



The influence of *Saccharomyces cerevisiae* on digestive enzyme activity, growth performance, hematological parameters, and biochemical composition of Nile tilapia (*Oreochromis niloticus*) during the grow-out stage

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Abstract. This study examines the effect of dietary supplementation with *Saccharomyces cerevisiae* on digestive enzyme activity, growth performance, hematological parameters, and biochemical body composition of Nile tilapia (*Oreochromis niloticus*) at the grow-out stage with an average initial weight of 32.36 ± 0.28 g fish⁻¹. Fish were fed diets supplemented with *S. cerevisiae* at doses of 0, 1, 4, 6, and 8 g kg⁻¹ for 8 weeks. The results showed that supplementation with *S. cerevisiae* at doses up to 6 g kg⁻¹ feed significantly increased the final body weight, relative growth rate, feed conversion ratio, protein efficiency ratio, apparent protein utilization, and energy utilization compared to feed without *S. cerevisiae* supplementation. Carcass crude protein content and moisture content were significantly higher in fish fed *S. cerevisiae* supplemented diets, whereas crude lipid levels decreased with increasing doses of *S. cerevisiae*. Digestive enzyme activity, especially that of protease and lipase, also increased with *S. cerevisiae* supplementation. The percentage counts of all three differential leukocytes - neutrophils, lymphocytes, and monocytes - showed significant stepwise increases with higher dietary *S. cerevisiae*, with the highest values observed in the 6 g kg⁻¹ diet ($p < 0.05$). Total erythrocyte (RBC) count, total leukocyte count, hemoglobin, hematocrit, and mean corpuscular volume (MCV) also showed similar trends of significant incremental increases with higher dietary *S. cerevisiae* up to an optimum at 6 g kg⁻¹ diet ($p < 0.05$). Overall, these results indicate that supplementation of *S. cerevisiae* in feed with 6 g kg⁻¹ optimizes growth, feed utilization, nutrient composition, hematology, and digestive function in Nile tilapia during the grow-out stage.

Key Words: diet, farming, feed, fish, supplementation.

Introduction. The success of intensive Nile tilapia (*Oreochromis niloticus*) farming is highly dependent on the availability of artificial feed. Artificial feed uses up to 50% fish meal as a source of animal protein, making it the main and most expensive protein ingredient (Tacon & Metian 2008). Fish meal is used as a source of animal protein in feed because it provides protein, essential amino acids, essential fatty acids, cholesterol, vitamins, and mineral content that are crucial for fish growth (NRC 2011). As aquaculture activities increase, the demand for fish meal continues to rise, which leads to limited fish meal availability and raises concerns about excessive fish capture that disregards the sustainability of natural ecosystems (Bai et al 2022). Therefore, it is necessary to seek plant-based ingredients as alternative protein sources with the potential to replace fish meal as part of efforts to develop sustainable and environmentally friendly aquaculture (Hussain et al 2020). However, plant based fish feed often suffers from poor digestibility and protein quality, thereby limiting its large-scale application in fish feed (Aragão et al 2022). One effort to address the problems associated with plant-based ingredients is to supplement feed with *Saccharomyces cerevisiae* to enhance the nutritional content of the feed.

S. cerevisiae is a well-known microorganism, and its benefits depend on functional components such as β -glucans, nucleic acids, mannan oligosaccharides, and chitin

(Dawood et al 2020). *S. cerevisiae* also produces various metabolites such as enzymes, oligosaccharides, amino acids, peptides, organic acids, vitamins, and other soluble factors (Khodadadi et al 2019). As a probiotic, *S. cerevisiae* improves growth, immunity, and disease resistance of various fish species (Hassaan et al 2015).

S. cerevisiae contains essential amino acids such as glutamine, lysine, and sulfur-containing amino acids and provides several important vitamins such as vitamin B and folic acid. It also has an amino acid profile similar to that of fish meal (Huyben et al 2017a), and contains unsaturated fatty acids as well as linoleic and alpha-linolenic acids, which can also be synthesized by fatty acid desaturase (Vidakovic et al 2020). Furthermore, Tewary & Patra (2011) reported that *S. cerevisiae* produces several enzymes that can enhance nutrient digestion, thereby significantly improving fish growth. Supplementation of feed with *S. cerevisiae* has been shown to increase feed utilization efficiency and growth in several fish species. El-Bab et al (2022) reported that adding *S. cerevisiae* at a rate of 4 g kg⁻¹ resulted in great improvements in the growth rate of *Sparus aurata*. Furthermore, El-Mokhlesany et al (2023) stated that supplementation with 5 g kg⁻¹ *S. cerevisiae* was the best for the immunity and growth of *Liza ramada*.

