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by Istiyanto Samidjan

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Effects of Yeast on the Growth Performance of Sangkuriang Catfish Fingerlings (*Clarias gariepinus* var. Sangkuriang)

Diana Rachmawati[1]*, Sarjito[1], Istiyanto Samidjan[1], Dewi Nurhayati[1] and Putut Har Riyadi[2]

[1]*Department of Aquaculture, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang, 1269, Central Java, Indonesia*

[2]*Department of Fisheries Product Technology, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang 50275, Central Java, Indonesia*

ABSTRACT

The success of the intensive culture of Sangkuriang catfish (*Clarias gariepinus* var. Sangkuriang) highly depends on the availability of feed. The feed is the most significant share of cost production hamper (50-60%). Therefore, it is suggested that feed utilization is inefficient. One of the solutions is to enrich the commercial feed with yeast (*Saccharomyces cerevisiae*). The research aimed to identify the impacts of yeast (*S. cerevisiae*) enhanced feed on feed efficiency, growth, and survival rate of Sangkuriang catfish fingerlings. The treatments research was yeast (*S. cerevisiae*) enrichment in the commercial feed at the various dosages: 0 %/kg feed (A), 3 %/kg feed (B), 6 %/kg feed (C), 9 %/kg feed (D), and 12 %/kg feed (E). The yeast (*S. cerevisiae*) enrichment in the commercial feed increased feed efficiency and survival rate of Sangkuriang catfish fingerlings. The optimum dosage of *S. cerevisiae* for apparent digestibility coefficients for protein (ADCp), efficiency feed utilization (EFU), protein efficiency ratio (PER), and relative growth rate (RGR) ranged from 6.10% to 6.51%/kg feed.

Keywords: Aquaculture, catfish, cost, feed, growth performance, yeast

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E-mail addresses:
dianarachmawati1964@gmail.com (Diana Rachmawati)
sarjito_msdp@yahoo.com (Sarjito)
istiyanto_samidjan@yahoo.com (Istiyanto Samidjan)
dewinurhayati24@gmail.com (Dewi Nurhayati)
putut.riyadi@live.undip.ac.id (Putut Har Riyadi)
*Corresponding author

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INTRODUCTION

The success of the intensive culture of Sangkuriang catfish (*Clarias gariepinus* var. Sangkuriang) is highly related to feeding availability. Intensive aquaculture feed is the most significant share of cost production, around 50-60% (Rachmawati & Samidjan, 2018). Due to the inefficiency of feed to support growth, the enrichment of the commercial feed with yeast (*Saccharomyces cerevisiae*) is urgently needed. The yeast (*S. cerevisiae*) could boost digestive enzyme activities; therefore, it increased the breakdown of complex nutrients into simpler forms to be easily absorbed in the digestive tract (de Azevedo et al., 2016). Sitohang et al. (2012) stated that *S. cerevisiae* produced metabolic products, including amylase and peptidase proteolytic. Protease enzymes could hydrolyze protein into peptides and amino acids. In addition, *S. cerevisiae* produced cellulase enzyme that could break down cellulose into glucose; in turn, it decreased raw fiber and the decrease of raw fiber related to the increase of carbohydrate. Manurung and Mose (2018) disclosed that yeast (*S. cerevisiae*) could increase fish appetite by allowing catfish to feed intensively and increasing catfish growth.

Some studies on the effect yeast (*S. cerevisiae*) on freshwater and marine fish have been done, such as in *Barbonymus gonionotus* (Rachmawati et al., 2019a), *Cyprinus carpio* (Al-Refaiee et al., 2016), *Oreochromis niloticus* (de Azevedo et al., 2016), *Pangasius hypothalamus* (Rachmawati et al., 2019b), *Labeo rohita* (Tewary & Patra, 2011), and *Sarotherodon galileaus* (Abdel-Tawwab et al., 2010). However, there is a lack of information about the effect of yeast (*S. cerevisiae*) to enhance commercial feed by increasing feed efficiency and growth of Sangkuriang catfish fingerlings. The present study was to identify the impacts of yeast (*S. cerevisiae*) enhancing feed efficiency, growth, and survival rate of Sangkuriang catfish fingerlings (*Clarias gariepinus* var. Sangkuriang).

