Incubating red NIFI strain of tilapia eggs in a closed-water recirculation system with varied salinity levels

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Abstract. This research aims to determine the impact of varying salinities on the hatching of red NIFI tilapia eggs in a closed-water recirculation system incubator. The eggs were hatched at salinities of zero ppt, one ppt, five ppt, and ten ppt, with three replications per treatment. The stocking density for each replication was set at 1,750 eggs per liter. After a six-day incubation period, the resulting larvae were reared under the same salinity conditions for four weeks, with a stocking density of 1,000 individuals per cubic meter. The hatching rate of eggs recorded for the zero ppt salinity treatment was 74%. There was no significant difference between the zero ppt, one ppt (73%), and five ppt (69%) salinity treatments, while the ten ppt (24%) yielded significantly different hatching rates of eggs results ($p<0.05$). The highest survival rate of reared larvae was achieved in zero ppt salinity treatment, reaching 75%. Salinities of one ppt, five ppt, and ten ppt yielded larvae survival rates of 70%, 55%, and 49%, with statistical significance ($p<0.05$). Egg hatching in an incubator with a closed water recirculation system at low salinity levels can be considered an initial adaptation step in brackish water tilapia seed production.

1 Introduction

Nile tilapia (*Oreochromis niloticus*) is a euryhaline species, which means it has a high tolerance to salinity levels [1–3]. The culture of tilapia in brackish water has gained popularity as an alternative farming option in idle pond areas [4]. Idle ponds are shrimp culture ponds that cannot be reused due to the high risk of failure. This can be influenced by decreased soil fertility or disease/virus residues that affect shrimp from the previous production cycle. Nile tilapia has high environmental adaptability [1], making it suitable for replacing shrimp as a culture commodity in idle ponds. Consequently, there is an increasing demand for tilapia fry in coastal areas [5]. In the coastal area of Pati Regency, Central Java, Indonesia, the pond area used for saline tilapia culture is about 642 hectares, and the tilapia seeds needed each year can reach 96,300,000 individuals [6]. Fulfillment of tilapia seed stocks locally is only 15%, so most sources are imported from outside the area, which adds

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to transportation costs [6]. However, the expansion of saline tilapia farming has not been accompanied by sufficient efforts in hatchery production.

Saline tilapia culture still relies on freshwater tilapia fry. The spawning of tilapia in brackish water is not yet optimal, as the brood produces fewer larvae, and the spawning time is longer than tilapia spawning in freshwater [1,7]. On the other hand, directly stocking tilapia fry in high salinity poses a higher mortality risk. The ability of Nile tilapia to survive in brackish water depends on its osmosis capability [8]. The adaptation of tilapia fry to brackish water should occur as early as possible to improve their survival rate during the grow-out phase [9]. The anatomy and physiology of tilapia in the early stages of post-fertilization growth allow them to respond and adapt to environmental conditions, including adjustments to salinity levels [1]. Tilapia larvae on the fifth day after hatching have better tolerance to salinity levels than those on the fifteenth-day post-hatching [9]. It is expected that freshwater fry producers can facilitate the adaptation of tilapia to low-salinity water, thereby minimizing the risk of fry mortality due to salinity changes when they are sent for saline tilapia farming.

Egg hatching in water with a salinity level exceeding ten ppt results in a hatching rate of less than 50% [10]. Using egg incubators can enhance the hatching rate and the quality of the produced larvae. Egg incubation for tilapia can achieve up to 97% hatching rate [11]. Egg incubation in tilapia occurs within 50 hours at temperatures of 25-27°C. The yolk sac in the larvae is absorbed by the eighth to tenth day of rearing [12]. The utilization of a closed recirculating water system in the incubator enables manipulation of environmental factors as the water flow agitates the hatching cylinder, causing the eggs to move, roll, and receive oxygen constantly [13], same as the treatment when the tilapia incubates the eggs in its mouth [14]. This technique yields fry of uniform size/age. The absence of incubation and parental care accelerates the maturation process of eggs for subsequent cycles. Red tilapia tends to have better salinity tolerance than black tilapia [4,15]. Red tilapia, such as the red NIFI (National Inland Fish Institute) strain, was cultured in 15 ppt salinity and showed a survival rate of 84% [16]. The application of this study can be carried out by combining aspects of hatching tilapia eggs at varied salinity levels using an incubator and the red NIFI tilapia strain to increase the egg hatching rate and seed survival.

