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Effects of *Saccharomyces cerevisiae* Supplementation on Growth Performance and Nutrient Utilization of African Catfish *Clarias gariepinus* (Burchell, 1822)

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Abstract This study evaluated the effects of *Saccharomyces cerevisiae* on the growth performance and nutrient utilization of *Clarias gariepinus* fingerlings. Five isoproteinous diets were formulated with *Saccharomyces cerevisiae* at inclusion levels of 0.0%, 0.5%, 1.0%, 1.5%, and 2.0%, representing one control and four treatment diets. Completely randomized design was employed. One hundred and fifty (150) *Clarias gariepinus* fingerlings were used for the experiment. Ten fish were randomly assigned to 1 m^2 Hapa net. A total of 15 Hapa nets were used in polythene-lined pond of 10 m × 7 m (l×b) and depth of 1.5 m, the five formulated diets were fed to the experimental fish at 5% body weight for a period of 8 weeks. Highest mean weight gain of 68.65±8.49 g was obtained in fish fed 0.5% followed by 54.37±8.49 g obtained in the fish fed 1.5%. The least mean weight gain of 37.66±8.49 g was recorded in fish fed 2.0%. The highest FCR value of 1.51 was recorded in fish fed the 1.5% diet, while the lowest and best FCR value of 0.52 was recorded in fish fed the 0.5% *S. cerevisiae* diet, no significant difference (P >0.05) was observed in the feed conversion ratio of the fish fed 0% and 1% inclusion level of *S. cerevisiae.* This study revealed that the fish fed 0.5% *Saccharomyces cerevisiae* had the best growth performance and nutrient utilization, unveiling the positive effect of *Saccharomyces cerevisiae* on the culture of *Clarias gariepinus*. Therefore, dietary supplementation with 0.5% *S. cerevisiae* may be considered a natural feed additive for improving growth performance and nutrient utilization in *C. gariepinus*. This study is expected to provide baseline information for the practical use of yeast-based probiotics in African catfish culture.

Keywords *Saccharomyces cerevisiae*; African catfish; Yeast; Natural growth promoter; *Clarias gariepinus*

1 Introduction

African catfish, *Clarias gariepinus* is of great economic importance to aquaculture in Nigeria because of its high market price, fast growth rate, ability to withstand adverse conditions especially low dissolved oxygen content, ability to practice aquatic and aerial respiration and resistance to parasites and diseases. African catfish production accounts for 85% total aquaculture production in Nigeria (Bolorunduro, 2016).

Dietary requirements are among the most important factors influencing the success of fish farming. Over the past three decades, fish nutrition research has expanded to include functional ingredients, feed additives, and probiotics that may improve growth, feed utilization, and fish health. In recent years, the role of probiotics in nutrition and health of certain aquaculture species have been investigated (Ringo et al., 2010). To improve aquaculture, the use of several types of feed additives known as growth promoters are increasingly used by fish farmers to improve growth performance and feed efficiency. These growth promoters enhance fish growth by increasing digestibility, immune stimulation, nutrient assimilation, and supplying essential micro-nutrients in the diet or combining these functions (Anwar, 2018).

Saccharomyces cerevisiae (Louis Pasteur (1857 or 1858 contextually, but name is Louis)) is a naturally occurring yeast (probiotics), is used in aquaculture as a dietary supplement. It contains functional components such as β-glucans and oligosaccharides, which may enhance immune responses and support fish growth. This fermented product includes various beneficial components but rarely contains living cells (El-Nobi, 2021). Probiotics are sometimes expected to have direct growth promoting effects on fish, either by directly involving nutrient uptake or by providing nutrients or vitamins. Using yeast as a probiotic was studied by Andlid et al. (1995), The supplementation of yeast (*Saccharomyces cerevisiae*) has significantly improved aquatic animals' health, physiological status, and productivity (Gonçalves and Gallardo-Escárate, 2017; Zaineldin et al., 2021). Yeast cell walls are known for their protective role against mycotoxin contamination by reducing aflatoxin B1 absorption in the GIT of fish (Pinheiro et al., 2020). Chemical product such as mycotoxins and Nitrates used as an additive cause undesirable effects on fish which also affect the consumer. Despite growing interest in the use of *S. cerevisiae* as a probiotic in aquaculture, limited information is available on its dietary effects in African catfish. Therefore, this study evaluated the effects of graded dietary supplementation with *S. cerevisiae* on growth performance nutrient utilization of *Clarias gariepinus* fingerlings.

