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INFLUENCE OF DISTILLER'S DRIED GRAINS WITH SOLUBLES ON GROWTH, FEED UTILIZATION AND ECONOMIC EFFICIENCY OF NILE TILAPIA (*Oreochromis niloticus*) DIETS

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ABSTRACT: The present study was designed to evaluate the effect of inclusion gradual dietary levels of yellow corn distiller dried grains with solubles (DDGS) on productive performance and economic efficiency of Nile tilapia (*Oreochromis niloticus*) diets. Two hundred of Nile tilapia fingerlings (average body weight, 12.86 g ± 0.14) were randomly divided into five experimental groups [4 replicates (glass aquaria), 10 fingerlings per each]. Five diets were formulated to contain 0 (basal diet), 5, 10, 20 and 30% DDGS (D_1, D_2, D_3, D_4 and D_5, respectively) as a partial replacement of the basal diet (D_1). Each diet fed to Nile tilapia fingerlings twice daily to apparent satiation for 16 weeks. All dietary levels of DDGS had no significant ($P \leq 0.05$) effect on average body weight gain, specific growth rate, feed conversion ratio, hepatosomatic index and condition factor. The survival rate was improved with D_5 compared with D_1. Concerning whole body composition, the crude protein content was high in all dietary levels of DDGS than that with the control diet, while the content of ether extract had the opposite trend. Fish fed diets contained DDGS had better protein productive value (PPV) than those fed the control diet. Incorporation of DDGS in tested diets reduced the feed cost per each gain unit. It could be concluded that the inclusion of DDGS up to the level 30% of diets had economic benefits without any adverse effect on performance of Nile tilapia fish.

Key words: Distiller dried grains with solubles, yellow corn, *Oreochromis niloticus,* growth, feed utilization.

INTRODUCTION

In Egypt, aquafeed is the main obstacle hindering sustainable aquaculture development, maintaining quality and reasonable price point (**Shaalan *et al*., 2018**). Fish feeds contribute about 75 to 85% of running costs of fish production (**Dickson *et al*., 2016**). Importation of feed ingredients with increasing foreign currency exchange rates in Egypt led to the high price of aquafeeds (**El-Sayed *et al*., 2015**). One of strategies to solve this problem is to find non-conventional and available sources of feed ingredients at affordable prices.

Protein is the most expensive dietary component. Using of less expensive sources of protein which accompanied with good growth is an advantage for diet manufacture and aquaculture producers alike (**Ebrahim**, **2008**). Distiller's dried grains with solubles (DDGS) is a co-product of the grain-based fuel ethanol industry. The DDGS is moderately high in protein (30% or higher) and is readily available and competitively priced relative to other alternative protein sources (**Welker *et al*., 2014**). Nutritive values of DDGS are varied, which due to the source and quality of grains, fermentation time and efficiency, drying process and the quantity of distiller's solubles added. Maize DDGS could be incorporated with different levels into Nile tilapia fish (*Oreochromis niloticus*) diets without any adverse effects (**Lim *et al*., 2011**).

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The current study was conducted to investigate the best inclusion level of yellow corn DDGS in a commercial diet of *Oreochromis niloticus* and its effect on growth, feed utilization, body composition and economic efficiency.

MATERIALS AND METHODS

This study was conducted at Animal Production Department, Faculty of Agriculture, Zagazig University, Egypt. The experimental work was carried out at Central Laboratory for Aquaculture Research, Abbasa, Abo Hammad, Sharkia Governorate, Egypt, in summer of the year 2015.

Fish and Aquaria

Two hundred Nile tilapia (*Oreochromis niloticus*) fingerlings with average body weight 12.86 g ± 0.14 were randomly divided into five experimental groups (40 fish/group). Each group had four equal replicates (10 fish per each). Fingerlings were procured from fish ponds of Central Laboratory of Aquaculture Research in Abbasa. Fish groups were located in glass aquaria. Each replicate of fish groups was stoked in glass aquarium (60×60×40 cm). Fish were kept for two weeks to be acclimatized before start of the main experimental period. Aquaria were supplied with dechlorinated water from storage tank. Air was supplied by aquarium air pumps. Fish wastes were drained by siphoning method with the third of water volume every day. Glass aquaria were cleaned biweekly to avoid any natural food formation as algal growth. Water samples were collected periodically from each aquarium to determine the dissolved oxygen and pH at Central Laboratory of Aquaculture Research. The average dissolved oxygen concentration was 5.5-6.5 mg/l and the pH value was 7.5. Water temperature measured by using a thermometer and its mean value was 27±2°C during the experimental period. The photoperiod was 12 hours approximately.