2 Methodology

2.1 Experimental design

The research was conducted at the Saline Tilapia Breeding Unit, Jepara Brackish Water Aquaculture Center, Directorate General of Aquaculture, Ministry of Marine Affairs and Fisheries, Indonesia. The study employed an experimental approach using eggs obtained from red NIFI tilapia broodstock spawning. The broodstock spawning was carried out on a mass scale for 20 days using fresh water. The harvested eggs were collected as the test material. Egg incubation was performed in a closed recirculating water system incubator. This technology aims to minimize water exchange and optimize water reuse, so better control over water quality, reduced environmental impact, and increased biosecurity. The treatments involved hatching the eggs at salinities of zero ppt, one ppt, five ppt, and ten ppt. This salinity is used in a range of freshwater conditions as a control for the optimal salinity that has been tested for saline tilapia seed culture [10]. Each treatment was replicated three times. The incubation period of the eggs until hatching and becoming larvae was six days. The hatched larvae were then reared for four weeks. Data collected for comparison included egg hatching rate, larval survival rate, and the growth of the produced fry. The obtained results were compared and statistically analyzed using One-Way ANOVA.

2.2 Experimental method

2.2.1 Fish spawning and eggs collection

The spawning of red NIFI tilapia broodstock in freshwater was conducted in a rectangle concrete tank with dimensions of 5 m x 8 m x 2 m. The tank was sterilized using a dosage of 10 g/m^2 of calcium hypochlorite. After sterilization, the tank was dried for two days. Freshwater was then added to the spawning tank until the water level reached a height of 0.5 m. Mature gonad-bearing red NIFI tilapia broodstock was selected, distinguishing between males and females. The spawning process was conducted on a mass scale with a male-to-female ratio of 1:3. A total of 40 male red NIFI tilapia broodstock with an average weight of 750±87 g and an average length of 36±2 cm was used. There were 120 female red NIFI tilapia broodstock with an average weight of 533±29 g and an average length of 31±1 cm. The spawning process to obtain red NIFI tilapia eggs was carried out in four cycles, with each cycle lasting 20 days. Feeding was provided regularly a day twice daily, at 09:00 AM and 03:00 PM. The daily feed dosage given was 3% of the fish biomass. Egg harvesting was performed by carefully extracting the eggs from the mouths of the female broodstock [17,18]. The total number of eggs obtained was calculated using a sampling method, and the eggs were divided equally for replication in each treatment.

2.2.2 Incubating and hatching of eggs

The eggs resulting from red NIFI tilapia broodstock spawning were semi-indoor hatched in an incubator with a closed-loop water recirculation system. The incubator unit consisted of 12 hatching tubes with a volume of 4 L, six aquariums with a volume of 20 L, three tanks with a volume of 80 L, a framework set, water channel installation, protein skimmer, filter, water pump, and heater. The incubation of red NIFI tilapia eggs was carried out four times. The water was filled into the hatching tubes according to the specified salinity treatment until all the volume spaces were fully occupied. The salinity treatment variations used were zero ppt, one ppt, five ppt, and ten ppt. Each treatment utilized three hatching tubes as replications. The water recirculation system in the incubator started once the pump was turned on. The egg incubation was conducted at approximately 30°C with a water flow rate of roughly 0.05 L/s. The stocking density of the eggs was 1,750 eggs/L. The larvae from egg hatching in the incubator were harvested after six days. Meanwhile, the hatching rate was calculated after egg hatching to compare the different treatments.

