08[a]	6.5 – 8.5	(SNI 6848-5:2022)
DO (mg/L)	4.66 ± 0.14[b]	4.08 ± 0.10[a]	4.03 ± 0.09[a]	3.95 ± 0.10[a]	Min 2 mg/L	(SNI 6848-5:2022)
TSS (mg/L)	188.7 ± 123.8[a]	384.7 ± 196.3[a]	254 ± 43.86[a]	313.3 ± 109.7[a]	600–800 mg/L	(Avnimelech, 2015)
TAN (mg/L)	0.71 ± 0.27[a]	1.05 ± 0.26[a]	0.97 ± 0.27[a]	1.00 ± 0.21[a]	<1 mg/L	(Hargreaves, 2013)
Nitrite (mg/L)	0.42 ± 0.04[a]	0.39 ± 0.21[a]	0.46 ± 0.02[a]	0.51 ± 0.06[a]	<0.5 mg/L	(Hargreaves, 2013)
Nitrate (mg/L)	2.57 ± 0.25[a]	2.75 ± 0.21[a]	2.79 ± 0.13[a]	2.31 ± 0.52[a]	<50–100 mg/L	(Avnimelech, 2015)

Note: TM = without molasses; M5 = 5% molasses; M10 = 10% molasses; M15 = 15% molasses. Values with different superscripts in the same column indicate statistically significant differences ($P < 0.05$).

volume and maintains better dissolved oxygen availability for catfish.

The TSS levels in this study showed no significant difference ($P > 0.05$) and remained within the limits tolerable by catfish. According to Avnimelech (2015), the optimal TSS range is 600–800 mg/L. The results showed that TSS levels in all molasses treatments (M5, M10, M15) were higher than in the control (TM), confirming that the addition of a carbon source stimulates the growth of heterotrophic microorganisms. In accordance with the explanation at that TSS is not merely residual solids, but rather a physical representation of an active microbial community consisting of bacteria, fungi, protozoa, and phytoplankton. The TSS concentration in the M5 treatment (384.7 ± 196.3 mg/L) was higher than in M10 and M15, although the difference was not statistically significant, indicating that a 5% molasses dose is sufficient to stimulate optimal biofloc formation This supports the suggestion that the use of low-dose molasses is more cost-effective without reducing the concentration of the formed biofloc mass. The relatively stable TSS concentration across all molasses doses also confirms the theory that the level of suspended solids in the biofloc system is not significantly correlated with C/N ratio fluctuations, as stated by W. J. Xu *et al.* (2016).

The TAN, nitrite, and nitrate levels in this study did not differ significantly ($P > 0.05$) among treatments, with values remaining within the tolerance limits for fish survival. Optimal TAN levels are <1 mg/L and nitrite levels are <0.5 mg/L (Hargreaves, 2013). The fact that nitrogen levels in the biofloc pond (without water exchange) were equivalent to those in the control pond (TM), which had 50% water changes weekly, demonstrates that this technology functions as a highly effective wastewater treatment bioreactor. Water changes in the control treatment were performed to maintain stable water quality. A similar finding was reported by Rind *et al.* (2023), which implemented a 30% water change in the control treatment as an effort to reduce the concentration of dissolved nitrogen in the culture medium.

Treatment M5 (5% molasses) was deemed more optimal because it was able to assimilate inorganic nitrogen with an effectiveness comparable to the routine water exchange method in the control pond and was able to maintain TAN, nitrite, and nitrate levels within a range equivalent to the 10% and 15% doses. Higher molasses doses did not provide significant additional improvements in nitrogen control; thus, the use of 5% molasses is more efficient in supporting biofloc microbial activity while minimizing carbon input. This indicates that a 5% dose is sufficient to optimize the nitrogen assimilation process and maintain water quality in biofloc catfish farming.