MATERIALS AND METHODS

Research Design

The study used a completely randomized design with five groups, and each treatment had three replications. The research was conducted in the Sido Makmur Catfish Farmers Association, which partnered with the researchers on May-July 2020. As many as 500 test fish used in the study were catfish fingerlings with a weight of 1.12±0.36 g/fish. The catfish was obtained from the Sido Makmur Catfish Farmers Association. Sangkuriang catfish fingerlings were adapted on feed and the environment in the fiber containers in 1.5 × 1 × 1.5 m^3 of diameter for seven days. During adaptation, the fish was fed without *S. cerevisiae* in commercial feed. After the fish had adapted, one-day fasting was introduced to neutralize metabolic residual, not affecting the initial weight. Sangkuriang catfish fingerlings were selected based on several criteria: disease-free, malformation-free, healthy, energetic, and uniform size (Rachmawati et al., 2017).

Experimental Feed

Test study used experimental feed, which contains 30% protein, 0.5% chromium oxide (Cr_2O_3), and five dosages of yeast (*Saccharomyces cerevisiae*) treatment: A (0 %/kg feed), B (3 %/kg feed), C (6 %/kg feed), D (9 %/kg feed) and E (12 %/kg feed). *Saccharomyces cerevisiae* was purchased at the bread store. Commercial feed was first finely ground and mixed evenly with 0.5% Cr_2O_3. The mixture was formed as pellets with a 2 mm diameter, adjusted to the mouth size of the catfish fingerlings, and then dried at room temperature. Next, *S. cerevisiae* was diluted in 100 ml water for 1 kg feed (de Azevedo et al., 2016). *Saccharomyces cerevisiae* suspension was put in the sprayer bottle and then sprayed on an experimental feed containing Cr_2O_3. After mixing, the mixture was preserved at room temperature and packed in labeled plastic bags. Then it was stored in the refrigerator until further use (Vendrell et al., 2008). Experimental feed was 5%/ biomass weight/day for 63 days. Fish growth was identified by weighing the fish weekly. Fifteen plastic fiber containers were used in the research with 1 × 1 × 1 m^3. Every treatment used three containers, equipped with a water circulation system and stocked with 50 Sangkuriang catfish fingerlings.

Analysis of Protein Digestion

The feeding at satiation was given twice a day, in the morning and afternoon. The feces were collected twice a day after being fed by siphoning the containers. First, the feces were collected in the plankton clothe net. The collected feces were then dried in the oven at 105 °C until constant weight. After the feces had dried, it was finely ground and stored at 4 °C until analyzed. Analyses for Cr_2O_3 content in the feed and feces were based on Association of Official Analytical Chemists (AOAC) (2005) using atomic absorption spectrometer.

Proximate Analysis

Proximate analysis of the feed and the fish body at the initial and final research was based AOAC (2005) method.

Moisture. Moisture was measured by 2 g of the samples in the oven at 105 ºC for 24 hours. Percentage of moisture was calculated using the following formula:

$$\text{Ka}\ (\%) = \frac{W_1 - W_2}{W_1} \times 100\% \qquad (1)$$

Ka = Percentage of moisture (wet weight)
W_1 = Weight of the sample (g)
W_2 = Weight of the dried sample (g)

Crude Protein. The crude protein content was determined using the micro-Kjeldahl method. Samples (2 g) were digested in the digestion unit for 45 minutes. The digester was then distilled in a distillation unit (Khjeltdahl System, VELP Scientifica Srl, Italy). It was titrated with 0.2 N hydrochloric acid (HCL), and crude protein was obtained by multiplying the total nitrogen by a conversion factor of 6.25.

