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# Using the Dried Yeast (*Saccharomyces cerevisiae*) as a Growth Promoter in the Nile Tilapia (*Oreochromis niloticus*) Diets

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## ABSTRACT

This study aimed to assess the impact of incorporating dried yeast (*Saccharomyces cerevisiae*) on growth performance, feed utilization, body composition, blood parameters, and economical evaluation. 120 fish post-acclimatization were randomly assigned to 12 experimental aquariums. In this setup, three aquariams acted as replicates for each treatment, with an average initial weight of 28.55±0.82g. *Saccharomyces cerevisiae* (Sc) levels of 0, 0.4, 0.8, and 1.2% (equivalent to 0, 4, 8, and 12g for diets $D_1$, $D_2$, $D_3$, and $D_4$, respectively) were used. The feeding trial lasted 56 days. The results revealed that diets varied in crude protein (CP) from 30.15 to 30.80% and gross energy from 4543 to 4559kcal/ kg DM. Mortality rates were 6.67% in the control and zero in the other groups. Protein efficiency ratio (PER) increased with 12g Sc/kg$^{-1}$ diets. Serum proteins rose at this level, while ALT, AST, and uric acid peaked at 4g Sc/kg. Body composition changed, where moisture, crude protein, and ash increased, whereas ether extract and growth energy decreased. Energy retention (ER)% decreased, while protein productive value (PPV)% was enhanced. Net improvements of 6.80, 9.47, and 19.03% were evident in $D_2$, $D_3$, and $D_4$, respectively, compared to controls. In conclusion, *Saccharomyces cerevisiae* acts as a growth promoter, especially at 12g/kg$^{-1}$ feed. These findings illuminate the potential benefits of incorporating Sc in fish diets for enhanced performance and economic gains.

## INTRODUCTION

The dry yeast *Saccharomyces cerevisiae* is one of the most common probiotics incorporated into aqua feeds, where the probiotics may improve feed utilization and enhance fish production (**Ramos *et al*., 2017; Chowdhury & Roy, 2020)**. Studies by **Smith *et al*. (2003)** and **Sørum (2006)** have noted the increased usage of traditional antibiotics in aquaculture feeding regimes over the last few decades. However, **Han *et al.***

**(2015)** observed that probiotics can lead to an improvement in gut health. Additionally, **Safari *et al*. (2016)** mentioned improved immune responses. **Dawood and Koshio (2016)** and **Dawood *et al*. (2016, 2020a)** have reported that probiotics also enhance feed utilization.

In their studies, **Abu-Elala *et al*. (2013)** and **Yang *et al*. (2020)** concluded that *Saccharomyces cerevisiae* is a promising probiotic in aqua-farming. Furthermore, **Alderman and Hastings (1998)** and **Teuber (2001)** have mentioned that the increased use of antibiotics has led to the prevention and control of bacterial diseases, but has also increased the prevalence of antibiotic-resistant bacteria.

On the other hand, **Kesarcodi-Watson *et al*. (2008)** have documented that the use of probiotics improves performance and feed utilization. Moreover, **Pooramini *et al*. (2009)** noted that *Saccharomyces* enhances performance. Therefore, this study aimed to investigate the effects of *Saccharomyces cerevisiae* at levels of 0, 4, 8, and 12g/kg$^{-1}$ diet on the productive and economical evaluation of the Nile tilapia fish.

## MATERIALS AND METHODS

This study was conducted at the Fish Laboratory of Animal Production Department of Biological and Agriculture Research Institute in collaboration with the Hydrobiology Department of the Veterinary Research Institute, National Research Centre.

### 1. Experimental unit

A total of 120 fish with an initial body weight of 28.55±0.82g were used. After acclimatization, the fish were randomly assigned to experimental aquariums. There were 12 aquariums in total, with 10 fish per aquarium, and among these, 3 aquariums served as replicates for each treatment. The fish were placed in aquariums measuring 80×40×30cm, with a capacity of 60 liters each.

### 2. Experimental diets

*Saccharomyces cerevisiae* (Sc) was incorporated in the diets at four levels: 0, 0.4, 0.8, and 1.2%, which corresponded to 0, 4, 8, and 12g of Sc for diets $D_1$, $D_2$, $D_3$, and $D_4$, respectively, as shown in Table (1). The experimental diets were administered continuously for 56 days. The fish were hand-fed the tested diets for 56 days from approximately mid-October to mid-December 2023.

