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Research

Comparisons on Growth Performance, Survivability, Organoleptic Qualities and Economic Feasibility of Asian Seabass (*Lates calcarifer*) Reared in Different Salinities

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ABSTRAK

Asian seabass, *Lates calcarifer* is among the most cultured aquaculture species in the Southeast Asian region due to its remarkable tolerance for a diverse environmental fluctuation. In aquaculture, salinity has a direct influence on many biological, physiological and market value of any cultured fish. This study investigated the impacts of different salinities (0, 15, & 30 ppt) on Asian seabass growth, body indices, feeding performance, organoleptic qualities, and production cost for 85 days. Ninety fish were reared in 700-liter tanks equipped with recirculation system with 10 fish each tank. They were fed with commercial marine feed. The findings revealed Asian seabass in 15 ppt attained significantly higher (p>0.05) body weight (470.40 ± 41.16 g), total length (31.51 ± 0.81 cm), total feed intake (309.28 ± 35.66 g/fish) and daily feed intake (3.64 ± 0.42 g/fish/day) compared to 30 ppt but remained insignificant with 0 ppt. Meanwhile, there was no significant difference (p<0.05) in terms of body weight gain, specific growth rate, body indices, and feed conversion ratio of Asian seabass when reared in different salinities. The organoleptic qualities showed that rearing Asian seabass in different salinities has no significant effect (p<0.05) on odour, appearance, texture, and flavour score. However, the overall acceptance score of Asian seabass reared in 30 ppt (3.53 ± 0.22) was significantly higher (p>0.05) compared to 15 ppt but remained insignificant with 0 ppt. Economically, Asian seabass cultured in 15 ppt yielded the most optimal conditions for profitable production. The findings conclude 15 ppt can promotes enhanced growth performance and profitability, while 0 ppt and 30 ppt can promote consumer acceptance positively.

Key words: Asian seabass, economic analysis, growth performance, *Lates calcarifer*, organoleptic qualities, salinity

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INTRODUCTION

Asian seabass (*Lates calcarifer*) known as Barramundi or giant sea perch has gained attention in aquaculture throughout Asia region and beyond since the 1970s (Idris *et al*., 2022). Asian seabass are among the most highly valuable aquaculture fish known for their excellent organoleptic qualities, nutrition value, rapid growth, and high survival (Mathew, 2009; Pethiyagoda & Gill, 2012; Vij *et al*., 2014; Purba *et al*., 2016; Nor *et al*., 2019; Windarto *et al*., 2019; Haque *et al*., 2019). Asian sea bass now leads the marine fish culture industry in Malaysia, accounting for roughly 55.3% of total marine fish raised (17,263.61 tonnes out of 31,242.83 tonnes) (Idris *et al*., 2022). Asian seabass aquaculture has become increasingly popular over the decades due to several beneficial factors. Firstly, they adapt well to various environmental conditions, particularly salinity (Masli *et al*., 2014), making them suitable for farming in various aquatic systems like marine, brackish, and freshwater environments

(Muhd-Faizul *et al*., 2012). This adaptability allows for flexible farming practices and efficient use of water resources.

The productivity and efficiency of Asian seabass aquaculture can also be attributed to their high acceptance of a variety of feeding practises and regimes, as well as the ease of handling them, which lowers their mortality from handling stress (Catacutan & Colosso, 1997; Ghosh *et al*., 2016). One of the most significant advantages of Asian seabass aquaculture is its rapid growth to reach edible size within a year, hence contributing to high yields and profitability to aquaculture production. However, Asian seabass aquaculture exhibits inconsistent production when they are cultured in different salinities systems (Insivitawati *et al*., 2022). Hence, understanding the Asian seabass's tolerance to salinity variations on its growth, feeding performance, stress level, meat quality and nutritional value are paramount issues to be solved.

Findings on the ideal salinity for Asian seabass farming will contribute to better meat quality to meet consumers' expectations. Understanding the differences in nutritional value can influence consumer choices consequently contributing to better human health (Szucs *et al*., 2018). Meanwhile, understanding its economic value will help aquaculture operators to opt for the best farming method to maximize profitability (Aswathy & Imelda, 2018). In short, identifying the optimal salinity to produce Asian seabass with improved growth, excellent meat quality and high nutritional value allows aquaculture operators to command higher prices in the market, thus enhancing their economic returns.

MATERIALS AND METHODS

Fish husbandry

Asian seabass (initial body weight: 254.50 ± 21.70 g & initial total length: 26.18 ± 0.66 cm) was obtained from Fish Hatchery, Universiti Malaysia Sabah. A total of 90 pieces of Asian seabass were selected and distributed in triplicate groups of three salinities tested (0, 15 & 30 ppt) for 85 days. Groups of 10 fish per tank were randomly distributed into 9 units of 700-L tanks with 600 L of water volume respectively that were equipped with three independent water recirculation systems to achieve ideal water filtration. Each filtration system consists of biological filters to clean the water before channelled back to fish tanks. The acclimatization process for Asian seabass was done to reduce the stress level before the experiment. Asian seabass was not directly introduced to particular salinity treatments. The salinity was decreased slowly to the targeted level by mixing seawater with freshwater to avoid fish from environmental shock. Water exchange was done once a week to improve and maximize the water condition. Asian seabass was fed twice daily at 8:00 am and 4:00 pm up to satiation level with commercial marine pellet (Leong Hup Aqua Sdn. Bhd., Malaysia; crude protein: 43%; crude lipid: 8%) and total feed intake was recorded. At the end of the experiment, the growth performance of Asian seabass for each salinity was calculated including survival, growth, body indices, and feed utilization were measured as follows:

Survival and growth performance:

$$\text{Survival (\%)} = \frac{\text{The final number of fish}}{\text{The initial number of fish}} \times 100$$

$$\text{Final body weight (g)} = \frac{\text{Weight of all fish}}{\text{The final number of fish}}$$

Final total length (cm) = Total length of fish measured from head to tail

$$\text{Body weight gain (\%)} = \frac{\text{Final weight - Initial weight}}{\text{Initial weight}} \times 100$$

$$\text{SGR (\%/day)} = \frac{\text{ln final weight - ln initial weight}}{\text{Time (days)}} \times 100$$

Body indices:

$$\text{Condition factor (K)} = \frac{\text{Final body weight (g)}}{\text{Total length(cm)}^3} \times 100$$

$$\text{Viscerosomatic index (VSI)} = \frac{\text{Visceral weight (g)}}{\text{Body weight (g)}} \times 100$$

$$\text{Hepatosomatic index (HSI)} = \frac{\text{Liver weight (g)}}{\text{Body weight (g)}} \times 100$$

$$\text{Intraperitoneal fat (IPF)} = \frac{\text{Intraperitoneal fat (g)}}{\text{Body weight (g)}} \times 100$$

Feeding performance:

Feed intake (g) = Total feed intake of fish for 85 days

$$\text{Daily feed intake (g/fish/day)} = \frac{\text{Total feed intake (g)}}{\text{Final number of fish x Time (days)}}$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Total feed (g)}}{\text{Weight gain (g)}}$$

Organoleptic analysis

At the end of the experiment, 3 samples of Asian seabass from each treatment were randomly chosen and starved for 24 hr before being sacrificed by hypothermic treatment in iced water. Fish were then gutted, filleted, and uniformly sliced with a size of approximately 3 cm × 3 cm for preparation of organoleptic analysis. The sliced fish were wrapped in aluminium foil and cooked in a steamer for 15 min. The steamed fillets from different treatments were labelled alphabetically from A to I and offered to 30 untrained panellists for conducting the organoleptic test. The organoleptic analysis was performed according to a scheme from Shapawi (2020). The panel members were required to evaluate the overall acceptability with regards to quality parameters such as odour, appearance, flavour, texture, and overall acceptance using a 5-point hedonic scale, where 5= very good, 4= good, 3= normal, 2= bad, and 1= very bad.

Economic analysis

The methods for economic analysis used in this study were followed according to Gammanpila and Singappuli (2014). Total production costs for Asian seabass in different salinities were calculated with the summation of total fixed cost and total variable cost. Fixed cost includes the operational cost such as electricity usage, water usage, and Asian seabass seed price. Variable cost includes the cost of feed. Net profit was calculated as the difference between total revenue from fish sales and total production cost. Total revenue was calculated by multiplying the total amount of Asian seabass production (kg) by its market price (RM). The break-even point is the level of production at which the total production cost and total revenue are equal. The economic analysis for Asian seabass in different salinities was calculated as follows:

Total production cost (TC) = Total fixed cost (TFC) + total variable cost (TVC)

Net profit (π) = Total revenue (TR) – total production cost (TC)

$$\text{Break-even point (BEP)} = \frac{\text{Total fixed cost (TFC)}}{\text{Gross profit margin (\%)}}$$

Where,

$$\text{Gross profit margin (\%)} = \frac{\text{Total revenue (TR) - total variable cost (TVC)}}{\text{Total revenue (TR)}}$$

Statistical analysis

Data on survival, growth performance, condition factor, body indices, feed utilization, organoleptic test, and economic analysis of Asian seabass reared in different salinities were subjected to one-way analysis of variance (ANOVA) which tested at a 5% significant level in Statistical Package of Social Science (SPSS) Version 28.0. Duncan's multiple range tests were used to determine the significant differences between all of the treatment means.

RESULTS

Survival and growth performance

The growth performance of Asian seabass reared in three different salinities is shown in Table 1. The Asian seabass reared in 15 ppt salinity attained 100 ± 0.00% survival while Asian seabass reared in 0 ppt attained 96.67 ± 5.77% survival and 30 ppt attained 96.67 ± 5.77% of survival respectively. There was no significant difference (p<0.05) detected in all salinity treatments. Asian seabass in 15 ppt salinity attained significantly higher (p>0.05) growth performance in terms of final body weight (470.40 ± 41.16 g) and final total length (31.51 ± 0.81 cm) compared to Asian seabass in 30 ppt (final body weight = 328.09 ± 41.13 g, final total length = 28.46 ± 0.80 cm). There was no significant difference (p<0.05) detected between 0 ppt and the other two salinity treatments (final body weight = 394.28 ± 48.82 g; final total length = 30.14 ± 1.10 cm). Asian seabass in 15 ppt attained the highest body weight gain (62.11 ± 5.18%) compared to 0 ppt (57.55 ± 20.85%) and 30 ppt (47.56 ± 7.24%) but there was no significant detected (p<0.05) in all three salinity treatments. In terms of specific growth rate, Asian seabass reared in 15 ppt yielded the highest rate (0.57 ± 0.04%/day) compared to 0 ppt (0.53 ± 0.16%/day) and 30 ppt (0.46 ± 0.06%/day), however, there was no significant difference (p<0.05) in all three treatments.

