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The Effectiveness of the Red Water System (RWS) Technique in African Catfish Culture (*Clarias gariepinus*): A review

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Authors' contributions

This work was carried out in collaboration among all authors. Author AY designed the study and wrote the protocol. Author APA wrote the first draft of the manuscript, managed the analyses of the study, and managed the literature searches. All authors conducted the review process and literature reviews. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

This article aims to analyzed the effectiveness of the Red Water System Technique on the survival and growth of cultivated catfish from the conclusions of several previous researchers. The method used in this literature study is to review several research articles on the success of catfish farming using the red water system technique. We collected and identified 50 academic articles, trusted databases, proceedings, books, dissertations, government regulations, and other international journals that were potentially relevant to the specified keywords. Upon review, the relevant

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literature was aggregated to 32. The collected review data is then compiled into a manuscript. The result is that probiotics in the red water system technique can maintain water quality according to quality standards by utilizing nutrient levels in waters as a food source for bacteria *L.casei* and catfish have high growth rates due to the addition of probiotics to the waters, which makes them resistant to disease. In conclusion, the Red Water System technique has improved growth performance, survival rate, digestibility, immunity, and disease resistance in African catfish compared to African catfish culture using conventional methods which can benefit the farmers.

Keywords: African catfish; growth; probiotics; red water system; water quality.

1. INTRODUCTION

The African catfish (*Clarias gariepinus*) according to the database of FAO and FishBase about introduced aquatic species, African catfish was introduced to Indonesia in 1985 [1]. The characteristics of this fish are has smooth and, slimy body, without scales, and has extra arborescent respiratory organs. Catfish has a Blackish gray, depressed body, flat head, and four pairs of whiskers. Catfish can live in all freshwater waters with calm streams and are classified as omnivorous fish [2]. Total production of catfish in Indonesia on 2022 such as *Clarias gariepinus* and *Clarias batrachus*, has estimated 343,414 T from aquaculture activity, where has increased by 0,14% from 2021 [3]. With the increase in catfish production per year, that means catfish is a fish in great demand by the people of Indonesia. Apart from its high nutritional content, catfish is easy to process, has a delicious taste, and has a relatively affordable price [4]. The nutritional content contained in 100 g of catfish is 78,5 g of water, 90 g of calories, 18,7 g of protein, 1,1 g of fat, 15 g of calcium, 260 g of phosphorus, 2 g of iron (Fe), 150 g of sodium, 0 g thiamin, and niashin 2 g [5]. Due to high consumer interest, there are more and more catfish cultivators to meet the needs of the Indonesian people. The local catfish species in Indonesia is *Clarias batrachus*, but those commonly cultivated are African catfish (*Clarias gariepinus*), Sangkuriang catfish, and Paiton catfish (*Clarias* sp.) [6]. The specific growth rate of African catfish is affected by the genetics and physiology of African catfish, also a supportive environment, water quality, and feed used. Certain growth limits (carrying capacity) of fish be affected by water quality, fish feed, and the size of African catfish [7].

Several methods of cultivating African catfish that are applied in Indonesia are the biofloc system, aquaponics, booster, Recirculating Aquaculture System (RAS), Green Water System (GWS), and Red Water System (RWS). The RWS is a catfish farming technology that utilizes the fermentation of *L. casei* bacteria and the fungus *Saccharomyces cerevisiae* during rearing. RWS is an application of adding probiotics to intensive catfish farming [8]. This addition this bacteria and fungus causes the decomposition of organic materials in ponds, and ammonia concentrations in ponds [9], also has a positive effect on water quality Dissolved Oxygen (DO), reduced ammonia (NH_3), nitrite (NO_2^-), and nitrate (NO_3^-) [10], this condition can support the survival of catfish. Probiotics have beneficial properties to improve the microbial balance in the intestinal tract of African catfish which can facilitate the digestion of fish [11]. The advantages of RWS system is no need water changes during fish culture, can rare in high stocking density, and easy to application, cost-effective feed, and increased resistance of catfish to disease, probiotics in this system also increase fish response to disease, and improve the quality environment [12], utilizing bacteria to increase fish digestibility, inhibiting the growth of pathogenic bacteria until satisfactory results are obtained [13]. The aims of this article are to know how effectiveness of the Red Water System Technique for the survival of cultivated catfish.

