International Journal of Life Science and Agriculture Research

ISSN (Print): 2833-2091, ISSN (Online): 2833-2105

Volume 04 Issue 07 July 2025

DOI: https://doi.org/10.55677/ijlsar/V04I07Y2025-03

Impact Factor: 7.88 , Page No : 423-427

Growth and Survival of Artemia, A Live Food for Ornamental Fish, in Low Salinity Culture Media Made from Crude Salt

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ABSTRACT

On-grown Artemia are ideally sized for feeding juveniles and adults of various popular ornamental fishes. With the simple technology, culture of Artemia can be easily implemented by ornamental fish hobbyists worldwide. Artemia live in hypersaline environment. The use of crude salt dissolved in freshwater is a practical and easy alternative in making artificial culture media to obtain the desired salinity. In this study, we evaluated the effect of different salt levels of the culture media to produce on-grown Artemia in low salinity range from 15 – 65 ppt, trough observing their growth and survival. This study used a completely randomized experiment design. The Artemia nauplii were reared with 6 levels of media salinity, namely 15 ppt, 25 ppt, 35 ppt, 45 ppt, 55 ppt, and 65 ppt. Survival rate, length growth, and water quality parameters (salinity, temperature, pH, and dissolved oxygen) were observed on days 1, 10, and 21. Data were analyzed using one-way analysis of variance (ANOVA) determine differences between treatments. The results of the study showed that Artemia can grow optimally to adulthood at a salinity of 35 – 65 ppt. Adult Artemia cultured for 21 days in a salinity of 35 – 65 ppt had an average body length of 7.99 ± 0.73 mm with an average survival rate of 47.39 ± 6.15%. We do not recommend rearing Artemia with too low salinities (15 and 25 ppt) because it results in poor Artemia growth and survival.

Published Online:
July 22, 2025

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KEYWORDS: Brine shrimp, crude salt, low salinity, live food, ornamental fish, aquarium.

INTRODUCTION

Our ornamental fish will be happy and show their best performance when given live food. A wide variety of live foods have been used as ornamental fish food and Artemia is one of the popular live foods. Artemia is used as live food for marine and freshwater aquaculture (Lim et al., 2001; Lim et al., 2003). Artemia is a dominant zooplankton found in many hypersaline environments, belonging to the family Artemiidae, order Anostraca, class Brachiopoda, subphylum Crustacea, and phylum Arthropoda. Artemia can survive in environments with a wide salinity range of 10-340 ppt, and can even survive in fresh water for short periods. The larval stage of Artemia has a body length of around 0.4 to 0.5 mm, while adult males are 8-10 mm long and females are 10-12 mm long. (Van Stappen, 1996; Dhont et al., 2013).

Nauplii-stage Artemia are primarily used in fish farms to feed fry or small ornamental fish such as guppies and neon tetras. Adult Artemia are ideally sized for feeding juveniles and adults of various popular ornamental fish species, such as cichlids, cyprinids, characids, and poeciliids. The adult form of Artemia is primarily used as a live, frozen, or freeze-dried food in the aquarium trade (Koru & Turkmen, 2010). Currently, on-grown Artemia is sold in live, frozen or dried form, to meet feed needs, especially for those who do not have enough time to culture Artemia. Compared to other types of live food, I believe that on-grown Artemia has more potential and is more in demand worldwide.

Some of the reasons that make on-grown Artemia a superior choice of live food for ornamental fish are (1) Artemia can be cultured easily by hatching cysts which are widely traded throughout the world. (2) Artemia can still live around 30 to 60 minutes in freshwater (Syukri et al., 2022), giving our ornamental fish enough time to prey, as long as we don't give them too much. (3) Under optimal conditions, Artemia can live for up to several months (Wee et al., 2021), so they can be harvested little by little, without having to worry that the cultivated Artemia will die soon. (4) On-grown Artemia contains high nutrition, with protein 49.7

- 62.5%, and lipid 9.4 - 19.5% (Dhont & Sorgeloos, 1996), so it can meet the nutrient requirements of ornamental fish. (Sales & Janssens, 2003). (5) Giving Artemia can increase color intensity, (Saha & Patra, 2013; Arce et al., 2018; Seidgar et al., 2019; Wee et al., 2021; Kiswara et al., 2020), growth (Saha & Patra, 2013; Noornissabegum et al., 2022; Seidgar et al., 2022) and gonad maturity (James & Sampath, 2004; Langroudi et al., 2009) of the ornamental fish.