### 3. Growth parameters

Body weight gain (BWG) = Final weight - Initial weight.

Survival rate (SR%) = Number of fish at final/ Number of fish at start x100.

Specific growth rate (SGR) = [In final weight (g) - In initial weight (g)]/ Experimental days *100

**Table 1.** Composition of the different experimental diets

| Ingredient | Experimental diet | | | | Price of ton LE |
|---|---|---|---|---|---|
| | Control zero Sc* | 4 g Sc*/kg $^{-1}$ diet | 8 g Sc*/kg $^{-1}$ diet | 12 g Sc*/ kg $^{-1}$ diet | |
| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | |
| ***Composition of tested diet*** | | | | | |
| Dried yeast | 0.00 | 0.40 | 0.80 | 1.20 | 150000 |
| Concentration (56% CP) | 17.00 | 17.00 | 17.00 | 17.00 | 25000 |
| Soybean meal (44% CP) | 40.00 | 40.00 | 40.00 | 40.00 | 33000 |
| Ground yellow corn (8% CP) | 28.00 | 28.00 | 28.00 | 28.00 | 12500 |
| Wheat bran (13% CP) | 10.00 | 9.60 | 9.20 | 8.80 | 9800 |
| Vegetable oil | 3.00 | 3.00 | 3.00 | 3.00 | 50000 |
| Vitamins and minerals mixture** | 2.00 | 2.00 | 2.00 | 2.00 | 180000 |
| Price of ten fed (LE) | 24692 | 25253 | 25814 | 26.375 | --- |

Sc*: Dried yeast (*Saccharomyces cerevisiae*)
** Vit. A (E672) (IU) 876.19, Vit. D3 (IU) 1141.39, Vit. E 114.30, Vit. K3 7.55, Vit. B1 13.71, Vit. B2 11.44, Vit. B6 15.33, Vit. B12 0.03, Niacin 60.96, Calpan 30.48, Folic Acid 3.04, Biotin 0.37, Vit. C 11.44, Selenium 0.27, Manganese 19.04, Iron 9.15, Iodine 0.77, Zinc 76.19, Copper 3.04, Cobalt 0.37, Choline Chloride 457.14.

### *3.1 Calculation of feed conversion ratio (FCR)*

FCR = total dry matter intake, (TDMI) g/ total body weight gain (TBWG), g.

### *3.2 Calculation of protein efficiency ratio (PER)*

(PER) = total body weight gain (TBWG) g/ total crude protein intake (TCPI), g.

### *3.3 Feed efficiency*

Feed efficiency (FE %) = [weight gain (g)/ feed intake (g)]

Protein productive value (PPV %) = $[PR_1 – PR_0 / PI]$ 100.

Where: $PR_1$ = is the total fish body protein at the end of the experiment.

$PR_0$ = is the total fish body protein at the start of the experiment.

PI = Protein intake.

### *3.4 Energy retention percentages (ER %)*

The energy retention percentage was calculated according to the following equation:

Energy retention (ER %) = $E-E_0/E_F$ X 100

Where: E= the energy in fish carcass (kcal) at the end of the experiment.

$E_0$= the energy in fish carcass (kcal) at the start of the experiment.

$E_F$ = the energy (kcal) in feed intake.

## 4. Blood measurements

Six fish from each group were chosen randomly, then the blood was isolated using a 3ml syringe after anesthetizing the fish with clove oil (0.5ml $L^{-1}$). The samples were then centrifuged at 3000rpm for 15 minutes, and the isolated serum was stored at -20°C.

### 5. Body composition

The evaluation of fish body composition was carried out both before and after the feeding experiment. Initially, 8 fish were used at the start of the trial, followed by the inclusion of 6 fish from each treatment group later on. This assessment was conducted to determine values pertaining to both energy and protein retention.