Floc Volume

Floc volume showed statistically significant differences ($P < 0.05$), with values tending to increase from the beginning to the end of the cultivation period (Table 2). At the end of the cultivation period, the M15 treatment produced the highest floc volume, followed by M10, M5, and TM. These results indicate that an increase in molasses dosage is directly proportional to an increase in floc volume, as the

Table 2 Average volume of biofloc in catfish (Clarias gariepinus) cultivation in the biofloc system

Day	Treatment			
	TM	M5%	M10%	M15%
10	0±0	$7.67{\pm}1.15^{b}$	$8.67{\pm}5.50^{b}$	$11.67{\pm}1.52^{b}$
20	$0.67{\pm}0.15^{a}$	11.33 ± 2.88^{b}	13.33 ± 4.50^{b}	20 ± 2.00^{c}
30	1.17 ± 0.05^{a}	21.67 ± 5.77^{b}	21 ± 3.00^{b}	37.33 ± 2.51^{c}
40	2.43 ± 0.32^{a}	29.33 ± 11.0^{b}	30.67 ± 8.14^{b}	44.67 ± 9.92^{b}

Note: TM = without molasses; M5 = 5% molasses; M10 = 10% molasses; M15 = 15% molasses. Values with different superscripts in the same column indicate statistically significant differences ($P < 0.05$).

addition of a carbon source supports the growth of heterotrophic bacteria in assimilating inorganic nitrogen and forming biofloc aggregates (Dauda *et al.,* 2018; Xu *et al,*, 2012). Greater carbon availability may enhance microbial biomass formation and suspended solid accumulation (Manik *et al.,* 2018).

The M15 treatment produced the highest floc volume, but was accompanied by a downward trend in dissolved oxygen levels. The M5 treatment was able to produce an adequate floc volume from the beginning to the end of the cultivation period, with a value of 29.33 ± 11.0 mL/L on day 40, while maintaining water quality within the optimal range. This indicates that the addition of 5% molasses is sufficient to support biofloc formation without excessively increasing the organic load and oxygen demand. Thus, the use of 5% molasses is considered more efficient because it is capable of producing an adequate amount of biofloc with more stable water quality. These results indicate that the optimization of the biofloc system is determined not only by high floc volume but also by the balance between floc formation and the stability of the culture environment.

Biofloc Consumption

Plankton is one of the organisms that make up biofloc. Biofloc consumption in this study was assessed by identifying plankton in the culture medium and fish intestines. The plankton identified in this study are listed in Table 3 (Fig. 1).

Plankton identification indicated that the addition of molasses as a carbon source increased microbial diversity in the aquaculture system (Ahmad *et al.,* 2017). In the control treatment (TM), plankton diversity was limited to seven species in the water and four pecies in the gut, dominated solely by phytoplankton of the classes *Cyanophyta* and *Diatomae.* In contrast, in the biofloc ponds, much higher diversity was found, namely 10 – 12 species in the water and 6 – 8 species in the fish gut. This confirms that proper regulation of the C/N ratio through molasses has a significant effect on species richness and microbial abundance, both in the aquatic environment and within the gut of the biota. This aligns with study by Xu *et al.* (2022), which states that the C/N ratio has a significant influence on the diversity and abundance of microorganisms in the water and the gut of biota in biofloc systems.

The presence of zooplankton from the *Rotifera* and *Ciliata* classes in the molasses-treated groups (M5, M10, M15) indicates the formation of a more complex and mature microbial food web compared to conventional ponds. The emergence of these higher-order microorganisms aligns with the findings of Hosain *et al.* (2021), which states that biofloc components consist not only of bacteria but also include *Ciliates* and *Rotifers* that serve as high-protein natural feed.

The addition of 5% molasses (M5) appeared to be the most efficient strategy for creating a biofloc ecosystem rich in plankton biodiversity. The M5 treatment produced sufficient diversity (ten plankton species in the water and six species in the gut) to serve as a natural supplementary feed for catfish. Increasing the dose to 10% or 15% did not significantly improve water quality or markedly increase plankton diversity; therefore, the use of 5% molasses is recommended because it provides equivalent functional results at a lower raw material cost.