2.2.3 Larvae rearing

The larvae resulting from the hatching of red NIFI tilapia eggs were reared in an outdoor rectangle concrete tank with dimensions of 2 m x 6 m x 1 m. The tank was sterilized using calcium hypochlorite with a dosage of 10 g/m^2. After sterilization, the tank was dried for two days. Freshwater was then filled into the spawning tank until it reached a height of 0.4 m. The salinity levels of the water used in each treatment corresponded to the respective salinity treatments during egg hatching: zero ppt, one ppt, five ppt, and ten ppt. The larvae were reared for four weeks until they reached a size of 2-3 cm and were ready for stocking. The stocking density of the larvae was 1,000 individuals/m^2. The larvae were fed powdered pellets three times a day, ad libitum, at 08:00 AM, 12:00 PM, and 04:00 PM. The calculation of the survival rate for comparison between treatments was performed after the harvest of the fingerlings.

2.3 Data collection and analysis

Data collection for the comparison between salinity levels was conducted at each testing stage. Data on egg incubation included egg size measurements, hatching rate, and larva size produced. Data on larva rearing had survival rate, growth rate, and harvest size measurements. Water quality parameters such as temperature (Lutron DO-5512SD), salinity (ATAGO), pH (ATC), and dissolved oxygen (Lutron DO-5512SD) were measured throughout the rearing period. The collected data were processed using Microsoft Excel and IBM SPSS26 software. Statistical analysis was performed using One-Way ANOVA with tests for data normality and homogeneity. The following formulas were used for data calculations.

2.3.1 Hatching rate

The egg-hatching rate was calculated using the following formula [19].

$$HR = \frac{Nt}{No}\ x\ 100\% \tag{1}$$

Information
HR : hatching rate of egg (%)
Nt : number of eggs hatched (grain)
No : total number of eggs incubated (grain)

2.3.2 Survival rate

The survival rate of the fry or juveniles can be calculated using the following formula [20].

$$SR = \frac{Nt}{No}\ x\ 100\% \tag{2}$$

Information
SR : survival rate of fry (%)
Nt : number of surviving fry (individual)
No : initial number of fry (individual)

2.3.3 Specific growth rate

The specific growth rate of the fry can be calculated using the following formula [21].

$$SGR = \frac{(\ln Wt - \ln Wo)}{t}\ x\ 100\% \tag{3}$$

Information
SGR : specific growth rate of fry (%/day)
Wt : final average weight of fry (g)
Wo : initial average weight of fry (g)
t : duration of testing time (day)

3 Result and discussion

The red NIFI tilapia broodstock mass spawning was conducted in freshwater (zero ppt salinity). The spawning process occurred in a sterilized concrete tank measuring 5 m x 8 m

x 2 m with a water depth of 0.5 m. The spawning was carried out in four cycles, each lasting 20 days. The male broodstock used had an average weight of 750±87 g and an average length of 36±2 cm, while the female broodstock had an average weight of 533±29 g and an average length of 31±1 cm. The number of male and female broodstock remained constant throughout the three cycles as there were no fish mortalities (100% survival rate). A total of 1.5 kg of feed (3% of biomass) was provided twice daily. On average, one female broodstock produced approximately 1,250 eggs. Approximately 15% of the total number of female broodstock were observed to be incubating eggs. The eggs had an average weight of 0.01 g and a length of 0.30 cm (Table 1). The eggs were collected and counted using a sampling method (350 eggs sampled once). The eggs were divided equally into three replicates and incubated in a closed-system recirculating water incubator (Figure 1). The collection and incubation of the eggs were conducted four times in alternating fashion for testing salinity levels of zero ppt, one ppt, five ppt, and ten ppt. The water quality parameters measured in the broodstock tank during the testing period were within a good range. The measured water temperature ranged from 27.5°C to 28.7°C, pH ranged from 7.1 to 7.9, and dissolved oxygen ranged from 4.2 mg/L to 4.9 mg/L.

