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EFFECT OF CHROMIUM CHLORIDE ON THE UTILIZATION OF BROKEN MACARONI IN BLUE TILAPIA, *Oreochromis aureus*, DIET.

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SUMMARY

A 5x2 factorial experiment with two replicates for each combination was conducted on blue tilapia, *Oreochromis aureus* (8.4±0.3 g/fish) for 12 weeks in 20 concrete tanks (3 × 1 × 1 m in diameter) to evaluate the use of broken macaroni (BM) as a carbohydrate source at 5 levels and chromium chloride ($CrCl_3$) supplementation at 2 levels. Five isocaloric (approximately 453.62 gross kcal gross energy/100 g) and isonitrogenous (32% crude protein) rations containing various levels of BM, 0 (control), 25, 50, 75 and 100% with or without $CrCl_3$ were formulated. Fish were fed at a rate of 3 % live body weight per day for six days a week for 12 weeks. The results demonstrated that $CrCl_3$ had positive effects on growth performance and feed utilization compared to diets free of $CrCl_3$. Irrespective of $CrCl_3$ supplementation, BM showed good potential as a carbohydrate source with significant ($P<0.05$) positive effects on growth and feed efficiency. The interaction of $CrCl_3$ and BM level was in favor of fish fed the diet of 100% BM without $CrCl_3$ and all levels of BM supplemented with $CrCl_3$ compared to fish fed other diets since growth performance and fed utilization were significantly ($P<0.05$) improved. Except for crude protein and ether extract percentages, other carcass composition assessments were not affected by BM levels, $CrCl_3$ or their interaction in the diets. The simple economical evaluation revealed that the best profit margin exhibited by fish fed the diet containing 100% BM without $CrCl_3$ as well as 75 or 100% BM with $CrCl_3$. Finally, the present results suggested the potentiality of using BM as a good source for carbohydrate with $CrCl_3$ supplementation without any adverse effect on growth or feed utilization of blue tilapia cultured in concrete tanks.

Keywords: blue tilapia, broken macaroni, chromium chloride, growth, feed utilization, Body composition, Economic evaluation.

INTRODUCTION

Increasing aquaculture production can only be sustained with a concomitant increase in the production of aquafeeds. Presently, the protein source of choice in most aquafeeds is fish meal. Global fish meal production has remained relatively static over the past two decades, and there is no evidence to suggest that it will increase in future (Naylor *et al.*, decades, and there is no evidence to suggest that it will increase in future (Naylor *et al.*, 2000). One of the reasons proposed for the higher dietary protein requirements of fish compared to terrestrial animals is that fish catabolise protein as an energy source rather than depositing it as growth (Halver, 1989). In terms of kilocalories of energy supplied, protein is the most expensive source of energy and thus the aim in fish feeds is to maximize the utilization of protein for growth by supplying adequate amounts of alternative dietary energy source (Shiau and Huang, 1990). Therefore, one of the challenges which face fish nutritionists is to spare expensive dietary protein with inexpensive non-protein energy such as carbohydrate (El-Husseiny *et al.* 1993; Deng *et al.*, 2005; Pantazis, 2005). Supporting this theory, carbohydrates are the most economical source of dietary energy for terrestrial animals. Consequently, carbohydrate content influences fish food costs due to its relatively low prices and higher abundance (Yengkokpam *et al.*, 2005). Of all the plant energy source feedstuffs, yellow corn is considered to be the most nutritious and is used as the major carbohydrate source in many fish diets. Due to the high demand for yellow corn caused by competition for its use as human food and industrial raw material, it is becoming scarcer and more expensive (Christopher *et al.*, 2007). Large proportion of yellow corn used in Egypt is imported. As a result, increase in the international price for yellow corn is reflected in higher cost of fish feed and ingredient This, encourages giving production of local and non-conventional ingredients primary importance (Ghazalah, *et al.*, 1998). On the other hand, considerable amounts of broken macaroni result from macaroni factories in Egypt. This by-product has no value as human food, some amounts are used in poultry feeding. Although these by-product have a high nutritional value, they were not exploited in fish feed. El-Husseiny *et al.* (1993) found that no significant ($P > 0.05$) differences in the final body weight, specific growth rate, feed intake and feed conversion ratio of Nile tilapia when fed on three carbohydrate sources (broken macaroni, yellow corn and crude starch). It was found that increasing the utilization of carbohydrate by fish, chromic oxide and chromium chloride ($CrCl_3$) improved the utilization of glucose. It has also been reported that dietary Cr supplements as chromic oxides (Shiau and Chen, 1993; Shiau and Liang, 1995; Shiau and Shy, 1998) and $CrCl_3$ (Shiau and Lin, 1993) significantly ($P<0.05$) increased weight gain, feed intake, protein and energy retention, as well as liver glycogen level, in hybrid tilapia fed diets containing high levels of glucose. Otherwise, chromic oxide markedly increased glucose utilization than that caused by dietary supplementation with other forms of chromium, including $CrCl_3$ (Shiau and Chen, 1993). On the other hand, in most aquaculture operations today, the cost of food accounts for one-half of the production cost of fish. This means that small reductions in the cost of feed can make aquaculture enterprises more profitable. However, the costs of feed cannot be compromised with decreased amounts of essential nutrients, nutrients availability, or unbalanced composition of nutrients. The requirements for optimum growth, survival and health of animals set the limits of "economic" diet formulation. The purpose of the present study therefore is to assess the feasibility of the incorporation value of various broken macaroni levels as unconventional carbohydrate source in the diet of blue tilapia and the effect of $CrCl_3$ on the utilization of this alternative carbohydrate source.