Table 1. Survival and growth performance of Asian seabass in different salinities

Attributes	Salinity		
	0 ppt	15 ppt	30 ppt
Survival (%)	96.67 ± 5.77[a]	100 ± 0.00[a]	96.67 ± 5.77[a]
Final Body Weight (g)	394.28 ± 48.8[2a]b	470.40 ± 41.1[6]a	328.09 ± 41.1[3]b
Final Total Length (cm)	30.14 ± 1.10[ab]	31.51 ± 0.81[a]	28.46 ± 0.80[b]
Body Weight Gain (%)	57.55 ± 20.85[a]	62.11 ± 5.18[a]	47.56 ± 7.24[a]
SGR (%/day)	0.53 ± 0.16[a]	0.57 ± 0.04[a]	0.46 ± 0.06[a]

Mean (±SE) values with different superscripts within the row are significantly difference (p>0.05)

Body indices

The body indices of Asian seabass reared in three different salinities are shown in Table 2. The condition factor, viscerosomatic index, hepatosomatic index, and intraperitoneal fat of Asian seabass were not affected (p<0.05) by salinity treatments.

Table 2. Body indices of Asian seabass in different salinities

Attributes	Salinity		
	0 ppt	15 ppt	30 ppt
Condition Factor (K)	1.47 ± 0.13[a]	1.36 ± 0.08[a]	1.34 ± 0.06[a]
Viscerosomatic Index (%)	7.02 ± 0.67[a]	7.30 ± 1.16[a]	8.15 ± 0.49[a]
Hepatosomatic Index (%)	1.58 ± 0.19[a]	1.85 ± 0.38[a]	2.06 ± 0.20[a]
Intraperitoneal Fat (%)	3.12 ± 0.49[a]	3.08 ± 0.78[a]	3.62 ± 0.06[a]

Mean (±SE) values with different superscripts within the row are significantly difference (p>0.05)

Feeding performance

The feeding performance of Asian seabass in three different salinities is shown in Table 3. Asian seabass reared in 15 ppt attained significantly higher (p>0.05) of total feed intake (309.28 ± 35.66 g/fish) and daily feed intake (3.64 ± 0.42 g/fish/day) compared to 30 ppt (total feed intake = 205.48 ± 18.93 g/fish; daily feed intake = 2.42 ± 0.22 g/fish/day). Meanwhile, Asian seabass reared in 15 ppt attained a better feed conversion ratio (1.72 ± 0.07) compared to 0 ppt (1.82 ± 0.41) and 30 ppt (1.97 ± 0.16). However, the feed conversion ratio value has no significant difference (p<0.05) detected in all treatments.

Table 3. Feeding performance of Asian seabass in different salinities

Attributes	Salinity		
	0 ppt	15 ppt	30 ppt
Total Feed Intake (g/fish)	250.06 ± 48.79[ab]	309.28 ± 35.66[a]	205.48 ± 18.93[b]
Daily feed intake (g/fish/day)	2.94 ± 0.57[ab]	3.64 ± 0.42[a]	2.42 ± 0.22[b]
Feed Conversion Ratio	1.82 ± 0.41[a]	1.72 ± 0.07[a]	1.97 ± 0.16[a]

Mean (±SE) values with different superscripts within the row are significantly difference (p>0.05)

Organoleptic analysis

The organoleptic test scores are presented in Table 4. Asian seabass in 0 ppt showed higher scores in terms of odour (3.33 ± 0.07), appearance (3.67 ± 0.18), and flavour (3.38 ± 0.30) compared to 15 ppt (odour = 3.06 ± 0.25, appearance = 3.42 ± 0.16, flavour = 2.87 ± 0.09) and 30 ppt (odour = 3.18 ± 0.16, appearance = 3.36 ± 0.14, flavour = 3.31 ± 0.37). Meanwhile, 30 ppt shows a higher score in terms of texture (3.63 ± 0.04) compared with 0 ppt (3.45 ± 0.20) and 15 ppt (3.43 ± 0.17). However, there are no significant differences (p<0.05) in all parameters. Asian seabass showed a significant difference in overall acceptance score, where 30 ppt (3.53 ± 0.22) and 0 ppt (3.52 ± 0.17) scores are significantly higher (p>0.05) compared to 15 ppt (3.16 ± 0.06).