2. METHODOLOGY

The analysis was carried out in May 2023. The analytical method used was in the form of literature studies both domestically and abroad related to catfish farming using the Red Water System technique. Use relevant search keywords such as "culture"; "African catfish"; "fish probiotics"; "catfish growth"; "red water systems"; “Water Quality”. As well as collecting literature from various sources such as Google Scholar, Elsevier, ScienceDirect, and Research Gate. With a systematic review method, which combines several previous primary research results to obtain accurate and clear facts. We have collected and identified 50 academic articles, trusted databases, proceedings, books, dissertations, government regulations, and other

Table 1. List of search terms and number of manuscripts found for review

Search Terms	Initial Literatur Search Results	Relevant Literature
Catfish growth	8	4
African Catfish + Culture	7	5
Fish probiotics	5	3
Red Water System	10	7
Red Water System + African Catfish	10	7
Red Water System + Catfish growth	5	3
Red Water System + Fish probiotics	5	3

international journals that are potentially relevant to the specified keywords. All relevant journals then review abstracts and discussion results from academic articles, trusted databases, proceedings, books, dissertations, and other international journals to identify those that discuss African catfish cultivation in the RWS system. This narrows the number of relevant papers to 32. The collected review data is then reviewed in sections compiled into a manuscript. Using multiple search terms and term combinations; so as to get the number of documents listed in Table 1.

3. RESULTS

3.1 Water Quality

The quality of the red water system for African catfish culture meets The quality standards for catfish farming water according to Government Regulations number 22 of 2021, and the National Standardization Agency (SNI) 6484.3: 2014 which can be seen in Table 2.

3.2 Previous Research

Several researchers have conducted research on catfish (*Clarias* sp.) farming using the Red Water System (RWS) technique and different treatments with various catfish growth results. The following results from various studies can be seen in Table 3.

4. DISCUSSION

Three types of fish were still classified as catfish as a comparison with one another, namely African catfish (*Clarias gariepinus*), Basa (*Pangasius bocourti)*, and American catfish *(Ictalurus punctatus)* (Table 3). Using the RWS technique with various additional treatments such as catfish stocking density, probiotic composition given, and the type of catfish strain used.

Probiotics are one of the solutions to maintain water quality by cultivation standards because they contain bacteria that can increase the conversion of nitrite to nitrate [23]. Probiotics can regulate the microbial environment in the fish gut and inhibit pathogenic microbes in the gut and can increase feed efficiency in fish [24]. Probiotics that are commonly used in the Red Water System Technique for African catfish cultivation are Bacillus, Lactobacillus, Streptococcus, and Nitrosomonas types [25] because these species play a good role in the digestive tract ecosystem of fish which will improve growth performance and other maintenance parameters such as conversion ratio and feed efficiency, digestibility, body resistance, and body composition [26].

Cultivating catfish using the RWS technique can also reduce the nutrient content in aquaculture waters, namely the average ammonia level is 1,43 mg/L, it can reduce nitrate by 67,89%, it can reduce Total Phosphate by 19%, and Total Nitrogen by 43%. Bacillus and Nitrosomonas bacteria in decomposing organic matter in waters are said to be very effective so that they can produce water quality in African catfish cultivation that remains stable. Bacillus is used to improve water quality in cultivation media [27]. High survival rates and growth rates are due to good water quality and are suitable for fish life so that fish will grow and develop optimally. Water quality greatly affects the survival and growth of fish [28]. Continuous provision of probiotics can help provide suitable aquatic ecosystem conditions in terms of efficient absorption of fish feed and nitrification processes in the waters [10]. The average survival of African catfish with the RWS technique was 81,9%, the growth rate was 7,1% body weight/day and experienced a relative growth increase of 40,4% compared to not using the RWS technique.