MATERIALS AND METHODS

The experiment was carried out at the experimental Fish Farm, Faculty of Agriculture - Saba Basha (the 10th Village, Abbis) Alexandria University.

Fish and culture facilities:

The feeding trial was conducted in twenty rectangle concrete tanks (each 3m × 1m × 1 m). Blue tilapia, *Oreochromis aureus*, fingerlings were obtained from the Experimental Fish Farm, Agriculture Faculty, Saba Basha, the 10th Village, Abbis, Alexandria. Fish were randomly allocated at a stocking rate of 30 fish per tank with two replicate tanks for each experimental diet, and acclimatized to the experimental conditions for 7 days. Individual fish from each replicate were weighed at the start of the study (average initial weight was 8.4±0.3 g/fish). About one third of water per each replicate was changed daily via continuous irrigation pipe and drainage pipe adapted to the same water flow rate. Water was completely changed biweekly, at the same time the tanks were carefully cleaned before refilling them with water. Water level was maintained at 0.8 m in height throughout the experimental period, water temperature was checked daily, and ranged between 21 – 27° C. Dissolved oxygen was checked daily in the morning and afternoon.

Experimental diets:

Ingredients used in the study were purchased from the local market. Dry ingredients were first ground to fine particles. The experiment was a designed as completely random factorial with 5 macaroni levels and 2 chromium chloride levels with two replicates for each level combination. The five macaroni levels were isonitrogenous (32 % crude protein) and isocaloric (453.62 kacl gross energy/100) (0, 25, 50, 75 and 100 % replacement of yellow corn). The two chromium chloride ($CrCl_3$, Fine-EHEM limited, Mumbai 400 030, India) levels were none or 2 mg/Kg diet as referred by Pan *et al.* (2003). All diets covered the minimum requirement of all essential nutrients to satisfy the needs of Nile tilapia (NRC, 1993). The diets were prepared by mixing the dry ingredients and oil, followed by the addition of warm water (45° C) and $CrCl_3$ until stiff dough was obtained. The moist diet was passed through a mincer with a 2 mm die. The resulting pellets were then dried at 60° C in a drying oven for 24 hrs. The diets were stored in plastic bags under ambient conditions over the experimental period. Fish were fed two times daily at a fixed feeding rate of 3 % body weight per day (dry matter basis) for 12 weeks (6 days a week). Subsequently, fish from each replicate were weighed at fortnightly intervals during the experimental period and the daily amounts of feeds were readjusted to be 3% of live body weight.

