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Effects of yeast (Saccharomyces cerevisiae) on growth performances, body composition and blood chemistry of Nile tilapia (Oreochromis niloticus Linnaeus, 1758) under different salinity conditions

Sutthi N.1*; Thaimuangphol W.1

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Abstract

The growth performance, body composition and blood chemistry of Nile tilapia (Oreochromis niloticus) reared under different salinities (0 ppt, 5 ppt, 10 ppt and 20 ppt) and different diets (0.5% yeast [Saccharomyces cerevisiae] supplement diet and basal diet) were investigated during 90 days. Fish fed with yeast supplement diet and reared at 5 ppt water salinity showed significantly improved (p<0.05) growth performances as weight gain (WG), specific growth rate (SGR) and average daily growth gain (ADG) compared to fish fed with basal diet. Feed conversion ratio (FCR) of fish fed with yeast supplement diet reared at all salinity levels (0, 5 and 10 ppt) was significantly lower than fish fed with basal diet (p<0.05). Cortisol levels of fish fed with yeast supplement diet were significantly lower than those of the basal diet group at 10 ppt (p<0.05). Both fish groups showed significant increases in cortisol and malondialdehyde (MDA) levels at salinity of 10 ppt compared to fish reared at 0 and 5 ppt (p<0.05). Crude protein content of fish fed with yeast supplement diet and reared at salinity levels of 0 and 10 ppt was higher than those fed with basal diet (p<0.05). Fish fed with yeast supplement diet showed a decrease in crude lipid content under salinity regime up to 10 ppt (p<0.05). Thus, Nile tilapia fed with yeast supplement diet at 0.5% showed improved growth performance, body composition and blood chemistry under salinity treatments (0 ppt and 5 ppt).

Keywords: Yeast, Nile tilapia, Growth performances, Blood chemistry, Salinity

¹⁻Department of Agricultural Technology, Faculty of Technology, Maha Sarakham University, Maha Sarakham 44150, Thailand

^{*}Corresponding author's Email: nantaporn.s@msu.ac.th

Introduction

Rising mean global temperatures are causing glaciers to retreat (Tandong et al., 2011). Global warming also directly reduces the area of inland water, especially during the summer season in Thailand. Maha Sarakham Province is located in the northeast of Thailand (16.0132° N, 103.1615° E) and a long period of warm dry weather resulted in a drought, with reservoir levels and irrigation systems severely affected (Office of Agricultural Economics, 2015). The area was declared a drought disaster zone. Drought conditions freshwater salinity because increase Province Maha Sarakham has approximately 2,848,000 of underground rock salt (Department of Mineral Resources, 2009). Soil salinity is a global threat to agricultural because it reduces plant growth (Yan et al., 2015). Soil salinity also has an adverse effect on freshwater fish growth. Tilapia are among the most important warm water fish species used for aquaculture production in Thailand, and Nile tilapia (Oreochromis niloticus) is the most popular with a yield of 205,896 tons in 2016 (Department of Fisheries, 2018). Tilapia can adapt to a wide range of environments (Charo-Karisa et al., 2006) and can be cultivated in brackish water after acclimatization (Dominguez et 2004). However, Nile tilapia niloticus) acclimated and adapted to high water salinity with lower survival rates compared to blue tilapia (Oreochromis aureus) and Oreochromis mossambicus (Kamal and Mair. 2005). Salinity an environmental factor that affects fish survival rates (Igbal et al., 2012; Küçük et al., 2013), and brackish water results in low survival rates of Nile tilapia (O. niloticus) larvae sized 1-2 cm (Basuki and Rejeki, 2015). Some published evidence have been reported that Nile tilapia (O. niloticus) cannot tolerate salinities above 20 ppt (Baroiller et al., 2000) and showed skin lesions and body injuries (Ali et al., 2006). However, 100% survival rate of Nile tilapia fingerlings was recorded at 0 to 7 ppt salinity levels (Lawson and Anetekhai, 2011), with 81.67% at 15 ppt (Basuki and Rejeki, 2015). Thus, salinity is one environmental factors that influences survival rate and growth rate of different stages of Nile tilapia (O. niloticus) (Pongthana et al., 2010; El-Dahhar et al., 2011; Iqbal et al., 2012; Küçük et al., 2013; Moorman et al., 2014; Basuki and Rejeki, 2015). Salinity tolerance affected performance dependent on fish species and was strain-specific (Suresh and Lin, 1992; Garcia-Ulloa et al., 2001). **Probiotics** have become now commonplace health-promoting in 'functional foods' for improved growth in animal production (Irianto and Austin, 2002; Newaj-Fyzul et al., 2014) and yeast (Saccharomyces cerevisiae) is commonly used in animal (Nalage et al., 2016). Yeast has high potential content of β-glucans, mannan oligosaccharides (MOS) and nucleic acid (Li and Gatlin, 2006; Refstie et al., 2010; Kühlwein et al., 2014) which improve growth, energy and high nutrient digestibility (Lara-Flores et al., 2003). Several previous reports have