2 Results

2.1 Proximate composition of the experimental diets

Table 1 shows the Proximate Composition of the four diets formulated and prepared for the feeding trial. The protein content of the diet ranged between 39.20 and Moisture content 9.79 to 12.00, ether extra on fat 10.00 to 19.50, crude fibre 1.00 to 7.50, Ash 1.00 to 1.50, Nitrogen free extract 23.66 to 32.79.

Table 1 Proximate composition of the experimental diets

	Inclusion level of *Saccharomyces cerevisiae*				
Parameters (%)	0%	0.5%	1.0%	1.5%	2.0%
MC	11.92	9.79	10.21	10.77	12.00
CP	39.20	43.66	40.00	44.07	41.10
EEF	10.00	19.00	14.00	19.50	16.50
CF	7.50	1.00	1.50	1.00	1.00
ASH	1.50	1.00	1.50	1.00	1.00
NFE	29.88	25.55	32.79	23.66	28.4

Means with the same superscript (s) across the same row are not significantly different ($p > 0.05$)

Table notes: MC = moisture content, CP = crude protein, EEF= ether extract on fat, CF= crude fibre, NFE= Nitrogen Free Extract

2.2 Growth performance and nutrient utilization of *Clarias gariepinus* feed diet containing *Saccharomyces cerevisiae*

The growth performance and nutrient utilization of *Clarias gariepinus* fed diets containing *Saccharomyces cerevisiae* are indicated in Table 2. The results show that the highest initial weight recorded was 3.13 g in the 1.5% inclusion level of *Saccharomyces cerevisiae*, followed by 3.06 g and 2.96 g in the 2.0% and 0% inclusion levels of *Saccharomyces cerevisiae*, respectively. The lowest weights were recorded in the 0.5% and 1.0% inclusion levels, with values of 2.93 g. No significant difference ($P > 0.05$) was observed among the treatments. The highest initial length recorded was 7.70 cm in the 2.0% inclusion level of *Saccharomyces cerevisiae*, followed by 7.60 cm and 7.40 cm in the 1.0 % and 0.5% inclusion levels of *Saccharomyces cerevisiae*, respectively. The lowest lengths were recorded in the 1.5% and 0% inclusion levels, with values of 7.33 cm and 7.11 cm, respectively. No significant difference ($P > 0.05$) was observed among the 0.5%, 1.0%, and 1.5% inclusion levels of *Saccharomyces cerevisiae*, whereas a significant difference was observed between the 0% and 2.0% inclusion levels of *Saccharomyces cerevisiae*. The highest final weight recorded was 71.59% in the 0.5% inclusion level of *Saccharomyces cerevisiae*, followed by 57.51% and 50.23 g in the 1.5% and 1.0% inclusion levels of *Saccharomyces cerevisiae*, respectively. The lowest weights were recorded in the 0% and 2.0% inclusion levels, with values of 48.34% and 40.73 g, respectively. No significant difference ($P > 0.05$) was observed among the 0%, 1.0%, and 1.5% inclusion levels of *Saccharomyces cerevisiae*. However, a significant difference was observed in the 0.5% inclusion level of *Saccharomyces cerevisiae*, which differed significantly from the other treatments.

Table 2 Growth performance and nutrient utilization of *Clarias gariepinus* feed diet containing *Saccharomyces cerevisiae*

