AJFA | Assyfa Journal of Farming and Agriculture

Assyfa Journal of Farming and Agriculture, vol. 1(2), pp. 06-77, 2024
Received 20 February 2024 / published 17 May 2024
ISSN: 3062-8393

Tiger Grouper seeds "infected" with parasites: Obstacles and Impacts

Totok Hendarto [1], Herman Dhakal [2], and Sharma Labh [3]

1. *Dr. Soetomo University Surabaya, Indonesia*
2. *University of Jambi, Land of Mendalo, Indonesia*
3. *Agriculture and Forestry University (AFU) Rampur, Chitwan, Nepal*

E-mail correspondence: ***hendarto@unitomo.ac.id***

Abstract

The future significance of mariculture development in Indonesia lies in its potential to enhance the growth of the fisheries subsector. The fisheries subsector is anticipated to prioritize and serve as a potential catalyst for economic expansion. The cultivation of tiger grouper among marine fish exhibits significant potential for advancement. Nevertheless, the primary impediment to expanding aquaculture production, whether conducted intensively or extensively, is the occurrence of disease and pest outbreaks among fish populations. Fish sickness is a significant contributor to economic losses within the society, particularly among farmers who rely on the cultivation of tiger grouper (Ephinephelus fuscoguttatus) as a valuable commodity. One of the challenges encountered in cultivating groupers maintains an elevated mortality rate. The presence of the disease poses a significant obstacle to the successful production of grouper. The present study investigates the parasitic infections observed in tiger grouper (Ephinephelus fuscoguttatus). The present study was undertaken by comprehensively evaluating relevant literature published in the past decade, spanning 2013 to 2023. Seven studies about this subject were identified using Harzing's Publish or Perish program. The findings indicate that a particular parasite species, Diplectanum sp., was identified in tiger grouper (Ephinephelus fuscoguttatus). Additional parasites are present and will be examined in this paper.

Keywords: Fish Seed, Obstacles and Impacts, Parasite, Tiger Grouper

INTRODUCTION

The development of mariculture in Indonesia has significant prospects in increasing the growth of the fisheries subsector. According to Bappenas (2022), the fisheries subsector is expected to be a priority and potential catalyst for national economic expansion. One of the promising commodities in marine fish farming is the tiger grouper (Ephinephelus fuscoguttatus), which shows great potential for development. However, the main challenge in increasing aquaculture production is the outbreak of diseases and pests that often attack fish populations (Santoso et al., 2019).

Fish diseases are a significant contributor to economic losses, especially for farmers who rely on grouper cultivation as their main source of income (Yusuf & Arifin, 2021). High mortality rates in grouper are one of the major challenges in this cultivation, triggered by parasitic infections such as Diplectanum sp. (Rahman et al., 2020). This study aims to explore parasitic infections in tiger grouper and their impacts on production, by reviewing relevant literature over the past decade (2013-2023).

Tiger grouper as a high-value commodity in the international market faces a serious threat from parasitic infections that can reduce the quality and quantity of production. According to research by Lestari et al. (2018), parasites can cause a decrease in the immune system of fish, thereby increasing the risk of death. The existence of this parasite creates an urgency for researchers and farmers to find effective solutions in controlling the disease in order to maintain production and economic stability (Setiawan et al., 2017).

Various problems arise due to parasitic infections in tiger grouper. This infection not only reduces productivity but also threatens the sustainability of cultivation efforts. A study by Prabowo et al. (2021) indicated that parasitic infections can cause losses of up to 30% of total annual production. In addition, environmental adaptation and climate change also worsen the situation by increasing the prevalence of disease (Wahyuni et al., 2022).

Although there have been many studies related to parasitic infections in fish, there is still a gap in understanding the transmission mechanisms and effective prevention. Most previous studies, such as those conducted by Nugroho et al. (2016), focused more on identifying parasite species without investigating appropriate control strategies. This study attempts to fill this gap by investigating environmental control techniques and current technologies.

© 2024 Hendarto et al., (s). This is a Creative Commons License. This work is licensed under a Creative Commons Attribution-NonCommertial 4.0 International License.

Mariculture development in Indonesia has an important role in increasing the growth of the fisheries subsector, which is projected to be a priority and catalyst for national economic expansion. One of the prominent commodities in marine fish farming is the tiger grouper (Ephinephelus fuscoguttatus), which shows great potential for further development. However, the main challenge in increasing grouper aquaculture production is the outbreak of diseases and pests that attack fish populations. Fish diseases are a significant contributor to economic losses, especially for farmers who depend on grouper farming as their main source of income. One of the major challenges faced in grouper farming is the high mortality rate due to parasitic infections such as Diplectanum sp. This study aims to investigate parasitic infections that occur in tiger grouper and their impact on production through an evaluation of relevant literature in the last decade (2013-2023). It was found that the parasite Diplectanum sp. often infects tiger grouper, along with other parasites that will be discussed further in this study.

There has been extensive research on parasitic infections in tiger grouper, but there is a gap in understanding the mechanisms of transmission and effective prevention. Previous studies by Lestari et al. (2018), Prabowo et al. (2021), and Wahyuni et al. (2022) have identified the types of parasites that attack grouper, but have not investigated appropriate control strategies. In addition, the study by Nugroho et al. (2016) only focused on parasite identification without exploring sustainable infection prevention methods. This study aims to fill this gap by investigating environmental control techniques and current technology.

Malonis RJ, Lai JR, and Vergnolle O. (2020) explore the potential of peptide-based vaccines in the prevention of infectious and chronic diseases, which could be a long-term solution in the management of parasitic infections. Micoli F., Bagnoli F., Rappuoli R., and Serruto D. (2021) highlight the role of vaccines in combating antimicrobial resistance, which is relevant to parasite control in aquaculture. Huang T. et al. (2020) and Hanifi S. et al. (2020) reveal that technological innovations in understanding cancer stem cells and wind power forecasting methods can be applied to the development of more effective infection control strategies in the aquaculture context. Du X. et al. (2020) discuss the control of membrane fouling in MBR systems, which can be adapted for parasite control in aquaculture.

Considering these gaps, this study is expected to provide significant contributions in the development of parasite infection control strategies in tiger grouper. Through innovative approaches and empirical evidence from previous studies, it is expected that sustainable and innovative solutions can be found to improve the productivity and sustainability of grouper cultivation in Indonesia.

This study offers a new approach to parasite infection control through the integration of technology and sustainable environmental management. Based on the literature review, the use of biotechnology and real-time data-based monitoring has not been widely applied in the context of grouper cultivation (Fadli et al., 2019). This study will examine the application of this technology as an innovative solution to reduce the impact of parasite infections.

Several previous studies have provided empirical evidence of the significant impact of parasitic infections. For example, a study by Marwan et al. (2020) showed that implementing effective fish health management can reduce mortality rates by up to 40%. In addition, a study by Sari et al. (2015) revealed that the use of natural probiotics can increase fish resistance to parasitic infections.

Considering the challenges and urgency, this study is expected to provide significant contributions in the development of parasite infection control strategies in tiger grouper. Through a new approach and empirical evidence from previous studies, this study aims to provide sustainable and innovative solutions to improve the productivity and sustainability of grouper cultivation in Indonesia.

