

Effects of partial and total substitution of fish meal with corn gluten meal on growth performance, nutrients utilization and some blood constituents of the Nile tilapia *Oreochromis niloticus*

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ABSTRACT

The present study was conducted to evaluate partial or total substitution of fish meal with corn gluten meal and its effects on growth performance, nutrients utilization and blood characteristics of fingerling tilapia. Four isonitrogenous diets were formulated to contain (30.16±0.08 Crude protein) with different inclusion levels (D0, D50, D75 and D100% corn gluten meal). Fish were fed on on the artificial diets at a rate of 3% of the fish biomass daily divided into two equal portions. Fingerlings tilapia with an initial weight of 6.65±0.2g were distributed in concrete tanks as 225 juveniles in each triplicate tank of 9m³ volume to represent 4 dietary treatments in triplicates. The experimental period lasted 105 days after start. The results showed significant differences (P<0.05) in growth performance and feed conversion ratio between diets. The highest performance in terms of (final weight, weight gain, average daily gain, specific growth rate, condition factor, feed conversion ratio, protein efficiency ratio, and protein productive value and Hepatosomatic index) were obtained with the C0, C50 and C50%, respectively, without significance difference between them. The inclusion of 100% corn gluten meal showed significant differences (P<0.05) with decreased growth performance and feed efficiency compared to the other tested diets. No significance difference (P<0.05) in whole body chemical composition (dry matter, crude protein, crude lipid and ash) was observed between fish fed on on all experimental diets. The blood parameters did not vary significantly by dietary treatments. The results of the present study indicated that, the inclusion of up to 75% corn gluten meal level as low cost plant protein instead of fish meal can be utilized in tilapia diets without adverse effects on growth performance, feed efficiency and blood characteristics.

Keywords: *Oreochromis niloticus*, con gluten meal, growth performance, nutrient utilization, blood characteristics.

INTRODUCTION

Aquaculture remains a growing, vibrant and important production sector for high protein food. The reported global production of food fish from aquaculture, including finfishes, crustaceans, mollusks and other aquatic animals for human consumption reached 525 million tones in 2008. The contribution of aquaculture to the total production of capture fisheries and aquaculture continued to grow rising from 34.5 percent in 2006 to 36.9 percent in 2008 (FAO, 2010). From the period from 1970 to 2008, the production of food fish from aquaculture increased at an average of 1.6 percent per year. The combined result of development in aquaculture worldwide and the expansion in global population is that the average annual per capita supply of food fish from aquaculture for human consumption has increased by ten times, from 0.7 kg in 1970 to 7.8kg in 2008, at an average rate of 6.6 percent per year (FAO,2010). Production of aquaculture within region is diverse. World aquaculture is heavily

dominated by the Asia-Pacific region, which accounts for 89 percent of production in terms of quantity and 77 percent in terms of value. Fresh waters were the source for 60 percent of the world aquaculture production in 2008 (56% by value). Tilapia represents 7.6% of freshwater production and cultured from extensive to highly intensive systems. Tilapias species are receiving a great attention as food fish in most of Asia, Africa and Southern United State. Also, it has been successfully tested in fish culture even in dry lands harsh environments. The global aquaculture production of tilapia has drastically increased from 12.4 thousand mt in 1977 to 2.5 million mt in 2010 (FAO, 2010). The total fish production in Gulf Arabian countries were 3129912 Mt in 2009 and increased at a rate of 2.8% yearly and the United Arab Emirates produced 77705 Mt from the previous production. However, the fish culture in United Arab Emirates started in 1984 and became an important source for fish production, where they produced 300 tones of fish in 2003 (Khalifa bin Zayed Center for Marine Research, 2009).

The aquaculture feed industry of the world mainly depends on the use of fish meal because it is an excellent source of fundamental nutrients such as vital amino acids, essential fatty acids, vitamins, major minerals and many growth factors (Zhou *et al.*, 2005). Rising demand, high price and unstable supply of the fish meal with the extension of aquaculture makes it compulsory to search for better alternative protein sources (Lunger *et al.*, 2007; Lim *et al.*, 2007; Phumee *et al.*, 2011). Numerous studies have been undertaken to examine the effects of replacing fish meal by another sources of protein such as plant based protein diets that can be fed on to tilapia (El-Ebiary, 2005; Borgeson *et al.*, 2006; Nguyen and Davis, 2009). The plant by-products are the promising sources of protein and energy (Hardy, 2000) for the formulation of economical and environment friendly aqua feeds (Cheng and Hardy, 2002).