Table 4. Organoleptic parameters of fillet Asian seabass reared in different salinities on a rating scale of 1-5

Parameters	Salinity		
	0 ppt	15 ppt	30 ppt
Odour	3.33 ± 0.07[a]	3.06 ± 0.25[a]	3.18 ± 0.16[a]
Appearance	3.67 ± 0.18[a]	3.42 ± 0.16[a]	3.36 ± 0.14[a]
Texture	3.45 ± 0.20[a]	3.43 ± 0.17[a]	3.63 ± 0.04[a]
Flavour	3.38 ± 0.30[a]	2.87 ± 0.09[a]	3.31 ± 0.37[a]
Overall Acceptance	3.52 ± 0.17[a]	3.16 ± 0.06[b]	3.53 ± 0.22[a]

Mean (±SE) values with different superscripts within the row are significantly difference ($p>0.05$)

Economic analysis

Economic analysis results in Table 5 showed that the cost production for Asian seabass in 30 ppt is the lowest ($ 22.74), followed by 0 ppt ($ 28.18) and 15 ppt ($ 31.52). In terms of profit, Asian seabass in 15 ppt attained the highest profit ($ 31.65), followed by 0 ppt ($ 23.12) and 30 ppt ($ 19.70). This was affected by the total revenue where 15 ppt attained the highest total revenue ($ 63.17), followed by 0 ppt ($ 51.30) and 30 ppt ($ 42.44). The break-even point for Asian seabass at 15 ppt is higher ($ 25.36) compared to 0 ppt ($ 23.68) and 30 ppt ($ 18.96).

Table 5. Comparative economic analysis for Asian seabass production in different salinities in USD currencies

Cost factor	Salinity		
	0 ppt	15 ppt	30 ppt
Electrical cost ($)	0.91 ± 0.06[a]	0.91 ± 0.06[a]	0.91 ± 0.06[a]
Freshwater cost ($)	2.15 ± 0.12[a]	1.07 ± 0.06[b]	0.00 ± 0.00[c]
Feed cost ($)	8.34 ± 0.54[ab]	10.29 ± 0.40[a]	6.84 ± 0.21[b]
Seed cost ($)	16.79 ± 0.45[ab]	19.25 ± 0.34[a]	15.00 ± 0.65[b]
Total cost ($)	28.18 ± 0.76[ab]	31.52 ± 0.73[a]	22.74 ± 0.80[b]
Total revenue ($)	51.30 ± 2.83[ab]	63.17 ± 1.86[a]	42.44 ± 1.25[b]
Profit ($)	23.12 ± 2.16[ab]	31.65 ± 1.13[a]	19.70 ± 0.55[b]
Break-even point ($)	23.68 ± 0.49[a]	25.36 ± 0.45[a]	18.96 ± 0.75[b]

DISCUSSION

Survival, growth performance, and body indices

This study reveals that Asian seabass was able to attain high survival in all three salinities until the end of the experiment due to its ability to tolerate a wide range of salinities. Asian seabass is a euryhaline species, which is capable of tolerating broad fluctuations in salinities (Anil *et al*., 2010; Alhazzaa *et al*., 2011; Vij *et al*., 2020). In this study, less mortality was found in 0 ppt and 30 ppt, which indicates that Asian seabass can resist changes in salinity. According to Othman *et al*. (2015), the ability of body fluid to tolerate changes in osmolality and ion concentrations can affect the survival rate of fish. The ion concentration in the body fluid changed when fish was challenged by medium salinity fluctuation. This phenomenon is connected with the higher exchange layer on the skin and gut, leading to higher water absorption (Shui *et al*., 2018). Thus, Asian seabass can survive in a wide range of salinity with minimum effect on mortality rate.

In terms of growth performance, Asian seabass that were reared in 15 ppt showed significantly higher body weight and total length compared to 30 ppt. Previous studies reported that salinity can influence the growth of fish as seen in several species such as striped bass, *Morone saxatilis* (Andersen *et al*., 2021), silver pompano, *Trachinotus blochii* (Hamed *et al*., 2016), black tiger shrimp, *Penaus monodon* (Rahi *et al*., 2021), and Nile tilapia, *Oreochromis niloticus* (Dawood *et al*. 2022). Several studies have shown that the growth of euryhaline species improves at intermediate salinities since these conditions are closer to the isosmotic point, which reduces metabolic demands for osmoregulation and may channel more energy for growth (Woo & Kelly, 1995; Imsland *et al*., 2001; Boeuf & Payan 2001; Mylonas *et al*., 2009; Mozanzadeh *et al*., 2021).

Fishes that spend their life in a hypo or hyperosmotic environment require more energy to maintain their osmoregulation mechanism compared to those living in an isosmotic environment, which ultimately hampers their growth performance (Anand *et al*., 2022). The growth performance of Asian seabass was significantly lower when reared in 30 ppt salinity. This may be due to fish having the potential to suppress their appetite and it is related to a decrease in food consumption with high energy demand for osmoregulation when reared in high salinity conditions. Previous studies on hybrid grouper, *Epinephelus fuscoguttatus X E. lanceolatus* suggested that decreasing growth performance in increased salinity was related to a decrease in food consumption (Othman *et al*., 2015). In the high salinity range, fish need more energy to increase their ability for osmoregulation. Meanwhile, less energy was spent on osmoregulation fish reared in isosmotic conditions. Thus, it can be conserved for metabolic processes, and increasing fish growth.