been stated that dietary supplements with MOS improved local velocity absorption surface in fish species such as Oncorhynchus mykiss (Staykov et al., 2007), Sciaenops ocellatus (Zhou et al.. 2010). Dicentrarchus labrax (Torrecillas et al., 2007, 2011), Sparus aurata (Gültepe et al., 2011), Carassius auratus gibelio (Akrami et al., 2012) and Channa striata (Talpur et al., levels 2014). Suitable of yeast supplement concentrations ranged 0.1-1% of diet kg⁻¹ but 0.5% of diet kg⁻¹ optimized growth rate and immune response in fish (Ortuño et al., 2002; Mazurkiewicz et al., 2005; Abdel-Tawwab et al., 2008). Under stress conditions, probiotics can prevent and reduce harmful effects of various stressors and enhance the immune system (Taoka et al., 2006). Probiotics antioxidant increased status by ameliorating oxidative stress factors (Mohapatra et al., 2012) such as waterborne cadmium exposure (Zhai et al., 2017) and crowding stress (Reyes-Cerpa et al., 2018). Scant published evidence exists concerning fish cultured under salinity stress and fed with probiotics. Researches on Nile tilapia fed with the probiotic Lactobacillus 10^{11} **CFU** $m1^{-1}$ plantarum at supplemented diet and cultured under 9-12 ppt salinity in a polyculture system marine shrimp (Litopenaeus vannamei) have indicated that tilapia groups fed with probioticsupplemented diet had high potential for growth performance and survival rate under salinity stress. Here, effects of yeast supplement diet on growth performances, body composition and

blood chemical analysis of Nile tilapia were evaluated under diverse salinity treatments.

Materials and methods

Supplemental diet preparation

Baker's yeast (S. cerevisiae) was obtained as a commercial preparation (Perfect®, Thailand). Procedures of feed preparation were modified from our previous reports (Sutthi et al., 2018b). Briefly, 0.5% yeast supplement diet was prepared from 5 g of baker's yeast mixed with 20 g of guar gum (pellet binder) and 1 kg of 32% protein commercial feed, then sprayed with water (10 ml kg⁻¹ diet) and air dried. The pellets then have been coated with 4% agar solution at 10 ml kg⁻¹ diet and air dried again (Panase et al., 2018). For the basal diet, the method also added guar gum with coating by 4% agar solution but without yeast supplement.

Fish and experimental design

Sex reversed (male) juveniles of Nile tilapia (O. niloticus) were obtained from Maha Sarakham Inland Fisheries Research and Development Center, Thailand. After acclimatization in 1.000 L of freshwater in fiberglass tanks for two weeks, healthy specimens with initial average weight of 7.51±0.26 g were randomly assigned into eighteen glass tanks (50×30×38 cm) with 10 fish in each tank. Rock salt from Maha Sarakham Province was used to prepare stock water salinity at 0, 5 and 10 ppt, measured using a salinity meter. Treatments were performed for three different salinities (0, 5 and 10 ppt) and two diet groups as (1) 0.5% yeast supplement diet, and (2) basal diet, with three replications. Fish were fed twice per day at 3% of body weight throughout the 90-days' experimental period (Panase et al., 2018). Water was changed every week for all treatments and the three different salinity levels maintained. Water quality parameters as temperature, dissolved oxygen and pH were measured using a PC CyberScan 650 (Eutech Singapore) Instruments, and total ammonia nitrogen (TAN) content was assessed using a test kit (Tetra[®], Germany).