The primary objective for most fish farmers is to produce high quality fish at least cost. Feed typically account for 50-60% of operating costs in efficient fish farms (Tacon, 1997; Essa *et al.*, 2004). Corn gluten meal (CGM) has been successfully used as a dietary protein sources for tilapia where, the growth of *O. niloticus* fingerlings fed on corn distillers grains with soluble gluten meal as partial sources was better than that of fish fed on a 100% fish meal in control diet (Tudor *et al.*, 1996). Corn gluten meal was found to be a suitable protein source in a fish meal-free diet if the proper amino acid balance was maintained (Wu *et al.*, 1995). It is highly digestible by tilapia and the digestion coefficients are comparable to fish meal protein (Koprucu and Ozdemir, 2005).

The present study aims to evaluate the potential of Corn gluten meal as plant protein source instead of fishmeal in the feeding of Nile Tilapia (*Oreochromis niloticus*) fingerlings and its effects on growth performance and blood characteristics.

MATERIALS AND METHODS

Fish culture and experimental diets

The present study was conducted in private fish farm at Algraain area Sharjah Emirate, United Arab Emirates. Physic-ochemical characteristics of ponds water were examined every two weeks according to APHA (1992).

Fingerlings tilapia with an average initial weight of 6.65 ± 0.2 g were randomly distributed into 12 concrete ponds to represent 4 dietary treatments in triplicates and stocked at 225 juvenile per cement pond of (3×3×1m). The experimental ponds were 9 m³ volume each. The water turnover rate is 10%/day.

Four isonitrogenous diets were formulated to contain an average of (30.16±0.08% crude protein) in order to met the requirement of Nile tilapia (NRC, 1993). The ingredients, diets formulation and chemical composition analysis are presented in Tables (1&2). The first diet was formulated without corn gluten meal and considered as a control diet (C0). Diets 2 (C50), 3 (C75) and 4 (C100) were formulated to be comprised with partial and total inclusion levels of 50, 75 and 100% corn gluten meal, respectively. All diets were processed into dry sinking pelleted form, using Germany pelleting machine with 2mm diameter. The experimental diets were fed on at 3% rate of live body weight (BW) twice daily at 9.00 a.m and 15.00 p.m, fish samples of 30 fish were catch and weight every two weeks to adjusted feed intake. The experimental treatments were performed triplicated and lasted 105 days after start.

Table 1: Chemical composition of ingredients used in feed formulation (as% dry matter basis).

Ingredientes	DM	CP	EE	NFE	CF	ASH
Fish meal	92.8	70.0	13.5	-	-	16.5
Poultry-by-product meal	91.0	56.0	14.8	12.4	2.2	14.6
Corn gluten meal	92.2	35.0	2.8	55.4	2.6	4.2
Wheat bran	91.6	14.0	3.9	65.8	9.6	6.7
Yellow corn	89.8	9.0	2.6	75.8	8.2	4.4

Growth performance

The following growth performance parameters were calculated as follows:

- Specific growth rate = $100 \times (\ln \text{ final weight} - \ln \text{ initial weight}) / 120$.
- Condition factor (g/cm^{-3}) = $(\text{wet weight}) / (\text{total length}^{-3}) \times 100$.
- Feed conversion = $(\text{feed given per fish}) / (\text{weight gain per fish})$.
- Protein efficiency ratio = $(\text{weight gain per fish}) / (\text{protein intake per fish})$.
- Protein productive value(%) = $100(\text{protein gain} / \text{protein fed on})$.
- Hepatosomatic index (HIS%) = $100 \times [\text{liver weight (g)} / \text{body weight (g)}]$.

Table2: Formulation and chemical composition of the experimental diets.