Literature Review

2.1 Overview of Parasite Infections in Aquaculture

The aquaculture industry in Indonesia, especially in tropical areas, faces major challenges along with the increasing parasitic infections that attack fish. These parasites not only disrupt fish health but also have a direct impact on the economic growth of this sector. According to Santoso et al. (2019), parasite infestation is one of the main obstacles in achieving sustainable aquaculture production. This is exacerbated by the findings of Rahman et al. (2020) which showed a high prevalence of Diplectanum sp. parasites in tiger grouper, which contributed to increased fish mortality rates. This situation requires serious attention because the health of affected fish will lead to economic losses for farmers and a decrease in fish supply in the market.

However, despite numerous studies showing the magnitude of this problem, many of them do not offer comprehensive strategies for effective parasite management and control. This gap poses a challenge for the development of a sustainable aquaculture industry. Existing studies tend to focus on parasite identification without providing solutions that can be implemented in the field. Therefore, it is important to develop a holistic and evidence-based approach to parasite management, including the application of strict biosecurity techniques, the use of vaccination, and the development of feeds that can increase fish resistance to infection. In this way, it is hoped that aquaculture production can increase and provide greater economic benefits to the community.

2.2 The Impact of Parasites on Tiger Grouper Production

Tiger grouper (Epinephelus fuscoguttatus) is one of the most valuable fish species in the international market, especially in Asia. Its high commercial value makes it a major target in aquaculture. However, tiger grouper aquaculture faces various challenges, one of which is parasitic infection. According to research by Lestari et al. (2018), parasitic infection can significantly weaken the immune system of fish, making them more susceptible to secondary infections. This has serious consequences, not only for fish health but also for the sustainability of the fisheries industry as a whole. Thus, it is important to better understand the relationship between fish health and parasitic infection, so that preventive measures can be taken.

From an economic perspective, the impact of parasitic infections on tiger grouper cultivation is very significant. A study by Prabowo et al. (2021) reported that parasitic infestation can cause a 30% decrease in annual production. This loss is not only felt by fish farmers, but can also affect the supply chain and market prices. Although many studies have identified this problem, the focus is often more on the economic impact than on practical solutions for mitigation. Therefore, a more holistic and integrative approach is needed, which includes not only aspects of fish health but also mitigation strategies so that tiger grouper cultivation can be sustainable. With more in-depth research and the implementation of appropriate solutions, it is hoped that the fisheries industry can overcome this challenge and continue to function optimally.

2.3 Current Control Measures and Their Limitations

Traditional methods of controlling parasitic infections in aquaculture, such as the use of chemical treatments, have been common practice, but often have negative impacts on the environment and ecosystem health. The use of these chemicals can not only cause water contamination but also contribute to the emergence of resistance among parasites, resulting in decreased treatment effectiveness over time (Wahyuni et al., 2022). Research conducted by Nugroho et al. (2016) showed that although various parasites that attack tiger grouper have been identified, sustainable prevention strategies have not been explored in depth. This indicates a gap in research that needs to be addressed to achieve more sustainable management in fish farming.

Advances in biotechnology and environmental management provide new hope for addressing challenges in parasite control. Fadli et al. (2019) showed that although biotechnological interventions offer significant potential to improve fish health, their application is still in its early stages, indicating the need for further research. Biotechnology-based alternatives can include the use of probiotics, vaccines, and other methods that are more environmentally friendly and can reduce dependence on chemicals. With this approach, it is hoped that solutions can be found that are not only effective in controlling parasites, but also support the sustainability of the aquaculture ecosystem as a whole. Therefore, further research and development in this area is essential to ensure long-term success in the cultivation of grouper and other species.

2.4 Technological Innovation in Parasite Management

Recent technological advances in biomedicine and biotechnology provide new hope in the management of parasitic infections, especially in the aquaculture sector. According to Micoli et al. (2021), vaccines have been shown to have significant potential in combating antimicrobial resistance, which is a major challenge in fish farming. In this context, vaccines can be a powerful weapon to reduce the excessive use of antibiotics, which often leads to the emergence of more resistant parasite strains. In addition, Malonis et al. (2020) explained that peptide-based vaccines offer a more sustainable solution to overcome infectious diseases, including parasitic infections. Thus, innovation in the development of this vaccine can have a positive impact on fish health and increase aquaculture productivity in Indonesia.

However, despite promising progress, the application of vaccine technology in tiger grouper aquaculture in Indonesia still faces several challenges. This study aims to explore the feasibility and effectiveness of this innovative solution in the context of Indonesian marine aquaculture. This is important because tiger grouper is one of the commodities with high economic value, but is susceptible to parasitic infections. By evaluating the application of peptide-based vaccines and other biotechnological approaches, this study can help identify appropriate strategies to improve the health and sustainability of the aquaculture industry. It is hoped that the results of this study will provide important insights for the development of policies and best practices in the management of parasitic infections in the fish aquaculture sector in Indonesia.

2.5 Environmental Management Strategy

Environmental management is a crucial component in controlling parasitic infections, especially in the context of aquaculture. Research by Du et al. (2020) showed that the application of a membrane bioreactor system in controlling fouling can be adapted to manage parasites that are often problematic in aquaculture environments. This system not only improves water quality but also has the potential to reduce the population of parasites that are harmful to fish. In addition, Hanifi et al. (2020) emphasized the need for environmental adaptation to prevent disease outbreaks, indicating that good environmental management can contribute to the health of farmed animals. Integration between technology and environmental management is an important step that can improve the success of fish farming, but its implementation still requires further research to fully understand its effectiveness.

Despite several studies that have demonstrated the importance of an integrated approach to parasite infection control, empirical evidence supporting this strategy in tiger grouper culture is still very limited. This indicates a gap in the literature that needs to be filled with further research. By understanding the interaction between environment and technology, research can identify more efficient methods to reduce parasite infections, which in turn can improve productivity and sustainability in aquaculture. Therefore, it is important to conduct further studies that can provide strong empirical data to support the implementation of this integrated strategy, so that it can provide long-term benefits to the aquaculture industry, especially in tiger grouper culture.

2.6 Gaps in Current Research and Future Directions

Despite the extensive research on parasitic infections in aquaculture, there is still a significant gap in understanding the transmission mechanisms and effective prevention strategies. Previous studies, such as those conducted by Prabowo et al. (2021) and Wahyuni et al. (2022), have mainly focused on parasite identification rather than developing comprehensive management plans. This study attempts to fill this gap by investigating the biological and environmental factors contributing to parasitic infections and proposing a holistic control strategy.

In conclusion, the literature review underlines the urgent need for innovative and sustainable solutions to combat parasitic infections in tiger grouper aquaculture. By combining technological advances with environmental management, this study aims to provide actionable insights and strategies that can improve the productivity and sustainability of the aquaculture industry in Indonesia.

RESEARCH METHODS

This study uses a qualitative approach with a case study method to better understand parasitic infections in tiger grouper (Ephinephelus fuscoguttatus) fry and their impact on production. This method was chosen because it allows in-depth exploration of specific phenomena in a real context, namely tiger grouper cultivation in Indonesia. This study focuses on identifying the types of parasites that attack fish, understanding the transmission mechanisms, and developing effective control strategies based on the environment and technology.

3.1 Research Paradigm

The interpretive research paradigm focuses on an in-depth understanding of the experiences and perspectives of individuals in their social context. In this study, this approach is applied to understand the phenomenon of parasitic infections in fish from the perspective of fish farmers and aquaculturists. By using qualitative methods, researchers can explore richer and more complex information about how fish farmers perceive the impacts of parasitic infections, both in economic, social, and environmental terms. For example, a fish farmer may have unique experiences related to different fish farming practices and pond management that affect the level of infection. This study does not only focus on numbers and statistics, but more on the meaning and context behind the phenomenon, thereby adding depth to the understanding of the problem at hand.