Sampling and analyses of biochemical parameters

the fish After 90 days, anesthetized by clove oil (5 ml L⁻¹) and blood samples were collected from the caudal vein following Van Doan et al. (2018) method. Collected blood was immediately transferred into two tubes as (1) sterile Eppendorf tubes without anticoagulant for keeping serum, and (2) anticoagulant (EDTA) tubes for collected plasma. Blood samples in Eppendorf tubes were allowed to clot (1 h at room temperature and 4 h at 4 °C) and then centrifuged at 5000×g, 10 min, at 4 °C. All serums were stored at -20 °C until required for use, while plasma separated from blood anticoagulant tubes (EDTA) centrifugation at 1.500×g, 10 min, at 4 °C and stored in a cryotube at -20 °C (Beheshtipour, 2019).

Blood biochemical analysis

Serum aspartate aminotransferase (AST) and alanine aminotransferase

(ALT) were detected using commercial reagent kits (AST/GOT Liqui-UV® and ALT/GOT Liqui-UV®, Stanbio, USA, respectively). **AST ALT** and L^{-1} concentration levels (units determined with kinetic assay using a TC6060L fully automated Chemistry Analyzer (Tecom Science Co., Ltd., China). Glucose level has been detected using commercial reagent kits (Glucose LiquiColor®, Stanbio, USA), glucose concentration level (mg dl⁻¹) has been determined with end-point assay using a TC6060L fully automated Chemistry Analyzer (Tecom Science Co., Ltd., China). Serum cortisol level (µg dl⁻¹) has been determined using radioimmunoassay (RIA) with cortisol test kit (Biogenetech, USA), and measured with an automatic wizard gamma counter 1470/2470 (Perkin Elmer. USA). Lipid analysis peroxidation measure thiobarbituric acid reactive substances (TBARS) has been conducted to determine malondialdehyde (MDA) following our previous method (Sutthi 2018a). Plasma al., **MDA** concentration level (µM L⁻¹) has been determined from the absorbance reading at 532 nm using a GENESYSTM 20 Visible Spectrophotometer (Thermo Fisher Scientific. Germany), and compared with the 1,1,3,3tetraethoxypropane (TEP) standard curve (Sigma-Aldrich, USA).

Proximate analysis and organosomatic indices

Fillets of three fish were randomly sampled from each tank for proximate analysis using standard methods (AOAC, 1995). Samples were dried in an oven at 60 °C for 24-36 h. Nitrogen was determined by the Kjeldahl method and crude protein was calculated as N×6.25. Crude lipid content was analyzed following the soxhlet method, while ash content was determined by incineration in a muffle furnace at 600 °C for 4 h. Organosomatic indices such as %fillet, gonadosomatic index (%GSI), hepatosomatic index (%HSI) and viscerosomatic index (%VSI) were computed as follows (Biswas and Takeuchi, 2003; Da et al., 2012; Panase et al., 2018):

Fillet (%) = $[100 \times \text{ (fillet weight (g)/body weight)}].$

Gonadosomatic index (% GSI) = $[100 \times (gonad weight (g)/body weight)]$.

Hepatosomatic index (% HSI) = $[100 \times (\text{liver weight (g)/body weight)}]$.

Viscerosomatic index (% VSI) = [100×(visceral weight (g)/body weight)].

Data analysis

All fish were determined for growth rate using the mathematical growth model described by Bagenal (1978) and Panase and Mengumphan (2015) as follows:

Weight gain (WG; g) = final weight (g) - initial weight (g).

Length gain (LG; cm) = final length (cm) – initial length (cm)

Average daily gain (ADG; g day⁻¹) = [final weight (g) – initial weight (g)]/days

Specific growth rate (SGR; %/day)= $100 \times [\{\text{Ln final weight (g)-Ln initial weight (g)}\}/\text{days}]$

Feed conversion ratio (FCR)=total feed (g)/weight gain (g)

Survival Rate (SR, %)=[number of survived fish/initial number of fish]×100

Statistical analysis

Data were tested for normality using Shapiro-Wilk test, and test homogeneity of variance using the Levene's Test before analysis. All data were examined for two-way analysis of variance (ANOVA), with means determined by Tukev's multiple comparison tests for pat a significance level of p < 0.05. Results were presented as mean±standard deviation (SD).