The incubator unit used for hatching red NIFI tilapia eggs utilizes a closed-system recirculating water system. The incubator unit consisted of interconnected components, each serving its function. The heater was set to maintain a stable temperature of approximately ±30°C within the water medium of the incubator. The incubator was filled with water to its total capacity. Water was pumped from three 80 L tanks through the main water pipeline and entered twelve 4 L hatching tubes (Figure 1). The hatched eggs followed the water flow out of the tubes and entered the larval-rearing containers. The larval-rearing containers consisted of six 20 L aquariums. Within these containers, water outlets directed the water toward the set of filters and a protein skimmer. The filter system included mechanical, biological, and chemical filters. The filter arrangement included coarse and fine cotton filters for mechanical filtration and ginger coral as a biological filter. The operation of the incubator for testing was conducted in cycles. Each cycle corresponded to the specific salinity level being tested.

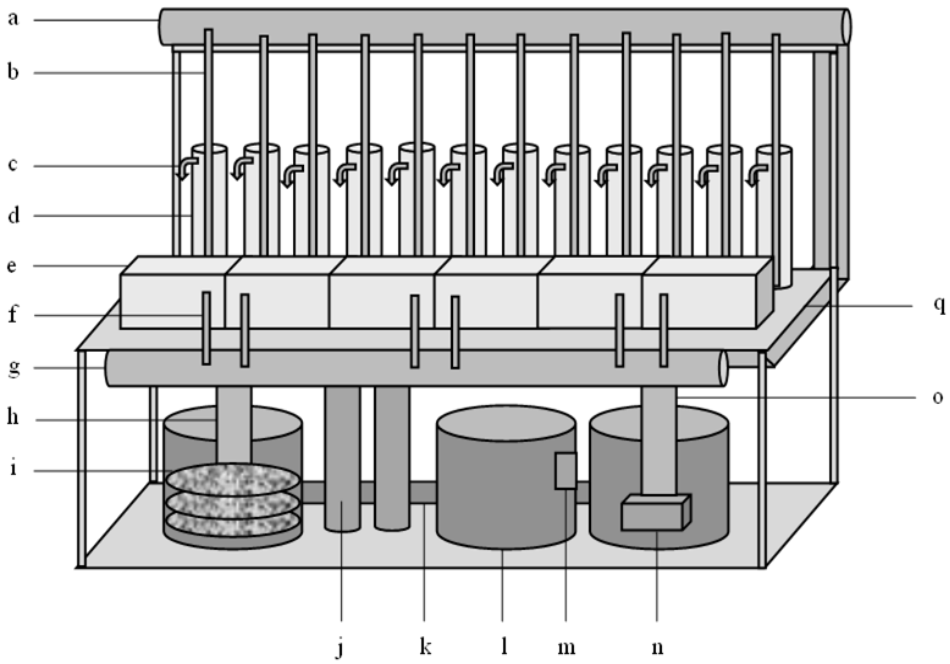

Fig. 1. Illustration of tilapia hatching incubator arrangement with closed air recirculation system.

Information

a	:	main inlet pipe	i	:	water filter
b	:	water pipe into the hatching tube	j	:	protein skimmer
c	:	water outlet to the aquarium	k	:	water piper into the reservoir
d	:	egg hatching tube	l	:	water reservoir
e	:	larva rearing aquarium	m	:	heater
f	:	water outlet	n	:	water pump
g	:	main outlet pipe	o	:	main inlet
h	:	water pipe into the filter reservoir	p	:	supporting framework