The application of *S. cerevisiae* supplementation in feed has been widely proven to improve protein digestibility, feed utilization efficiency, growth, and disease resistance in several fish species, including *S. aurata* (Rimoldi et al 2020), *Pelteobagrus fulvidraco* (Huang et al 2024), *Barbonymus gonionotus* (Rachmawati et al 2021), *Litopenaeus vannamei* (Zhang et al 2022), *Clarias gariepinus* var. Sangkuriang (Rachmawati et al 2022), *Ictalurus punctatus* (Hao et al 2022; Xia et al 2022), and *Oncorhynchus mykiss* (Huyben et al 2017b; Yousefi et al 2025). This study aimed to examine the effects of *S. cerevisiae* in feed on digestive enzyme activity, growth performance, hematological parameters, and biochemical composition of Nile tilapia during the grow-out stage.

Material and Method

Preparation of test fish. A total of 900 Nile tilapia with an initial average weight of 32.36±0.28 g were used in this study. The fish were acclimatized for one week to the environment and feed, and then selected as test fish based on their uniform size, active swimming behavior, and good health (Rachmawati et al 2023). After acclimatization, the fish were randomly distributed into experimental tanks. There were a total of 18 tanks with 50 fish per tank, each tank measuring 1 x 1 x 1 m³ with a water volume of 600 liters and equipped with a recirculating system, where every three fiber tanks served as replicates for each treatment.

Preparation of test feed. The test feed consisted of artificial pellets with a protein content of 31% (Rachmawati et al 2025) supplemented with *S. cerevisiae* according to the treatment. The treatments in this study were supplementation with *S. cerevisiae* in the feed at different doses, namely A (0 g/kg feed), B (2 g/kg feed), C (4 g/kg feed), D (6 g/kg feed), and E (8 g/kg feed), with three replicates for each treatment. The *S. cerevisiae* used was Beta Glucan Yeast Powder (Avena Sativa L, Bioway, China) with a concentration of 10¹⁰ CFU g⁻¹. Before being mixed into the feed ingredients, *S. cerevisiae* was first activated by adding 1% liquid molasses and warm water at 15°C, following Zhang et al (2022). Feed preparation began by weighing the raw materials according to the feed formulation, then mixing the feed ingredients starting from the smallest amount to the largest and stirring until homogeneous using a mixing machine. Finally, fish oil, corn oil, and sufficient water were added, and the mixture was stirred until it was evenly mixed and homogeneous. The dough was then molded into floating pellets with a diameter of 2 mm using an extruder (LX-75, China). The dried pellets were then packed in airtight plastic bags and stored under dry conditions to ensure safety. After molding, the feed was dried at room temperature, approximately 26°C, then packed in airtight plastic, and stored until use. The test feed formulation is presented in Table 1.

Proximate composition analysis of test fish. Proximate composition analysis of the test feed and test fish was conducted based on the method of Jayant et al (2018) to

analyze the biochemical content of the test fish carcasses. The protein content was determined using a semi-automatic Kjeldahl system (FOSS Kjelttec 2300). The fat content was determined using the ether extraction method based on the Soxhlet method (FOSS Soxtec 2043). Ash content was determined by incinerating the test feed and fish samples in a furnace at 550°C for 24 h.