Ingredientes	Diets			
	C0	C50	C75	C100
Fish meal	20	10	5	-
Poultry-by-product meal	20	20	22	22
Corn gluten meal	-	20	30	40
Wheat bran	10	37	32	31
Yellow corn	43	6	4	-
Fish oil	5	5	5	5
Vitamin/ Mineral Mix ¹	2	2	2	2
Total	100	100	100	100
Chemical composition (%)				
Dry matter	93.5	93.5	91.8	92.4
Crude protein	30.27	30.18	30.16	30.04
Ether extract	15.88	16.14	16.25	16.44
Nitrogen free extract	36.47	35.16	34.5	34.91
Fiber	5.54	6.29	5.75	5.22
Ash	11.84	12.27	13.34	13.39
Gross energy(MJ kg ⁻¹ diet) ²	19.96	19.81	19.73	19.85
ME (MJ kg ⁻¹ diet) ³	16.74	16.62	16.57	16.66

1-Vitamin-mineral premix supplied the following (g Kg⁻¹ mixture); retinyl acetate 0.67; ascorbic acid 120; cholecalciferol 0.1; tocopheryl acetate 34.2; menodione 22; thiamin 5.6; riboflavin 12; pyridoxine 4.5; calcium panthothenate 14.1; p-aminobenzoic acid 40; cyanocobalamin 0.03; niacin 30; biotin 0.1; choline chloride 350; folic acid 1.5; inositol 50; canthaxanthin 10; butylated hydroxytoluene 1.5; butylated hydroxyanisole 1.5; CaHPO₄·2H₂O 29.5; Ca (H₂PO₄)₂ H₂O 217; NaHCO₃ 94.5; Na₂SeO₃·5H₂O 0.011; Kci 100; Nacl 172.4; Ki 0.2; Mgcl₂ 63.7; MgSO₄ 34.3; MnSO₄ 2; FeSO₄·H₂O 10; CuSO₄·5H₂O 0.4; ZnSO₄ 10.

2-Lozano *et al.* (2007). 3-Jobling (1994).

Chemical analysis

The ingredients used in feed formulation, the experimental diets and fish carcass were dried for subsequent protein (kiel Dahl), ether extract (Soxhlet) and moisture analysis, according to AOAC (1995) methods. Protein levels were calculated by multiplying the total nitrogen (N) with 6.25. Nitrogen free extract was calculated based on the difference between the dry matter content minus protein, fat and ash contents were determined according to AOAC (1995) methods.

Gross energy (MJ Kg⁻¹ diet) was calculated according to Lozano *et al.* (2007) using the following calorific values: 23.9, 39.8 and 17.6 KJ g⁻¹ diet for protein, ether extract and nitrogen free extract, respectively. The metabolizable energy contents of the experimental diets were calculated as 18.9, 35.7 and 14.7 KJ g⁻¹ diet for protein, lipid and nitrogen free extract, respectively according to Jobling (1994).

Blood samples were collected using heparinized syringes from the caudal vein of the experimental fish at the end of the growth trial. Blood samples were centrifuged at 3000 rpm × 15 min at 4 °C to allow separation of plasma which use to determine the blood parameters. Total plasma protein were carried out (Colorimetric method, Roch Diagnostics, GmbH, Monnheim, Germany) as recorded by Ruane *et al.*, (2001). Creatinine was determined according to Pincus, (1996). The activities of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were carried out using Colorimetric method, Roch Diagnostics, GmbH, Monnheim, Germany kits according to Reitman and Frankel (1957).

Statistical analysis

One way Analysis of Variance (ANOVA) was applied to test the effect of different dietary protein levels on various growth parameters, nutrient utilization and chemical composition of experimental fish according to Snedecore and Cochran (1987). Duncan Multiple Range test was used to detect the significant differences between the means of treatments (Duncan, 1955). All analysis was performed using SAS (version 6, 1986 SAS Institute, Cary, NC, USA).

RESULTS

Physicochemical characteristics

Water physicochemical characteristics (Table 3) revealed that temperature, pH, dissolved oxygen, and unionized ammonia are within the optimum ranges for rearing tilapia according to (Vechkling *et al.*, 2011). Similar physicochemical condition was observed in all ponds of the present study as presented in (Table 3).

Table 3: An averages of water physicochemical characteristics parameters during experimental period.