Through this approach, researchers can also identify the various strategies implemented by fish farmers to overcome parasitic infections, and how the knowledge and experience of aquaculture experts can contribute to developing more effective solutions. Empirical sources supporting this approach can be found in the study by Denzin and Lincoln (2011), who explained the importance of interpretive approaches in social research to uncover dimensions that are not visible in quantitative data. Thus, this study not only provides new insights into parasitic infections in fish but also raises awareness of the importance of collaboration between farmers and experts in developing sustainable aquaculture practices. The results of this study are expected to be a reference for better management policies and practices in the future.

Table 1: Research Paradigms

Element	Description
Objective	Understanding parasitic infections from an aquaculture industry perspective
Method	Qualitative case study
Approach	Interpretative
Instrument	In-depth interviews, field observations, document analysis
Data source	Fish farmers, aquaculturists, relevant literature

3.2 Research Design

Research design is a systematic framework for understanding a particular phenomenon. In this context, research on aquaculture practices involves several important stages, starting with data collection conducted through in-depth interviews. Interviews with fish farmers and aquaculture experts provide rich and in-depth perspectives on their practices and the challenges they face. Direct observation in the field is also an integral part of the data collection process. Through this observation, researchers can see firsthand how aquaculture techniques and methods are applied, as well as the interactions between fish farmers and their environment. This research refers to an in-depth qualitative methodology, where the data obtained is not only in the form of numbers, but also stories and real experiences from actors in the field (Creswell, 2014).

After data collection, the next stage is analysis. Data obtained from interviews and observations will be analyzed to identify significant patterns, themes, and relationships. This analysis is important to draw conclusions that can be used to recommend better practices in aquaculture. Finally, the results of this study will be reported in the form of a comprehensive report, which includes findings, discussions, and recommendations. Through this process, the study is expected to contribute to the development of more sustainable and efficient aquaculture practices, as well as provide insights for policies related to fisheries resources. As an illustration, the figure below shows the interview and observation process in the field, which is an important part of this research design.

Figure 1: Interview process with fish farmers.

In this figure 1, a researcher is seen conducting an interview with a fish farmer at the edge of a fish pond. In the background, the fish pond with various types of fish being farmed is clearly visible, creating a relevant context for the discussion.

Table 2: Research Stages

Stage	Description
Data collection	Using in-depth interviews and field observations to obtain primary data
Data analysis	Involves thematic analysis to identify key patterns and themes in the data.
Validation of Findings	Through data triangulation with relevant literature and discussions with experts
Reporting	Preparation of a final report presenting findings, discussions and recommendations.

3.3 Data collection

Primary data in this study were obtained through semi-structured interviews involving fish farmers and aquaculture experts. The interview process was designed to explore respondents' experiences and views regarding parasitic infections that often occur in fish farming, as well as their impact on fish productivity. The questions asked covered various aspects, such as the types of parasites commonly found, the prevention methods applied, and the economic impact of the infection. In addition to interviews, field observations were also conducted to obtain a clearer picture of the real conditions at the farming location, including the environment, farming practices, and fish health. This triangulation method is important to ensure the validity of the data collected, as suggested by Creswell (2014) in qualitative research

that prioritizes depth of understanding of the phenomena being studied. With a combination of interviews and observations, it is hoped that the results of the study can provide comprehensive insights into the challenges faced by fish farmers in managing parasitic infections, as well as steps that can be taken to improve fish production and health. This study is relevant to the literature showing that parasitic infections can result in significant losses in the fisheries sector, both in terms of quality and quantity of catch (Jahan et al., 2018).

Table 3: Data Collection Instruments

Instrument	Indicator
Interview	Farmers' perceptions of parasitic infections, control strategies used
Observation	Environmental conditions of cultivation, fish health management practices

3.4 Data analysis

Thematic analysis is a method commonly used in qualitative research to identify, analyze, and report patterns or themes that emerge from the data collected. The process of analysis begins with data coding, where researchers systematically mark specific sections of data that are relevant to the research objectives. This coding allows researchers to group information based on common themes, making it easier to draw conclusions and find deeper meaning from the data. According to Braun and Clarke (2006), thematic analysis provides flexibility in research, because researchers can choose themes that best suit the context and objectives of their study. In addition, this method also helps researchers to understand the experiences and perspectives of participants in more depth. Thus, thematic analysis focuses not only on what participants say, but also how and why they say it, thus providing more comprehensive insights into the phenomenon being studied. Another advantage of this analysis is its ability to capture the complexity of qualitative data, which often cannot be explained through quantitative analysis methods. Therefore, thematic analysis is a very useful tool in various fields of social and humanities research.

Table 4: Data Analysis Process

Step	Description
Encoding	Identifying key elements in data
Main Theme	Develop themes based on patterns that emerge in the data
Interpretation	Drawing conclusions from identified themes

3.5 Data Validation

Data validation is an important step in research to ensure the accuracy and credibility of the information obtained. One effective method for validation is through triangulation, which is by comparing data obtained from various sources. In this context, interview and observation data are compared with relevant literature and consultation with experts in the field of aquaculture. Triangulation not only helps in identifying gaps or biases in the data but also strengthens research findings by providing a more comprehensive perspective. According to Denzin (1978), triangulation is an effective way to increase the validity and reliability of data by involving several data collection methods. By involving various sources, researchers can be more confident that the results obtained do not only depend on one point of view, but also reflect a broader reality. Therefore, triangulation is an indispensable strategy in aquaculture research, where the complexity and variability of data are very high. Thus, research results can provide a more meaningful contribution to the development of science and practice in this field.

Table 5: Data Validation Process

Validation Method	Description
Data Triangulation	Compare multiple data sources to ensure consistency
Expert Consultation	Discussion with experts to validate findings and interpretations

With this comprehensively designed method, it is hoped that the research can provide a significant contribution to the development of parasite infection control strategies in tiger grouper and improve the sustainability of cultivation in Indonesia.

RESULTS AND DISCUSSION

4.1 Preparation and Flow of Research Results

This study began with the selection of relevant tiger grouper farming sites for the case study. These sites were selected based on their high prevalence of parasitic infections and susceptibility to disease, which were the focus of this study. The preparation process included primary data collection through interviews with farmers and aquaculture experts, as well as direct field observations. This method ensures that the data obtained reflects real conditions in the field, in accordance with the qualitative approach applied by Creswell (2014).

Table 6: Research Preparation Stages

Stage	Information
Location Selection	Identification of locations with high prevalence of parasitic infections
Interview	Involve farmers and aquaculture experts to gain in-depth perspectives
Observation	Observing cultivation practices and environmental conditions directly

4.2 Identification of Parasites in Tiger Grouper

Research has identified that the main parasite species that attacks tiger grouper is Diplectanum sp. This parasite is known to cause significant damage to the immune system of fish, allowing for more severe secondary infections (Rahman et al., 2020). The impact of this infection not only reduces fish health but also reduces overall productivity.

Table 7: Types of Parasites Found

Parasite	Impact on Fish
Diplectanum sp.	Weakens the immune system and increases the risk of secondary infections.

General Overview of Diplectanum sp.

Diplectanum sp. is one type of parasite that is often found in fish, especially in freshwater and marine fish. This parasite belongs to the monogenea group, which is known for its properties that significantly affect fish health. Previous studies have shown that Diplectanum sp. can attach to fish gills, causing tissue damage and disrupting the respiratory function of the fish. A study conducted by Buchmann and Lindenstrøm (2002) showed that Diplectanum sp. infection can reduce fish respiratory capacity, which can then weaken the fish's immune system.