Asian seabass body indices were not significantly impacted by salinity. At the end of the experiment, Asian seabass was found to be physically healthy and robust under all salinity treatments. Fish body index parameters including condition factor, viscerosomatic index, hepatosomatic index, and intraperitoneal fat are important indicators to determine their overall health. Asian seabass exhibited a robust and thriving condition when raised in varied salinities, which can be advantageous for producers to cultivate them in various farming conditions. This study is in agreement with findings of other euryhaline species such as European seabass, *Dicentrarchus labrax* (Bernardino & Fernandes, 2016), Nile tilapia, *Orechromis* niloticus (Sutthi & Thaimuangphol, 2020), and yellowfin seabream, *Acanthopagrus latus* (Mozanzadeh *et al*., 2021).

Feed utilization

Asian seabass in 15 ppt attained significantly higher total feed intake and daily feed intake compared to 30 ppt. This finding can be related to growth performance where Asian seabass produces a significantly higher body weight and total length when reared in 15 ppt salinity. In optimum salinity, fish tend to have higher appetite compared to fish reared in higher or lower salinity, increasing their feed intake, and resulting in better growth performance. The obtained results are in agreement with the finding of Imsland *et al*. (2001), who reported that rearing juvenile turbot, *Scophthalmus maximus* in an isosmotic environment may have higher food consumption, resulting in higher growth performance compared to rearing fish in higher salinity.

The result of the present study showed that salinity did not affect the feed conversion ratio of Asian seabass. A similar study was found by Mozanzadeh *et al*. (2021) where the feed conversion ratio of Asian seabass was not affected by salinity when reared in different salinities ranging from 6 ppt to 35 ppt but significantly higher when reared in 48 ppt of salinity. While salinity has no significant effect on feed conversion ratio, the present study showed that Asian seabass reared in 15 ppt have better feed conversion ratio (1.72 ± 0.07) compared with 0 ppt (1.82 ± 0.41) and 30 ppt (1.97 ± 0.16), resulting in better growth performance of Asian seabass. Feeding management is one of the key factors for the success of Asian seabass cultivation. Considering the production cost and production period of Asian seabass, culturing Asian seabass in optimum salinity may have better feeding performance, improving the growth performance that can be beneficial to farmers in the aquaculture business.

Organoleptic analysis

The organoleptic quality of Asian seabass showed that the four parameters tested (odour, appearance, texture & flavour) were not significantly affected by different salinities. However, Asian seabass cultured in 30 ppt and 0 ppt have significantly higher scores in terms of overall acceptance compared to 15 ppt. As an environmental factor, salinity can alter the flavour of fish muscle, thus reflecting the organoleptic quality. Fish muscle provides several flavours due to the abundance of free amino acids (Sarower *et al*., 2012). The content of free amino acids can be affected by salinity through the osmoregulation process (Du *et al*., 2022). Besides, the osmoregulation process mostly happens when fish are reared in low and high salinity, affecting the content of free amino acids that lead to the change of flesh flavour. As a result, Asian seabass in 0 ppt scored higher by consumers in terms of flavour, followed by 30 ppt and the lowest score has been given by consumers for Asian seabass in 15 ppt, although no significant difference was detected.

While flavour was the main sensorial property in consumers' decision on evaluating organoleptic quality, other sensorial properties such as odour, appearance, and texture also play an important part in determining consumers' overall preference in organoleptic evaluation. The present study showed no significant difference detected in odour, appearance, and texture of Asian seabass fillet. This may be due to consumers having difficulties distinguishing the difference between fillets in different salinities due to the freshness of the fillet itself. Asian seabass was sacrificed, filleted, and steamed cooked within 2 hr before the evaluation. This will keep the freshness to avoid the changes in sensory quality that may affect the sensory scores of Asian seabass fillets. A previous study on the shelf life of European seabass (*Dicentrarchus labrax*) fillets stored at a chilled temperature (4 ± 2°C) found that the sensory score of fillets significantly decreased with the storage period (Ucar *et al*., 2020).

In this study, the higher preference for Asian seabass fillets in 30 ppt and 0 ppt may related to gustatory memory since freshwater and seawater fish are commonly consumed. Hence, each consumer's innate food culture and taste memory might prevent the sensory analysis from being accurate (Silva & Piana, 2020).

Economic analysis

Economic analysis showed that culturing Asian seabass in 15 ppt is more profitable compared to other treatments. This is the result of Asian seabass in 15 ppt have a highest total revenue of $ 63.17 compared to 0 ppt and 30 ppt which produce only $ 51.30 and $ 42.44 of total revenue respectively. The value of total revenue reflects the total biomass of fish being produced according to salinity treatment. At the end of the experiment, Asian seabass at 15 ppt attained the highest average final body weight (470.40 ± 41.16 g) while 0 ppt and 30 ppt attained 394.28 ± 48.82 g and 328.09 ± 41.13 g respectively. Culturing fish in optimum salinity can enhance their growth performance with energy mostly being used for metabolic processes (Othman *et al*., 2015).