Table 1

Formulation of test feed used in the study (1000 g) and proximate composition analysis results

Feed ingredients (g)	Test feed				
	A	B	C	D	E
Fish meal	339	339	339	339	339
Soybean meal	320	320	320	320	320
Corn meal	60	60	60	60	60
Bran	79	79	79	79	79
Wheat flour	122	120	118	116	114
Fish oil	30	30	30	30	30
Corn oil	20	20	20	20	20
Vitamin-mineral mix ¹⁾	10	10	10	10	10
CMC	10	10	10	10	10
Cr ₂ O ₃	10	10	10	10	10
<i>S. cerevisiae</i>	0	2	4	6	8
Total	1000	1000	1000	1000	1000
<i>Proximate composition analysis (%)</i>					
Dry matter	92.1	92.2	92.5	92.7	92.8
Crude protein	31.1	31.2	31.3	31.4	31.4
Crude fat	7.6	7.8	7.8	7.9	7.9
Ash	8.5	8.7	8.5	8.5	8.6
Fiber	5.4	4.8	4.9	4.8	4.7
NFE ²⁾	47.4	47.5	47.5	47.4	47.4
Gross energy (MJ kg ⁻¹) ³⁾	16.92	16.97	16.98	16.99	16.99

Notes: ¹⁾ Vitamin and mineral mixture: each 1 kg of the mixture contains 6 g Vitamin B6, 4.0 g pantothenic acid, 4800 IU Vitamin A, 2400 IU cholecalciferol (Vitamin D), 40 g of Vitamin E, 8 g of Vitamin K, 4.0 g of Vitamin B12, 4.0 g of Vitamin B2, 8.0 g nicotinic acid, 400 mg folic acid, 20 mg biotin, 26 mg D-calcium pantothenate, 6 mg pyridoxine HCl, 7.2 mg riboflavin, 1.2 mg thiamine HCl, 3077 mg sodium chloride (NaCl, 39% Na, 61% Cl), 65 mg ferrous sulphate (FeSO₄ · 7H₂O, 20% Fe), 89 mg of manganese sulfate (MnSO₄, 36% Mn), 150 mg zinc sulfate (ZnSO₄ · 7H₂O, 40% Zn), 200 gm choline, 4 g copper, 0.4 g iodine, 12 g iron, 22 g manganese, 22 g zinc, 0.04 g selenium, 1.2 mg folic acid, 12 mg niacin, 28 mg copper sulphate (CuSO₄ · 5H₂O, 25% Cu), 11 mg potassium iodide (KI, 24% K, 76% I), 1000 mg Celite AW521 (acid-washed diatomaceous earth silica). w% on dry matter (DM) basis; ²⁾ Nitrogen-Free Extract (calculated by difference) = 100 – (protein + lipid + ash + fiber); ³⁾ Gross energy was calculated using the following factors: protein, 23 MJ kg⁻¹; lipid, 35 MJ kg⁻¹; carbohydrates, 15 MJ kg⁻¹ (Molina-Poveda et al 2013).

Digestive enzyme activity analysis. Digestive enzyme activity was analyzing five fish, one fish from each treatment group. The middle section of the intestine was collected, homogenized, and centrifuged. The resulting supernatant was used to measure protease, lipase, and amylase activities according to the method described by Abd El-Naby et al (2023). All digestive enzymes were analyzed using commercial reagent kits (Cusabio Biotech, China), according to the manufacturer's protocol.

Analysis of hematological parameters. Five fish, consisting of one fish from each treatment group, were fasted for 24 h, after which they were anesthetized with clove oil. The next step was to collect blood samples from the caudal vein of the fish, which were then placed into tubes containing heparin. The differential white blood cell count was calculated according to Klontz (1994). The numbers of red blood cells (RBC), total leukocytes, and platelets were determined using a Neubauer hemocytometer according to Martins et al (2004). The mean cell volume (MCV), mean cell hemoglobin (MCH), and

mean cell hemoglobin concentration (MCHC) were calculated using the Winthrobe (1933) method. Hemoglobin (Hb) levels were measured according to Collier (1944), and hematocrit (HCT) values were determined according to Goldenfarb et al (1971).