CONCLUSIONS

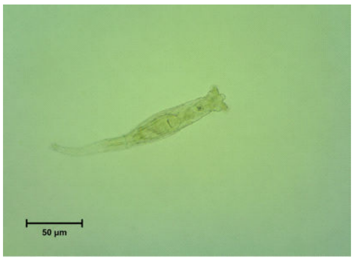
The addition of 5% molasses is effective in maintaining water quality and supporting biofloc formation, yielding results that are relatively comparable to those achieved with 10% and 15% doses. Although increasing the molasses dose produces a higher floc volume, the 5% molasses treatment is considered more efficient because it maintains water quality parameters such as temperature, pH, DO, TAN, nitrite, and nitrate within optimal ranges without excessively increasing microbial respiratory load. Thus, the 5% molasses treatment can be recommended as a more optimal and sustainable dose for catfish farming in biofloc systems.

RECOMMENDATIONS

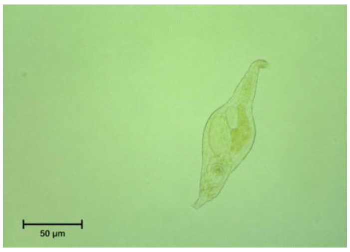
In this study, floc consumption was identified by

Table 3. Results of Plankton Species Identification

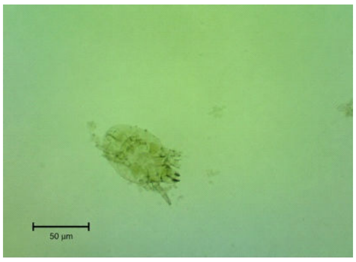
Treatment	Plankton Species in Water	Plankton Species in the Intestines
TM	*Microcystus aeruginosa Kuta, Microcystus flosaqua Kirch, Anabaena circularis Wal, Nitzschia curvula, Synedra acus, Asterionella formosa, Synura uvella Ehrbg,*	*Microcystus flosaqua Kirch, Cyclotella operculata, Nitzschia curvula, Synedra acus,*
M5	*Microcystus aeruginosa Kuta, Microcystus flosaqua Kirch, Anabaena circularis Wal, Gloeotrica echinulata Smith, Cyclotella operculata, Ceratium extensum, Paramecium sp., Rotifer citrinus, Synchaeta kitin, Noteus militaris*	*Microcystus aeruginosa Kuta, Gloeotrica echinulata Smith, Anabaena circularis Wal, Cyclotella operculata, Ceratium extensum, Rotifer citrinus,*
M10	*Microcystus aeruginosa Kuta, Microcystus flosaqua Kirch, Coelosphaerium dubium Gronow, Gloeotrica echinulata Smith, Eudorina wallichii Turner, Paramecium sp., Frontaria sp., Ciliate, Lacrymaria sp., Rotifer citrinus*	*Microcystus aeruginosa Kuta, Microcystus flosaqua Kirch, Gloeotrica echinulata Smith, Eudorina wallichii Turner, Lacrymaria sp., Rotifer citrinus*
M15	*Microcystus aeruginosa Kuta, Microcystus flosaqua Kirch, Anabaenopsis raciborskii Wal, Eudorina wallichii Turner, Cyclotella operculata, Nitzschia curvula, Netrium digitum Ehrbg, Euglena acus Ehrbg, Ciliate., Frontaria sp., Lacrymaria sp., Rotifer citrinus*	*Microcystus flosaqua Kirch, Anabaenopsis raciborskii Wal, Cyclotella operculata, Nitzschia curvula, Netrium digitus Ehrbg, Lacrymaria sp., Ciliate, Rotifer citrinus,*



Rotifera



Rotifera



Ciliatas

Diatom pennate
(phytoplankton)

Figure 1. Microscopic observation of microorganisms identified in the biofloc system.

comparing the types of plankton in the rearing water and the fish intestines; however, bacteria are another major component of bioflocs. Therefore, the types and abundance of bacteria need to be examined in future research.

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REFERENCES

Aboseif, A. M., Flefil, N. S., Taha, M. K. S., Tahoun, U. M., Mola, H. R. A., El-haroun, E., Doan, H. Van, & Goda, A. M. S. (2022). Influence of Dietary C/ : N/ : P Ratios On Nile Tilapia Oreochromis Niloticus Growth Performance and Formation of Water Biotic

Communities Within A Biofloc System Containment. *Aquaculture Reports*, *24*(January), 101136. https://doi.org/10.1016/j.aqrep.2022.101136

Ahmad, I., Babitha Rani, A. M., Verma, A. K., & Maqsood, M. (2017). Biofloc technology: an emerging avenue in aquatic animal healthcare and nutrition. *Aquaculture International*, *25*(3), 1215–1226. https://doi.org/10.1007/s10499-016-0108-8

Apriyani, I. (2017). *Budidaya Ikan Lele Sistem Bioflok/ : Teknik Pembesaran Ikan Lele Sistem Bioflok Kelola Mina Pembudidaya* (Edisi/ ! Ce). Deepublish.