Samples collection and analysis:

Both yellow corn and broken macaroni were analyzed for proximate composition prior to the formulation of diets. At the beginning of the trial, 25 fish were taken and at the end of the trial 5 fish per tank were taken along with the five experimental diets as samples to determine the chemical composition according to AOAC (1999) standard procedures. Otherwise, at the termination of the experiment, fish were collected, weighed and counted per each replicate in each treatment. Nutrition parameters were calculated according to Hepher (1988). Hepatosomatic index (HSI) was calculated as reported earlier (Lone and Matty, 1980). All data were statistically analyzed with ANOVA, and examined by linear regression modeling using SAS package for the IBM-PC (SAS User's Guide, 1988). Duncan's multiple range tests were used to resolve the differences between treatment means (Steel and Torrie, 1980). Differences between treatment means were considered significant at ($P<0.05$).

RESULTS AND DISCUSSION

Results presented in (Table 1) show the chemical composition of yellow corn and broken macaroni (BM) used in experimental diets formulation. BM contained higher contents of crude protein (CP %), ether extract (EE %) and gross energy (kcal/100 g dry matter) compared to yellow corn. Whereas, yellow corn contained higher percentages of dry matter (DM), ash, crude fiber (CF) and nitrogen free extract (NFE) compared to BM.

Table (1): Chemical composition of yellow (YC) corn and broken macaroni (BM).

Ingredients	DM	Composition (%), on DM basis					GE*
		CP	EE	Ash	CF	NFE	
Yellow corn	90.50	7.50	4.60	1.30	2.30	84.30	432.2
Broken macaroni	88.10	14.18	15.80	0.79	0.45	83.00	570.3

DM = Dry matter; CP = Crude protein; EE = Ether extract; CF = Crude fiber and NFE = Nitrogen free extract.
*Gross energy (kcal/100g DM), calculated on the basis of 5.64, 4.11 and 9.44 kcal GE/g CP, NFE and EE, respectively (NRC, 1993).

Results of formulation and chemical composition of diets are shown in Table 2. All diets were isocaloric (about 453.62 Kcal/100 g dry matter) and isonitogenous (32.1 % crude protein). The mean value of CP to gross energy ratio (P:E ratio) was 70.77 mg CP/kcal gross energy. As the incorporation level of BM in the diets increase, ether extract (EE) and ash (%) decreased. Meanwhile, nitrogen free extract and crude fiber (%) were slightly incremented.

Table (2): Formulation and composition of the experimental diets (%) containing different levels of broken macaroni with or without chromium chloride.

Item	Broken macaroni (%)				
	0	25	50	75	100
Fish meal	18.0	18.0	18.0	18.0	18.0
Soy bean meal	47.0	44.5	43.0	41.5	39.0
Yellow corn	24.0	18.0	12.0	6.0	0.0
Broken macaroni	0.0	6.0	12.0	18.0	24.0
Wheat bran	4.1	7.8	10.6	13.3	17.0
Vegetable oil	4.9	3.7	2.4	1.2	0.0
V&M[1]	2.0	2.0	2.0	2.0	2.0
Total	100.0	100.0	100.0	100.0	100.0
Proximate composition (%):					
Dry matter	88.70	89.24	89.02	88.97	88.83
On dry matter basis (%):					
CP[3]	32.0	31.9	32.1	32.3	32.2
EE[3]	12.1	11.6	11.0	10.4	9.8
NFE[3]	38.6	40.0	41.1	42.2	43.6
CF[3]	5.1	5.2	5.4	5.5	5.6
Ash	12.2	11.3	10.4	9.6	8.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
GE[3]	453.35	453.82	453.81	453.79	453.32
P:E ratio[2]	70.59	70.29	70.74	71.18	71.03