Research procedures. This study was conducted from June to August 2025 in the fish farmer group of Tambaksari village, Rowosari District, Kendal Regency, Central Java, Indonesia. The research began by randomly placing test fish, which had already been weighed for their initial average weight, into fiber tanks containing 500 liters of water, at a density of one fish per five liters. Feed was given ad satiation with a feeding frequency of three times a day, at 07:00, 13:00, and 18:00. Sampling was conducted weekly for 56 days to determine the weight gain of the test fish by weighing them. The observed water quality parameters referred to Boyd & Tucker (1998), including pH 6.5-8.6 (Jenway 3510), dissolved oxygen (DO) ≥ 3 mg L⁻¹ (Jenway 970), and temperature 25-30°C (Water quality checker) which were observed daily, and ammonia (HANNA: HI.8633), which were observed at the beginning and end of the study. Siphoning was also carried out daily, approximately 2 h after feeding to remove feces and leftover feed, aiming to maintain the water quality of the culture medium. The observed parameters included the weight gain, feed conversion ratio (FCR), protein efficiency ratio (PER), relative growth rate (RGR), survival rate (SR), apparent protein utilization (APU), and energy utilization (EU) according to NRC (2011). The calculations of formulae are as follows:

$$\text{Weight gain (g)} = \text{final weight (g)} - \text{initial weight (g)}$$

$$\text{FCR} = \text{feed intake (g)} / \text{body weight gain (g)}$$

$$\text{PER} = 100 \times [\text{final weight (g)} - \text{initial weight (g)}] / \text{amount of diet consumed (g)} \times \text{protein content of diet}$$

$$\text{RGR (\% day}^{-1}\text{)} = 100 \times [\text{final weight (g)} - \text{initial weight (g)}] / ([\text{times of experiment (day)} \times \text{initial weight (g)}])$$

$$\text{SR (\%)} = 100 \times (\text{final fish count} / \text{initial fish count})$$

$$\text{APU (\%)} = 100 \times [\text{protein gain in fish (g)} / \text{protein intake in the diet (g)}]$$

$$\text{EU (\%)} = 100 \times [\text{energy gain in fish (g)} / \text{energy intake in diet (g)}]$$

Statistical analysis. Before conducting a one-way analysis of variance (ANOVA), the data were first tested for normality (Shapiro-Wilk test) and homogeneity of variance (Levene's test) at a 5% significance level. Subsequently, a one-way analysis of variance (ANOVA) was performed; if the ANOVA results showed a significant ($p < 0.05$) or highly significant ($p < 0.01$) effect, this was followed by Duncan's multiple range test to compare mean values among treatments at ($p < 0.05$) to determine the best treatment (Steel et al 1997). All statistical data analyses were performed using SPSS (version 22.0, SPSS Inc., Chicago, Illinois).

Results. Supplementation with *S. cerevisiae* in the feed (test feeds B, C, D, and E) significantly improved the growth performance and feed utilization parameters in Nile tilapia compared to the feed without *S. cerevisiae* supplementation (test feed A); detailed data are presented in Table 2. Growth performance parameters showed a significant increase ($p < 0.05$) in the RGR with increasing doses of *S. cerevisiae* in the feed, up to 6 g/kg of feed. No significant differences in SR were observed between the tested feed treatments. The feed efficiency parameters, including FCR, PER, APU, and EU, showed significant improvements ($p < 0.05$) with supplementation of *S. cerevisiae* in the feed, with the highest values observed in fish fed *S. cerevisiae* at a dose of 6 g/kg (test feed D). A significant decrease ($p < 0.05$) in FCR was observed with increasing doses of *S. cerevisiae* in the feed.

Table 2

Growth performance and feed utilization of tilapia with *S. cerevisiae* supplementation in feed for 56 days

Parameters	Test feed				
	A	B	C	D	E
Initial weight (g)	42.36±0.28	42.28±0.26	42.48±0.30	42.30±0.28	42.38±0.28
Final weight (g)	105.90±0.02 ^e	127.08±0.12 ^d	131.16±0.14 ^c	148.26±0.12 ^a	139.78±0.12 ^b
Weight gain (g)	65.54±0.14 ^e	84.80±0.11 ^d	88.68±0.12 ^c	106.00±0.12 ^a	97.40±0.13 ^b
Feed intake (g feed/fish)	280.31±0.28 ^e	290.53±0.48 ^d	300.71±0.14 ^c	352.63±0.37 ^a	328.71±0.16 ^b
RGR (% day ⁻¹)	2.21±0.12 ^e	2.78±0.10 ^d	3.56±0.14 ^c	4.39±0.01 ^a	3.01±0.02 ^b
FCR	1.68±0.03 ^e	1.52±0.02 ^d	1.42±0.02 ^c	1.22±0.01 ^a	1.35±0.02 ^b
PER	1.51±0.04 ^c	2.24±0.03 ^b	2.67±0.02 ^a	3.28±0.01 ^a	2.86±0.02 ^a
SR (%)	100 ^a	100 ^a	100 ^a	100 ^a	100 ^a
APU (%)	54.98±0.14 ^e	57.11±0.17 ^d	58.97±0.12 ^c	59.81±0.18 ^a	59.29±0.18 ^b
EU (%)	7.28±0.03 ^e	7.66±0.05 ^d	7.98±0.02 ^c	8.96±0.12 ^a	8.43±0.18 ^b