Avnimelech, Y. (2015). *Biofloc Technology, A Practical Guidebook, third ed.* World Aquaculture Society.

Aziz, R., & Oktaviana, A. (2021). Application of Carbon and Nitrogen Ratio in the Sangkuriang Catfish Culture Clarias gariepinus var in Tarpaulin Tanks. *IOP Conference Series: Earth and Environmental Science*, *1012*(1). https://doi.org/10.1088/1755-1315/1012/1/012017

Dauda, A. B. (2020). Biofloc technology: a review on the microbial interactions, operational parameters and implications to disease and health management of cultured aquatic animals. *Reviews in Aquaculture*, *12*(2), 1193–1210.

Dauda, A. B., Romano, N., Ebrahimi, M., Teh, J. C., Ajadi, A., Chong, C. M., Karim, M., Natrah, I., & Kamarudin, M. S. (2018). Influence of carbon/nitrogen ratios on biofloc production and biochemical composition and subsequent effects on the growth, physiological status and disease resistance of African catfish (Clarias gariepinus) cultured in glycerol-based biofloc systems. *Aquaculture*, *483*, 120–130.

Emerenciano, M. G. C., Martinez-Cordova, L. R., Miranda-Baeza, A., Pinho, S. M., Garibay-Valdez, E., & Martínez-Porchas, M. (2023). Advancing toward a more integrated aquaculture with polyculture, aquaponics, biofloc technology , FLOCponics. *Aquaculture International*, *31*(2), 1057–1076.

Fujiana, F., Setyowati, D. N., & Setyono, B. D. H. (2020). Budidaya Ikan Patin (Pangasius Hypopthalmus) Berbasis Bioflok Dengan Penambahan Molase Pada Ratio C/ : N Berbeda. *Jurnal Perikanan Unram*, *10*(2), 148–157. https://doi.org/10.29303/jp.v10i2.203

Hargreaves, J. A. (2013). *Biofloc production systems for aquaculture.*

Hosain, M. E., Amin, S. M. N., Arshad, A., Kamarudin, M. S., & Karim, M. (2021). Effects of carbon sources on the culture of giant river prawn in biofloc system during nursery phase. *Aquaculture Reports*, *19*, 100607. https://doi.org/10.1016/j.aqrep.2021.100607

Imron, A., Sudaryono, A., & Harwanto, D. (2014). Pengaruh rasio C/N berbeda terhadap rasio konversi pakan dan pertumbuhan benih lele (Clarias sp.) dalam media bioflok. *Aquaculture Management and Technology*, *3*(3), 69–74. http://ejournal-s1.undip.ac.id/index.php/jamt

Kaya, D., Genc, M. A., Aktas, M., Yavuzcan, H., Ozmen, O., & Genc, E. (2019). Effect of biofloc technology on growth of speckled shrimp, Metapenaeus monoceros (Fabricus) in different feeding regimes. *Aquaculture Research*, *50*(10), 2760–2768. https://doi.org/10.1111/are.14228

Kumar, V., Roy, S., Meena, D. K., & Sarkar, U. K. (2022). Application of biofloc technology in aquaculture: Opportunities and challenges. *Journal of Cleaner Production*.

Li, J., Li, J., Li, W., Sun, Y., Liu, X., Liu, M., & Cheng, Y. (2019). Juvenile Procambarus clarkii farmed using biofloc technology or commercial feed in zero-water exchange indoor tanks: A comparison of growth performance, enzyme activity and proximate composition. *Aquaculture Research*, *50*(7), 1834–1843. https://doi.org/https://doi.org/10.1111/are.14065

Manik, R. A., Rusliadi, & Putra, I. (2018). *Pengaruh Penambahan Sumber Karbon Molase Dengan Dosis Berbeda Pada Sistem Bioflok Terhadap Pertumbuhan dan Kelulushidupan Ikan Nila Merah (Oreochromis sp) Pada Media Air Payau*. 1–26.