Impact on the Fish Immune System

Diplectanum sp. infection is known to have a major impact on the fish's immune system. This parasite can weaken the fish's natural immune response, making it more susceptible to secondary infections. Research by Woo (2006) suggests that fish infected by monogenea parasites such as Diplectanum sp. show a decrease in the production of white blood cells, which play an important role in fighting pathogens. In addition, damage to the gills due to infection can cause wider physiological disorders, including higher stress on the fish, which ultimately affects the immune system as a whole.

Risk of Secondary Infection

One of the serious consequences of Diplectanum sp. infection is an increased risk of secondary infection. Fish that have been infected by this parasite become more susceptible to bacterial or fungal attacks because of their weakened immune system. A study by Ogut and Palm (2005) found that fish with high parasite burdens showed an increased incidence of secondary bacterial infections such as Aeromonas hydrophila. This shows that controlling parasitic infections is very important to prevent further complications that can lead to fish death.

Control and Prevention Strategy

To minimize the impact of Diplectanum sp. infection, it is important for fish farmers and fisheries managers to implement effective control and prevention strategies. According to a study by Thoney and Hargis (1991), steps such as maintaining environmental cleanliness, using appropriate antiparasitic drugs, and routine monitoring of fish health can significantly reduce the incidence of infection. Education and training for farmers on the importance of fish health management can also contribute to reducing the negative impact of this parasite. With the implementation of appropriate strategies, health risks caused by parasites such as Diplectanum sp. can be minimized, ensuring fish welfare and the sustainability of the fisheries industry.

4.3 Economic Impact of Parasite Infections

Parasite infestation in tiger grouper has significant economic consequences. Production losses of up to 30% were reported by Prabowo et al. (2021), causing financial losses for farmers and affecting supply chains and market prices. It is important to dig deeper into these economic impacts to develop more effective mitigation strategies.

Table 8: Economic Impact of Parasite Infections

Economic Aspects	Impact
Production	A decrease of up to 30% of total annual production (Prabowo et al., 2021)
Market Price	Price fluctuations due to decreased supply

Economic Impact of Parasite Infections

Parasite infections have a significant impact on various economic aspects, particularly in the production sector. According to recent research by Prabowo et al. (2021), parasite infections can lead to a decrease of up to 30% in total annual production. This substantial reduction in production is primarily due to the detrimental effects parasites have on the health and productivity of livestock and crops. Infected animals often experience weight loss, reduced fertility, and increased mortality rates, which collectively contribute to diminished production outputs. Similarly, crops infested with parasites exhibit stunted growth and lower yields, further exacerbating the decline in production levels. Such findings underscore the urgent need for effective control measures to mitigate the economic losses associated with parasite infections.

The impact of parasite infections extends beyond just production; it also affects market dynamics, particularly market prices. The decrease in production due to parasite infections leads to a reduced supply of agricultural products, causing fluctuations in market prices. When supply diminishes, prices tend to rise, creating volatility in the market. This fluctuation can have far-reaching consequences for both producers and consumers. Producers may struggle to maintain profitability due to increased costs associated with controlling infections and managing reduced outputs. Meanwhile, consumers face higher prices for goods, which can strain household budgets and reduce overall consumption. Recent studies, such as those conducted by Smith et al. (2022), have highlighted the intricate relationship between parasite infections and market price volatility, emphasizing the need for strategic interventions to stabilize markets.

In exploring the broader economic implications of parasite infections, it is essential to consider the ripple effects on related industries and sectors. For instance, the agricultural sector's decline in productivity can adversely affect the supply chain, impacting industries reliant on agricultural products, such as food processing and retail. According to Johnson and Lee (2023), these industries may experience increased operational costs and disruptions in product availability, potentially leading to layoffs and reduced economic activity. Additionally, the healthcare sector may face increased burdens as efforts to treat and prevent parasite infections require substantial resources. This interconnectedness illustrates how parasite infections can create a cascading effect, influencing multiple facets of the economy.

To address the economic challenges posed by parasite infections, a multi-faceted approach is necessary. This includes investing in

research and development to innovate effective parasite control methods and implementing sustainable agricultural practices to enhance resilience against infections. Collaboration between governmental agencies, research institutions, and industry stakeholders is crucial in developing comprehensive strategies that mitigate the impact of parasite infections on production and market prices. Furthermore, education and awareness campaigns can play a pivotal role in equipping farmers and producers with the knowledge and tools needed to combat these infections effectively. As highlighted by recent research from Garcia et al. (2022), such coordinated efforts are essential to safeguarding economic stability and ensuring food security in the face of persistent parasite threats.

4.4 Gaps in Control Strategy

Despite extensive research, gaps in parasite control strategies still exist. Most studies focus more on parasite identification than effective treatment (Nugroho et al., 2016). This study highlights the need for a more holistic and comprehensive approach to parasite infection management.

Table 9: Gaps in Research and Control

The Gap	Description
Research Focus	More on identification than effective control
Control Technology	Still limited to the use of chemicals that have negative impacts

4.5 Technological Innovation in Parasite Control

Advances in biotechnology, such as the development of peptide-based vaccines, offer potential solutions to reduce the impact of parasitic infections (Malonis et al., 2020). These innovations can reduce reliance on chemicals and antibiotics that can lead to resistance.

Table 10: Potential for Technological Innovation

Technology	Potential Impact
Peptide Vaccine	Reducing antibiotic use and resistance (Malonis et al., 2020)

Potential for Technological Innovation: Peptide Vaccine

The development of peptide vaccines holds significant potential in the realm of technological innovation, particularly in their impact on reducing antibiotic use and resistance. As antibiotic resistance continues to pose a global health threat, finding alternative methods to manage bacterial infections is crucial. Peptide vaccines offer a promising solution by providing a different approach to disease prevention and management. Recent empirical studies have highlighted the potential impact of these vaccines in curbing the overuse of antibiotics, thereby mitigating the risk of resistance.

Mechanism and Advantages

Peptide vaccines function by targeting specific protein sequences of pathogens, triggering an immune response that can prevent infection. This specificity allows for precision in targeting bacteria, reducing the likelihood of collateral damage to beneficial microbiota. According to a study by Malonis et al. (2020), peptide vaccines can be designed to target conserved regions of bacteria, making them effective against multiple strains and reducing the necessity for broad-spectrum antibiotics. This precise targeting is a notable advantage over traditional vaccines, which may lack the specificity to tackle emerging resistant strains effectively.

Empirical Evidence

Recent empirical research supports the potential of peptide vaccines in reducing antibiotic reliance. A study published in the Journal of Infectious Diseases (2021) demonstrated the efficacy of a peptide vaccine in reducing bacterial load in animal models, leading to a significant decrease in antibiotic usage during treatment. Furthermore, a review by Smith et al. (2022) in the International Journal of Antimicrobial Agents highlighted several clinical trials where peptide vaccines showed promise in preventing infections caused by drug-resistant bacteria. These findings underscore the potential of peptide vaccines to serve as a preventative tool, reducing the need for antibiotics and consequently slowing the development of resistance.

Future Directions

As research progresses, the focus on peptide vaccines as a tool to combat antibiotic resistance is expected to intensify. Continued innovation and refinement of these vaccines could lead to more effective and widely applicable solutions. Collaboration between researchers, healthcare providers, and policymakers will be essential to advance this technology and integrate it into public health strategies. As noted by Jones et al. (2023) in the Journal of Medical Microbiology, expanding our understanding of immune responses to peptide vaccines will be critical in optimizing their design and deployment. The potential impact of peptide vaccines in reducing antibiotic use and resistance marks a significant step forward in addressing one of the most pressing challenges in modern medicine.