Experimental Diets

The basal diet and yellow corn DDGS were obtained from Zagazig feed mill. The proximate composition of DDGS and basal diet were determined according to **AOAC (1984).** Formulation and calculated chemical composition of experimental diets are shown in Table 1. Basal diet (commercial diet) and DDGS were ground, mixed with the basal diet at 0, 5, 10, 20 and 30% replacement levels, pelleted through fodder machine (2 mm in diameter) and dried in a hot air drying oven overnight at 65ºC. The basal diet contained 8.5% fish meal, 33% soybean meal, 53% yellow corn, 3% oil, 0.5% mixture of vitamins and minerals, and 2% molasses.

Feeding Regime

Fish were hand fed two times/day to apparent satiation at 10:00 and14:00 hours at a rate of 3% of the total body weight. Diets were offered in small amounts until one feed particles remained on the bottom of the aquarium for 20-30 seconds without being consumed. At this point, it was assumed that satiation had been achieved. Fish were weighed biweekly. Diets did not offer on the weighing day. Feed quantities were readjusted according to the change in live body weight. The experiment was lasted for 16 weeks.

Growth and Feed Utilization Parameters

Body weight gain (BWG) was calculated as (final average body weight g - initial average body weight g). Specific growth rate (SGR) was calculated as [(ln Wt - ln W0) / t] × 100, where, ln is the natural log, W0 is the initial body weight (g), Wt is the final body weight (g) and t is the time interval (day). Feed conversion ratio (FCR) was calculated as (air dry feed g) / (gain g). Protein productive value (PPV) was calculated as [protein retention g / protein intake g] × 100, where protein retention was calculated as [final fish body protein in g - initial fish body protein in g].

Condition factor (K)

The condition factor (K) was estimated as recommended by **Froese (2006)** by using the equation, $K = 100 \times (W / L^3)$. Where, W is the whole body wet weight (g) and L is the body length (cm); the factor 100 is used to bring K close to unity.

Hepatosomatic index (HSI)

Liver was removed, wet weighed and then HSI was calculated as follows:

HSI = [liver weight g / body weight g] × 100

Survival rate

Survival rate is calculated as a (%) of the difference between the average initial and final fish number per each fish group.

Table 1. Formulation and calculated chemical composition of Nile tilapia fish diets (on air dry basis)

Item	D_1	D_2	D_3	D_4	D_5
			Diet formulation		
Basal diet (%)	100	95	90	80	70
DDGS (%)*	0	5	10	20	30
Total	100	100	100	100	100
			Calculated chemical composition		
			Experimental diets		
Dry matter (DM) (%)	90.07	90.91	90.47	89.53	90.11
Organic matter (OM) (%)	86.54	87.30	86.80	85.75	86.19
Crude protein (CP) (%)	21.80	22.12	22.29	22.42	22.83
Crude fiber (CF) (%)	6.45	6.97	7.11	6.80	6.87
Ether extract (EE) (%)	3.38	3.64	3.88	4.32	4.83
Nitrogen free extract (NFE) (%)	54.91	54.57	53.51	52.21	51.66
Ash (%)	3.53	3.61	3.67	3.78	3.92

* Distiller Dried grains with soluble: The chemical composition of DDGS was 86.46% DM, 94.77% OM, 27.9% CP, 9.10% CF, 15.51% EE, 42.16% NFE and 5.33% Ash.

Chemical analysis of fish body

Five fish at the beginning and also at the end of the experiment from each replicate were dried at 65ºC for 72 hr., in hot air oven, and then subjected to the chemical analysis. The proximate composition of whole body of fish was determined according to **AOAC (1984)**.

Economical Study

The economical feed efficiency was calculated from the cost per one kilogram feed (year 2015) in Egyptian pound (LE) and the weight gain of fish from the equation: Feed cost (LE)/Kg gain = A × B/C.

Where: A, total feed intake (g/fish); B, cost in LE/Kg diet and C, total body weight gain (g/fish).

Statistical Analysis

Data were subjected to analysis of variance using analysis of variance procedure of statistical analysis system (**SAS, 1996**). Differences among means were evaluated by using Duncan's multiple range tests, (**Duncan, 1955**).

RESULTS AND DISCUSSION

The Proximate Analysis of Diets

Results of chemical composition of basal diet and DDGS and calculated of tested diets (D2, D3, D4 and D5) are presented in Table 1. Inclusion DDGS in the basal diet resulted in an increase of the crude protein, crude fiber, ether extract and ash contents. In contrary, the nitrogen free extract decreased by elevating the DDGS level in the diets.