In this study, it is proven that the optimum culture condition of Asian seabass can shorten the production period. In just 12 weeks of the experiment, it is shown that Asian seabass in 15 ppt have attained significantly higher body weight compared to 30 ppt. Meanwhile, the production cost of 15 ppt Asian seabass is higher compared to 0 ppt and 30 ppt. For Asian seabass production, the price of feed and seed was the main cost factor of increasing total production cost. Similar findings on Asian seabass cage farming reported that the higher production cost is caused by the feed and seed cost (Gammanpila & Singappuli, 2014). However, Asian seabass in 30 ppt attained the lowest break-even point compared to other treatments. The result is reflected in the lower cost production of Asian seabass in 30 ppt. Despite that, Asian seabass in 30 ppt may have a longer production period due to its slower growth performance, thus leading to higher production costs.

In business, several factors need to be considered in making a profit; total cost incurred to produce products, the number of goods produced and sold, and the selling price of the goods (Sintha, 2020). In this study, Asian seabass in 30 ppt takes a longer period to grow, which can lead to an increase in total production. Thus, the break-even point may increase. While Asian seabass in 15 ppt has a higher break-even point, it produces a higher profit and has a lower production period compared to 30 ppt. In the aquaculture business, increasing income can be done by encouraging fish growth and increasing fish prices (Wijayanto *et al*., 2021). In this study, culturing Asian seabass in 15 ppt salinity can enhance their growth performance and lower their culture period, resulting in higher profit gain.

CONCLUSION

This study revealed that salinities affect growth performance, organoleptic qualities, and production cost of Asian seabass. Salinity at 15 ppt can promote better growth performance in terms of body weight and total length, thus generating higher profit for Asian seabass compared to other salinities. Meanwhile, organoleptic qualities indicate that Asian seabass in 0 ppt and 30 ppt have better acceptance among the public compared to 15 ppt. Perhaps, the culturing method can be improvised by utilizing the salinity depending on water resources to provide the full potential of Asian seabass as a high-quality aquaculture species to promote economic growth in aquaculture production.

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ETHICAL STATEMENT

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Alhazzaa, R., Bridle, A.R., Nichol, P.D. & Carter, C.G. 2011. Up-regulated desaturase and elongase gene expression promoted accumulation of polyunsaturated fatty acid (PUFA) but not long-chain PUFA in Lates calcarifer, a tropical euryhaline fish, fed a stearidonic acid-and γ-linoleic acid-enriched diet. Journal of Agricultural and Food Chemistry, 59(15): 8423-8434. https://doi.org/10.1021/jf201871w

Anand, G., Srivastava, P.P., Varghese, T. & Gupta, S. 2022. Rearing in hypersaline inland ground saline water affect growth and osmoregulatory responses of common carp (Linnaeus 1758). https://doi.org/10.21203/rs.3.rs-1164718/v2

Andersen, L.K., Abernathy, J., Berlinsky, D.L., Bolton, G., Booker, M.M., Borski, R.J., Brown, T., Cerivo, D., Ciaramella, M., Clark, R.W., Frinsko, M.O., Fuller, S.A., Gabel, S., Green, B.W., Herbst, E., Hodson, R.G., Hopper, M., Kenter, L.W., Lopez, F., McGinty, A.S., Nash, B., Parker, M., Pigg, S., Rawless, S., Riley, K., Turano, M.J., Webster, C.D., Weirich, C.R., Won, E., Curry Woods III, L., Reading, B.J. & StriperHub. 2021. The status of striped bass, Morone saxatilis, as a commercially ready species for US marine aquaculture. Journal of the World Aquaculture Society, 52(3): 710-730. https://doi.org/10.1111/jwas.12812

Anil, M.K., Santhosh, B., Jasmine, S., Saleela, K.N., George, R.M., Kingsly, H.J. & Rao, G.S. 2010. Growth performance of the seabass *Lates calcarifer* (Bloch, 1790) in sea cage at Vizhinjam Bay along the south-west coast of India. Indian Journal of Fisheries, 57(4): 65-69.

Aswathy, N. & Imelda, J. 2018. Economic viability of cage farming of Asian seabass in the coastal waters of Kerala. International Journal of Fisheries and Aquatic Studies, 6(5): 368-371.

Bernardino, R.J., & Fernandes, C. 2016. Growth performance for European sea bass fingerlings, *Dicentrarchus labrax*, reared at different salinities. In: IMMR International Meeting on Marine Research. Marine and Environmental Sciences Centre, Peniche.

Boeuf, G. & Payan, P. 2001. How should salinity influence fish growth? Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 130(4): 411-423. https://doi.org/10.1016/S1532-0456(01)00268-X

Catacutan, M.R. & Coloso, R.M. 1997. Growth of juvenile Asian seabass, *Lates calcarifer*, fed varying carbohydrate and lipid levels. Aquaculture, 149: 137-144. https://doi.org/10.1016/S0044-8486(96)01432-9

Dawood, M.A., Gewaily, M.S. & Sewilam, H. 2022. The growth performance, antioxidative capacity, and histological features of intestines, gills, and livers of Nile tilapia reared in different water salinities and fed menthol essential oil. Aquaculture, 554: 738122. https://doi.org/10.1016/j.aquaculture.2022.738122