Results

Growth performance and survival rate **Effects** yeast (*S*. cerevisiae) supplement in diet on growth performance and survival rate under different salinity levels for 90 days are displayed in Fig. 1. Weight gain $(52.67\pm2.10 \text{ g})$, SGR $(2.45\pm1.98 \text{ % day})$ 1) and ADG $(0.58\pm0.45 \text{ g day})$ of fish fed with 0.5% yeast supplement diet reared at 5 ppt water salinity were significantly higher than fish fed with basal diet (p < 0.05). Under diverse salinity levels, fish in the group fed with 0.5% yeast supplement and reared at 10 ppt showed significantly lower weight gain than fish reared at 5 ppt by Tukey's test (p<0.05). Fish fed with basal diet and reared at 10 ppt showed weight gain (38.23±3.33 g), **SGR** day⁻¹) (1.90 ± 0.13) % and **ADG** $(0.42\pm0.03 \text{ g day}^{-1})$, lower than fish reared at 0 and 5 ppt salinity. No significant improvements were observed in length gain and survival rate. FCR of fish fed with 0.5% yeast supplement diet reared at 0, 5 and 10 ppt salinities were 1.33±0.09, 1.14±0.09 1.42 ± 0.15 , respectively, and significantly lower than those fed with basal diet (1.82±0.12, 1.75±0.39 and 1.96±0.12, respectively) by Tukey's test (p<0.05). Throughout the 90-days' experimental period, water temperature ranged between 24.52 and 26.20 °C, dissolved oxygen 4.21-5.83 mg L⁻¹, pH 6.54-7.37 and TAN 0.25-2.00 mg L⁻¹. These parameters presented significant difference (p>0.05) between all treatments.

Biochemical parameters

Effects of yeast (S.cerevisiae) supplement in diet on biochemical parameters and lipid peroxidation under different salinity levels for 90 days are displayed in Fig. 2. Significant difference was observed in cortisol $(5.04\pm0.30 \text{ µg dl}^{-1})$ levels of fish fed with 0.5% yeast supplement diet, lower than those of the basal diet group at 10 ppt salinity level $(7.06\pm1.60 \mu g dl^{-1})$ (p<0.05). Under different salinity concentrations, cortisol and MDA levels significantly increased in both fish groups fed with 0.5%

supplement (86.33 \pm 8.38 unit L⁻¹ and 88.50 \pm 8.80 μ M L⁻¹, respectively) and fish fed with basal diets (7.06 \pm 1.60 μ g dl⁻¹ and 103.30 \pm 12.97, respectively) at 10 ppt than those reared at 0 and 5 ppt salinities (p<0.05). No significant difference was observed in AST, ALT and glucose levels by Tukey's test (p>0.05).

Proximate analysis and organo-somatic indices

Proximate analyses of fish fillets exposed to 0.5% yeast under diverse salinities are presented in Table 1. Under the three different salinity concentrations (0, 5 and 10 ppt), fish fed with 0.5% yeast supplement showed crude protein content higher than fish fed with basal diet (p<0.05). However, crude lipid contents of fish fed 0.5% yeast supplement diet reared at 0 and 5 ppt (2.57% and 2.60 %, respectively) were significantly higher compared 10 ppt (1.59%) by Tukey's test (p < 0.05). No significant differences were observed in % ash. %fillet, gonadosomatic index (%GSI), hepatosomatic index (%HSI) viscerosomatic index (%VSI) in all treatments by Tukey's test (p>0.05).