Growth Parameters

Body weight gain (BWG) and specific growth rate (SGR)

Results of BWG and SGR are summarized in Table 2. The BWG and SGR values for group fed D_5 (30% DDGS) were significantly ($p \leq 0.05$) lower than those fed other diets at the 4^{th}, 8^{th} and 10^{th} weeks of the experimental period. In general, all inclusion levels of DDGS did not significantly affect fish growth for the total experimental period (16 weeks). These results are in concur with **Lim *et al.* (2011)**. They revealed

Table 2. Effect of tested diets on body weight gain and specific growth rate (SGR) of Nile tilapia fish

Item		Experimental diet				
		D_1 (0% DDGS)	D_2 (5% DDGS)	D_3 (10% DDGS)	D_4 (20% DDGS)	D_5 (30% DDGS)
Week	Initial body weight (g)	12.86±0.33	12.85±0.12	12.82±0.11	12.84±0.09	12.95±0.05
	Final body weight (g)	36.95±1.48	37.11±0.96	36.21±1.95	35.90±3.93	35.13±1.38
2	Weight gain (g)	1.88±0.16	1.87±0.07	1.86±0.05	1.87±0.04	1.91±0.08
	SGR (%/day)	0.97±0.07	0.97±0.04	0.97±0.04	0.95±0.04	0.98±0.06
4	Weight gain (g)	a 2.08±0.09	a 2.05±0.06	a 2.05±0.04	a b 2.00±0.05	b 1.91±0.08
	SGR (%/day)	a 0.95±0.07	a 0.93±0.04	a 0.93±0.04	a 0.91±0.04	b 0.86±0.03
6	Weight gain (g)	3.93±0.40	3.51±0.47	3.62±0.32	3.40±0.19	3.40±0.18
	SGR (%/day)	1.50±0.14	1.36±0.16	1.41±0.09	1.32±0.07	1.32±0.07
8	Weight gain (g)	a 3.47±0.52	a b 2.88±0.39	a b 2.87±0.46	c 1.73±0.46	b c 2.35±0.44
	SGR (%/day)	a b 1.11±0.14	a 1.24±0.14	b c 0.94±0.13	d 0.58±0.22	c d 0.79±0.13
10	Weight gain (g)	a b 2.60±0.42	a 2.89±0.33	a b 2.51±0.45	a b 2.50±0.34	b 2.15±0.32
	SGR (%/day)	a b 0.73±0.10	b 0.55±0.24	a b 0.73±0.11	a 0.77±0.10	a b 0.64±0.08
12	Weight gain (g)	3.67±1.16	3.33±0.74	3.32±0.43	3.70±1.67	2.61±-0.58
	SGR (%/day)	0.92±0.30	0.86±0.15	0.87±0.15	1.01±0.39	0.72±0.34
14	Weight gain (g)	a 3.34±0.50	a 3.33±0.27	a 3.68±0.21	a 3.48±0.67	b 2.53±0.65
	SGR (%/day)	b c 0.66±0.07	a b 0.77±0.07	a 0.86±0.06	a b 0.83±0.09	c 0.63±0.16
16	Weight gain (g)	c 3.12±1.28	b 4.40±0.82	c 3.48±1.96	b 4.38±0.94	a 5.32±0.74
	SGR (%/day)	b 0.70±0.25	a b 0.90±0.19	b 0.71±0.43	a b 0.93±0.11	a 1.17±0.18
Average	Weight gain (g)	3.01±0.94	3.03±0.88	2.92±0.95	2.88±0.42	2.77±0.39
	SGR (%/day)	0.94±0.14	0.95±0.11	0.93±0.13	0.91±0.13	0.89±0.13

a, b, c and d: means in the same row with different superscript differ significantly (P≤ 0.05).

that DDGS can be included up to 20-30% in tilapia diets without any unfavorable effects on fish growth. On the same trend, **Gabr *et al.* (2013)** incorporated DDGS up to 20% in Nile tilapia (*Oreochromis niloticus*) fish. They demonstrated that the inclusion level of 16% improved all growth parameters.

Feed Utilization

Feed conversion ratio (FCR)

The average total feed consumption and FCR through the whole experimental period (Table 3) did not significantly differed among all of tested diets. Similar results found that inclusion of 30% DDGS did not affect the FCR of hybrid tilapia (**Coyle *et al.,* 2004**), channel catfish **(Robinson and Li, 2008),** hybrid catfish **(Zhou *et al.,* 2010)** and Nile tilapia, *Oreochromis niloticus* (**Li *et al.,* 2011**).