The use of probiotics can reduce toxic levels in water and can reduce diseases caused by

pathogenic bacteria [29]. Large microorganisms from probiotics can oxidize ammonia. Bacteria in carrying out the process of photosynthesis also use ammonia as a nitrogen source for the decomposition process of organic matter as well as its growth and development. The water quality results obtained from several previous studies are still at a good quality standard according to the specified catfish cultures' water quality standards, such as an average temperature of 26 °C, pH 8, and Dissolved Oxygen (DO) obtained between 1 - 6 mg /L and still in the same range as African catfish farming without using the RWS system, namely the temperature range of 25 °C – 30 °C, and the pH range of 6,5 – 9,0 [30,31]. Cultivating African catfish without the RWS system and probiotics produces African catfish that increase in length and gain in weight slower or smaller. This is presumably due to the low levels of DO in aquaculture waters. Low DO levels can cause stress on African catfish. So that catfish appetite will decrease. The probiotic solution contains lactic acid bacteria namely *Lactobacillus* sp. so the pH in RWS technique cultivation starts from acidic or low [32].

From Table 3 can be seen that catfish farming using the RWS technique can improve growth performance, increase fish survival, increase fish digestibility, and increase immunity and disease resistance in African catfish. This does not only apply to one species of catfish, but applies to all groups of catfish, both American catfish, African catfish, and sea bass which are relatives of catfish. Some of the weaknesses of the RWS technique are the need several days for probiotic fermentation process, the possibility of probiotic fermentation failure, uneven spread of bacteria, and rainwater that goes directly into the pond causing an acidic pH. These deficiencies can be anticipated by ensuring the ingredients in the manufacture of probiotics are following the dosage and type, followed by adding aerators to the aquaculture ponds.

Table 2. Aquaculture water quality for catfish

Parameter	Unit	National Standardization Agency 6484.3:2014 [14]	Government Regulations number 22 of 2021 [15]	Water quality standards for catfish farming with RWS [16]
Water Brightness	cm	25-30	-	27-30
Ammonia (NH_3)	mg/L	Maximum 0,1	0,2-0,5	0,5-5
Dissolved Oxygen (DO)	mg/L	Minimun 3	3-4	0,3-4,7
Temperature	℃	25-30	26-30	25,1-30,2
pH	-	6,5-8	6-9	7,1-9,2

Table 3. Cultivating catfish using RWS techniques and different treatments

No	Type of Catfish	Treatment	Result	Reference
1.	*Clarias* sp.	A: RWS 7,5 µl/L/week no probiotic. B: no probiotic RWS. C: with probiotic RWS 7,5 µL/L/week. D: with probiotic RWS 10 µL/L/week. E: with probiotic RWS 12,8 µL/L/week.	The lowest ammonia, nitrate and phosphate values were obtained in the aquaponic experimental group with RWS 10 µL/l/week (Treatment D). Treatment D had the lowest average ammonia of 0,50 ppm, nitrate reduction of up to 60,78% and temperature and pH remained relatively unchanged.	[8]
2.	Channel Catfish *(Ictalurus punctatus)*	A = no probiotic *Bacillus velezensis.* B = with strain *B. velezensis* AB01. C = with strain *B. velezensis* AP79. D = with strain *B.*	Catfish fed *B. velezensis* AP193 experienced a growth increase of 40,4% compared to the control feed on catfish fry, each of which came from aquariums or raceways. Water quality was improved where fish were treatment fed with probiotic modified	[17]