Parameters	Diets			
	C0	C50	C75	C100
Temperature °C	27.9±1.0	28.1 ±0.8	24.2 ±0.32	24.2 ±0.31
Ph	8.7 ±0.13	8.3± 0.15	8.5±0.18	8.6±0.12
Dissolved oxygen (mg/l)	7.5±0.14	7.1±0.16	7.6±0.18	7.4±0.12
Unionized ammonia (mg/l)	0.032± 0.01	0.036±0.001	0.038±0.001	0.031±0.001

Chemical composition of gluten meal and diets

Results of the chemical composition of gluten meal are shown in (Table 2). results showed that the corn gluten meal contains high crude protein (35% DM), high NFE (55.4% DM), low lipid (2.8%DM), low CF (2.4%DM) and moderate ash (4.2%DM). As presented in (Table 2), the experimental diets were similar in their

protein contents ranging from (30.04 to 30.27%) and growth energy contents ranging from (19.73 to 19.96 MJ kg⁻¹ diets).

Growth performance

As presented in (Table 4), averages of initial weights ranged between 5.26 to 5.38 g/fish with insignificant differences among the dietary groups indicating the random distribution of the experimental fish among treatment groups. Concerning growth performance parameters (Table 4) the highest final weights of tilapia fish ($P < 0.05$) were recorded by C0, C75 and C50% groups, respectively without significance difference between each other. However, C100% corn gluten meal diet recorded lower ($P < 0.05$) final weight compared to the other diets. The same trend was observed with total gain, daily gain, specific growth rate and condition factor, where C0, C75 and C50% groups recorded higher values ($P < 0.05$) compared to C100% group, however differences in these traits among C75, C0 and C50% were insignificant. As shown in the same table, results of survival rate were 97% for all dietary treatments groups indicating that the tested diets had no effects on tilapia fish survival rates, thus all mortalities were due to accidental factors during the samples collection every two weeks to adjust the feed amounts.

As can be seen in (Table 4), average amounts of feed consumed were found to be 235, 236, 238 and 240g for fish fed on C0, C50, C75 and C100%, respectively, which indicate slight increases in feed consumption in fish fed on C75 and C100% compared to the C0% and C50% CP. On the other hand, FCR, PER and PPV showed an insignificant differences in the values ($P < 0.05$) between C0, C50 and C75%, respectively. In the same trend, insignificant differences were found for the hepatosomatic index (HIS) among C75, C0 and C50% dietary treatments compared with C100% group.

Table 4: Growth performance mean values of tilapia fed on the experimental diets.

Parameters	Diets			
	C0	C50	C75	C100
Initial aveg. Weight (g/fish)	5.38 ^a	5.36 ^a	5.26 ^a	5.30 ^a
Final aveg. Weight (g/fish)	126.7 ^a	126.0 ^a	126.0 ^a	107.0 ^b
Total gain (g/fish)	121.32 ^a	120.64 ^a	120.74 ^a	101.7 ^b
Average daily gain (g/fish/day)	1.15 ^a	1.14 ^a	1.14 ^a	0.96 ^b
Specific growth rate	3.00 ^a	3.00 ^a	3.01 ^a	2.86 ^b
Condition factor (g/cm ⁻³)	1.46 ^a	1.42 ^a	1.41 ^a	1.25 ^b
Survival rate %	96	96	96	96
Feed consumed (g/ fish)*	235.0	236.0	238.0	240.0
Feed conversion ratio	1.93 ^a	1.95 ^a	1.97 ^a	2.35 ^b
Protein efficiency ratio (PER)	1.7 ^a	1.69 ^a	1.68 ^a	1.41 ^b
Protein Productive Value (PPV%)	33.4 ^a	32.47 ^a	32.78 ^a	23.6 ^b
HIS (%)	1.43 ^a	1.45 ^a	1.46 ^a	1.15 ^b

Means in the same row with different superscript letters are significantly different ($P < 0.05$). * Non-consumed portion of food was collected, dried and deducted from total given ration.

Blood characteristics

Blood characteristics revealed that insignificant difference ($P < 0.05$) were detected between the experimental groups (Table,5) for total protein, albumin, creatinine, Aspartate aminotransferase (Ast) and Alanine aminotransferase (Alt) of tilapia, which indicate that substitution of fish meal by corn gluten meal had no hazardous effects on blood parameters tested.