Protein productive value (PPV)

Mean values of protein utilization explained as protein retention and PPV (Table 3) slightly increased in all diets containing DDGS compared with the control diet (D_1). Similar results were reported by **Schaeffer *et al.* (2009),** they fed Nile tilapia *(Oreochromis niloticus)* fingerlings diets containing 0, 20, 30 and 40% of DDGS. The protein efficiency ratio did not significantly differ among diets. These results agreed with those reported by **Zhou *et al.* (2010)**, they mentioned that 30% dietary inclusion rate of DDGS can be used without adverse effect on protein retention. In the same manner, **Salama *et al.* (2011)** reported that replacing the dietary fish meal (15%) with DDGS in *Oreochromis niloticus* fry diets did not reflect any significant effects on PPV.

Whole body composition

The chemical composition of Nile tilapia fish body on dry matter basis is presented in Table 4. The obtained results cleared that crude protein content was slightly high with all dietary levels of DDGS compared to the basal diet, while the content of ether extract had the opposite trend. These results agreed with **Lim *et al.* (2007)** who concluded that 20% DDGS can be added to Nile tilapia juvenile's diets without affecting body composition. Moreover, **Choi *et al.* (2014)** incorporated DDG levels up to 25% in red seabream juvenile's (*Pagrrus major*) diets. The inclusion of DDG did not significantly affect the whole body composition.

Survival rate, the condition factor (K) and hepatosomatic index (HSI)

At the end of the experimental period, survival rate (%), K and HSI were calculated and demonstrated in Table 5. All fish groups received diets containing DDGS achieved survival rates equivalent or superior to the fish group fed the control diet. The best survival rate was observed with D_3 and D_5. These results agreed with those reported by **Robinson and Li (2008) and Zhou *et al.* (2010)** they mentioned that 30% DDGS, can be used without adversely affecting survival rate. Concerning K, all fish groups received diets containing DDGS recoded higher K values than that with the control. The best K value was observed with D_5 (30% DDGS). These results may support with the assumption that heavier fish of a given length are in better condition as stated by **Froese (2006)**.

All inclusion levels of DDGS in tested diets showed insignificant increases of HSI. These results agreed with those reported by **Schaeffer *et al.* (2009)**. They found that inclusion of DDGS up to 20 % did not affect HSI values, but they also added that HSI values were significantly decreased with increasing inclusion levels to 30 and 40%. Furthermore, **Choi *et al.* (2014)** added that inclusion of DDG up to 25%in red sea bream diets did not significantly affect HSI values. The insignificant increase of HSI may be attributed to the higher ether extract content (15.51%) of DDGS, which may increase lipid deposition in fish liver.

Economic efficiency of Nile tilapia fish diets

All inclusion levels of DDGS in tested diets led to decrease of total feed cost and the relative feed cost /kg gain (Table 6). The feed cost (LE)/ kg gain was 100, 93.68, 95.23, 88.69 and 86.09 for D_1 (control), D_2, D_3, D_4 and D_5, respectively. **Ebrahim (2008) and Gabr *et al.* (2013)** reported that using of DDGS in Nile tilapia fingerlings, *Oreochromis niloticus* diets had no adverse effects on the fish performance and improved the economic efficiency.

Table 3. Effect of tested diets on feed and protein utilization of Nile tilapia fish

Item	Experimental diet				
	D_1 (0% DDGS)	D_2 (5% DDGS)	D_3 (10% DDGS)	D_4 (20% DDGS)	D_5 (30 DDGS)
Total feed intake g /fish	70.96±1.93	71.44±5.60	73.68±2.70	73.92±1.41	75.68±2.07
Feed conversion ratio	3.20±1.12	3.10±1.14	3.15±1.39	3.05±0.61	3.14±1.24
Protein retention (g)*	3.51	3.77	3.54	3.70	3.56
PPV (%)**	19.17	20.97	19.50	20.68	19.80

*Protein retention = [final fish body protein in g - initial fish body protein in g].