The incubation period of tilapia eggs in a closed-loop water recirculation system with a semi-indoor setting lasted six days. On the sixth day, all the larvae that had absorbed their yolk sacs were swimming in the larval rearing tank (20 L aquarium). The egg-hatching process took place within 1-3 days, with variations influenced by the different spawning periods of the male and female breeders, as mass spawning occurs over 20 days. The egg-hatching process was carried out in four cycles, each involving filling the incubator with water of different salinity levels, according to the testing method. There was no replacement or addition of water during the egg-hatching period, as the incubator operates on a closed-loop water recirculation system. Each treatment repetition used the same egg stocking density of 1,750 eggs/L. The eggs that were stocked had an oval shape and a yellow-orange color. The weight and length of the stocked eggs were 0.01 g and 0.30 cm, respectively (Table 1). Egg hatching in water with salinity levels of zero ppt, one ppt, five ppt, and ten ppt resulted in different hatching rates. The hatching rate decreased with increasing salinity levels (Figure 2). The highest hatching rate was observed at zero ppt salinity, with a value of 74±0.09%. This value did not significantly differ from the hatching rates obtained at one ppt and five ppt salinity, which are 73%±0.03 and 69±0.15%, respectively ($p>0.05$). A significant decrease in hatching rate occurred at ten ppt salinity, with a value of 24%±0.15% ($p<0.05$).

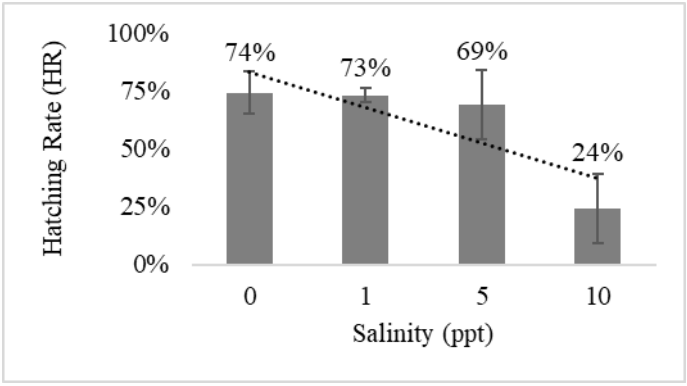

Fig. 2. The results of calculating the hatching rate of eggs hatched in different salinities.

The average weight of the tilapia eggs stocked for incubation in the incubator was 0.01 g, and the average length was 0.30 cm. The four salinity treatments during the egg-hatching process did not affect the weight and size of the resulting larvae (Table 1). The weight of the hatched larvae in all salinity treatments was the same (0.01 g). The length of the larvae in the zero ppt salinity treatment was 0.94±0.08 cm; in the one ppt salinity treatment, it was 0.94±0.07 cm. In the five ppt, salinity treatment was 0.94±0.10 cm, and in the ten ppt, salinity treatment was 0.93±0.05 cm ($p>0.05$). There was no significant fluctuation in water temperature due to a temperature-stabilizing device (heater) in the incubator. The measured water temperature ranged from 29°C to 30°C. The measured pH values ranged from 6.4 to

7.5. Slightly lower pH values below the standard range (6.5-8.5) were observed due to increased acidity from higher CO2 levels. The developing egg stage led to increased respiration rates. The measured dissolved oxygen levels in the incubator were sufficient for the respiratory needs during the egg-hatching process, ranging from 7.5 mg/L to 9.4 mg/L. The measured salinity levels in the water within the incubator remained consistent with the applied salinity treatments.

Table 1. The results of weight and length measurements of eggs, larvae, and fry reared in different salinities.

Salinity	Egg		Larvae		Fry	
	Weight (g)	Length (cm)	Weight (g)	Length (cm)	Weight (g)	Length (cm)
zero ppt	0.01	0.30	0.01	0.94±0.08	0.30±0.08	2.56±0.42
one ppt	0.01	0.30	0.01	0.94±0.07	0.29±0.03	2.55±0.35
five ppt	0.01	0.30	0.01	0.94±0.10	0.27±0.05	2.18±0.15
ten ppt	0.01	0.30	0.01	0.93±0.05	0.22±0.02	1.88±0.18