#### 5.1. Analytical procedures

The diets were analyzed, and the fish body composition was assessed using the methods of **AOAC (2016)**. Total protein and albumin levels were determined colorimetrically following the procedures outlined by **Cannon *et al*. (1974)** and **Tietz (1990)**. Globulin levels were calculated as the difference between total protein and albumin. Liver function parameters, including alanine aminotransferase and aspartate aminotransferase, were determined using the method outlined by **Reitman and Frankel (1957)**. Kidney function parameters, such as uric acid and creatinine, were assessed colorimetrically using standard commercial kits (Bio-diagnostics, Giza, Egypt), following the procedure described by **Tietz (1990)**.

### 6. Calculated data

Gross energy of experimental diets and fish body composition were calculated according to the method of **Blaxter (1968)** and **MacRae and Lobley (2003)**. While, metabolizable energy and protein energy ratio were calculated according to the guidelines of **NRC (2011)**.

### 7. Statistical analysis

The collected data were subjected to statistical analysis using one-way analysis of variance (ANOVA) as per **SPSS (2020)**, with means separated using Duncan's multiple range test **(Duncan, 1955)**.

## RESULTS

### 1. Chemical analysis of the experimental diets

The crude protein percentages ranged from 30.15 to 30.80% among the four tested diets. Gross energy ranged from 4543 to 4559, and metabolizable energy (ME) ranged from 351.37 to 353.94. Additionally, the protein energy ratio varied from 85.18 to 87.66mg CP/Kcal ME among the four tested diets. These values are considered adequate to meet the requirements of the Nile tilapia fish (Table 2).

**Table 2.** Chemical analysis of the different experimental diets

| **Ingredient** | **Tested diet** | | | |
|---|---|---|---|---|
| | **Control zero Sc*** | **4 g Sc*/kg $^{-1}$ diet** | **8 g Sc*/kg $^{-1}$ diet** | **12 g Sc*/kg $^{-1}$ diet** |
| | **$D_1$** | **$D_2$** | **$D_3$** | **$D_4$** |
| Moisture | 8.15 | 9.74 | 9.13 | 9.48 |
| Dry matter | 91.85 | 90.26 | 90.87 | 90.52 |
| ***Chemical analysis on DM basis*** | | | | |
| OM | 93.66 | 93.23 | 93.44 | 93.14 |
| CP | 30.15 | 30.41 | 30.65 | 30.80 |
| CF | 6.55 | 6.60 | 6.24 | 6.85 |
| EE | 4.18 | 4.15 | 4.11 | 4.10 |
| NFE | 52.78 | 52.07 | 52.44 | 51.39 |
| Ash | 6.34 | 6.77 | 6.56 | 6.86 |
| Gross energy kcal/ kg DM | 4559 | 4543 | 4553 | 4543 |
| Metabolizable energy kcal/ kg DM | 353.94 | 352.39 | 354.37 | 351.37 |
| Protein energy ratio (mg CP/ Kcal ME) | 85.18 | 86.30 | 86.49 | 87.66 |

Sc*: Dried yeast (*Saccharomyces cerevisiae*) OM: Organic matter CP: Crude protein
CF: Crude fiber EE: Ether extract NFE: Nitrogen free extract.

## 2. Growth and survival ratio

As presented in Table (3), the results indicate that dietary treatments increased the FW, TBWG, ADG, SGR, and SR in the group of fish fed diets with 4, 8, and 12g of Sc/kg$^{-1}$ diet ($D_2$, $D_3$, and $D_4$, respectively) compared to the control group ($D_1$). Furthermore, the mortality rate was recorded at 6.67% in the control group ($D_1$) but was zero in the other three groups of fish ($D_2$, $D_3$, and $D_4$). Generally, with an increasing level of inclusion of *Saccharomyces cerevisiae* in the diet, the mentioned parameters' values tend to show significant improvements.