The simplicity and ease of on-grown Artemia culture technology are the main attractions for ornamental fish hobbyists to try it. With its simple technology, Artemia culture can be easily implemented by ornamental fish hobbyists worldwide. Essentially, the most important things are the availability of artemia feed and media with optimal salinity. The simplicity and ease of Artemia culture technology are the main attractions for ornamental fish hobbyists. With this simple technology, Artemia culture can be easily implemented by ornamental fish hobbyists worldwide. Basically, the availability of Artemia feed and optimal media salinity are important factors. Various types of feed for Artemia have been applied in many studies with good results, such as microalgae, flour, agriculture by products, waste products from the food industry (Mohabbi et al., 2016; Vahdat & Oroujlou, 2021; Lavens and Sorgeloos, 1991; Amin et al., 2022; Ogburn et al., 2023). According to Amin et al. (2023) microalgae is the best diet in Artemia culture. However, for fish hobbyists, providing live microalgae for Artemia diet is a difficult effort and takes time, so it is more practical to use microalgae flour. In our research and another study show that *Spirulina plantasis* algae flour is a good diet for Artemia (Arumugam et al., 2013; Sulistiyarto & Restu, 2024). Currently, spirulina flour for fish feed is available at an inexpensive price on the market.

The culture of Artemia usually uses natural sea water as culture medium to obtain the desired salinity of around 35 ppt. (Lavens and Sorgeloos, 1991). This method is sometimes an obstacle for ornamental fish hobbyists who do not have easy access to sea water, such as those who live far from the coast. The use of crude salt dissolved in freshwater is a practical and easy alternative in making artificial culture media to obtain the desired salinity. In this study, we evaluated the effect of low salinity made from crude salt for media in producing on-grown Artemia, based on observations of Artemia survival and growth.

MATERIALS AND METHODS

This research was conducted at the Aquaculture Laboratory, Faculty of Fisheries, Palangka Raya Christian University, Indonesia. The Artemia nauplii used for the experiment were obtained from the hatching of *Artemia franciscana* cysts (Artemia of the Great Salt Lake) using 30 ppt salt water in a 2 L glass hatching jar. After hatching, the nauplii were reared in a 30x20x15 cm plastic container filled with 8 L of media with a certain salinity. Rearing was carried out for 21 days with 6 levels of media salinity, namely 15 ppt, 25 ppt, 35 ppt, 45 ppt, 55 ppt, and 65 ppt. The media was made according to Islam et al. (2015) by mixing crude salt with freshwater to achieve the desired salinity. Nauplii were stocked in each container at a density of 400 nauplii/L and maintained under 12-hour light/dark conditions. Moderate aeration was provided to supply dissolved oxygen and keep food suspended longer. Artemia were fed twice daily with spirulina powder at a rate of 2% of their body weight. The spirulina powder was dissolved in water and sieved through a 50 µm sieve to obtain feed particles of the appropriate size.

The population density and body length of Artemia were observed on days 1, 10, and 21. The survival rate (SR) was calculated by calculating the percentage of the population density of live Artemia in each tank. The body length of Artemia was measured using a digital microscope. Water quality parameters of the rearing media were observed on days 1, 10, and 21, including salinity, temperature, pH, and dissolved oxygen (DO). Data on water temperature, pH, dissolved oxygen, survival rate, and length growth of the Artemia were analyzed using one-way analysis of variance (ANOVA) followed by the Least Significant Difference (LSD) test to determine differences between treatments.

RESULTS AND DISCUSSION

We evaluated the effect of different salt levels of the culture media for produce on-grown Artemia in low salinity range from 15 – 65 ppt. The salinity of the culture media was maintained at 15, 25, 35, 45, 55 and 65 ppt, according to each treatment applied. During culture time, salinity tends to increase, due to water evaporation. Therefore, the water volume is always controlled by adding distilled water so that the volume remains the same. Water quality conditions of the Artemia culture media during 21 days of rearing are presented in Table 1. The results of water quality monitoring include salinity in the range of 16.11 – 65.59 ppt, temperature 27.76 – 28.39 ^{O}C, pH 6.66 – 7.10, and dissolved oxygen 5.88 – 6.93 mg L^{-1}. Based on analysis of variance (ANOVA), the temperature, pH and dissolved oxygen conditions of the culture media between treatments were not significantly different ($p<0.05$). According to Lavens & Sorgeloos (1991), Artemia prefers environmental conditions with temperatures ranging from 25–30°C, a pH of 6.5–8, and dissolved oxygen levels of >2 ppt. Therefore, the water quality of the Artemia culture medium in this study was within the range that supports Artemia life. Salinity is an important factor influencing the growth and survival of Artemia, where increasing salinity will increase the growth and survival of Artemia (Castro-Mejia et al., 2011). Meanwhile, Ngarari et al. (2024) found that increasing salinity can reduce the growth and survival of Artemia because salinity affects energy use for Artemia metabolism. In general, Artemia prefers a salinity of 35–110 ppt (Lavens & Sorgeloos, 1991).