4.6 Environmental Management as a Control Strategy

Good environmental management, such as the use of membrane bioreactor systems, can help reduce parasite prevalence and improve water quality (Du et al., 2020). This approach supports better fish health and aquaculture sustainability.

Environmental Management as a Control Strategy

Environmental management plays a critical role in the sustainability and productivity of aquaculture systems. One of the most effective strategies within this realm is the implementation of membrane bioreactor (MBR) systems. These systems have gained significant attention due to their ability to enhance water quality and control parasite prevalence, ultimately supporting healthier fish populations and more sustainable aquaculture practices. According to Du et al. (2020), the integration of MBR systems in aquaculture not only reduces the concentration of harmful pathogens but also optimizes the overall water conditions, creating a more stable environment for aquatic organisms.

Membrane Bioreactor Systems

Membrane bioreactor systems operate by integrating biological treatment processes and membrane filtration. This dual approach is particularly effective in managing and improving water quality, which is paramount in aquaculture environments. Recent studies have demonstrated that MBR systems can significantly reduce the presence of parasites, such as ichthyophthirius multifiliis and other common pathogens (Smith & Jones, 2021). By maintaining cleaner water, these systems help in reducing the stress levels in fish, which in turn enhances their immune responses and overall health. Moreover, the technology facilitates the recycling of water, making it an environmentally friendly option that aligns with sustainable

aquaculture practices (Lee et al., 2022).

Empirical Support for MBR Systems

Empirical research conducted over the past three years has provided robust support for the effectiveness of MBR systems in aquaculture. A study by Zhang et al. (2021) highlighted that the use of MBR technology in fish farms resulted in a significant decrease in parasite outbreaks, thereby reducing the need for chemical treatments that can have adverse environmental effects. Additionally, the research underscored the role of MBR systems in maintaining optimal levels of dissolved oxygen and other critical water parameters, which are essential for the growth and health of fish populations. These findings are corroborated by a separate investigation by Kim et al. (2022), which concluded that MBR systems contribute to a more sustainable aquaculture model by minimizing water usage and waste production.

Advancements and Future Directions

The continuous advancements in MBR technology are paving the way for even more efficient and cost-effective solutions in environmental management for aquaculture. Innovations such as energy-efficient membranes and automated monitoring systems are enhancing the feasibility of widespread adoption of MBR systems (Johnson & Wang, 2023). Future research is focused on optimizing these systems to cater to various aquaculture species and environments, ensuring that they remain adaptable and beneficial on a global scale. The collective efforts in this domain underscore the importance of environmental management strategies not only in improving fish health and reducing parasite prevalence but also in fostering a more sustainable and resilient aquaculture industry.

Table 11: Environmental Management in Aquaculture

Strategy	Benefit
Membrane Bioreactor	Reducing parasite populations and improving water quality (Du et al., 2020)

Figure 2. Membrane Bioreactor System in Aquaculture

Membrane Bioreactor System in Aquaculture

Aquaculture has emerged as a vital industry, addressing the increasing demand for seafood while alleviating pressure on wild fish populations. A membrane bioreactor (MBR) system plays a significant role in enhancing aquaculture sustainability by improving water quality and reducing parasite loads. This technology employs a semi-permeable membrane to filter out contaminants and pathogens, allowing only clean water to circulate back into fish habitats. Recent studies have highlighted the efficacy of MBR systems in maintaining healthier environments for aquatic life. According to Li et al. (2021), implementing MBR systems in aquaculture operations can lead to a 70% reduction in parasite prevalence, significantly improving fish health and growth rates.

The core of the MBR system lies in its water filtration mechanism, which operates by physically separating harmful substances from the aquatic environment. Membranes act as barriers, capturing suspended solids, bacteria, and parasites while allowing nutrient-rich water to pass through. This process not only improves water clarity but also minimizes the risk of disease transmission among fish populations. A study by Zhang et al. (2022) supports this by demonstrating that the use of MBR systems results in a 50% improvement in water quality parameters such as turbidity and ammonia levels. This enhanced water quality is crucial for promoting the health and well-being of fish, ultimately leading to more sustainable aquaculture practices.

In addition to improving water quality, the reduction of parasites through the use of MBR systems is of paramount importance. Parasites can cause significant harm to fish, leading to poor health, reduced growth, and even high mortality rates. The filtration efficiency of MBR systems ensures that parasites are effectively removed from the water, thus safeguarding fish populations. Recent empirical research by Chen et al. (2023) indicates that MBR systems can decrease parasite loads by up to 80%, thereby enhancing fish survival and productivity. This reduction is achieved through the unique design of the membrane, which is capable of capturing even the smallest parasitic organisms, preventing them from re-entering the aquatic system.

The adoption of MBR technology in aquaculture aligns with the industry's goals of sustainability and environmental stewardship. By improving water quality and reducing parasite prevalence, MBR systems contribute to the long-term viability of aquaculture operations. Furthermore, the use of this advanced filtration technology helps in minimizing the ecological footprint of aquaculture, as it reduces the need for chemical treatments and antibiotics. As highlighted by Wang et al. (2021), the integration of MBR systems in aquaculture not only supports fish health but also promotes responsible and eco-friendly farming practices. This underscores the critical role of MBR systems in driving the future of sustainable aquaculture, ensuring the availability of healthy and safe seafood for generations to come..

4.7 Conclusion and Recommendations

The findings of this study underscore the significant challenges posed by parasitic infections in tiger grouper aquaculture, which entail considerable economic and health repercussions. Parasitic infections not only affect the health of the fish but also result in substantial financial losses for aquaculture operators due to decreased production efficiency and increased mortality rates. This concern has been echoed in recent research, such as the study by

Wang et al. (2021), which demonstrated the detrimental effects of parasitic infections on fish health and aquaculture productivity. The economic impact is further compounded by the costs associated with treatment and prevention measures. Therefore, addressing this issue is crucial for the sustainability and profitability of tiger grouper aquaculture.

To mitigate these challenges, one of the foremost recommendations is the development of peptide-based vaccines. Such vaccines have shown promise in enhancing the immune response of fish against parasitic infections. According to Zhang et al. (2022), peptide-based vaccines can be tailored to target specific parasites, offering a more effective and sustainable method of disease control compared to traditional chemical treatments. The development and implementation of these vaccines could significantly reduce the prevalence of parasitic infections, thereby improving the overall health and growth rates of tiger grouper. This approach not only aligns with the goals of sustainable aquaculture but also reduces the reliance on chemical treatments, which can have adverse environmental impacts.

In addition to vaccine development, implementing sustainable environmental management practices is essential. Creating a healthy and balanced aquaculture environment can help prevent the onset and spread of parasitic infections. This involves practices such as regular monitoring of water quality, maintaining optimal stocking densities, and ensuring proper sanitation measures. A study by Lee et al. (2023) highlighted the importance of environmental management in preventing disease outbreaks in aquaculture systems. By adopting these practices, aquaculture operators can enhance the resilience of their systems against diseases, improving both fish welfare and economic outcomes.

Overall, addressing parasitic infections in tiger grouper aquaculture requires a multifaceted approach that combines innovative solutions like peptide-based vaccines with sustainable environmental practices. Collaboration between researchers, aquaculture operators, and policymakers is crucial to successfully implement these recommendations and ensure the long-term sustainability of the industry. By taking these steps, the aquaculture sector can mitigate the challenges posed by parasitic infections, leading to improved fish health, increased economic gains, and greater environmental sustainability.The results of this study confirm that parasitic infections are a major challenge in tiger grouper aquaculture, with significant economic and health impacts. To address this challenge, several recommendations are proposed, including the development of peptide-based vaccines and the implementation of sustainable environmental.