**Table 3.** Growth, specific growth rate and survival ratio of different experimental groups

| **Item** | **Tested diets** | | | | | |
|---|---|---|---|---|---|---|
| | **Control zero Sc*** | **4 g Sc*/kg $^{-1}$ diet** | **8 g Sc*/kg $^{-1}$ diet** | **12 g Sc*/kg $^{-1}$ diet** | **SEM** | **Sign. *P*<0.05** |
| | **$D_1$** | **$D_2$** | **$D_3$** | **$D_4$** | | |
| Number of fish | 30 | 30 | 30 | 30 | - | - |
| Initial weight, g (IW) | 287 | 283 | 288 | 284 | 0.82 | NS |
| Final weight, g (FW) | 548$^{c}$ | 558$^{c}$ | 580$^{b}$ | 614$^{a}$ | 7.90 | * |
| Total body weight gain, g (TBWG) | 261$^{d}$ | 275$^{c}$ | 292$^{b}$ | 330$^{a}$ | 7.94 | * |
| **Duration experimental period** | | | **56 days** | | | |
| Average daily gain, g (ADG) | 4.66$^{d}$ | 4.91$^{c}$ | 5.21$^{b}$ | 5.89$^{a}$ | 0.14 | * |
| Specific growth rate (SGR) | 0.51$^{d}$ | 0.53$^{c}$ | 0.55$^{b}$ | 0.60$^{a}$ | 0.01 | * |
| Number of fish at the starter | 30 | 30 | 30 | 30 | - | - |
| Number of fish at the end | 28 | 30 | 30 | 30 | - | - |
| Survival ratio (SR) | 93.33$^{b}$ | 100$^{a}$ | 100$^{a}$ | 100$^{a}$ | 1.12 | * |
| Number of dead fish | 2 | Zero | Zero | Zero | - | - |
| Mortality rate percentages | 6.67 | Zero | Zero | Zero | - | - |

a, b, c and d: Means in the same row having different superscripts differ significantly ($P< 0.05$).
SEM: Standard error of mean NS: Not significant *: Significant at ($P< 0.05$).
Sc*: Dried yeast (*Saccharomyces cerevisiae*).

## 3. Feed utilization of the different experimental groups

Results of feed utilization (Table 4) show that the values of FI, FCR, CPI, and PER increased when *Saccharomyces cerevisiae* was incorporated into the diets of the Nile tilapia fish. Values of FCR and PER increased with the addition of 4 to 12g per $kg^{-1}$ of *Saccharomyces cerevisiae* in the diet.

**Table 4.** Feed utilization of the different experimental groups

| **Item** | **Tested diet** | | | | | |
|---|---|---|---|---|---|---|
| | **Control zero Sc*** | **4 g Sc*/kg $^{1}$ diet** | **8 g Sc*/kg $^{-1}$ diet** | **12 g Sc*/kg $^{-1}$ diet** | **SEM** | **Sign. *P*<0.05** |
| | **$D_1$** | **$D_2$** | **$D_3$** | **$D_4$** | | |
| TBWG, g | $261^{d}$ | $275^{c}$ | $292^{b}$ | $330^{a}$ | 7.94 | * |
| Feed intake (FI), g | $864.51^{bc}$ | $851.06^{c}$ | $879.96^{b}$ | $898.76^{a}$ | 5.88 | * |
| Feed conversion ratio (FCR) | $3.31^{d}$ | $3.09^{c}$ | $3.01^{b}$ | $2.72^{a}$ | 0.06 | * |
| Crude protein % | 30.15 | 30.41 | 30.65 | 30.80 | - | - |
| Crude protein intake (CPI) g | $260.65^{c}$ | $258.81^{c}$ | $269.71^{b}$ | $276.82^{a}$ | 2.31 | * |
| Protein efficiency ratio (PER) | $1.00^{c}$ | $1.06^{b}$ | $1.08^{b}$ | $1.19^{a}$ | 0.02 | * |

a, b, c and d: Means in the same row having different superscripts differ significantly ($P$< 0.05).
FCR: Expressed as g of DM intake/g gain PER: Expressed as g of g gain/g CP intake.
Sc*: Dried yeast (*Saccharomyces cerevisiae*)
TBWG: Total body weight gain.

## 4. Biochemical parameters of the different experimental groups

Data from Table (5) indicate that the serum levels of total protein, albumin, and globulin increased in the group of fish that received a diet containing 12g Sc/$kg^{-1}$ ($D_4$) compared to the control group. Additionally, dietary treatments decreased the values of the albumin: globulin ratio compared to the control. Concerning the values of liver function, including ALT and AST, the highest values were recorded in the group of fish fed a diet containing 4g Sc/$kg^{-1}$ diet ($D_2$). Moreover, uric acid recorded the highest value in the group of fish that received the same diet ($D_2$). Furthermore, the group of fish that received the diet containing $D_4$ recorded the highest value of creatinine. Meanwhile, the lowest values of uric acid and creatinine were observed in the group of fish that received $D_3$, which contained 8g Sc/$kg^{-1}$ diet.