Experimental diets were supplemented with zero or 2 mg $CrCl_3$/kg diet (Pan *et al.*, 2003)
[1]Vitamin & Mineral (Mevečo premix) every 1.5 kg contains Vit. A 5 million IU, D_3 3 million IU, E 15 g, K_3 2.5 g, B_1 1.5 g, B_2 5 g, B_6 2 g, Pantothenic acid 10 g, B_{12} 0.01g, Nicotenic acid 30 g, , Folic acid 1.2 g, Fe 30 g, Mn 60 g, Cu 10 g, I1 g, Cobalt 0.25 g, Se 10 g and Zn 55 g.
[2]P to gross energy ratio (mg/Kcal)
[3]Appreciations as footnoted in Table (1).

The growth response and performance data of blue tilapia (*O. aureus*) fed diets containing various levels of BM with or without $CrCl_3$ are presented in Table 3. Growth performance in terms of final weight (g/fish), gain (g/fish), average daily gain, (ADG, mg/fish) and specific growth rate (SGR, %/day) were significantly (P<0.05) higher in fish receiving diets with $CrCl_3$ than those receiving diets without $CrCl_3$. Regarding the effect of BM levels on growth performance, insignificant (*P* >0.05) differences were observed among groups of fish receiving diets with 25, 50, and 75% BM which were better than the control and lower than diet containing 100% BM. However, the group fed 100% BM surpassed significantly (P<0.05) that fed the control diet in growth performance. Results of interaction revealed that fish groups fed diets containing 0, 75 and 100% BM with $CrCl_3$ achieved insignificantly higher growth performance. However, fish fed diet containing 0% BM without $CrCl_3$ achieved insignificantly the lowest values compared to other treatments. Table 4 shows that there is a positive correlation between BM levels (with or without $CrCl_3$ supplementation) and growth parameters (final weight, weight gain, ADG and SGR).

Table (3): Growth performance of blue tilapia (*O. aureus*) fed different levels of broken macaroni (BM) with or without chromium chloride.

Item	Initial weight (g/fish)	Final weight (g/fish)	Gain[1] (g/fish)	ADG[2] (mg/fish)	SGR[3] %/day
Chromium chloride ($CrCl_3$)					
With	8.4	72.80^a	64.40^a	770^a	2.57^a
Without	8.4	65.20^b	56.80^b	680^b	2.44^b
Broken macaroni level, % (BM)					
0	8.4	66.75^b	58.35^b	690^b	2.46^b
25	8.4	67.75^{ab}	59.35^{ab}	720^{ab}	2.48^{ab}
50	8.4	68.75^{ab}	60.35^{ab}	720^{ab}	2.50^{ab}
75	8.4	69.00^{ab}	60.60^{ab}	720^{ab}	2.50^{ab}
100	8.4	72.75^a	64.35^a	770^a	2.57^a
Interaction $CrCl_3$ × BM					
Diets*					
1	8.4	75.50	67.10	800	2.61
2	8.4	69.50	61.10	730	2.52
3	8.4	70.00	61.60	730	2.52
4	8.4	75.50	67.10	800	2.61
5	8.4	73.50	65.10	780	2.58
6	8.4	58.00	49.60	590	2.30
7	8.4	66.00	57.60	690	2.45
8	8.4	67.50	59.10	710	2.48
9	8.4	62.50	54.10	640	2.38
10	8.4	72.00	63.60	760	2.56
$LSD_{0.05}$		7.48	7.48	90	0.16

Means in the same column within each item having different superscript are significantly different (*P* < 0.05).

Diets 1, 2, 3, 4 and 5 contained 0, 25,50,75 and 100 % BM, respectively with $CrCl_3$ supplementation.
Diets 6,7,8,9 and10contained 0,25,50,75 and 100 %BM, respectively without $CrCl_3$ supplementation.