Table 1. The mean ± SD value of water quality parameters of the Artemia culture media

Parameters	Treatments					
	A	B	C	D	E	F
salinity (ppt)	16.11 ±0.91	26.43 ±1.06	35.29 ±0.47	45.36 ±0.93	55.61 ±0.82	65.59 0.72
Temperature (°C)	28.09 ±1.54	28.37 ±1.24	28.39 ±2.27	28.29 ±2.38	28.23 ±2.89	27.76 ±2.34
pH	6.86 ±0.16	6.78 ±0.20	7.10 ±0.44	6.86 ±0.35	6.66 ±0.40	6.85 ±0.29
Dissolve oxygen (mgL^{-1})	6.02 ±0.81	6.23 ±0.98	5.88 ±0.82	6.01 ±0.78	6.93 ±0.73	6.79 ±0.88

In this research, initially Artemia nauplii was stocked with a density of 400 nauplii. L^{-1} in each plastic container. The Artemia population density of each treatment was monitored again on the 10th and 21st days. The Artemia appeared to have reached adulthood and showed mating activity on the 21st day of the observation. The Artemia survival decreased on the 10th day of observation in all treatments. The Artemia survival decreased to 89.53% in the 65 ppt salinity treatment, but fell to 24.26% in the 15 ppt treatment. Furthermore, on the 21st day, the survival of the Artemia in the 65 ppt salinity treatment decreased to 56.37%, and to 11.69% in the 15 ppt salinity treatment. The survival of the Artemia population for all treatments are presented in Figure 1. The results of LSD test explained that the highest survival was obtained in the salinity treatment of 65 ppt, followed by the salinity treatment of 45 ppt, 55 ppt, 35 ppt, 25 ppt, and the lowest was 15 ppt. The survival of the Artemia in the 45 ppt and 55 ppt salinity treatments was not significantly different ($p<0.05$).

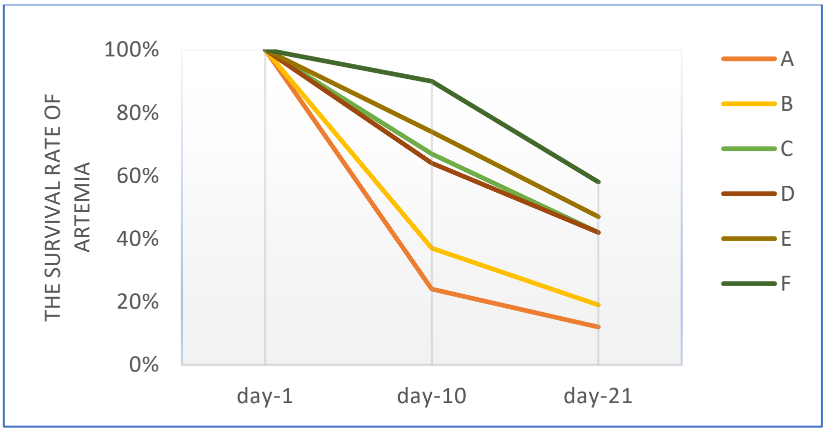

Figure 1. The survival rates of the Artemia on days 1, 10 and 21.

The results of this study show that the survival rate decreased after 10 days of age. Artemia can survive in a wide range of salinities, however, this study shows that higher salinities tend to have better survival rates. The use of salinity of 15 ppt and 25 ppt resulted in a very low survival rate compared to the use of salinity above 35 ppt. Suneetha et al. (2024) obtained high survival rates for Artemia using salinity of 30-40 ppt. Castro-Mejia et al. (2011) found that higher salinity provided better Artemia survival rates. Salinities of 35, 45, 55, and 65 ppt provided survival rates of >42%. Amin et al. (2023) obtained a survival rate of 47.29% for Artemia reared in seawater (35 ppt salinity) fed with spirulina powder. According to Lavens & Sorgeloos (1991), the optimal salinity for Artemia culture is 35-110 ppt, and if it is below 20 ppt, mortality will occur. However, Lim et al. (2001) successfully used a salinity of 20 ppt for Artemia production.