## 5. Fish body composition of different experimental groups

Feeding on diets containing *Saccharomyces cerevisiae* resulted in a significant ($P$< 0.05) increase in fish body composition, including moisture, crude protein, and ash% contents. Meanwhile, values of dry matter, organic matter, ether extract, and growth energy decreased (Table 6).

**Table 5.** Blood parameters of different experimental groups

| Parameter | Tested diet | | | | | |
|---|---|---|---|---|---|---|
| | Control zero Sc* | 4 g Sc*/kg $^{-1}$ diet | 8 g Sc*/kg $^{-1}$ diet | 12 g Sc*/kg $^{-1}$ diet | | Sign. |
| | D1 | D2 | D3 | D4 | SEM | P<0.05 |
| Total protein (g/dl) | $3.15^{b}$ | $3.26^{b}$ | $2.64^{c}$ | $4.17^{a}$ | 0.17 | * |
| Albumin (g/dl) | $1.12^{b}$ | $1.07^{b}$ | $0.73^{c}$ | $1.19^{a}$ | 0..05 | * |
| Globulin (g/dl) | $2.03^{c}$ | $2.19^{b}$ | $1.91^{d}$ | $2.98^{a}$ | 0.13 | * |
| Albumin: Globulin ratio | $0.55^{a}$ | $0.49^{b}$ | $0.38^{c}$ | $0.40^{c}$ | 0.02 | * |
| ***Liver function*** | | | | | | |
| AST (Unit/l) | $114.6^{b}$ | $127.60^{a}$ | $114.60^{b}$ | $110.10^{b}$ | 2.11 | * |
| ALT (Unit/l) | $85.35^{b}$ | $90.06^{a}$ | $88.71^{a}$ | $84.36^{b}$ | 0.74 | * |
| ***Kidneys function*** | | | | | | |
| Uric acid (mg/l) | $3.80^{c}$ | $6.37^{a}$ | $1.21^{d}$ | $5.47^{b}$ | 0.59 | * |
| Creatinine (mg/l) | $0.84^{b}$ | $0.89^{ab}$ | $0.10^{c}$ | $0.94^{a}$ | 0.10 | * |

a , b, c and d: Means in the same row having different superscripts differ significantly ($P$< 0.05).
AST: Aspartate aminotransferase. ALT: Alanine aminotransferase
Sc*: Dried yeast (*Saccharomyces cerevisiae*) .

**Table 6.** Fish body composition of different experimental groups

| Item | Initial body composition | Tested diet | | | | | |
|---|---|---|---|---|---|---|---|
| | | Control zero Sc* | 4 g Sc*/kg $^{-1}$ diet | 8 g Sc*/kg $^{-1}$ diet | 12 g Sc*/kg$^{-1}$ diet | | Sign. |
| | | D1 | D2 | D3 | D4 | SEM | P<0.05 |
| Moisture | 71.00 | $71.59^{c}$ | $71.65^{c}$ | $72.94^{b}$ | $73.80^{a}$ | 0.28 | * |
| Dry matter (DM) | 29.00 | $28.41^{a}$ | $28.35^{a}$ | $27.06^{b}$ | $26.20^{c}$ | 0.28 | * |
| ***Chemical analysis on DM basis*** | | | | | | | |
| Organic matter (OM) | 82.25 | $85.23^{a}$ | $84.03^{b}$ | $82.10^{c}$ | $81.16^{d}$ | 0.48 | * |
| Crude protein (CP) | 53.60 | $56.15^{d}$ | $59.78^{c}$ | $62.33^{b}$ | $64.66^{a}$ | 0.95 | * |
| Ether extract (EE) | 28.65 | $29.08^{a}$ | $24.25^{b}$ | $19.77^{c}$ | $16.50^{d}$ | 1.43 | * |
| Ash | 17.75 | $14.77^{d}$ | $15.97^{c}$ | $17.90^{b}$ | $18.84^{a}$ | 0.48 | * |
| Gross energy kcal/100g | 572.15 | $590.60^{a}$ | $565.71^{b}$ | $538.00^{c}$ | $520.43^{d}$ | 8.07 | * |
| Gross energy cal/g DM | 5.7215 | $5.9060^{a}$ | $5.6571^{b}$ | $5.3800^{c}$ | $5.2043^{d}$ | 0.08 | * |

a, b, c and d: Means in the same row having different superscripts differ significantly ($P$<0.05).
Sc*: Dried yeast (*Saccharomyces cerevisiae*).