Ogello, E. O., Outa, N. O., Obiero, K. O., Kyule, D. N., & Munguti, J. M. (2021). The prospects of biofloc technology (BFT) for sustainable aquaculture development. *Scientific African*, *14*, e01053. https://doi.org/10.1016/j.sciaf.2021.e01053

Pérez-Fuentes, J. A., Hernández-Vergara, M. P., Pérez-Rostro, C. I., & Fogel, I. (2016). C:N ratios affect nitrogen removal and production of Nile tilapia Oreochromis niloticus raised in a biofloc system under high density cultivation. *Aquaculture*, *452*, 247–251. https://doi.org/10.1016/j.aquaculture.2015.11.010

Rind, K. H., Habib, S. S., Ujan, J. A., Fazio, F., Naz, S., Batool, A. I., Ullah, M., Attaullah, S., Khayyam, K., & Khan, K. (2023). The Effects of Different Carbon Sources on Water Quality, Growth Performance, Hematology, Immune, and Antioxidant Status in Cultured Nile Tilapia with Biofloc Technology. *Fishes*, *8*(10). https://doi.org/10.3390/fishes8100512

Saha, J., Hossain, M. A., Mamun, M. Al, Islam, M. R., & Alam, M. S. (2022). Effects of carbon-nitrogen ratio manipulation on the growth performance, body composition and immunity of stinging catfish Heteropneustes fossilis in a biofloc-based culture system. *Aquaculture Reports*, *25*(July), 101274. https://doi.org/10.1016/j.aqrep.2022.101274

Subhan, U., Afriza, A. R., Maulina, I., & Herman, R. G. (2025). Kondisi Faktor Dan Keragaman Ukuran Benih Ikan Lele Pada Pemeliharaan Super Intensif Dalam Sistem UFBs-RAS. *Jurnal Teknologi Perikanan Dan Kelautan*, *Vol 16 No 4 (2025): NOVEMBER 2025*, 351–359. https://journal.ipb.ac.id/jtpk/article/view/62075/31861

Terkula, B., Chiaaondo, B., Nazli, M., Nor, M., Rozaimah, S., Abdullah, S., Shukri, M., Shafie, B., Manan, H., Ikhwanudin, M. H. D., & Azman, N. (2025). Application of Biofloc technology in shrimp aquaculture/ : A review on current practices , challenges , and future perspectives. *Journal of Agriculture and Food Research*, *19*(January), 101675. https://doi.org/10.1016/j.jafr.2025.101675

Xu, W. J., Morris, T. C., & Samocha, T. M. (2016). Effects of C/N ratio on biofloc development, water quality, and performance of Litopenaeus vannamei juveniles in a biofloc-based, high-density, zero-exchange, outdoor tank system. *Aquaculture*, *453*, 169–175. https://doi.org/10.1016/j.aquaculture.2015.11.021

Xu, W. J., & Pan, L. Q. (2012). Effects of bioflocs on growth performance, digestive enzyme activity and body composition of juvenile Litopenaeus vannamei in zero-water exchange tanks manipulating C/N ratio in feed. *Aquaculture*, *356–357*, 147–152. https://doi.org/https://doi.org/10.1016/j.aquaculture.2012.05.022

Xu, W., Wen, G., Su, H., Xu, Y., Hu, X., & Cao, Y. (2022). *Effect of Input C / N Ratio on Bacterial Community of Water Biofloc and Shrimp Gut in a Commercial Zero-Exchange System with Intensive Production of Penaeus vannamei*.

Yu, Z., Li, L., Zhu, R., Li, M., & Wu, L.-F. (2020). Effects of bioflocs with different C/N ratios on growth, immunological parameters, antioxidants and culture water quality in Opsariichthys kaopingensis Dybowski. *Aquaculture Research*, *51*(2), 805–815. https://doi.org/https://doi.org/10.1111/are.14430