The results of the measurement of the body length of 1-day-old nauplii were 0.62 ± 0.10 mm. The growth of Artemia body length during 21 days is presented in Figure 2. Based on the growth graph curve in Figure 2, the growth rate of Artemia was faster in the 1-10 days age phase compared to the 10-21 days age phase. Based on ANOVA and LSD tests, the growth of Artemia length was significantly affected by salinity ($p<0.01$). Artemia growth was low at salinity of 15 ppt and 25 ppt, so that at 21 days of culture age only obtained a body length of 3.85 ± 1.01 mm. This indicates that at 15 ppt and 25 ppt salinities, Artemia is in suboptimal environmental conditions, so more energy is used to overcome suboptimal environmental conditions than for growth. The use of salinity of 35, 45, 55, and 65 ppt provided no significant difference in the length growth of Artemia, and this salinity range provided optimal Artemia growth. The average length of adult Artemia at the age of 21 days using a salinity of 35 – 65 ppt was 7.99 ± 0.73 mm. Khadka et al. (2023) obtained the length of adult Artemia was 8.7 mm and Wee et al. (2021) obtain a length of 8 mm. Variations may be caused by water quality, food type, and strain. According to Agh, et al. (2008), Artemia had the highest growth at a salinity of 35 ppt. While Lyubomirova et al. (2023) stated that in the nauplii phase, increasing salt concentration from 30 to 90 ppt is a tendency to decrease the growth of nauplii.

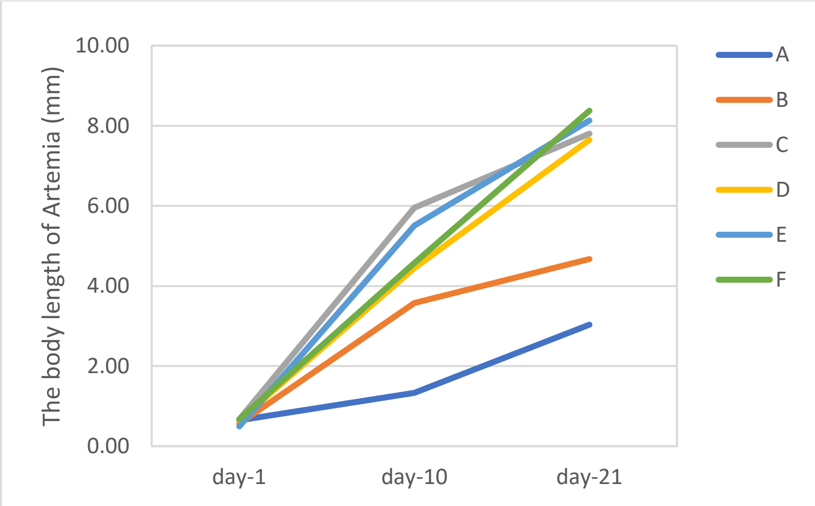

Figure 2. The body length of the Artemia on days 1, 10 and 21.

CONCLUSIONS

The simple way to culture on-grown Artemia is to use a media culture made by dissolving crude salt in freshwater to obtain the desired salinity, and feed with spirulina powder. The Artemia can grow optimally to adulthood by using culture media with a salinity of 35 – 65 ppt. To get this salinity, around 35-65 grams of crude salt is dissolved in 1L of freshwater. Adult Artemia cultured for 21 days in a salinity of 35 – 65 ppt had an average body length of 7.99 ± 0.73 mm with an average survival rate of 47.39 ± 6.15%. Rearing Artemia using culture media with a salinity of 65 ppt provided the highest survival (56.37%). We do not recommend rearing Artemia in low salinities (15 and 25 ppt) because it results in poor Artemia growth and survival.

ACKNOWLEDGEMENTS

This research was supported by the Aquaculture Laboratory of Palangka Raya Christian University which includes: appropriate research space, equipment and materials. Thank you to our students who have actively participated in helping during the preparation and implementation of this research.

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