## 6. Energy retention and protein productive value percentages

Data from Table (7) demonstrate that the incorporation of *Saccharomyces cerevisiae* in the Nile tilapia fish resulted in a significant ($P$< 0.05) decrease in their energy retention (ER)% values, while protein productive value (PPV)% was significantly ($P$< 0.05) increased. It can also be mentioned that protein ER% decreased by 1.66, 9.17, and 4.94% for fish that received $D_2$, $D_3$, and D4, respectively, compared to the control ($D_1$). Meanwhile, values of PPV% were improved by 119.03, 130.53, and 149.81% for fish that were fed $D_2$, $D_3$, and $D_4$, respectively, compared to the control.

**Table 7.** Energy retention (ER) and protein productive value (PPV) percentages

| Item | Tested diet | | | | SEM | Sign. |
|---|---|---|---|---|---|---|
| | Control zero Sc* | 4 g Sc*/kg $^{-1}$ diet | 8 g Sc*/kg $^{-1}$ diet | 12 g Sc*/kg $^{-1}$ diet | | |
| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $P$<0.05 |
| Initial weight (IW) g | 287 | 283 | 288 | 284 | 0.82 | NS |
| Final weight (FW) g | 548$^c$ | 558$^c$ | 580$^b$ | 614$^a$ | 7.90 | * |
| Energy content in final body fish (cal/g ) | 5.9060$^a$ | 5.6571$^b$ | 5.3800$^c$ | 5.2043$^d$ | 0.08 | * |
| Total energy at the end in body fish (E) | 3236$^a$ | 3157$^c$ | 3120$^d$ | 3195$^a$ | 13.07 | * |
| **Energy content in initial body fish (cal/g)** | 5.7215 | | | | | |
| Total energy at the start in body fish ($E_0$) | 1642$^a$ | 1619$^b$ | 1648$^a$ | 1625$^b$ | 3.85 | * |
| Energy retained in body fish ($E-E_0$ ) | 1594$^a$ | 1538$^c$ | 1472$^d$ | 1570$^b$ | 13.89 | * |
| Energy of the feed intake (Cal/g feed) | 4.559 | 4.543 | 4.553 | 4.543 | - | - |
| Quantity of feed intake | 864.51$^{bc}$ | 851.06$^c$ | 879.96$^b$ | 898.76$^a$ | 5.88 | * |
| Total energy of feed intake (EF) | 3941$^c$ | 3866$^d$ | 4006$^b$ | 4083$^a$ | 24.18 | * |
| Energy retention (ER)% | 40.45$^a$ | 39.78$^b$ | 36.74$^d$ | 38.45$^c$ | 0.43 | * |
| Crude protein% in final body fish | 56.15$^d$ | 59.78$^c$ | 62.33$^b$ | 64.66$^a$ | 0.95 | * |
| Total protein at the end in body fish ($PR_1$) | 308$^d$ | 334$^c$ | 362$^b$ | 397$^a$ | 10.08 | * |
| **Crude protein % in initial body fish** | 53.60 | | | | | |
| Total protein at the start in body fish ($PR_2$) | 154 | 152 | 154 | 152 | 1.29 | NS |
| Protein Energy retained in body fish ($PR_3$) = ($PR_1 – PR_2$) | 154$^d$ | 182$^c$ | 208$^b$ | 245$^a$ | 10.26 | * |
| Crude protein in feed intake (CP%) | 30.15 | 30.41 | 30.65 | 30.80 | - | - |
| Total Protein intake (PI), g | 260.65$^c$ | 258.81$^c$ | 269.71$^b$ | 276.82$^a$ | 2.31 | * |
| Protein productive value (PPV)% | 59.08$^d$ | 70.32$^c$ | 77.12$^b$ | 88.51$^a$ | 3.22 | * |

a, b, c and d: Means in the same row having different superscripts differ significantly ($P$<0.05).
Sc*: Dried yeast (*Saccharomyces cerevisiae*).