$$\text{Crude protein (\%)} = \frac{\text{ml titration (blank} - \text{sample)} \times \text{N} \times 14{,}007 \times 6.25 \times 100\%}{\text{Weight of the sample (g)} \times 1000} \quad (2)$$

Crude Lipid. The content of crude lipid was analyzed using the Soxhlet extraction method. Samples with known constant weight were put into Soxhlet extracted using hexane or petroleum ether. After extraction, the sample was removed from the Soxhlet and dried.

$$\text{Crude lipid (\%)} = \frac{\text{Initial sample weight (g)} - \text{Final sample weight (g)}}{\text{Final sample weight (g)}} \times 100\% \quad (3)$$

Ash. The ash was obtained by putting samples into the furnace at 500 ºC for 10 hours. The cooled and stable ash results are then weighed so that the formula can calculate the total ash content:

$$\text{Ash (\%)} = \frac{W_1 - W_2}{W} \times 100\% \quad (4)$$

W = Sample weight before turn to ashes (g)
W_1 = Sample weight + porcelain dish after turn to ashes(g)
W_2 = Weight of an empty porcelain dish (g)

Observed Parameters

Parameters observed included feed conversion ratio (FCR), protein efficiency ratio (PER), relative growth rate (RGR), and efficiency feed utilization (EFU) based on National Research Council (NRC) (2011), apparent digestibility coefficients for protein (ADCp) based on Fenucci (1981), survival rate (SR) based on Tacon (2002). The equations to analyze the parameters were as follows:

ADC_P = 100(% Cr_2O_3 in the feed/% Cr_2O_3 in the feces) x (% protein in the feces/% protein in the feed)

EFU = 100 (final weight-initial weight/ the amount of feed consumed)

RGR = 100 $(W_t - W_o)/(W_o \text{ x } T)$; where W_o and W_t are the initial and final weight, respectively, and T is the number of days in the feeding period

FCR = 100 [feed intake (g) /weight gain (g)]

PER = 100 [weight gain (g) /protein intake (g)]

SR = 100 (final count/initial count)

Data Analysis

The impacts of yeast (*S. cerevisiae*) on experimental parameters were identified using analysis of variance (ANOVA). Suppose the treatments were significant ($P<0.05$) or highly significant ($P<0.01$), and then applied the Duncan's multiple range test. The optimum dosage of *S. cerevisiae* in the feed was analyzed using the polynomial orthogonal test in SAS (version 9) and Maple (version 12).

RESULTS

The proximate analysis (Table 1) indicated that the average percentage of raw protein was 30.27±0.28%, while the average percentage of raw fat was 8.25±0.24%. The values of ADCp, EFU, PER, RGR, and SR of Sangkuriang catfish fingerlings, which were given yeast (*S. cerevisiae*) enhanced feed, treatments B, C, D, and E were higher than that without yeast (*S. cerevisiae*) enhanced feed, treatment A. The yeast (*S. cerevisiae*) enhanced feed significantly affected ($P<0.05$) on ADCp, EFU, PER, and RGR; however, it did not affect significantly ($P>0.05$) on SR Sangkuriang catfish fingerlings (Table 2).

Table 1

The results of proximate analysis of test feed

Proximate analysis	Diets				
	A	B	C	D	E
Moisture (%)	6.98±0.12^{a}	7.18±0.11^{a}	6.78±0.21^{a}	7.03±0.15^{a}	6.88±0.10^{a}
Crude protein (%)	30.35±0.34^{a}	30.28±0.36^{a}	30.18±0.23^{a}	30.39±0.21^{a}	30.16±0.35^{a}
Crude lipid (%)	8.21±0.15^{a}	8.34±0.12^{a}	8.20±0.11^{a}	8.29±0.20^{a}	8.21±0.24^{a}
Ash (%)	10.23±0.25^{a}	10.31±0.20^{a}	10.73±0.12^{a}	10.28±0.22^{a}	10.13±0.24^{a}
Energy (kJ/g)	8.76±0.001^{a}	8.85±0.001^{a}	8.84±0.001^{a}	8.70±0.002^{a}	8.83±0.003^{a}