The hatched larvae of red NIFI tilapia collected in the incubator were harvested after six days for nursery rearing. The post-hatching larval rearing was conducted to produce fingerlings measuring 2-3 cm using water with the same salinity levels as tested before. The larvae were reared outdoors in a rectangular concrete tank with dimensions of 2 m x 6 m x 1 m and water depth of 0.4 m. The stocking density of larvae used was 1,000 individuals/L. The larval rearing was carried out for four weeks for each salinity treatment. The resulting survival rate of the fingerlings showed a similar trend to the egg hatching, decreasing as the salinity levels increased (Figure 3). The highest survival rate was observed in the zero ppt salinity treatment, reaching 75%. It was followed by the one-ppt, five-ppt, and ten-ppt salinity treatments, with corresponding survival rates of 70%, 55%, and 49%. The four salinity treatments significantly affected the fingerlings' survival rate ($p<0.05$).

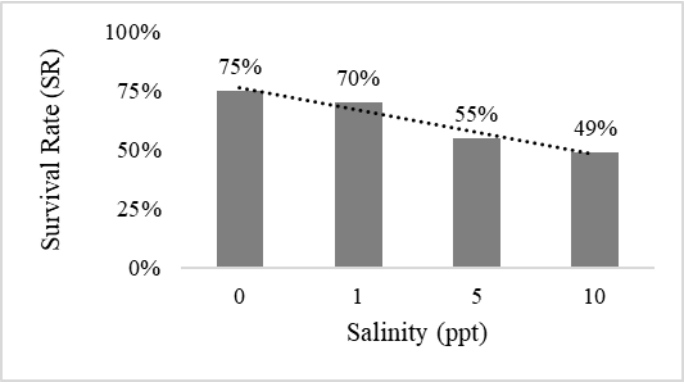

Fig. 3. The results of calculating the survival rate of seeds maintained at different salinities.

The variation in salinity levels in the larval-rearing water significantly affected the weight and length of the resulting fingerlings ($p<0.05$) (Table 1). The weight and length of the fingerlings reared in zero ppt salinity were 0.30±0.08 g and 2.56±0.42 cm, respectively. The weight and length of the fingerlings reared in one ppt salinity were 0.26±0.03 g and 2.55±0.35 cm, respectively. The weight and length of the fingerlings reared in five ppt salinity were 0.27±0.05 g and 2.18±0.15 cm, respectively. The weight and length of the fingerlings reared

in ten ppt salinity were 0.22±0.02 g and 1.88±0.18 cm, respectively. The lowest weight and length values, significantly different from the others, were observed in the ten ppt salinity treatment ($p < 0.05$). Meanwhile, the different salinity treatments in larval rearing did not have a significant effect on the survival growth rate (SGR) of the resulting fingerlings ($p > 0.05$) (Figure 4). The highest SGR was observed in the zero ppt salinity treatment, with a value of 0.121 g/day. It was followed by the treatments with five ppt, one ppt, and ten ppt salinity, which yielded survival growth rates of 0.118 g/day, 0.114 g/day, and 0.110 g/day, respectively. The measured water temperature in tilapia fingerlings cultured fell within the range of 25°C-27°C. The dissolved oxygen levels ranged from 9 mg/L to 11 mg/L. The measured pH of the water fell within the range of 6-7. The measured salinity levels in the water within the incubator remained constant and corresponded to the salinity treatments applied.

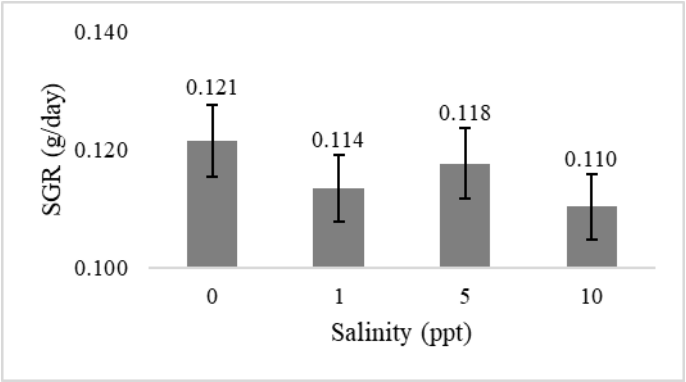

Fig. 4. The results of calculating the specific growth rate of seeds maintained at different salinities.