## 7. Economical evaluation of different experimental groups

Values of economic evaluation showed that the incorporation of *Saccharomyces cerevisiae* in feed formulations increased the cost of feed formulation from 24.692LE in the control diet ($D_1$) to 25.253, 25.814, and 26.375LE per ton for the other diets ($D_2$, $D_3$, and $D_4$, respectively). However, a net improvement was realized by 6.80, 9.47, and 19.03% for $D_2$, $D_3$, and $D_4$, respectively, compared to the control that did not contain *Saccharomyces cerevisiae* in the diet (Table 8).

**Table 8.** Economical evaluation of different experimental groups

| Item | Tested diet | | | |
|---|---|---|---|---|
| | Control zero Sc* | 4 g Sc*/kg $^{-1}$ diet | 8 g Sc*/kg $^{-1}$ diet | 12 g Sc*/kg $^{-1}$ diet |
| | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
| Costing kg feed (LE) | 24.692 | 25.253 | 25.814 | 26.375 |
| Relative to control (%) | 100 | 102.27 | 104.54 | 106.81 |
| Feed conversion ratio (FCR) | 3.31 | 3.09 | 3.01 | 2.72 |
| Feeding cost (LE) per (Kg weight gain) | 81.73 | 78.03 | 77.70 | 71.74 |
| Relative to control (%) | 100 | 95.47 | 95.07 | 87.78 |
| Net improving in feeding cost (%) | Zero | 6.80 | 9.47 | 19.03 |

LE.: Egyptian pound
Diet formulation calculated according to the local prices at year 2023, as presented in Table (1)
Feed cost (L.E) FCR×FI. Cost per Kg diet
Sc*: Dried yeast (*Saccharomyces cerevisiae*).

## DISCUSSION

The results of the growth performance and survival ratio of the different experimental groups showed that the inclusion of *Saccharomyces cerevisiae* in fish diets led to an increase in their FW, TBWG, ADG, specific growth rate (SGR), and survival ratio (SR). Previous studies by **Goda *et al*. (2012)** have shown that fish fed yeast exhibited higher growth than the control group, suggesting that *S. cerevisiae* enhances growth performance. Additionally, they noted that the SR of the Nile tilapia at 119 days was recorded at 100%.

The impact of different dietary supplements of yeast on growth has been observed in the rainbow trout, *Oncorhynchus mykiss* **(Irianto & Austin, 2002)**, the Nile tilapia **(Ng *et al*., 2002; Wing-Keong & Chong, 2002; Medri *et al*., 2005)**, and common carp, *Cyprinus carpio* **(Singh *et al*., 2011)**. On the other hand, **Tewary and Patra (2011)** noted an increase in weight gain and SGR with the addition of *S. cerevisiae* at 5%. Furthermore, **Tolan (2006)** showed an enhancement in the total gain of the Nile tilapia by increasing the level of dry yeast supplementation from 1 up to 3g/kg diet. Additionally, **Diab *et al*. (2006)** established that dietary dried yeast fed to the Nile tilapia from 1 up to 5% recorded higher average body weight. The same trend was observed by **Tolan and Sherif (2007)** for the Nile tilapia fed diets containing 4% *S. cerevisiae*. **Goda *et al*. (2012)** indicated that the addition of *S. cerevisiae* improved FCR, dietary protein, and energy utilization. Similar results were found by **Lara-Flores *et al*. (2003)** when *S. cerevisiae* was used in diets for the Nile tilapia. Furthermore, **Pooramini *et al*. (2009)** stated that the use of probiotics decreased the amount of feed necessary for growth, resulting in reduced production costs.

Values of feed intake FI, FCR, CPI, and PER increased when *Saccharomyces cerevisiae* is included in the diets of the Nile tilapia fish. **Goda *et al*. (2012)** mentioned that the exogenous application of enzymes improved the FCR.