Note: Means with the same letter in the same row are not significantly different at $p < 0.05$.

Proximate composition analysis of fish carcasses showed no significant difference in ash content between the feed treatments (Table 3). However, crude protein content showed a gradual and significant increase ($p < 0.05$) with higher doses of *S. cerevisiae* in the feed. The test fish without *S. cerevisiae* had the lowest crude protein content in their carcasses. The moisture content was significantly ($p < 0.05$) higher in the groups treated with *S. cerevisiae*. The total lipids content decreased significantly with *S. cerevisiae* supplementation in the feed up to the highest dose of 8 g/kg.

Table 3
Composition of tilapia in response to *S. cerevisiae* supplementation in feed for 56 days

Parameters (%)	Test feed				
	A	B	C	D	E
Moisture	72.32±0.01 ^b	73.29±0.02 ^a	73.30±0.01 ^a	73.56±0.02 ^a	73.30±0.01 ^a
Crude protein	17.10±0.02 ^b	17.82±0.12 ^b	18.46±0.14 ^a	18.78±0.12 ^a	18.62±0.12 ^a
Total lipids	8.21±0.02 ^a	6.88±0.01 ^b	6.74±0.02 ^b	6.65±0.02 ^b	6.48±0.01 ^b
Ash	4.47±0.02 ^a	4.42±0.02 ^a	4.45±0.02 ^a	4.46±0.02 ^a	4.47±0.02 ^a

Note: Means with the same letter in the same row are not significantly different at $p < 0.05$

The effect of *S. cerevisiae* supplementation on digestive enzyme activity in the intestines of Nile tilapia is shown in Table 4, which shows that Nile tilapia fed with *S. cerevisiae* supplementation had a significant ($p < 0.05$) increase in protease and lipase activities. The highest protease and lipase activities were observed in Nile tilapia fed with *S. cerevisiae* at a dose of 6 g/kg (test feed D). Conversely, amylase activity was lower in Nile tilapia fed *S. cerevisiae* (test feeds B, C, D, and E) compared to those without *S. cerevisiae* supplementation (test feed A). These results indicate that *S. cerevisiae* has the potential to provide beneficial effects on protein and lipid digestibility in grow-out stage of Nile tilapia.

Table 4
Digestive enzyme activity of tilapia in response to the addition of *S. cerevisiae* in the feed over 56 days

Enzymes	Test feed				
	A	B	C	D	E
Protease (U L ⁻¹)	2405±32.46 ^e	4498±23.18 ^d	2653±21.32 ^c	2864±28.12 ^a	2741±25.34 ^b
Lipase (U L ⁻¹)	1298±18.26 ^e	1529±20.47 ^d	1687±19.25 ^c	1842±14.53 ^a	1762±18.67 ^b
Amylase (U L ⁻¹)	1687±12.45 ^e	1568±10.86 ^d	1513±10.81 ^c	1510±10.32 ^c	1512±10.12 ^c

Note: Means with the same letter in the same row are not significantly different at $p < 0.05$

The effects of dietary *S. cerevisiae* supplementation on hematological parameters are presented in Table 5. The percentage counts of all three differential leukocytes - neutrophils, lymphocytes, and monocytes - showed significant stepwise increases with higher dietary *S. cerevisiae*, with the highest values observed in the 6 g/kg diet (test feed D) ($p < 0.05$). Total erythrocyte (RBC) count, total leukocyte count, hemoglobin, hematocrit, and mean corpuscular volume (MCV) also showed similar trends of significant incremental increases with higher dietary *S. cerevisiae* up to an optimum at 6 g/kg diet (test feed D) ($p < 0.05$).