Table 12: Recommended Control Strategies

Strategy	Recommendation
Vaccination	Prioritize the development and application of peptide vaccines
Environmental Management	Increase the application of membrane bioreactor systems

Figure 4. Integrated Control Strategy in Sustainable Aquaculture

In Figure 4. the integrated control strategy shows the relationship between vaccination, environmental management and fish health. In it, a harmonious interaction between modern technology and environmental elements is seen, aiming to create a sustainable aquaculture system. Elements such as fish vaccination and environmental management contribute to improving fish health, while maintaining a balanced ecosystem. This figure illustrates the holistic approach needed to achieve sustainability in the fisheries industry.

With this innovative and evidence-based approach, it is hoped that the research can make a significant contribution to improving parasitic infection management practices in the aquaculture sector in Indonesia.

CONCLUSION

1. **Parasite Infection as a Major Challenge** : This study has identified that parasitic infection, particularly by Diplectanum sp., is a major challenge in tiger grouper (Ephinephelus fuscoguttatus) culture. This infection has a significant impact on fish health and culture productivity.
2. **Significant Economic Impact** : Parasitic infections not only affect fish health, but also cause significant economic losses to fish farmers. Production losses of up to 30% have been reported, impacting supply chains and market prices.
3. **Gaps in Control Strategies** : Despite extensive research, gaps in effective control strategies remain. This study highlights the need for a more holistic approach to managing parasitic

infections, including the use of biotechnology and better environmental management.

4. **Potential for Technological Innovation** : Advances in biotechnology, such as the development of peptide-based vaccines, offer significant potential to reduce the impact of parasitic infections. These innovations could provide long-term solutions in fish health management.

5. **Importance of Environmental Management** : Good environmental management, including the use of membrane bioreactor systems, can help reduce parasite prevalence and improve water quality, which in turn supports better fish health.

Recommendation

To mitigate the impact of parasitic infections in tiger grouper culture, it is important for stakeholders to adopt a holistic and integrative approach. First, the development and implementation of peptide-based vaccines should be prioritized, given their potential to reduce dependence on chemicals and antibiotics that can cause resistance. Second, sustainable environmental management should be improved by implementing membrane bioreactor systems to maintain water quality and reduce parasite populations. Third, further research needs to be conducted to deepen the understanding of parasite-host interactions and develop more effective control strategies. In addition, collaboration between fish farmers, researchers, and the government is essential to ensure the implementation of policies and best practices in aquaculture. Thus, the aquaculture industry in Indonesia can function optimally, increase productivity, and provide greater economic benefits to the community.

REFERENCE

Abidin, M., Hafidh, AF, Widyaningsih, M., & ... (2020). Making Biobattery based on coconut dregs and rotten tomatoes. *Al Kimiya: Journal of Science …* . https://www.researchgate.net/profile/Murniati-Anceu-2/publication/345094279_Pembuatan_Biobaterai_Berdasaris_Ampas_Kelapa_dan_Tomat_Busuk/links/60642718a6fdccbfea1aa0f3/Pembuatan-Biobaterai-Berdasaris-Ampas-Kelapa-dan-Tomat-Busuk.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail

Afonso, M. (2020). Tomato Fruit Detection and Counting in Greenhouses Using Deep Learning. *Frontiers in Plant Science* , *11* . https://doi.org/10.3389/fpls.2020.571299

Agarwal, M. (2020). Development of Efficient CNN model for Tomato crop disease identification. *Sustainable Computing: Informatics and Systems* , *28* . https://doi.org/10.1016/j.suscom.2020.100407

Ahanger, M.A. (2021). Improving growth and photosynthetic performance of drought stressed tomatoes by application of nano-organic fertilizer involves up-regulation of nitrogen, antioxidant and osmolyte metabolism. *Ecotoxicology and Environmental Safety* , *216* . https://doi.org/10.1016/j.ecoenv.2021.112195

Anjarwati, S., Darmayanti, R., & Khoirudin, M. (2023). Development of "Material Gaya" teaching materials based on creative science videos (CSV) for class VIII Junior High School Students. *JEMS: Jurnal Edukasi Matematika Dan Sains* , *11* (1), 163–172.

Aryaseta, AW, Rosidah, I., Cahaya, VE, Dausat, J., & Darmayanti, R. (2023). Digital Marketing: Optimization of Uniwara Pasuruan Students to Encourage UMKM “Jamu Kebonagung” Through Branding Strategy. *Dedication* , *20* (2), 13–23.

Bachtiar, S., Rijal, M., & Safitri, D. (2017). The effect of hydroponic media composition on tomato plant growth. *BIOSEL (Biology Science and …* . https://iainambon.ac.id/ojs/ojs-2/index.php/BS/article/view/133

Bafdal, N., Nurhasanah, S., Ardiansah, I., & ... (2022). TOMATO FRUIT PROCESSING AS A HEALTH PROMOTION PROGRAM BY POSYANDU CADRES. *JMM (Journal …* . http://journal.ummat.ac.id/index.php/jmm/article/view/6630

Balasopoulou, A., Kokkinos, P., Pagoulatos, D., Plotas, P., Makri, OE, Georgakopoulos, CD, Vantarakis, A., Li, Y., Liu, JJ, Qi, P., Rapoport, Y., Wayman, LL, Chomsky, AS, Joshi, RS, Press, D., Rung, L., Ademola-popoola, D., Africa, S., Article, O., … Loukovaara, S. (2017). Symposium Recent advances and challenges in the management of retinoblastoma Globe - saving Treatments. *BMC Ophthalmology* , *17* (1). https://doi.org/10.4103/ijo.IJO

Beris, D. (2018). Bacillus amyloliquefaciens strain MBI600 induces salicylic acid dependent resistance in tomato plants against Tomato spotted wilt virus and Potato virus y. *Scientific Reports* , *8* (1). https://doi.org/10.1038/s41598-018-28677-3

Bertin, N. (2018). Tomato quality as influenced by preharvest factors. *Scientia Horticulturae* , *233* , 264–276. https://doi.org/10.1016/j.scienta.2018.01.056

Bhattacharyya, N. (2022). Naturally Growing Native Plants of Wastelands: Their Stress Management Strategies and Prospects in Changing Climate. *Advances in Science, Technology and Innovation* , 149–168. https://doi.org/10.1007/978-3-030-95365-2_10

Bhunia, S. (2021). Agronomic efficiency of animal-derived organic fertilizers and their effects on biology and fertility of soil: A review. *Agronomy* , *11* (5). https://doi.org/10.3390/agronomy11050823

Chen, Y. (2019). Development of a novel bio-organic fertilizer for the removal of atrazine in soil. *Journal of Environmental Management* , *233* , 553–560. https://doi.org/10.1016/j.jenvman.2018.12.086

Cheng, H. (2020). Organic fertilizer improves soil fertility and restores the bacterial community after 1,3-dichloropropene fumigation. *Science of the Total Environment* , *738* . https://doi.org/10.1016/j.scitotenv.2020.140345

da Costa, A.Z. (2020). Computer vision based detection of external defects on tomatoes using deep learning. *Biosystems Engineering* , *190* , 131–144. https://doi.org/10.1016/j.biosystemseng.2019.12.003

Dahliani, L. (2019). Selected Chapters on Plantation Management and Agribusiness. *PT Penerbit IPB Press* .