Biochemical analyses are important tools for evaluating the health status of fish and their response to new food additives. Total protein, albumin, and globulin have important immunological and nutritional impacts **(Vali *et al*., 2020)**. The significant increase in total protein and globulin in the present study, particularly in group $D_4$ which was fed the highest yeast concentration (12g *Saccharomyces cerevisiae*/kg$^{-1}$ diet) revealed an improved feed intake and an increase in the immunity status of fish. Similar to this, **Abdel-Tawwab *et al*. (2008)** estimated the growth-promoting influence of bakers' yeast on the Nile tilapia at a concentration of 1.0 to 5.0g yeast/kg diet.

Liver enzymes (ALT and AST) represent important biomarkers that indicate any disturbance in liver function **(McGill, 2016)**. According to our observations, the lowest liver enzymes (ALT and AST) were recorded in $D_4$ (12g Sc*/kg $^{-1}$ diet), which is the best treatment compared to the control and other treatments. As noted by **Decie and Lewis (1991)** and **Goda *et al*. (2012)**, blood is a pathophysiological reflector of the whole body therefore, blood parameters are important in diagnosing the status of fish health. On the other hand, **Goda *et al*. (2012)** found that the albumin: globulin ratio decreased when fish received a diet containing *Saccharomyces cerevisiae* compared to the control diet. A similar observation was reported by **Siwicki *et al*. (1994)** for rainbow trout, and by **Esteban *et al*. (2000)**, **Ortuno *et al*. (2002)** and **Cuesta *et al*. (2003)** for Gilthead Sea bream. **Sahoo and Mukherjee (2001)** and **Abozaid *et al.* (2023)** mentioned that the albumin: globulin ratio might be due to the increase in globulin level, which signifies increased protective mechanisms for fish.

Feeding fish on diets containing *Saccharomyces cerevisiae* revealed a significant ($P< 0.05$) increase in their body composition, including moisture, crude protein, and ash% contents, while organic matter and growth energy decreased compared to the control. **Goda *et al*. (2012)** mentioned that the incorporation of *Saccharomyces cerevisiae* in the Nile tilapia fish showed no differences among treatments for body moisture content (%). On the other hand, **Ali and El-Feky (2019)** and **Abo-State *et al*. (2021)** noted that no differences were recorded in whole-body moisture, ether extracts, and ash when prebiotics were used in commercial diets of the Nile tilapia fingerlings. Furthermore, **El-Dakar *et al*. (2023)** and **Abozaid *et al.* (2024)** showed significant differences between crude protein, lipids, ash, and gross energy in fish body composition; however, they observed no differences between treatments ($P> 0.05$).

The inclusion of *Saccharomyces cerevisiae* in the diet of the Nile tilapia fish resulted in a significant ($P< 0.05$) decrease in their values of energy retention (ER)%, however significantly ($P< 0.05$) increased the protein productive value (PPV)%. These results are in line with those found by **Abo-State *et al*. (2021)**, who revealed differences ($P< 0.05$) in PPV and ER% between treatments. Additionally, they noted that no differences ($P> 0.05$) were recorded among various levels of MOS and β-glucan on PPV and ER.

Net revenue showed an improvement of 6.80, 9.47, and 19.03% when *Saccharomyces cerevisiae* was incorporated at 4, 8, and 12g Sc/kg$^{-1}$ diet for $D_2$, $D_3$, and $D_4$, respectively, compared to the control that did not contain *Saccharomyces cerevisiae* in the diet. **Goda *et al*. (2012)** mentioned that the increasing price of feed is considered one of the most important factors limiting profitability in fish culture. They also showed that the diet containing 1g *Saccharomyces cerevisiae* per 100g diet$^{-1}$ was the cheapest and recommended for culturing the Nile tilapia fingerlings. Economic efficiency includes both technical efficiency and productive efficiency, along with price efficiency. Thus, economic efficiency is the result of multiplying productive efficiency by price efficiency **(Azevedo *et al*., 2015)**.

## CONCLUSION

The present results indicate that the inclusion of dried yeast (*Saccharomyces cerevisiae*) improves the feed utilization efficiency in the Nile tilapia fingerlings fed diets containing 4, 8, and 12g *Saccharomyces cerevisiae* per kg-1 diet for 56 days.

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