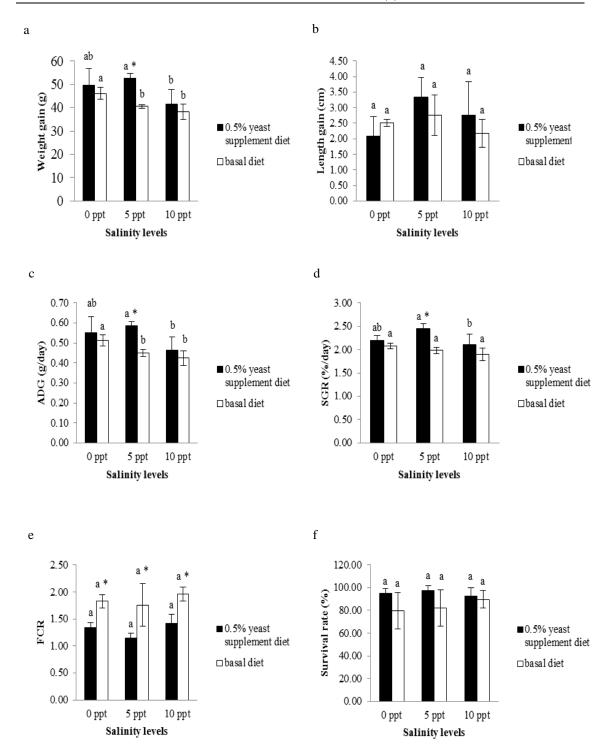


Figure 1: Effects of yeast supplement diet on growth performances of Nile tilapia for 90 days. Data are presented as mean \pm SD. Different superscripts (a,b) indicate significant differences between levels of salinity in the same diet group (p < 0.05). An asterisk (*) indicates significant differences in diet groups at the same salinity level (p < 0.05).

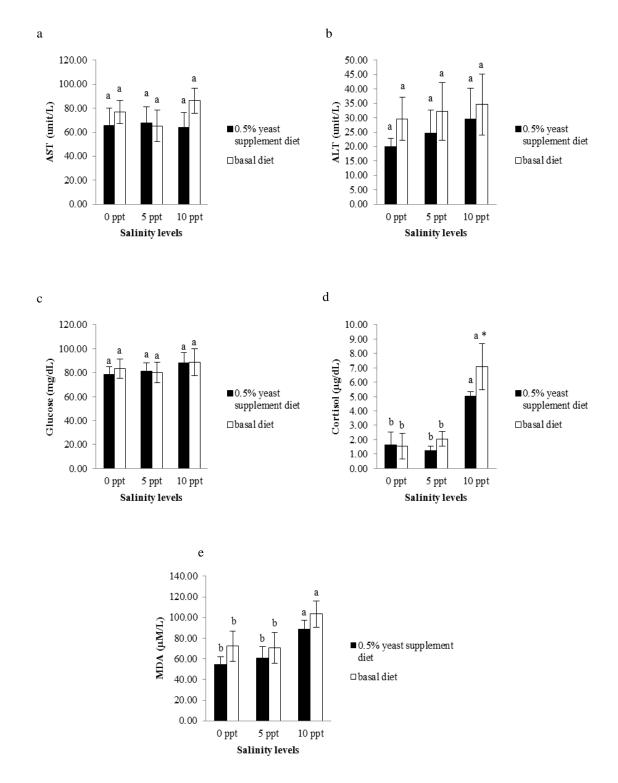


Figure 2: Effects of yeast supplement diet on blood chemistry of Nile tilapia for 90 days. Different superscripts $({}^{a,b,c})$ indicate significant differences between levels of salinity in the same diet group (p<0.05). An asterisk $({}^*)$ indicates significant differences in diet groups at the same salinity level (p<0.05).

Table 1: Proximate chemical analysis (%dry matter basis) of fish fillets and organosomatic indices (%fillet, gonadosomatic index (%GSI), hepatosomatic index (%HSI) and viscerosomatic index (%VSI)) of Nile tilapia fed on 0.5% yeast supplement and basal diet at different salinities for 90 days.