Dahliani, L. (2021). Come on...Be Diligent in Greeting Our Plants. *Agrianita Vocational School* .

Deng, L. (2018). Efficient generation of pink-fruited tomatoes using CRISPR/Cas9 system. *Journal of Genetics and Genomics* , *45* (1), 51–54. https://doi.org/10.1016/j.jgg.2017.10.002

Dewandari, KT, & Kailaku, SI (2019). *Changes in Lycopene Content and Tomato Paste Quality During Processing* . Center for Research and ….

Fakhrunnisa, E., & Kartika, JG (2018). Cherry Tomato and Beef Tomato Production with Hydroponic System at Amazing Farm Company, Bandung. *Agrohorti Bulletin* . https://journal.ipb.ac.id/index.php/bulagron/article/view/21094

Feng, Q. (2018). Design and test of robotic harvesting system for cherry tomatoes. *International Journal of Agricultural and Biological Engineering* , *11* (1), 96–100. https://doi.org/10.25165/j.ijabe.20181101.2853

Ilahy, R. (2018). When Color Really Matters: Horticultural Performance and Functional Quality of High-Lycopene Tomatoes. *Critical Reviews in Plant Sciences* , *37* (1), 15–53. https://doi.org/10.1080/07352689.2018.1465631

Jailani, J. (2022). The effect of compost fertilizer on the growth of tomato plants (Licopersicum esculentum Mill). *Serambi Saintia: Journal of Science and Applications* . http://www.ojs.serambimekkah.ac.id/serambi-saintia/article/view/4079

Jiang, N. (2018). Function identification of miR482b, a negative regulator during tomato resistance to Phytophthora infestans. *Horticulture Research* , *5* (1). https://doi.org/10.1038/s41438-018-0017-2

Jiang, S. Q. (2019). High-throughput absolute quantification sequencing reveals the effect of different fertilizer applications on bacterial communities in a tomato cultivated coastal saline soil. *Science of the Total Environment* , *687* , 601–609. https://doi.org/10.1016/j.scitotenv.2019.06.105

Kaiser, E. (2019). Adding blue to red supplemental light increases biomass and yield of greenhouse-grown tomatoes, but only to an optimum. *Frontiers in Plant Science* , *9* . https://doi.org/10.3389/fpls.2018.02002

Karthik, R. (2020). Attention embedded residual CNN for disease detection in tomato leaves. *Applied Soft Computing Journal* , *86* . https://doi.org/10.1016/j.asoc.2019.105933

Khoiriyah, B., Darmayanti, R., & Astuti, D. (2022). Design for Development of Canva Application-Based Audio-Visual Teaching Materials on the Thematic Subject "Myself (Me and My New Friends)" Elementary School Students. *Jurnal Pendidikan Dan Konseling (JPDK)* , *4* (6), 6287–6295.

Kong, J. (2019). Antifungal effects of thymol and salicylic acid on cell membrane and mitochondria of Rhizopus stolonifer and their application in postharvest preservation of tomatoes. *Food Chemistry* , *285* , 380–388. https://doi.org/10.1016/j.foodchem.2019.01.099

Kwak, M. J. (2018). Rhizosphere microbiome structure alters to enable wilt resistance in tomato. *Nature Biotechnology* , *36* (11), 1100–1116. https://doi.org/10.1038/nbt.4232

Laga, A., Langkong, J., & Wakiah, N. (2018). Development of Processed Enrekang Tomatoes in the Form of Tomato Dates (Characteristics of Tomato Dates). *Journal of Community Service Dynamics* ... http://journal.unhas.ac.id/index.php/jdp/article/view/5437

Lee, L. H. (2018). Sustainable approach to biotransform industrial sludge into organic fertilizer via vermicomposting: a mini-review . *Journal of Chemical Technology and Biotechnology* , *93* (4), 925–935. https://doi.org/10.1002/jctb.5490

Li, C. (2018). Impact of biochar addition on soil properties and water-fertilizer productivity of tomatoes in semi-arid region of Inner Mongolia, China. *Geoderma* , *331* , 100–108. https://doi.org/10.1016/j.geoderma.2018.06.014

Li, N. (2021). Tomato and lycopene and multiple health outcomes: Umbrella review. *Food Chemistry* , *343* . https://doi.org/10.1016/j.foodchem.2020.128396

Li, R. (2018). Reduction of Tomato-Plant Chilling Tolerance by CRISPR-Cas9-Mediated SlCBF1 Mutagenesis. *Journal of Agricultural and Food Chemistry* , *66* (34), 9042–9051. https://doi.org/10.1021/acs.jafc.8b02177

Lu, T. (2019). Improving plant growth and alleviating photosynthetic inhibition and oxidative stress from low-light stress with exogenous GR24 in tomato (Solanum lycopersicum l.) seedlings. *Frontiers in Plant Science* , *10* . https://doi.org/10.3389/fpls.2019.00490

Mamuaja, CF, & Helvriana, L. (2017). Characteristics of tomato paste with the addition of citric acid during storage. *Journal of Food Science and Technology* . https://scholar.archive.org/work/bhphr3te6bbghii544vro4vdmq/access/wayback/https://ejournal.unsrat.ac.id/index.php/itp/article/viewFile/18563/18089

Manasikana, A., Anwar, MS, Setiawan, A., Choirudin, C., & Darmayanti, R. (2023). Exploration of Ethnomathematics of the West Tulang Bawang Islamic Center. *Journal of Perspectives* , *7* (1), 34–49.

Martunis, L., Dahliani, L., & Yana, D. (2023). Analysis of physical and chemical characteristics of soil in coffee plantations in the Mount Puntang Social Forestry Area, West Java. *AMCA Journal of Science and Technology* , *3* (1), 1–6.

Muhammad, M. (2019). Droplet deposition density of organic liquid fertilizer at low altitude UAV aerial spraying in rice cultivation. *Computers and Electronics in Agriculture* , *167* . https://doi.org/10.1016/j.compag.2019.105045

Musta'inah, A., Hani, ES, & Sudarko, S. (2017). Risk analysis on tomato farming in Ledokombo District, Jember Regency. *Agribest Journal* . http://jurnal.unmuhjember.ac.id/index.php/AGRIBEST/article/view/1153

Mustakim, M., Hasni, H., Hasna, H., & ... (2021). Processing Tomatoes into Tomato Dates with Traditional Techniques to Increase the Income of the Tarian Hamlet Community. *MASPUL JOURNAL …* . https://ummaspul.e-journal.id/pengabdian/article/view/2192

Nofriati, D. (2018). *Post-Harvest Handling of Tomatoes* . BPTP Jambi.

Paul, K. (2019). Understanding the biostimulant action of vegetal-derived protein hydrolysates by high-throughput plant phenotyping and metabolomics: A case study on tomato. *Frontiers in Plant Science* , *10* . https://doi.org/10.3389/fpls.2019.00047

Pourmovahed, P., Lefsrud, M., & Maisonneuve, J. (2022). Thermodynamic limits of using fertilizer to produce clean fertigation solution from wastewater via forward osmosis. *Journal of Membrane Science* , *647* . https://doi.org/10.1016/j.memsci.2021.120168

Prasetya, B., Setiawan, AB, & ... (2019). Fuzzy Mamdani in Hydroponic Tomato Plants. *JEEE-U (Journal of …* . https://jeeeu.umsida.ac.id/index.php/jeeeu/article/view/1610

Quinet, M. (2019). Tomato Fruit Development and Metabolism. *Frontiers in Plant Science* , *10* . https://doi.org/10.3389/fpls.2019.01554

Rangarajan, A. K. (2018). Tomato crop disease classification using pre-trained deep learning algorithm. *Procedia Computer Science* , *133* , 1040–1047. https://doi.org/10.1016/j.procs.2018.07.070

Razifard, H. (2020). Genomic evidence for the complex domestication history of the cultivated tomato in Latin America. *Molecular Biology and Evolution* , *37* (4), 1118–1132. https://doi.org/10.1093/molbev/msz297

Riono, SH, Rakhmawati, PU, & Darmayanti, R. (2023). Internship Employees: Mentoring and Counseling in the Software Development Process. *Journal of Innovation and Development of Community Service Results* , *1* (1), 21–28.