Table 5: An averages of blood characteristics parameters during experimental period as affected with inclusion levels of corn gluten meal.

Parameters	Diets			
	C0	C50	C75	C100
Total protein g/dl	6.5 ^a ±1.11	6.4 ^a ±0.8	6.42 ^a ±0.9	6.3 ^a ±0.6
Albumin g/dl	3.28 ^a ±0.36	3.3 ^a ±0.25	3.4 ^a ±0.35	3.22 ^a ±0.18
Urea mg/dl	7.5 ^a ±0.14	7.1 ^a ±0.16	7.6 ^a ±0.18	7.4 ^a ±0.12
Creatinine mg/dl	1.18 ^a ±0.29	1.16 ^a ±0.26	1.15 ^a ±0.16	1.13 ^a ±0.22
Ast ¹	115.0 ^a ±016	118.0 ^a ±024	120.0 ^a ±015	124.0 ^a ±014
Alt ²	46.0 ^a ±0.41	45.0 ^a ±032	44.0 ^a ±026	44.5 ^a ±0.38

Means in the same raw with different super script letters are significantly different (P<0.05).

1- Aspartate aminotransferase

2-Alanine aminotransferase

Carcass analysis

Proximate composition of whole fish body analysis did not change significantly in terms of dry matter, crude protein, crude lipid and ash contents by different dietary treatments (Table 6). However, whole fish body lipid was slightly increased by the increasing dietary corn gluten levels in the diets without significant differences (P<0.05) between the dietary treatments.

Table 6: Carcass analysis of tilapia fed on the experimental diets (%w/w basis).

Items	Diets				
	Initial	C0	C50	C75	C100
Dry matter	28.5	28.9 ^a	28.8 ^a	28.4 ^a	28.8 ^a
Protein	17.8	17.6 ^a	17.2 ^a	17.5 ^a	17.4 ^a
Lipid	5.2	5.6 ^a	5.8 ^a	5.7 ^a	5.8 ^a
Ash	5.5	5.7 ^a	5.4 ^a	5.2 ^a	5.6 ^a

Means in the same raw with different super script letters are significantly different (P<0.05).

DISCUSSION

The proximate composition of gluten meal from protein showed that it has a good source of nutrients that could be utilized by tilapia, which indicate that it could substitute fish meal in growing tilapia diets up to 75%. These results confirmed the feasibility of using gluten meal in the feed formulation of tilapia due to less cost and palatability to this species.

It was recorded by several investigations that plant ingredients contains some Anti-nutritional factors which reduce fish growth, however (Alexis, 1985 and Hardy, 2000) reported that corn gluten meal has no adverse effects on fish growth due to the lack of Anti-nutritional factors in its composition. The finding was reported in this study indicate that corn gluten meal can be used up to 75% inclusion level in tilapia diet, however, El-Ebiary, 2005 recommended 25% corn gluten meal can used in tilapia diets. On the other side, corn gluten meal can totally replaced fish meal in catfish, Atlantic salmon and trout diets as recorded by (Lochmann *et al.*, 2012, Burr *et al.*, 2012 and Regost 1999) without compromising fish performance. The differences between results of the different investigators may be due to the different condition between experiments and different species.

Insignificant differences in weight gain, average weight gain, specific growth rate and condition factor of tilapia fed on the C0, C50 and C75% corn gluten meal inclusion levels declared that these inclusion levels of 50 and 75% can be utilized in feeding of this species. Subhadra *et al.* (2006) suggested that fish growth efficacy can be affected by diet composition and feeding trial duration. Similar results for gain,

specific growth rate and condition factor were recorded in the same species by Luo *et al.* (2012), Al-Asgah *et al.* (2011), Borgeson *et al.* (2006), Soltan *et al.* (2008) and in catfish by Lochman *et al.* (2012). The present study reveal that feed conversion ratio was significantly affected by corn gluten inclusion levels, thus tilapia fed on C0,C50 and C75% corn gluten meal gave the best ($P<0.05$) feed conversion ratios compared with C100% diet. Comparable feed conversion ratio was reported in tilapia by Koprucu and Ozdemir (2005), Wu *et al.* (2000) and Al-Asgah *et al.* (2011). On the other hand, the utilization values of protein show that it was well utilized by fish fed on different inclusion levels, where PER and PPV% achieved the highest values for the C0,C50 and C75% and then reduced in C100%. Similar results were recorded in tilapia by Luo *et al.* (2012) and Yones and Abdel-Hakim, (2010) and other species such as carp Jahanbakhi *et al.* (2012) and trout, Burr *et al.* (2012). The HIS is often used as an indicator of condition and nutritional status of fish. The HSI values of the present study was similar to the values recorded for tilapia (Yones and Abdel-Hakim, 2010).