The hatching test of red NIFI tilapia eggs under different salinity levels was conducted in several stages. The eggs were obtained from the spawning of red NIFI tilapia broodstock. The stocking density and sex ratio followed the Indonesian National Standards (SNI): one male for every three females [22,23,24]. The average number of eggs produced by female broodstock with an average weight of 533±29 g was approximately 1,250 eggs. The number of eggs produced by female broodstock depends on their body size. Female broodstock weighing 100 g can already produce around 100 eggs, while those weighing between 600 g and 1,000 g can produce 1,000 to 1,500 eggs [14]. The eggs were then incubated in a closed-system recirculating water incubator. The salinity level of the water used in the incubator was adjusted according to the testing method. The egg stocking density used was 1,750 eggs/L. This quantity yielded the most optimal hatching rate than other independently explored stocking densities. In a study on egg incubation using a commercial incubator with a volume of 2.5 L, the stocking density used was 40 eggs/L [25].

Egg incubation at a water temperature of 30°C took place for 1-3 days. One drawback of mass spawning was the different spawning times among the broodstock, resulting in varying egg development stages. In a rearing system with a temperature of 30°C, the larvae absorbed the yolk sac on the sixth day of the incubation period. However, in other references, the yolk sac was absorbed on the eighth to tenth day of larval rearing at a water temperature of 25°C-27°C [12] and on the seventh day of larval rearing at a water temperature of 28°C [11]. The rate of egg maturation and larval development was primarily influenced by temperature [11,18]. Higher water temperatures lead to faster absorption of the yolk sac in the larvae. One advantage of the egg incubator unit used in the testing was the availability of a heater component for temperature enhancement and stabilization. Tilapia egg incubators without a

heater and placed indoors had an average temperature ranging from 23°C to 25°C [26]. Additionally, other research results have shown that using an incubator reduced the hatching time for tilapia eggs by six hours [11].

The hatching rate of eggs obtained from testing with different salinity levels yielded varying results. However, there was no significant difference in the hatching rate of eggs at salinity levels of zero ppt (74%), one ppt (73%), and five ppt (69%). This is consistent with research indicating that tilapia egg hatching in water media with salinity levels exceeding ten ppt results in hatching rates of less than 50% [10]. The trend observed aligns with other studies, where higher salinity levels correspond to increased mortality rates in tilapia [9]. All four treatments yielded hatching rates below the standard value of 80% [18]. Both internal and external factors influence the hatching rate of tilapia eggs. Internal factors are affected by egg quality, with successfully fertilized eggs exhibiting an orange-yellow color, while unfertilized eggs appear whitish-yellow. The egg hatchability is an inherited trait from the parents. Eggs that fail to hatch may be attributed to low fertility levels in the broodstock [18]. External factors that affect egg development include water quality (temperature, pH, dissolved oxygen, salinity, ammonia) [11], water flow rate, stocking density [27], and the presence of predation/cannibalism [27,28]. The water flow rate for incubation in the 4 L tube was 0.05 L/s, with a stocking density of 1,750 eggs/L. In other research, the water flow rate in tilapia egg incubators was 2.36 L/s [11]. The water flow rate was adjusted to suit the shape of the incubator's hatching tube. It was set to provide sufficient agitation for the eggs without causing damage or clumping [27].

Red NIFI tilapia larvae resulting from egg hatching in the incubator were reared until they reached a size of 2-3 cm and were ready for stocking. Larval rearing was conducted at a stocking density of 1,000 individuals/m^3. The salinity level in the rearing water media corresponded to the salinity level used during the egg-hatching test. The survival rate at the end of the four-week rearing period varied among treatments. The survival rate in larval rearing with a salinity level of zero ppt (75%) was not significantly different from the rate at one ppt salinity (70%). Similar results were obtained in a referenced study on tilapia seedling rearing [5]. The lowest survival rate was observed in rearing at a salinity level of ten ppt (24%). A referenced study also reported the lowest survival rate for tilapia seedlings reared at a salinity level of ten ppt, as the fish required more energy for osmoregulation under this salinity level [17].