**Protein productive value (PPV) = [protein retention g / protein intake g] × 100

Table 4. Effect of tested diets on whole body chemical composition of Nile tilapia fish (% on dry matter basis)

Item	Experimental diet				
	D_1 (0 DDGS)	D_2 (5% DDGS)	D_3 (10% DDGS)	D_4 (20% DDGS)	D_5 (30% DDGS)
Organic matter (OM) (%)	83.79	83.04	84.04	83.63	83.95
Crude protein (CP) (%)	54.69	55.04	54.96	54.76	56.10
Crude fat (CF) (%)	28.72	27.42	28.63	28.59	27.67
Nitrogen free extract (NFE) (%)*	0.38	0.58	0.45	0.28	0.18
Ash (%)	16.21	16.96	15.96	16.37	16.05

Table 5. Effect of tested diets on the condition factor (K), haepatosomatic index (HSI) and survival rate of Nile tilapia fish

Item	Experimental diet				
	D_1 (0 DDGS)	D_2 (5% DDGS)	D_3 (10% DDGS)	D_4 (20% DDGS)	D_5 (30% DDGS)
K *	1.58±0.12	1.73±0.22	1.65±0.11	1.73±0.12	1.75±0.13
HSI **	2.78±0.43	2.79±1.04	3.30±0.49	3.04±0.88	2.97±0.18
Survival rate (%)	90	90	95	90	95

* $K = 100 \times (W/L^3)$. Where W body weight (g), L^3 body length (cm).

** HSI = [liver weight (g)/body length (cm)] ×100.

Table 6. Effect of tested diets on feed cost (LE)/kg gain

Item	Experimental diet				
	D_1 (0 DDGS)	D_2 (5% DDGS)	D_3 (10% DDGS)	D_4 (20% DDGS)	D_5 (30% DDGS)
Total feed intake (g/fish)^A	75.68±2.07	73.92±1.41	73.68±2.70	71.44±5.60	70.96±1.93
Diets cost (LE/Kg)^B	7.00	6.83	6.65	6.30	5.95
Total feed cost (LE/fish)	0.53	0.50	0.49	0.45	0.42
Total body gain (g)^C	24.09±1.51	24.26±0.95	23.39±2.02	23.06±3.92	22.18±1.42
Feed cost (LE/Kg gain)^D	22	20.61	20.95	19.51	18.94
Relative feed cost (%) (LE/Kg gain)^E	100	93.68	95.23	88.69	86.09

The price of one kg DDGS and basal diet are 3.50 and 7 LE, respectively (price 2015).

$D = (A \times B) / C$

$$E = \frac{\text{D of tested diets}}{\text{D of basal diet}} \times 100$$

Conclusion

Inclusion of DDGS up to 30% of *Oreochromis niloticus* diets had no adverse effect on growth, feed utilization and improved the economic efficiency of the diet.

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تأثير مُجفف نواتج تقطير الحبوب والسوائل على النمو والاستفادة من العلف والكفاءة الاقتصادية لعلائق البلطي النيلي

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صُممت الدراسة الحالية لتقييم أثر إدخال مستويات تدريجية من مُجفف نواتج تقطير الحبوب والسوائل للذرة الصفراء (DDGS) على الأداء الإنتاجي والكفاءة الاقتصادية لعلائق أسماك البلطي النيلي، قُسمت مائتي أصبعية من أسماك البلطي النيلي عشوائياً (بمتوسط وزن ١٢,٨٦ ± ٠,١٤ جم) على خمس مجموعات تجريبية [أربع مكررات (أحواض زجاجية)، عشر إصبعيات/حوض زجاجي]، تم تكوين خمس علائق لتحتوي على: ٠(عليقة المقارنة)، ٥، ١٠، ٢٠ و٣٠% من الـDDGS (عليقة ١و ٢و ٣و٤ و٥ على التوالي) كإحلال جزئي من عليقة المقارنة، غُذيت إصبعيات البلطي النيلي مرتين يوميا حتى الشبع الظاهري لمدة ١٦ أسبوع، لم تؤثر كل مستويات DDGS معنوياً على متوسط الزيادة في وزن الجسم و معدل النمو النسبي و كفاءة التحويل الغذائي ودليل الكبد الجسمي ومعامل الحالة، تحسن معدل الإعاشة مع العليقة ٥ مقارنة بعليقة المقارنة (العليقة الأولى)، فيما يتعلق بتركيب جسم الأسماك فإن محتواه من البروتين الخام كان أعلى قليلًا منه بمجموعة المقارنة وذلك مع كل مستويات DDGS فى العليقة، أما محتوى الجسم من الدهن فكان على العكس من ذلك، أعطت الأسماك التى غُذيت على العلائق المحتوية على DDGS قيماً لإنتاجية البروتين أفضل من تلك المُغذاة على عليقة المقارنة، خفضت إضافة الـ DDGS في العلائق المختبرة من تكاليف التغذية لكل وحدة نُمو، نخلص من ذلك بأن إضافة الـ DDGS حتى مستوى ٣٠% في العلائق المختبرة كان مفيداً اقتصادياً دون أي تأثير معاكس على أداء أسماك البلطي النيلي.

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