Table 5

Hematological parameters of tilapia in response to *S. cerevisiae* supplementation in feed for 56 days

Parameters	Test feed				
	A	B	C	D	E
Lymphocytes (%)	83.16±0.35 ^e	84.28±0.18 ^d	85.62±0.24 ^c	87.62±0.21 ^a	86.18±0.13 ^b
Monocytes (%)	1.22±0.17 ^e	1.98±0.13 ^d	2.59±0.12 ^c	3.43±0.16 ^a	3.02±0.13 ^b
Neutrophil (%)	8.54±0.23 ^e	9.66±0.14 ^d	10.43±0.32 ^c	12.98±0.41 ^a	11.35±0.56 ^b
Eosinophils (%)	1.52±0.24 ^a	1.53±0.22 ^a	1.58±0.20 ^a	1.58±0.24 ^a	1.58±0.23 ^a
RBCs (× 10 ¹² L ⁻¹)	2.12±0.02 ^e	2.68±0.04 ^e	3.60±0.01 ^c	4.18±0.02 ^a	3.06±0.03 ^b
Total leukocyte count (× 10 ⁹ L ⁻¹)	0.86±0.02 ^e	1.48±0.01 ^d	2.43±0.12 ^c	2.98±0.03 ^a	2.01±0.12 ^b
HCT (%)	18.35±0.20 ^e	19.84±0.30 ^d	23.52±0.25 ^c	25.89±0.10 ^a	24.45±0.27 ^b
Hb (g deciliter ⁻¹)	5.63±0.14 ^e	6.22±0.26 ^d	7.38±0.23 ^c	8.96±0.20 ^a	8.12±0.24 ^b
MCV (femtoliters)	81.57±0.18 ^e	82.63±0.25 ^d	83.89±0.13 ^c	84.70±0.17 ^a	83.02±0.14 ^b
MCH (deciliter)	27.36±0.13 ^a	27.36±0.14 ^a	27.30±0.10 ^a	27.32±0.11 ^a	27.35±0.10 ^a
MCHC (g deciliter ⁻¹)	32.74±0.32 ^a	32.73±0.22 ^a	32.74±0.30 ^a	32.73±0.30 ^a	32.74±0.30 ^a

Note: Means with the same letter in the same row are not significantly different at $p < 0.05$

Discussion. *S. cerevisiae* is a product with probiotic activity that can enhance growth performance (Li et al 2020). Specifically, β -glucan and mannan-oligosaccharides (MOS) found in the cell wall of *S. cerevisiae* can improve growth performance and animal health (Ramos et al 2022). In this study, Nile tilapia test fed diets supplemented with *S. cerevisiae* at doses of 2-8 g/kg feed showed improved growth, as evidenced by increases in final weight, weight gain, and RGR, as well as better feed utilization (PER) and a significant reduction in FCR ($p < 0.05$). Similar results were reported by El-Bab et al (2022), who found that adding 4 g/kg feed *S. cerevisiae* produced the best results in improving the growth rate of *S. aurata*. El-Mokhlesany et al (2023) reported that supplementing 5 g/kg of *S. cerevisiae* yielded the best results for immunity and growth in *Liza ramada*. Zhang et al (2022) reported that feed enriched with 1-3% *S. cerevisiae* increased the growth of *L. vannamei*. Feed enriched with *S. cerevisiae* not only improves growth performance but also enhances feed utilization and nutrient digestibility (Owatari et al 2022).

The results of this study show that supplementation with *S. cerevisiae* at a dose of 6 g/kg feed maximally stimulates the secretion of digestive enzymes, thereby increasing nutrient digestibility and resulting in improved feed efficiency and the highest growth performance in Nile tilapia. The improvement in growth performance and feed utilization observed in this study is suspected to be linked to the presence of glutamine as one of the active components in *S. cerevisiae*. Several studies indicate that glutamine is a significant amino acid in *S. cerevisiae*. Glutamine is a non-essential amino acid that plays an important role in fish nutrition and physiology. Studies have reported the role of glutamine in the regulation of growth, stimulation of appetite, protein synthesis, and skeletal muscle growth (Li et al 2020; Ramos et al 2022; Carvalho et al 2023). In this study, there was no significant difference in the SR among the test feed treatments, indicating that the addition of *S. cerevisiae* to the feed did not have a significant effect ($p > 0.05$) on the survival of Nile tilapia. Similar results have been reported by El-Bab et al (2022), Sutthi & Thaimuangphol (2022), Rachmawati et al (2022), El-Mokhlesany et al (2023), and Yousefi et al (2025).