Note. Mean values ± SD with different superscript indicated a significant difference ($P<0.05$)
The proximate analysis performed at the Laboratory of Animal Feed, Faculty of Animal Sciences and Agriculture, Diponegoro University

Table 2

Growth performance of Sangkuriang catfish fingerlings fed yeast enriched feed

Parameters	Treatments				
	A	B	C	D	E
ADC_P (%)	64.14±0.22^{e}	78.89±0.29^{b}	85.12±0.25^{a}	73.34±0.21^{d}	68.23±0.20^{c}
EFU (%)	63.26±0.32^{e}	75.03±0.36^{b}	83.29±0.32^{a}	72.42±0.37^{d}	66.25±0.32^{c}
PER	2.05±0.24^{e}	3.58±0.22^{b}	4.63±0.23^{a}	3.23±0.24^{d}	2.96±0.22^{c}
RGR (%/day)	2.41±0.15^{c}	3.72±0.26^{c}	4.58±0.25^{a}	3.12±0.26^{b}	2.88±0.27^{b}
SR (%)	83.33±2.57^{a}	93.33±2.48^{a}	100±0.00^{a}	93.33±2.65^{a}	83.33±2.53^{a}

Note. Mean values ± SD in different superscript indicated a significant difference ($P<0.05$)

The results of the polynomial orthogonal test showed that the relation of yeast (*S. cerevisiae*) in the feed and ADCp has a quadratic pattern, $Y = -0.4582x^2 + 5.5858x + 65.171$, 0.857. The optimum dosage of 6.10 %/kg feed created a maximum value of ADCp as high as 85.73% (Figure 1). The relation of yeast (*S. cerevisiae*) in the feed and EFU was also in the quadratic form, Y = -0.4366x2 + 5.3514x + 63.517, R^2 = 0.882, with the optimum dosage of 6.12%/kg feed that generated a maximum value of EFU as much as 79.72% (Figure 2).

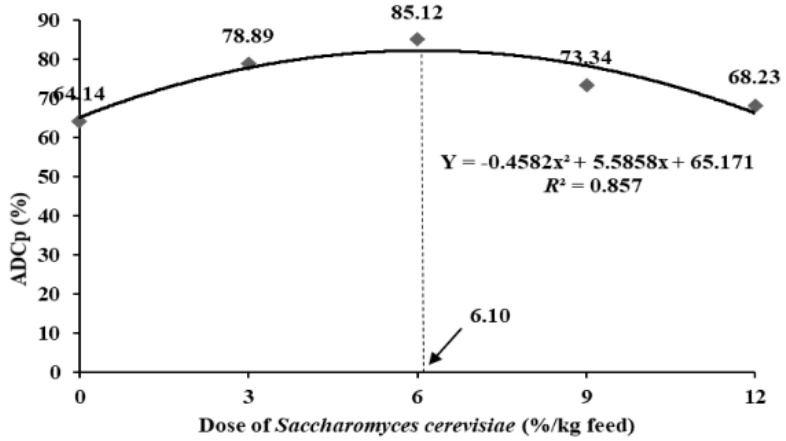

Figure 1. The relation of yeast (*Saccharomyces cerevisiae*) in the feed and ADCp