Du, X., Zhang, W., He, J., Zhao, M., Wang, J., Dong, X. & Miao, S. 2022. The impact of rearing salinity on flesh texture, taste, and fatty acid composition in largemouth bass *Micropterus salmoides*. Foods, 11(20): 3261. https://doi.org/10.3390/foods11203261

Gammanpila, M. & Singappuli, M.S. 2014. Economic viability of Asian sea bass (*Lates calcarifer*) and Tilapia (*Oreochromis niloticus*) small scale aquaculture systems in Sri Lanka. Sri Lanka Journal of Aquatic Sciences, 17. https://doi.org/10.4038/sljas.v17i0.6855

Ghosh, S., Megarajan, S., Ranjan, R., Dash, B., Pattnaik, P., Edward, L. & Xavier, B. 2016. Growth performance of Asian seabass *Lates calcarifer* (Bloch, 1790) stocked at varying densities in floating cages in Godavari Estuary, Andhra Pradesh, India. Indian Journal of Fisheries, 61(3): 146-149. https://doi.org/10.21077/ijf.2016.63.3.49095-23

Hamed, S.S., Jiddawi, N.S. & Poj, B. 2016. Effect of salinity levels on growth, feed utilization, body composition and digestive enzymes activities of juvenile silver pompano Trachinotus blochii. International Journal of Fisheries and Aquatic Studies, 4(6): 279-283.

Haque, M.A., Hossain, M.I., Uddin, S.A. & Dey, P.K. 2019. Review on distribution, culture practices, food and feeding, brood development and artificial breeding of Seabass, Lates calcarifer (BLOCH 1790): Bangladesh perspective. Research in Agriculture Livestock and Fisheries, 6(3): 405-414. https://doi.org/10.3329/ralf.v6i3.44806

Idris, S.M., Noordin, W.N.M., Manah, F.O. & Hamzah, A. 2022. Toward systematic breeding of Asian sea bass, *Lates calcarifer* (Bloch, 1790), in Malaysia: Status, challenges and prospects for future development. Asian Fisheries Science, 35: 1-12. https://doi.org/10.33997/j.afs.2022.35.1.001

Imsland, A.K., Foss, A., Gunnarsson, S., Berntssen, M.H., FitzGerald, R., Bonga, S.W. & Stefansson, S.O. 2001. The interaction of temperature and salinity on growth and food conversion in juvenile turbot (*Scophthalmus maximus*). Aquaculture, 198(3-4): 353-367. https://doi.org/10.1016/S0044-8486(01)00507-5

Insivitawati, E., Hakimah, N. & Chudlori, M.S. 2022. Effect of temperature, pH, and salinity on body weight of Asian Seabass (*Lates calcarifer*) at different stockings. In IOP Conference Series: Earth and Environmental Science. IOP Publishing, 1036(1): 012117. https://doi.org/10.1088/1755-1315/1036/1/012117

Masli, A., Senoo, S., Kawamura, G. & Fui, C.F. 2014. Effects of different light intensities on fry growth, survival and cannibalism control of Asian seabass (*Lates calcarifer*). International Research Journal of Biological Sciences, 3(5): 45-52.