Treatment	Inclusion level of *Saccharomyces cerevisiae* (%)				
Parameters	0%	0.5%	1%	1.5%	2.0%
IW (g)	2.96±0.07^{a}	2.93±0.07^{a}	2.93±0.07^{a}	3.13±0.07^{a}	3.06±0.07^{a}
IL (cm)	7.11±0.15^{a}	7.40±0.15^{a}	7.60±0.15^{a}	7.33±0.15^{a}	7.70±0.15^{a}
FW (g)	48.34±8.47^{ab}	71.59±8.47^{a}	50.23±8.47^{ab}	57.51±8.47^{ab}	40.73±8.47^{b}
FL (cm)	19.00±0.96^{a}	19.66±0.96^{a}	19.33±0.96^{a}	20.00±0.96^{a}	19.33±0.96^{a}
MWG(g)	45.37±8.49^{ab}	68.65±8.49^{a}	47.30±8.49^{ab}	54.37±8.49^{ab}	37.66±8.49^{b}
PWG(%)	93.81±0.84^{ab}	95.67±0.84^{a}	94.13±0.84^{ab}	93.90±0.84^{ab}	92.23±0.84^{b}
SGR(%)	2.06±0.15^{ab}	2.45±0.15^{a}	2.12±0.15^{ab}	2.06±0.15^{ab}	1.82±0.15^{b}
CF	0.71±0.08^{ab}	0.94±0.08^{a}	0.69±0.08^{ab}	0.68±0.08^{ab}	0.58±0.08^{b}
SR(%)	100±11.83^{a}	100±11.83^{a}	96±11.83^{a}	94±11.83^{a}	96±11.83^{a}
PER	1.13±0.21^{ab}	1.71±0.21^{a}	1.18±0.21^{ab}	1.35±0.21^{ab}	0.94±0.21^{b}
FCR	0.70±0.25^{b}	0.52±0.25^{bc}	0.73±0.25^{b}	1.51±0.25^{a}	1.14±0.25^{ab}

Means within the same row with different superscript letters are significantly different (P>*0.05*)

Table notes: SC=*Saccharomyces cerevisiae*, IW= initial weight, IL= initial length, FW= final weight, FL= final length, MWG=Mean weight gain, SGR=Specific growth rate, SR=Survival rate, PWG=Percentage weight gain, PER=Protein efficiency ratio, FCR =Feed conversion ratio, CF=Condition factor

2.3 Carcass composition of *Clarias gariepinus* fed experimental diet

The carcass composition of *Clarias gariepinus* fed the experimental diet is indicated in Table 3. The highest crude protein content recorded was 44.07% in the 1.5% inclusion level of *S. cerevisiae*, followed by 43.66% and 41.10% in the 0.5% and 2.0% inclusion levels of *Saccharomyces cerevisiae*, respectively. The lowest crude protein contents were recorded in the 1.0% and 0% inclusion levels, with values of 40.00% and 37.20%, respectively. There was no significant difference between the 0.5% and 1.5% inclusion levels, but the 0%, 1.0%, and 2.0% inclusion levels showed significant differences with one another. The highest ether extract (fat) content recorded was 19.50% in the 1.5% inclusion level of *S. cerevisiae*, followed by 19.00% and 16.50% in the 0.5% and 2.0% inclusion levels of *S. cerevisiae*, respectively. The lowest ether extract (fat) contents were recorded in the 1.0% and 0% inclusion levels, with values of 14.00% and 10.00%, respectively. There was no significant difference between the 0.5% and 1.5% inclusion levels, but the 0%, 1.0%, and 2.0% inclusion levels showed significant differences with one another.

Table 3 Carcass composition of *Clarias gariepinus* fed experimental diet

Treatment	Inclusion level of *Saccharomyces cerevisiae*					
Parameters	0%	0.5%	1.0%	1.5%	2.0%	SEM
MC	37.92^{b}	25.33^{c}	31.41^{d}	33.32^{c}	44.50^{a}	0.02*
CP	37.20^{d}	43.66^{a}	40.00^{c}	44.07^{a}	41.10^{b}	0.26*
EEF	10.00^{d}	19.00^{a}	14.00^{c}	19.50^{a}	16.50^{b}	0.46*
ASH	5.50^{a}	1.00^{a}	1.50^{a}	1.00^{a}	1.00^{a}	0.48*
NFE	9.38^{c}	11.01^{a}	13.09^{b}	2.11^{d}	10.5^{e}	0.02*

Means with the same superscript (s) across the same row are not significantly different (*p >0.05*)

± = Standard Error Mean

Table notes: MC = moisture content, CP = crude protein, EEF= ether extract on fat, CF= crude fibre, NFE= Nitrogen Free Extract

2.4 Water quality parameters of culture medium

The summary of the mean values of the water quality parameters of the culture medium are presented in Table 4. There was no significant difference (P>0.05) in the physico-chemical parameters observed in this study. The temperature ranged from 29.55℃~32.38℃, the pH ranged from 5.70 to 6.16, while the dissolved oxygen ranged from 4.99 to 5.85 mg/L.