Diet group	Parameter	Salinity level		
		0 ppt	5 ppt	10 ppt
0.5% Yeast supplement diet	%Crude protein	$82.35\pm3.96^{a*}$	$83.94\pm0.24^{a*}$	81.79±3.29 ^{a*}
	%Crude lipid	2.57 ± 0.15^{a}	2.60 ± 0.25^{a}	1.59 ± 0.50^{b}
	% Ash	5.25 ± 2.04^{a}	4.45 ± 0.08^{a}	5.41 ± 1.14^{a}
	%Fillet	27.21 ± 5.92^{a}	31.10±3.98 ^a	26.71 ± 4.83^{a}
	%GSI	2.15 ± 1.04^{a}	2.09 ± 1.19^{a}	0.92 ± 0.50^{a}
	%HSI	2.16 ± 0.35^{a}	2.41 ± 0.65^{a}	2.26 ± 0.25^{a}
	%VSI	5.01 ± 0.55^{a}	5.23 ± 0.45^{a}	4.93 ± 0.23^{a}
	%Crude protein	76.63 ± 1.08^{a}	75.82 ± 2.11^{a}	72.63±5.99 ^a
	%Crude lipid	2.45 ± 0.72^{a}	2.39 ± 0.57^{a}	1.89 ± 0.49^{a}
Basal diet	% Ash	4.67 ± 0.09^{a}	4.90 ± 0.08^{a}	4.71 ± 0.13^{a}
	%Fillet	27.81 ± 4.41^{a}	27.54 ± 3.27^{a}	23.12±3.85 ^a
	%GSI	1.31 ± 0.23^{a}	1.92 ± 1.19^{a}	0.80 ± 0.53^{a}
	%HSI	2.06 ± 0.85^{a}	2.36 ± 0.95^{a}	2.19 ± 0.75^{a}
	%VSI	5.11 ± 0.63^{a}	5.03 ± 0.35^{a}	4.98 ± 0.31^{a}

Data are given as mean \pm SD. Mean values in the same row with different superscripts (a,b) indicate significant differences between levels of salinity in the same diet group (p<0.05). An asterisk (*) indicates significant differences in diet groups at the same salinity level (p<0.05).

Discussion

In this study, growth performance results of diet supplemented with yeast (S. cerevisiae) under diverse salinities during the 90-day experiment show, fish fed with 0.5% yeast supplement diet under 5 ppt salinity had better growth in terms of weight gain, SGR and ADG than those fed with basal diet (p<0.05). The lowest FCR has been found in fish fed with 0.5% yeast supplement diet, significantly lower than fish fed with basal diet under salinities diverse (p<0.05). Furthermore, fish reared at 0-5 ppt salinity showed higher potential growth performance than fish reared at 10 ppt (Fig. 1). Scant data exist concerning the effects probiotics of on salinity tolerance in Nile tilapia. Jatobá et al. (2011) investigated Nile tilapia fed with the probiotic (Lactobacillus plantarum) as 10¹¹ CFU ml⁻¹ supplemented diet in a polyculture system with marine shrimp (Litopenaeus vannamei) at 9-12 ppt salinity concentrations. They have found that tilapia groups fed with a probiotic-supplemented diet showed higher potential for final weight, feed efficiency and yield than fish fed with basal diet. This result has indicated that Nile tilapia fed with probiotics were able enhance their growth performance at higher salinities. SGR, weight gain, and food intake of blue tilapia (Oreochromis aureus) were high in 12 ppt salinity, with lowest results recorded in 24 ppt (Kücük et al., 2013), while FCR of hybrid tilapia (O. niloticus×O. urolepis urolepis) was better in 15, 25 and 35 ppt salinities than 2 ppt (Mapenzi and Mmochi, 2016). El-Zaeem et al. (2011) reported that genetically modified Nile tilapia gave poorest FCR at 32 ppt salinity, which did not differ significantly with the result at 16 ppt salinity. Normally, salinity tolerance was found to be more closely related to body size than age (Villegas, 1990). Chowdhury et al. (2006) have reported that biomass growth of adult Nile tilapia was significantly affected by salinity at 8 ppt, more than net production at 15 ppt and 22 ppt. However, we found that survival rate (79.49-97.44%) of Nile tilapia fingerlings was not significantly different for fish fed with 0.5% yeast supplement and basal diet under different salinities (0-10 ppt) for 90 days. Our results were similar to Jatobá et al. (2011) who also had found that probiotics did not affect survival rate under 9-12 ppt water salinity polyculture with marine shrimp. Lawson and Anetekhai (2011) reported 100% survival rate of Nile tilapia fingerlings reared between 0 and 7 ppt salinity. Other tilapia, as juveniles of blue tilapia (Oreochromis aureus), Nile tilapia (O. niloticus) and Florida red tilapia showed optimal survival (>81%) in salinity levels up to 20 ppt (Nugon, 2003), while poor survival rates were recorded at 35 ppt salinity regimes for O. aureus (54%) and Florida red tilapia (33%) (Nugon, 2003). Mississippi commercial tilapia survived salinity up to 10 ppt but recorded poor survival at 20 ppt (5%) (Nugon, 2003). The hybrid niloticus×O. (O. tilapia urolepis urolepis) gave better survival and growth rates in saline water than O. niloticus (Mapenzi and Mmochi, 2016). Scientists believe that since Nile tilapia is a euryhaline species, it had been developed from marine teleost ancestry (Suresh and Lin, 1992). Fish can control their homeostasis via chloride cells in gill filaments, which proliferate