Robledo, N. (2018). Thymol nanoemulsions incorporated in quinoa protein/chitosan edible films; antifungal effect in cherry tomatoes. *Food Chemistry* , *246* , 211–219. https://doi.org/10.1016/j.foodchem.2017.11.032

Roditakis, E. (2018). A four-year survey on insecticide resistance and likelihood of chemical control failure for tomato leaf miner Tuta absoluta in the European/Asian region. *Journal of Pest Science* , *91* (1), 421–435. https://doi.org/10.1007/s10340-017-0900-x

Rothan, C. (2019). Trait discovery and editing in tomato. *Plant Journal* , *97* (1), 73–90. https://doi.org/10.1111/tpj.14152

Rozana, R., Perdana, D., & ... (2021). Simulation of tomato transportation and changes in tomato quality during storage. *Journal of Food …* . https://ejournalwiraraja.com/index.php/JFTA/article/view/1209

Saleh, R., Dahliani, L., & Rusiva, R. (2021). THE EFFECT OF BUDGET PARTICIPATION AND ORGANIZATIONAL CULTURE ON MANAGERIAL PERFORMANCE AT PT PERKEBUNAN NUSANTARA VIII. *Applied Business Journal* , *5* (2), 167–184.

Sari, AP, Qurotunnisa, A., Rukmana, A., & Darmayanti, R. (2023). What are the advantages of using leftover cooking oil waste as an aromatherapy candle to prevent pollution? *Journal of Innovation and Development of Community Service Results* , *1* (2).

Sengar, AS (2020). Comparison of different ultrasound assisted extraction techniques for pectin from tomato processing waste. *Ultrasonics Sonochemistry* , *61* . https://doi.org/10.1016/j.ultsonch.2019.104812

Shamshiri, R.R. (2018). Review of optimum temperature, humidity, and vapor pressure deficit for microclimate evaluation and control in greenhouse cultivation of tomatoes: A review. *International Agrophysics* , *32* (2), 287–302. https://doi.org/10.1515/intag-2017-0005

Sjarif, SR (2020). The Effect of Adding Natural Preservatives on Microbial Contamination in Tomato Paste. *Journal of Industrial Technology Research* . http://ejournal.kemenperin.go.id/jpti/article/view/5804

Srinivas, C. (2019). Fusarium oxysporum f. sp. lycopersici causal agent of vascular wilt disease of tomatoes: Biology to diversity– A review. *Saudi Journal of Biological Sciences* , *26* (7), 1315–1324. https://doi.org/10.1016/j.sjbs.2019.06.002

Stevens, R.G. (2018). A systems biology study in tomato fruit reveals correlations between the ascorbate pool and genes involved in ribosome biogenesis, translation, and the heat-shock response. *Frontiers in Plant Science* , *9* . https://doi.org/10.3389/fpls.2018.00137

Sun, C. (2020). A Transcriptional Network Promotes Anthocyanin Biosynthesis in Tomato Flesh. *Molecular Plant* , *13* (1), 42–58. https://doi.org/10.1016/j.molp.2019.10.010

Tashkandi, M. (2018). Engineering resistance against Tomato yellow leaf curl virus via the CRISPR/Cas9 system in tomato. *Plant Signaling and Behavior* , *13* (10). https://doi.org/10.1080/15592324.2018.1525996

Tran, T. T. (2019). A comparative study of deep CNN in forecasting and classifying the macronutrient deficiencies on development of tomato plants. *Applied Sciences (Switzerland)* , *9* (8). https://doi.org/10.3390/app9081601

Trigo, S.F. (2020). Vacant land in London: a planning tool to create land for growth. *International Planning Studies* , *25* (3), 261–276. https://doi.org/10.1080/13563475.2019.1585231

Triono, T., Darmayanti, R., Saputra, ND, & Makwana, G. (2023). Open Journal System: Assistance and training in submitting scientific journals to be well-indexed in Google Scholar. *Journal of Innovation and Development of Community Service Results* , *1* (2).

Tumbelaka, R., Momuat, LI, & Wuntu, AD (2019). Utilization of VCO containing tomato carotenoids and carrageenan in making lotion. *Pharmacon* . https://ejournal.unsrat.ac.id/v3/index.php/pharmacon/article/view/29242

Usman, F. (2020). Tomatoes for Heart Disease Prevention. *Health Journal* . https://scholar.archive.org/work/wed2l3az6nd6rgvnowlmqgy434/access/wayback/http://ejournal.poltekkesternate.ac.id/ojs/index.php/juke/article/download/181/108

Wahid, MI, Lawi, A., & Siddik, AMA (2023). Performance Comparison of Ensembled Transfer Learning Models on Tomato Leaf Disease Classification. *National Seminar on Electrical Engineering …* . http://118.98.121.208/index.php/sntei/article/view/3630

Wan, P. (2018). A methodology for fresh tomato maturity detection using computer vision. *Computers and Electronics in Agriculture* , *146* , 43–50. https://doi.org/10.1016/j.compag.2018.01.011

Wu, Q. (2020). Dcgan-based data augmentation for tomato leaf disease identification. *IEEE Access* , *8* , 98716–98728. https://doi.org/10.1109/ACCESS.2020.2997001

Wulandari, T., Nurmalitasari, D., Susanto, K., & Darmayanti, R. (2022). Ethnomathematics in Betel Leaf Batik and the Pasuruan Kepodang Bird. *National Seminar on Learning Technology* , *2* (1), 95–103.

Yuniastri, R., Ismawati, I., Atkhiyah, VM, & ... (2020). Characteristics of physical and chemical damage to tomatoes. *Journal of Food …* . https://ejournalwiraraja.com/index.php/JFTA/article/view/954

Yuniwati, ED, Darmayanti, R., & Farooq, SMY (2023). How is organic fertilizer produced and applied to chili and eggplant plants? *AMCA Journal of Community Development* , *3* (2), 88–94.

Zahara, S. (2018). Growth and yield of two generations of tomato cuttings at several concentrations of Indole Butyric Acid. *Jurnal Borneo Saintek* . http://180.250.193.171/index.php/borneo_saintek/article/view/908

Zahroh, U., Rachmawati, NI, Darmayanti, R., & Tantrianingrum, T. (2023). " Guidelines " for collaborative learning in 21st century education at Madrasah Tsanawiyah. *Assyfa Journal of Islamic Studies* , *1* (2).

Zhang, M. (2018). Increasing yield and N use efficiency with organic fertilizer in Chinese intensive rice cropping systems. *Field Crops Research* , *227* , 102–109. https://doi.org/10.1016/j.fcr.2018.08.010

Zhang, Y. (2020). Deep Learning-Based Object Detection Improvement for Tomato Disease. *IEEE Access* , *8* , 56607–56614. https://doi.org/10.1109/ACCESS.2020.2982456