Table 4 Shows the water quality parameters of culture medium

	T°C	pH	DO (mg/L)
SC1	32.38[a]	6.10[a]	5.30[a]
SC2	31.28[a]	5.90[a]	5.61[a]
SC3	31.74[a]	5.78[a]	5.45[a]
SC4	29.71[a]	5.70[a]	5.85[a]
SC5	29.55[a]	6.16[a]	4.99[a]
Pr>F(Model)	0.51	0.86	0.35

Mean with the same superscript across the same row we're not significantly different (P>0.05)

Table notes: SC= *Saccharomyces cerevisiae,* T= Temperature, DO= Dissolved oxygen

3 Discussion

The growth performance of *Clarias gariepinus* fed diets containing *Saccharomyces cerevisiae* was evaluated in this study. The results showed that dietary inclusion of *S. cerevisiae* significantly improved growth performance, nutrient utilization, and carcass composition of *C. gariepinus,* particularly at the 0.5% supplementation level. The mean weight gain (MWG) recorded in this study ranged from 37.66 g to 68.65 g, with the highest value obtained in the 0.5% inclusion level of *S. cerevisiae*. This result is similar to the findings of Kela et al. (2022), who recorded a MWG of 71.60 g/fish in *C. gariepinus* fed diets containing 100% black cumin (*Nigella sativa*). However, the MWG recorded in this study is lower than the value reported by Abdullahi et al. (2024), who recorded a MWG of 120.33 g in *C. gariepinus* fed diets containing 2.5% *Nigella sativa* meal as a growth promoter. The percentage weight gain (PWG) recorded in this study ranged from 92.23% to 95.67%, with the highest value obtained in the 0.5% inclusion level of *S. cerevisiae*. This result is similar to the findings of Abdullahi et al. (2024), who recorded a PWG of 94.12% in *C. gariepinus* fed diets containing 2.5% *N. sativa* meal. The specific growth rate (SGR) recorded in this study ranged from 1.82 to 2.45, with the highest value obtained in the 0.5% inclusion level of *Saccharomyces cerevisiae*. This result is similar to the findings of Kela et al. (2022), who recorded an SGR of 1.33%/day in *C. gariepinus* fed diets containing 100% black cumin. The lowest FCR value of 0.52 in fish fed the 0.5% *S. cerevisiae* diet indicates better feed utilization, whereas the higher FCR value of 1.51 in the 1.5% group suggests lower feed efficiency.

The carcass composition of *C. gariepinus* fed diets containing *Saccharomyces cerevisiae* was evaluated in this study. The results showed that the inclusion of *Saccharomyces cerevisiae* in the diet had a significant effect on the dry matter, moisture, crude protein, ether extract, and crude fibre contents of the carcass. The highest crude protein content recorded was 44.07% in the 1.5% inclusion level of *Saccharomyces cerevisiae*, which is lower than the value reported by Abdullahi et al. (2024), who recorded crude protein contents of 61.33%, in *Clarias gariepinus* fed diets containing black seed. The ether extract content recorded in this study ranged from 10.00% to 19.50%, which is similar to the range reported by Abdullahi et al., (2024) who recorded ether extract contents ranging from 10.66% to 16.56%. The moisture content recorded in this study ranged from 25.33% to 44.50%, which is higher than the range reported by Abdullahi et al., (2024) and who recorded moisture contents ranging from 6.45% to 8.06%. The ash content recorded in this study ranged from 1.00% to 1.50%, which is similar to the range reported by Abdullahi et al., (2024), who recorded ash contents ranging from 3.38% to 7.04%.

Saccharomyces cerevisiae in the diet of *Clarias gariepinus* significantly improved growth performance and nutrient utilization. The optimal inclusion level of *Saccharomyces cerevisiae* was 0.5%, which resulted in the highest mean weight gain, percentage weight gain, specific growth rate, condition factor, protein efficiency ratio, and lowest feed conversion ratio. This study revealed that the fish fed 0.5% *Saccharomyces cerevisiae* had the best growth performance, unveiling the positive effect of *S. cerevisiae* on the growth of *Clarias gariepinus*. The improved growth and feed utilization observed with 0.5% *S. cerevisiae* supplementation could be attributed to enhanced nutrient absorption, beneficial yeast components such as β-glucans and mannan oligosaccharides, and better feed efficiency. Therefore, under the conditions of this study, 0.5% dietary *S. cerevisiae* may be considered a promising natural feed additives for improving growth performance and nutrient utilization in African catfish.