Internal and external factors can influence the seedlings' high or low survival rate. Female broodstock producing smaller eggs will produce lower yolk content, reducing larval viability and decreasing survival during rearing [18]. External factors that affect the survival rate include water quality parameters, the quality of the provided feed, the presence of predation/cannibalism, and the occurrence of diseases. On the other hand, the specific growth rate did not significantly differ among treatments, ranging from 0.11 g/day to 0.12 g/day. The specific growth rate can be interpreted as the fish's ability to digest feed and convert it into flesh and muscle [20,29]. Growth is the size, length, and weight increase over time [20,30]. The average size of the larvae and seedlings produced exceeded the reference values. The lowest average weight and length were observed in the treatment with a salinity level of ten ppt. The study results indicated that tilapia reared at salinity levels above ten ppt undergo histomorphology changes in the kidneys, leading to impaired body osmosis function [9]. The average weight and length of the seedlings produced were 0.22±0.02 g and 1.88±0.18 cm, respectively. These values were higher than those reported in the referenced study [11].

One of the challenges brackish water tilapia farmers face is the high mortality rate of fingerlings during the early stages of stocking. The imperfect adaptation process from freshwater to brackish water causes the tilapia fingerlings to experience environmental shock, resulting in stress and mortality. The optimal salinity adaptation process for tilapia fingerlings is to increase the salinity by five ppt every week [17]. Breeding mature tilapia in brackish

water has not been conducted commercially because the number of eggs produced is lower than breeding in freshwater [1,7]. Early adaptation of tilapia fingerlings to brackish water is necessary to reduce the mortality rate when stocked in brackish water ponds. The post-fertilization adaptation of tilapia involves the development of various body organs that can respond and adapt to the environmental conditions [1]. Chloride cells, which play a role in osmoregulation, increase in number as salinity levels rise [17]. The post-fertilization phases of tilapia include zygote, blastula, gastrula, pharyngula, larva, and juvenile stages [5]. During these stages, tilapia can be acclimated to brackish salinity to ensure that the developed organs respond effectively to brackish conditions. As a result, when salinity is increased during the grow-out phase, the mortality rate of the fish can be minimized.

The eggs of the red NIFI tilapia were hatched in an incubator with a closed water recirculation system, as this technology offered several advantages. Egg hatching in the incubator can improve the hatching rate and the quality of the resulting larvae [11]. An incubator can be a temperature stabilizer since egg hatching is carried out in a semi-closed container. Water temperature affects the metabolic rate of the eggs. This technique can produce seedlings with relatively uniform size/age, reducing the risk of mortality due to predation/cannibalism [27,28]. The water flow in the pipes inside the hatching tube keeps the eggs constantly moving/agitated, preventing settling or clumping. Additionally, water flow helps remove waste materials and encourages the larvae to exit the hatching tube. This technique mimics the natural egg incubation conditions in the oral cavity of the female broodstock, ensuring continuous oxygen supply to the eggs [13].

4 Conclusion

The hatching of red NIFI tilapia eggs using an incubator with a closed water recirculation system was carried out to increase the resulting hatching rate. Using one ppt and five ppt salinity levels resulted in hatching rates of 73% and 69%, respectively, which were not significantly different from the hatching rate of 74% at zero ppt salinity. Larval rearing at the same salinity levels used during egg hatching resulted in different survival rates, namely 75% at zero ppt, 70% at one ppt, 55% at five ppt, and 49% at ten ppt. Egg hatching in an incubator with a closed water recirculation system can be done at low salinity levels as an initial adaptation to produce tilapia seeds stocked in brackish water. Adaptation carried out since the egg phase is projected to reduce the mortality rate of tilapia seeds when stocked in brackish water ponds.

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