and increase Na⁺/K⁺ ATPase activity to regulate blood salt concentration when subjected to high salinity levels (Avella et al., 1993). Normally, tilapia species can be reared from freshwater into brackish and seawater after acclimatization (Dominguez et al., 2004). However, fish require preacclimation for an optimal period before transfer to a new environment (Kamal and Mair, 2005). Nile tilapia showed slower acclimation and low survival rate in full strength seawater compared with blue tilapia (Oreochromis aureus) and tilapia (Oreochromis Mozambique mossambicus) (Kamal and Mair, 2005). Blood chemical analysis for AST and ALT activities involves aminotransferases produced hepatocyte cells in the liver. Plasma levels are low when animals are healthy but increase when they become sick and enzymes leak into the blood causing liver damage or death (Park et al., 2012; Pakhira et al., 2015). Stress conditions also induce higher levels of AST and ALT (Park et al., 2012; Nandi et al., 2018). For example, under stress through long-term starvation, AST and ALT levels of the olive flounder (Paralichthys olivaceus) significantly increased compared to the fed group (Park et al., 2012). Rohu (Labeo rohita) under stress condition with pathogens showed significantly higher AST and ALT levels than the control group fed with probiotic (Nandi et al., 2018). We previously reported that Nile tilapia reared in water treated with probiotics Bacillus (B.subtilis. B. spp. megaterium and B. licheniformis) and

yeast (S. cerevisiae) showed decreased AST and ALT levels compared with the control group (Sutthi et al., 2018a). Present study showed no significant differences of AST and ALT levels between Nile tilapia fed with 0.5% yeast (S. cerevisiae) and basal diet under 0-10 ppt salinity. This result indicated that fish fed with yeast at salinity of 0-10 ppt show no effects on liver cells. Moreover, we also found no significant difference on glucose level between Nile tilapia fed with 0.5% yeast (S. cerevisiae) and basal diet under 0-10 ppt salinity (p<0.05). Similarly, Küçük et al. (2013) found that plasma glucose in blue tilapia (Oreochromis aureus) was not significantly affected by salinity difference (8-24 ppt). Other studies also have been found that glucose level in fish did not change during salinity exposure (Morgan et al., 1997; Arjona et al., 2009; Mylonas et al., 2009). Generally, glucose is an indicator of secondary phase stress response in fish (Barton and Iwama, 1991; Morgan and Iwama, 1997; Wendelaar-Bonga, 1997). Under stress conditions, catecholamine hormones, adrenaline and noradrenaline are released into blood circulation, and in conjunction with cortisol, they elevate glucose production through glucogenesis and glycogenolysis pathways (Iwama et al., 1999) to cope with the energy demand produced by the stressor. Thus, 0-10 ppt of salinity stress had no effect on AST, ALT and glucose levels because the fish may have become acclimatized to high concentrations salinity before experiment began (Küçük et al., 2013).