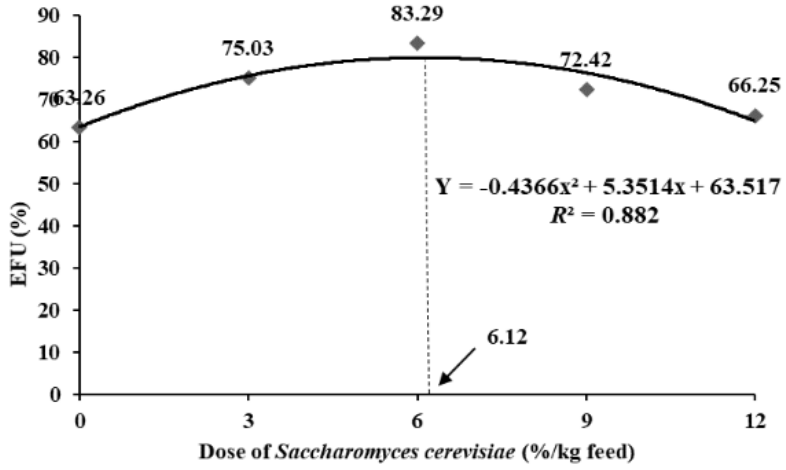

Figure 2. The relation of yeast (*Saccharomyces cerevisiae*) in the feed and EFU

The relation of yeast (*S. cerevisiae*) in the feed and PER were in the quadratic equation, $Y = -0.048x^2 + 0.6252x + 2.1317$, $R^2 = 0.801$. The maximum value of PER (4.17) was obtained from the optimum dosage of 6.51 %/kg feed (Figure 3). The relation of yeast (*S. cerevisiae*) in the feed and RGR has quadratic pattern, $Y = -0.043x^2 + 0.5275x + 2.4997$, $R^2 = 0.7512$. The maximum value of PER (4.12%/day) was obtained from the optimum dosage of 6.13%/kg feed (Figure 4). Water quality for Sangkuriang catfish cultivation during research was displayed in Table 3. The water quality was still in a viable condition for Sangkuriang catfish cultivation.