No	Type of Catfish	Treatment	Result	Reference
		velezensis AP143. E = with strain *B. velezensis* AP193	feeds, as reductions in total phosphorus / TP (19%), total nitrogen / TN (43%) and nitrate (75%).	
3.	African Catfish (*Clarias gariepinus*)	Observation of average survival with stocking density: A = 250 head/m^3 B = 500 head/m^3, and C = 750 head/m^3	The best treatment was a stocking density of 250 head/m^3 with an average survival rate of 88,5% (B=74,3% and C=82,9%) and a daily growth rate of 7,25% body weight/day (B= 7,15% and C = 6,91%). Water quality is still in the temperature tolerance range of 27,3-30,9 °C, pH 8,28-8,61, DO 1,41-5,68 mg/L, ammonia 0,3-3,5 mg/L. However, from an economic point of view, it is better to use a stocking density of 750 individuals/m^3 because each treatment has slight differences.	[18]
4.	African Catfish *(Clarias gariepinus)*	Capacity density: A = 250 head/m^3 B = 500 head/m^3, and C = 750 head/m^3 Look for the highest protein retention and energy retention	The results obtained did not have a significant effect on protein retention and fish energy retention. The highest yields were in treatment B (500 individuals/m^3) of 44,94% and 39,70%, the lowest yields were in treatment C (750 individuals/m^3) namely 37,72% and 33,03%. Water quality is quite optimal. The temperature range of all rearing ponds in this study was 26,5-28 °C. Dissolved oxygen (DO) is between 0,2-6,5 mg/L in the morning and 0,3-10 mg/L in the afternoon. The average pH is 7,5 – 9.	[19]
5.	African Catfish *(Clarias gariepinus)*	Treatment A = 250 head/m^3 Treatment B = 500 head/m^3 Treatment C = 750 head/m^3	The higher the stocking density, the lower the total bacterial density. The water quality during the study was still in the tolerance level for catfish. However, from an economic point of view, it is better to use a stocking density of 750 individuals/m^3 because each treatment has slight differences.	[20]
6.	African Catfish *(Clarias gariepinus)*	Treatment A = 250 head/m^3 Treatment B = 500 head/m^3 Treatment C = 750 head/m^3	The highest protease activity was in treatment C, but inversely proportional to the highest growth rate in treatment A. Treatment A had a growth rate of 7,23% body weight/day and protease enzyme activity of 55,93 U/mL. treatment B = 7,14% body weight/day and 60,08 U/mL. treatment C = 6,89% body weight/day and 75,15 U/mL. The water quality during the study was still within the tolerance limits of catfish. However, from an economic point of view, it is better to use a stocking density of 750 individuals/m^3 because each treatment has slight differences.	[21]
7.	Basa (*Pangasius*	Probiotic diet for 60 days without	A significant increase in body weight, growth rate and feed conversion ratio	[22]

No	Type of Catfish	Treatment	Result	Reference
	bocourti)	probiotics and with a mixture of 6 strains of *Bacillus* spp. different: *S.lutetiensis* L7c, *L. paraplantarum* L34b-2, *L. plantarum* L42g, *B. amyloliquefaciens* B44v, *Bacillus* sp. B51f, and *B. aerius* B81e	compared to without probiotics. Humoral & cellular immunity was higher in the probiotic-treated fish. Has a higher survival rate than control fish after injection with virulent *A. hydrophila*. *B. aerius* strain B81e and *L. paraplantarum* strain L34b-2 significantly increased innate immunity, growth performance, and disease resistance of *P. bocourti*.	

5. CONCLUSION

Based on the discussion above, the advantage of the RWS method when compared to conventional methods is that the Red Water System technique can improve the growth performance of African catfish and improve other rearing parameters such as feed conversion ratio and efficiency, digestibility, body resistance, and body composition, the RWS method is proven to the better survival rate, digestibility, immunity, and disease resistance in catfish, compared to catfish farming without using the RWS method. The weakness of the RWS method compared to the conventional method is that it requires additional costs to buy materials for making probiotic solutions, requires more time to ferment probiotics, needs the exact dose of probiotic ingredients, and needs many experiences for successful probiotic fermentation. It is recommended further research focus on research on differences in the immune system of African catfish cultivated with the RWS system and not, as well as how to prevent and treat the failure of probiotic fermentation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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