However, our results presented that fish fed with 0.5% yeast supplement in diet and reared at 10 ppt salinity had cortisol levels lower than those fed with basal diet (p<0.05). Cortisol levels of both fish groups fed with 0.5% yeast supplement and basal diet showed an increased trend for salinity regimes from 0 to 10 ppt (Fig. 2d). Our results concurred with Kammerer et al. (2010) who reported that plasma cortisol and osmolality in tilapia changed rapidly in response to salinity stress. High salinity concentration is associated with changes in blood chemistry (Küçük et al., 2013) and increased metabolic rates (Othman et al., 2015) which may inhibit growth. Normally, salinity chronic stress can promote physiological changes in cortisol level after an exposure period of hours, days, or weeks (McEwen, 2008). Cortisol level is a primary feature and good target indicator for stress studies in fish (Barton and Iwama, 1991) and is frequently used as a stress indicator Iwama, 1997). (Morgan and Furthermore, MDA is a biomarker, which is used to assay cell oxidative damage (Livingstone, 2001; stress Valavanidis et al., 2006) and a pollution stress detector in aquatic animals (Favari et al., 2002). MDA levels found here showed significant increase in both fish fed with 0.5% yeast supplement and basal diet at 10 ppt than at 0 and 5 ppt (p<0.05). Nile tilapia fed with Lactobacillus plantarum CCFM8610 supplement in diet and reared under waterborne cadmium exposure showed improved lower levels of MDA than the control group (Zhai et al., 2017). Atlantic salmon (Salmo salar) fed with veast (Xanthophyllomyces dendrorhous) subjected crowding stress showed decreased MDA levels compared to the control group (Reyes-Cerpa et al., 2018). Bglucan is a major structural component of yeast cell walls (Vallejos-Vidal et al., 2016) which inhibits MDA levels against cell oxidative stress (Sener et al., 2005). Thus, our results indicated that Nile tilapia survived at salinity regimes up to 10 ppt and exhibited good growth and blood chemistry at 0-5 ppt.

Proximate analysis results demonstrated that Nile tilapia fed 0.5% under all salinity yeast stress concentrations (0-10 ppt) showed crude protein content higher than fish fed with basal diet (p<0.05). Our results agreed with Asadi Rad et al. (2012) who reported that body protein of Nile tilapia fed with yeast (S. cerevisiae) supplementation in diet significantly have been affected. Yeast has high potential contents of β-glucans, mannan oligosaccharides (MOS) and nucleic acid (Li and Gatlin, 2006; Refstie et al., 2010; Kühlwein et al., 2014) which improve growth, energy and high nutrient digestibility (Lara-Flores et al., 2003). Moreover. veast supplementation enhanced food intake and improved fish body composition with increase in deposited nutrients (Abdel-Tawwab et al., 2008). Our results showed increasing levels of crude lipid content in fish fed 0.5% yeast supplement diet reared at 0 and 5 ppt compared with 10 ppt (p<0.05), while fish fed with basal diet recorded

no significant differences in crude lipid percentage under diverse salinity. These findings concurred with El-Zaeem et al. (2011) who reported that protein content of Nile tilapia at salinity levels of 0-16 ppt was higher than fish reared at 32 ppt, while lipid content showed no significant differences. High salinity concentrations 20 - 24of ppt significantly decreased the hepatosomatic index of blue tilapia (Oreochromis aureus) (Küçük et al., 2013). Our results showed that Nile tilapia reared under salinity concentrations of 0-10 ppt had similar hepatosomatic indices. Normally, Nile tilapia do not tolerate salinities above 20 ppt and are not suitable for culture in full-strength salinities (Baroiller et al., 2000). Our results suggested that Nile tilapia fed with 0.5% yeast diet showed enhanced body compositions of crude protein and crude lipid content, even when reared under salinity stress up to 10 ppt.

Our results demonstrated that fish fed with 0.5% yeast (*S. cerevisiae*) supplement diet showed high growth performance, with enhanced crude protein and crude lipid content in fillets. Cortisol levels and MDA content also improved under salinity stress. Salinity regimes of 0-10 ppt were well tolerated by fish fed with 0.5% yeast supplement; however, we suggest that culture of Nile tilapia (*O. niloticus*) in aquatic environments should be better in salinities up to 5 ppt than 10 ppt.

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