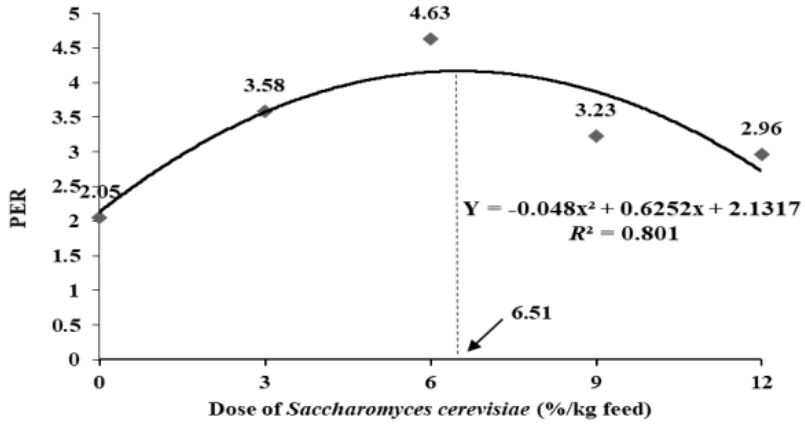

Figure 3. The relation of yeast (*Saccharomyces cerevisiae*) in the feed and PER

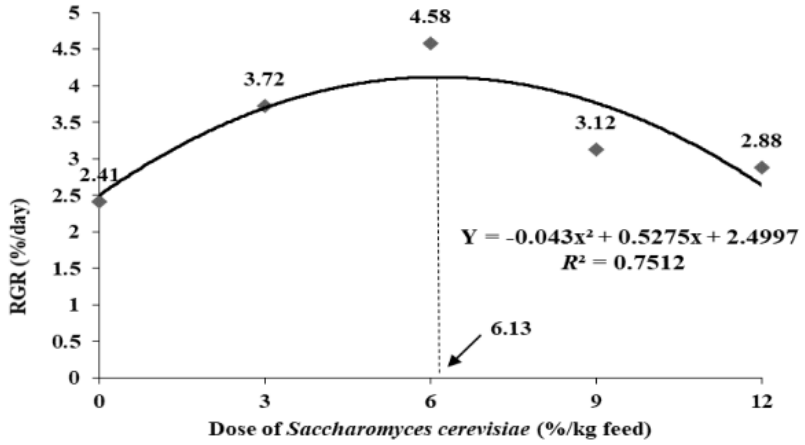

Figure 4. The relation of yeast (*Saccharomyces cerevisiae*) in the feed and RGR

Table 3
Water quality for Sangkuriang catfish cultivation during research

Treatment	Water Quality			
	Temperature (°C)	pH	DO (mg/l)	NH_3 (%)
A	26 - 30	7.26 - 7.48	5.01 – 5.78	0.002 - 0.002
B	26 - 30	7.31 - 7.52	5.23 – 5.64	0.002 - 0.002
C	26 - 30	7.29 - 7.53	5.12 – 5.69	0.002 - 0.002
D	26 - 30	7.32 - 7.47	5.17 – 5.76	0.002 - 0.002
Feasibility	14-38*	6.50 - 8.5*	>2*	<0.1*

Note. DO = Dissolved oxygen; NH_3 = Ammonia;* Data from the reference (Boyd, 2003)

DISCUSSION

Sangkuriang catfish fingerlings that were fed with the yeast *S. cerevisiae* enhanced feed (treatments B, C, D, and E) had a greater value of ADCp than that without the enrichment of yeast *S. cerevisiae* (A). It was indicated that the enrichment feed with *S. cerevisiae* could produce the digestive enzyme in the fish digestive tract (Welker et al., 2012). The highest value of ADCp (85.12%) was found in the catfish fed with *S. cerevisiae* enhanced feed with the dosage of 6 %/kg (C) and followed by the values of 78.89%, 73.34%, 68.23%, and 64.14% for B (3%), D (9%), E (12%), and A (0%). The highest value of ADCp in the catfish fed as in treatment C (6%) suggested that the dosage of yeast (*S. cerevisiae*) at 6% was the right amount of yeast addition to boosting digestive enzyme activities increased protein digestion optimally. In comparison, the dosage other than 6% resulted in not maximum enzyme activities. The same result was obtained in the *Barbonymus gonionotus* (Rachmawati et al., 2019a).

The yeast (*S. cerevisiae*) enhanced feed at the various dosages exhibited significant impacts ($P<0.05$) on EFU of Sangkuriang catfish fingerlings. It was suggested that the yeast (*S. cerevisiae*) supplementation in the feed could improve feed absorption; therefore, it increased feed efficiency utilization as the findings of the research by de Azevedo et al. (2016). Sangkuriang catfish fingerlings fed without the enhancement of *S. cerevisiae* (treatment A) has the lowest value of EFU 63.26% compared to the catfish fed with the enhancement of *S. cerevisiae* (treatments B, C, D, and E) with the values of 75.03%, 83.29%,72.42%, and 66.25% respectively. It was suspected that the absence of *S. cerevisiae* in the feed caused no enzyme activity in the digestive tract of the fish. Otherwise, the availability of *S. cerevisiae* in the feed could break down nutrients to easily be absorbed, so it could boost feed efficiency, as reported by Welker et al. (2012). It was suspected that yeast also raises enzymes activity in the digestive tract, such as peptidase, protease, and amylase.

According to the study by Tewary and Patra (2011), the yeast (*S. cerevisiae*) in the feed increased enzymes activity, such as peptidase, protease, and amylase in the digestive tract. Hence, it improved the decomposition of complex nutrients into simpler nutrients; in turn, it made absorption easier yeast can increase enzymes activity, such as peptidase, protease, and amylase in the digestive tract. As a result, the enzymes could decompose nutrients into a more straightforward form; therefore, the fish would easily absorb the nutrients (Tewary & Patra, 2011). According to Hurriyani (2017), the enrichment of yeast (*S. cerevisiae*) could improve feed digestion. *Saccharomyces cerevisiae* was known to produce vitamin B complex, especially biotin and vitamin B12 required by the fish digestion system. In addition, the content of peptides in the yeast plays an essential role in enzymatic digestion so that the fish can digest more efficiently. Similar results were reported by Rachmawati et al. (2019a) in the *Barbonymus gonionotus* and Abdel-Tawwab et al. (2010) in the *Sarotherodon galilaeus*.