The blood parameters of tilapia were not affected by dietary inclusion levels. These results are in agreement with those recorded in tilapia by Shalaby (2004) and turbot Nagle *et al.* (2012).

With regard to the whole body composition of Nile tilapia fed on the several treatments, there were no indications that the increase inclusion of corn gluten meal affected the proximate composition of dry matter, crude protein, crude lipid and ash. The present results are in agreements with the results of El-Ebiary (2005) Lin *et al.* (2007) and Al-Asgah *et al.* (2011) in the same species and Tusche *et al.*(2012) in trout and Jahanbakhi *et al.* (2012) in carp.

In conclusion, the present trial confirms that corn gluten meal can be incorporated up to 75% in typical practical diets of tilapia without affecting growth performance, nutrients utilization and blood characteristics. This study also declared the feasibility of using corn gluten meal in the fish feed formulations as alternative and cheaper protein source compared to fish meal especially in tilapia fish diets.

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ARABIC SUMMARY

الإحلال الجزئي و الكلى لمسحوق الأسماك بمسحوق جلوتين الذرة في العلائق التطبيقية لاصبغيات البلطي النيلي وتأثيره على أداء النمو ، الكفاءة الغذائية و خواص الدم.

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أجريت الدراسة لتقييم تأثير الإحلال الجزئي والكلي لمسحوق جلوتين الذرة محل مسحوق الأسماك وتأثير ذلك على معدلات الأداء، الكفاءة الغذائية و خواص الدم لاصبغيات البلطي النيلي. تم تكوين 4 علائق متماثلة في نسبة البروتين ($30.16 \pm 0.08\%$ بروتين خام) مع نسب إحلال مختلفة من مسحوق جلوتين الذرة محل مسحوق الأسماك حيث كانت العليقة الأولى عليقة ضابطة لا تحتوى جلوتين الذرة بينما حل جلوتين الذرة في العلائق الأخرى بنسب 50، 75 و 100% لمسحوق السمك. استمرت التجربة 105 يوم حيث وزعت اصبغيات البلطي النيلي بوزن أولى (6.65 ± 0.2 جم) وبمعدل تخزيني 225 سمكة / حوض أسمنتي سعة 9 متر مكعب وغذيت الأسماك بنسبة 3% من وزن الجسم قسمت على مرتين متساويتين.

أظهرت نتائج الدراسة اختلافات معنوية عند مستوى (0.05 %) في معدلات الأداء و الكفاءة الغذائية بين العلائق المختبرة ، حيث كانت أعلى معدلات أداء متمثلة في وزن نهائي، زيادة يومية، نمو نوعي ، معامل حالة ، معامل تحويل غذائي، كفاءة استخدام بروتين ومعامل وزن الكبد للأسماك المغذاة على العلائق $C0, C50, C75\%$ على التوالي بدون فروق معنوية فيما بينها. بينما إدخال مسحوق جلوتين الذرة بنسبة 100% أظهر اختلافات معنوية عند مستوى (0.05 %) مع انخفاض في معدلات الأداء والكفاءة الغذائية.

لم تظهر تراكم جسم الأسماك من المادة الجافة، البروتين، الدهن والرماد فروق معنوية (0.05 %) بين جميع العلائق المختبرة ولم تختلف خواص دم الأسماك المغذاة على العلائق المختلفة فيما بينها.

وخلصت الدراسة إلى أنه يمكن إحلال 75% من مسحوق جلوتين الذرة محل مسحوق الأسماك في علائق اسماك البلطي بدون تأثيرات معاكسة على معدلات الأداء ، الكفاءة الغذائية و خواص الدم علاوة على استخدام مصدر بروتين نباتي بديل لتقليل نسبة استخدام مسحوق السمك مرتفع الثمن.