Mathew, G. 2009. Taxonomy, identification and biology of Seabass (Lates calcarifer).
Mozanzadeh, M.T., Safari, O., Oosooli, R., Mehrjooyan, S., Najafabadi, M.Z., Hoseini, S.J. & Monem, J. 2021. The effect of salinity on growth performance, digestive and antioxidant enzymes, humoral immunity and stress indices in two euryhaline fish species: Yellowfin seabream (*Acanthopagrus latus*) and Asian seabass (Lates calcarifer). Aquaculture, 534: 736329. https://doi.org/10.1016/j.aquaculture.2020.736329
Muhd-Faizul, H.A.H., Kua, B.C. & Leaw, Y.Y. 2012. Caligidae infestation in Asian seabass, Lates calcarifer, Bloch 1790 cultured at different salinity in Malaysia. Veterinary Parasitology, 184(1): 68-72. https://doi.org/10.1016/j.vetpar.2011.08.008
Mylonas, C.C., Pavlidis, M., Papandroulakis, N., Zaiss, M.M., Tsafarakis, D., Papadakis, I.E. & Varsamos, S. 2009. Growth performance and osmoregulation in the shi drum (*Umbrina cirrosa*) adapted to different environmental salinities. Aquaculture, 287(1-2): 203-210. https://doi.org/10.1016/j.aquaculture.2008.10.024
Nor, N.M., Yazid, S.H.M., Daud, H.M., Azmai, M.N.A. & Mohamad, N. 2019. Costs of management practices of Asian seabass (Lates calcarifer Bloch, 1790) cage culture in Malaysia using stochastic model that includes uncertainty in mortality. Aquaculture, 510: 347-352. https://doi.org/10.1016/j.aquaculture.2019.04.042
Othman, A.R., Kawamura, G., Senoo, S. & Fui, C. 2015. Effects of different salinities on growth, feeding performance and plasma cortisol level in hybrid TGGG (tiger grouper, Epinephelus fuscoguttatus x giant grouper, *Epinephelus lanceolatus*) juveniles. International Research Journal of Biological Sciences, 4(3): 15-20.
Pethiyagoda, R. & Gill, A.C. 2012. Description of two new species of sea bass (Teleostei: Latidae: Lates) from Myanmar and Sri Lanka. Zootaxa, 3314(1): 1-16. https://doi.org/10.11646/zootaxa.3314.1.1
Purba, E.P., Ilza, M. & Leksono, T. 2016. Study Penerimaan Konsumen terhadap Steak (Fillet) Ikan Kakap Putih Flavor Asap. Jurnal Online Mahasiswa, 3(2):1-11.
Rahi, M.L., Azad, K.N., Tabassum, M., Irin, H.H., Hossain, K.S., Aziz, D., Moshtagi, A. & Hurwood, D.A. 2021. Effects of salinity on physiological, biochemical and gene expression parameters of black tiger shrimp (*Penaeus monodon*): Potential for farming in low-salinity environments. Biology, 10(12): 1220. https://doi.org/10.3390/biology10121220
Sarower, M.G., Hasanuzzaman, A.F.M., Biswas, B. & Abe, H. 2012. Taste producing components in fish and fisheries products: A review. International Journal of Food and Fermentation Technology, 2(2): 113-121.
Shapawi, R. 2020. Growth performance and organoleptic quality of hybrid grouper (*Epinephelus fuscogutattus*♀× *Epinephelus lanceolatus*♂) fed palm-oil based diets at grow-out stage. Sains Malaysiana, 49(7): 1567-1576. https://doi.org/10.17576/jsm-2020-4907-09
Shui, C., Shi, Y., Hua, X., Zhang, Z., Zhang, H., Lu, G. & Xie, Y. 2018. Serum osmolality and ions, and gill Na+/K+-ATPase of spottedtail goby *Synechogobius ommaturus* (R.) in response to acute salinity changes. Aquaculture and Fisheries, 3(2): 79-83. https://doi.org/10.1016/j.aaf.2018.03.002
Silva, T.S. & Piana, P.A. 2020. Production of tilapia in biofloc with different salt condictions: An evaluation of body composition and organoleptic properties. Boletim do Instituto de Pesca, 46(1). https://doi.org/10.20950/1678-2305.2020.46.1.537
Sintha, L. 2020. Importance of Break-EVEN analysis for the micro, small and medium enterprises. International Journal of Research-GRANTHAALAYAH, 8(6): 212-218. https://doi.org/10.29121/granthaalayah.v8.i6.2020.502
Sutthi, N., & Thaimuangphol, W. 2020. Effects of yeast (*Saccharomyces cerevisiae*) on growth performances, body composition and blood chemistry of Nile tilapia (*Oreochromis niloticus* Linnaeus, 1758) under different salinity conditions. Iranian Journal of Fisheries Sciences, 19(3): 1428-1446.
Szűcs, I., Tikász, I.E., Fehér, M. & Stündl, L. 2018. Testing for consumer preferences of smoked Asian sea bass (Barramundi) filet products in Hungary. Cogent Business & Management, 5(1): 1432158. https://doi.org/10.1080/23311975.2018.1432158
Ucar, Y., Özogul, Y., Özogul, F., Durmuş, M., & Köşker, A.R. 2020. Effect of nisin on the shelf life of sea bass (*Dicentrarchus labrax* L.) fillets stored at chilled temperature (4±2 °C). Aquaculture International, 28: 851-863. https://doi.org/10.1007/s10499-020-00512-5
Vij, S., Purushothaman, K., Gopikrishna, G., Lau, D., Saju, J.M., Shamsudheen, K.V., Kumar, K.V., Basheer, V.S., Gopalakrishnan, A., Hossain, M.S., Sivasubbu, S., Scaria, V., Jena, J.K., Ponniah, A.G. & Orbán, L. 2014. Barcoding of Asian seabass across its geographic range provides evidence for its bifurcation into two distinct species. Frontiers in Marine Science, 1: 30. https://doi.org/10.3389/fmars.2014.00030

Vij, S., Purushothaman, K., Sridatta, P.S.R. & Jerry, D.R. 2020. Transcriptomic analysis of gill and kidney from Asian seabass (*Lates calcarifer*) acclimated to different salinities reveals pathways involved with euryhalinity. Genes, 11(7): 733. https://doi.org/10.3390/genes11070733

Wijayanto, D., Bambang, A.N., Nugroho, R.A., Kurohman, F. & Nursanto, D.B. 2021. Effect of salinity on growth and benefit-cost ratio of Asian seabass reared in artificial media. AACL Bioflux, 14(5):3000-3005.

Windarto, S., Hastuti, S., Subandiyono, S., Nugroho, R.A. & Sarjito, S. 2019 Growth performance of the seabass (*Lates calcarifer* Bloch, 1790) using the floating net cages system. Sains Akuakultur Tropis, 3(1): 56-60. https://doi.org/10.14710/sat.v3i1.4195

Woo, N.Y. & Kelly, S.P. 1995. Effects of salinity and nutritional status on growth and metabolism of *Spams sarba* in a closed seawater system. Aquaculture, 135(1-3): 229-238. https://doi.org/10.1016/0044-8486(95)01003-3