The value of PER in the Sangkuriang catfish fingerlings fed with the yeast (*S. cerevisiae*), as in the treatments (B, C, D, and E), was higher than that without the yeast, as in treatment A. According to Tovar et al. (2002), the existence in the feed could boost protein digestion that supported an increased protein efficiency ratio. This finding was shown in Table 1 that explained the fish fed with the yeast (*S. cerevisiae*) enhanced feed has a higher value of ADCp compared to the fish fed without additional yeast in the feed. The fish fed with the additional *S. cerevisiae* dosage of 6% (C) generated the fish to efficiently consume the highest PER, which meant feed with additional yeast. In turn, it could hike protein retention to boost the protein efficiency ratio; however, the higher the yeast dosage caused the protein efficiency ratio to decrease. The findings were in line with Hurriyani's (2017) research that discovered that the additional yeast in the feed increased feed digestion and protein digestibility, resulting in more significant growth and feed efficiency. The level of protein efficiency ratio was also related to the size of the fish and feeding. The same results were found in the *Barbonymus gonionotus* (Rachmawati et al., 2019a) and *Oreochromis niloticus* (Abdel-Tawwab et al., 2008).

The yeast (*S. cerevisiae*) enhanced feed influenced significantly ($P<0.05$) on RGR Sangkuriang catfish fingerlings. It was suggested that *S. cerevisiae* contains nucleotides, significantly affecting the relative growth rate. The findings were supported by Manoppo and Kolopita's (2016) findings. They discovered that the additional yeast could hike growth because *S. cerevisiae* contains nucleotide in wet purine and pyrimidine as much as 0,9%. The increasing growth by adding yeast in the feed happened because the nucleotide in the yeast could increase fish appetite to feed; therefore, the feed absorption would increase. The highest value of RGR was 4.58%/day, which was obtained at the dosage of 6% *S. cerevisiae*, as in treatment

C. The result indicated that the dosage was just the right amount to optimize fish growth. According to Mohammadi et al. (2016), yeast stuck on the surface of the intestine and triggered amylase secretion and hiked digestive enzymes activity; therefore, it increased nutrient digestion. The additional yeast also improved the feeding pattern, boosting growth, and feed efficiency.

The yeast (*S. cerevisiae*) enrichment in the feed insignificantly influenced ($P<0.05$) on SR of Sangkuriang catfish fingerlings. The survival rate of Sangkuriang catfish fingerlings in the research ranged from 83.33% to 100%. A reasonable survival rate indicated that the additional yeast (*S. cerevisiae*) in the feed at the dosages of 0, 3, 6, 9, and 12 % did not cause mortality of the fish. The survival rate of Sangkuriang catfish is the percentage of surviving fish at the end study compared to the number of fish at the start of rearing. Therefore, the survival rate can be used to gauge the tolerance level and ability of the fish to survive. In addition, the survival rate was affected by abiotic factors, such as the ability to adjust to the environment, treatment, stocking density, competitors, diseases, age, and predators (Tacon et al., 2002).

CONCLUSION

Supplementing yeast (*Saccharomyces cerevisiae*) in the commercial feed could increase feed efficiency and growth in Sangkuriang catfish fingerlings. However, it did not affect the survival rate of Sangkuriang catfish fingerlings. The optimum dosages of the yeast (*S. cerevisiae*) in the commercial feed for ADCp, EFU, PER, and RGR ranged from 6.10% to 6.51%/kg feed.

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