4 Materials and Methods

4.1 Experimental site

The study was conducted at fish nutrition unit of the Department of Fisheries, Faculty of Agriculture, University of Maiduguri, Nigeria. The University is located along Bama Road, Maiduguri, Borno state with the mean monthly temperature is highest (40.2 ℃) prior the onset of the rain in June and the lowest (31.3 ℃) during the peak of the rainy period of August. The area has an average mean annual rainfall of about 550 mm (Shettima et al., 2018).

4.2 Experimental fish

One hundred and fifty *Clarias gariepinus* fingerlings were procured from Aquarium Planet Agric Business Services, a private fish farm in Maiduguri, Borno State.

4.3 Source of experimental feed ingredients

Feed ingredients was purchased at Custom Market, Maiduguri Borno State which include: soybeans, fishmeal, maize, oil and *Saccharomyces cerevisiae.* Other ingredients including premix, lysine, methionine, calcium, vitamin C, salt and binder were procured at Gidan madara. The soybean was toasted and ground into powdered form separately.

4.4 Feed formulation and compounding

Pearson's square method was employed to formulate the experimental diets at 38.89cp the experimental feed ingredients were grounded separately into a powdered form and measured based on the inclusion level (Table 5), then mixed thoroughly to obtain a homogeneous product and water was added to form dough. *S. cerevisiae* was supplemented at different concentrations (0, 0.5, 1.0, 1.5 and 2.0%). The dough was then pelleted using pelleting machine. The pelleted diets were sun dried and packaged in polythene bag in well-ventilated room under ambient temperature.

Table 5 Gross composition of ingredients with *Saccharomyces cerevisiae*

	Inclusion level				
Ingredient	SC 0.0%	SC 0.5%	SC 1.0%	SC 1.5%,	SC 2.0%
Fish Meal	24.37	24.37	24.37	24.37	24.37
Soybean Meal	48.75	48.75	48.75	48.75	48.75
Maize	16.88	16.88	16.88	16.88	16.88
Lysine	2	2	2	2	2
Methionine	1.7	1.7	1.7	1.7	1.7
Vitamin premix	1	1	1	1	1
Vitamin c	0.3	0.3	0.3	0.3	0.3
Bone meal	1	1	1	1	1
Salt	0.5	0.5	0.5	0.5	0.5
Palm oil	3.5	3.5	3.5	3.5	3.5
Yeast	0	0.5	1.0	1.5	2.0

4.5 Experimental design

Complete Randomized design (CRD) was employed. One hundred and fifty *C. gariepinus* fingerings were used for the treatment. Ten fish were randomly assigned to each 1 m^2 hapa net. A total of 15 hapa net were used in polythene lined pond of 10 m × 7 m (l × b) and depth of 1.5 m, and the five formulated diets were fed at 5% body weight to the experimental fish for 8 weekss and the pond water was monitored daily.

4.6 Determination of nutrient contents

The proximate composition of the diets and carcass composition of the fish was determined using the methods of the AOAC (2019).

4.7 Determination of growth performance and feed utilization

The data was obtained on the growth performance and nutrient utilization of *Clarias gariepinus* fed on the formulated diets was determined as following the methods of Abdullahi et al. (2023).

Mean Body Weight Gain

This is the difference between the final weight and the initial weight of the fish that is been cultured. The difference between the final weight and the initial weight was determined as:

$MWG = W_2 - W_1$

Where, W_1 = Initial weight, W_2 = Final weight

Specific Growth Rate (SGR)

It is an index showing the best growth in a set of growth. This was determined to observe the best growth in a set of growth.

$SGR\ (\%/day) = [(\ln W2 - \ln W1) / (T2 - T1)] \times 100$

Where, In = Natural logarithm; W1 = Initial weight; W2 = Final weight; T1 = Initial time; T2 = Final time

Feed Conversion Ratio (FCR)

It is a numerical value used to measure the gross utilization of feed for growth in fish and other animal. It is assuming that weight gain in fish and other animals is due to increase in body weight. A lower FCR therefore implies efficient food utilization by the animal. This was measured as gross utilization of food for growth in fish as described by Olukunle (2006).

FCR = Feed intake / Weight gain

Condition factor (CF)

$CF = (W / L^3) \times 100$

Where, W = Body weight (g) and L = Total length (cm)

4.8 Data analysis

Data obtained were subjected to one-way analysis of variance (ANOVA) using XLSTAT version 2022. Duncan's multiple range tests was used to separate treatment means, and differences were considered significant at $P < 0.05$. The difference between mean was compared at 95% confidence level.

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