The results of this study show that supplementation of feed with *S. cerevisiae* has a positive effect on protein content and total fat in the bodies of Nile tilapia (Table 3). Similar findings were reported by Abu-Elala et al (2018), who found that supplementation of feed with *S. cerevisiae* had a positive impact on the nutritional composition and growth of Nile tilapia. Ayiku et al (2020) reported the similar results for *L. vannamei*, and Sharawy et al (2016) observed an increase in crude protein content in *Fenneropenaeus indicus* juveniles after feeding with *S. cerevisiae* supplemented feed at a dose of 2.5 g/kg. These findings indicate that the physiological performance of aquatic animals can be improved by supplementing their feed with *S. cerevisiae*.

Fish growth and performance are closely related to the function of digestive enzymes (Liu et al 2022). In this study, supplementation of *S. cerevisiae* in feed decreased amylase activity but increase protease and lipase activities at various dosage levels of *S. cerevisiae*. Increased protease and lipase activity can improve the digestion of proteins and lipids, thereby enhancing nutrient absorption and promoting growth. Darafsh et al (2020) stated that the addition of *S. cerevisiae* to fish feed can increase the activity of protease, lipase, and amylase, thus potentially enhancing the growth rate in fish. This finding is supported by Hao et al (2022), who reported that *S. cerevisiae* can produce or release various digestive enzymes after cell lysis in the fish digestive tract; which can effectively improve nutrient absorption in the fish's digestive tract, thereby increasing growth rate and improving feed efficiency in fish. *S. cerevisiae* also produces cellulase enzymes capable of breaking down cellulose into glucose. This process contributes to the reduction of crude fiber content in the feed, which is indirectly related to an increase in carbohydrate content. The addition of *S. cerevisiae* to feed can enhance production, promote growth, increase immunity, and improve feed efficiency in fish (Islam et al 2021). These results are consistent with previous studies showing that *S. cerevisiae* acts as an immunostimulant and can positively affect digestive enzymes in fish (Qu et al 2019). Hematological parameter indicators can provide useful information regarding the health status of aquatic organisms (Liu et al 2022). In this study, hematological values (RCB, HCT, HGB, and MCV) increased significantly with higher doses of *S. cerevisiae* in the feed along with improved growth. This increase may be due to the presence of the vitamin B complex and other hemotonic substances in *S. cerevisiae*, which play important role in the production of various blood cells (Huyben et al 2017b). Similar findings were reported by Rimoldi et al (2020) for *S. aurata*, Huang et al (2024) for *P. fulvidraco*, and Xia et al (2022) for *I. punctatus*.

Conclusions. Overall, the findings of this study indicate that feed supplementation with *S. cerevisiae* can effectively improve the growth performance, feed utilization, nutritional composition, hematological parameters, and digestive function of Nile tilapia during the grow-out stage. The optimal supplementation dose of *S. cerevisiae* at 6 g/kg resulted in the most significant improvement. These results highlight the potential of *S. cerevisiae* as a valuable functional feed additive for enhancing tilapia productivity in aquaculture systems.

Acknowledgements. The authors express their gratitude to the Directorate General of Research and Development, Ministry of Higher Education, Science, and Technology, Fiscal Year 2025, for providing funding for this applied research through Research Implementation Contract Number: 359-090/UN7.D2.1/PP/VI/2025, dated June 2, 2025.

Conflict of interest. The authors declare that there is no conflict of interest.

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Received: 20 August 2025. Accepted: 09 September 2025. Published online: 30 September 2025.

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How to cite this article:

Rachmawati D., Elfitasari T., Yuniarti T., 2025 The influence of *Saccharomyces cerevisiae* on digestive enzyme activity, growth performance, hematological parameters, and biochemical composition of Nile tilapia (*Oreochromis niloticus*) during the grow-out stage. *AAFL Bioflux* 18(5):2174-2184.