[1]Gain (g/fish) = Final wt., g. – Initial wt., g.

[2]Average daily gain (mg/fish) = (Final wt. – Initial wt.) / period (days).

[3]Specific growth rate (%/day) = 100 (ln final weight–ln initial weight) / time (days).

Table (4): Linear regression of growth performance parameters (y) of dietary macaroni inclusion level (x) supplemented with or without $CrCl_3$.

Item	With $CrCl_3$	Without $CrCl_3$
Final weight	y = 72.4+0.008x	y = 60.3+0.098x
Weight gain	y = 64+0.008x	y = 51.9+0.098x
ADG*	y = 0.762+9.400x	y = 0.618+0.001x
SGR*	y = 2.564– 0.001x	y = 2.355+0.001x

*Abbreviations as footnoted in Table 3.

The effect of various inclusions of BM with or without $CrCl_3$ in the diet on feed and nutrient utilization of blue tilapia is shown in Table 5. Chromium chloride had no effect on feed intake and energy utilization (EU, %) of blue tilapia. Fish groups fed diets with $CrCl_3$ achieved significantly ($P<0.05$) better FCR, PER and PPV compared to those fed diets without $CrCl_3$. Concerning BM levels, utilization of blue tilapia was not significantly ($P > 0.05$) affected by different levels of BM. In relation to interaction, fish fed diet containing 0% BM without $CrCl_3$ consumed insignificantly lower feed than other groups while insignificantly higher feed was recorded by group fed diet containing 100% BM with $CrCl_3$. Worst values of FCR, PER, PPV and EU were obtained by group fed 0% BM without $CrCl_3$. Meanwhile, better insignificant values of FCR, PER and PPV were obtained by groups fed diets containing 0, 25, 50, 75 and 100% BM with $CrCl_3$ or fish that fed a diet containing 100 of BM without $CrCl_3$. However, better assessment of EU was attained by fish groups fed diets containing 0, 25, 50, 75 and 100% BM with $CrCl_3$ or those groups fed diets containing 25 and 100 of BM without $CrCl_3$. As summarized in Table 6, positive correlations were observed between BM levels (with or without $CrCl_3$ supplementation) and feed and nutrient utilization (feed intake, FCR, PER, PPV and EU).

Carcass proximate analysis results (%) and hepatosomatic index (HSI) are summarized in Table 7. Both of $CrCl_3$ and different BM levels and the interaction between them had no significant effect on the dry matter, ash, energy contents and HSI of tested fish. However, fish fed diets with $CrCl_3$ had significantly ($P<0.05$) higher protein and lower ether extract as compared to fish fed diets without $CrCl_3$. Concerning BM levels effect, significantly ($P < 0.05$) higher protein and lower ether extract percentages were shown by groups receiving diets containing 50, 75 and 100% BM with insignificant ($P >0.05$) differences between each other. Results of the interaction revealed that feeding fish groups diets containing different levels of BM with or without $CrCl_3$ had no effect on body dry matter, ash, energy contents and HSI. However, fish fed diet with 100% BM with $CrCl_3$ gained insignificantly higher percentages of protein and lower ether extract in their bodies compared to other groups. Notably, the insignificantly lower protein and higher ether extract percentages were recorded by fish fed diet containing 0% BM without $CrCl_3$. On the other hand, Table 8 reveals a positive correlation between BM levels (with or without $CrCl_3$ supplementation) and carcass composition as well as HSI.

Table (5): Feed and nutrient utilization of blue tilapia (*O. aureus*) fed different levels of broken macaroni with or without chromium chloride.

Item	Feed intake (g/fish)	FCR[1]	Feed utilization		Energy utilization[4] (%)
			PER[2]	PPV[3] (%)	
Chromium chloride ($CrCl_3$)					
With	109.97[a]	1.71[a]	1.83[a]	26.73[a]	16.59[a]
Without	105.81[a]	1.88[b]	1.68[b]	24.27[b]	15.46[a]
Broken macaroni level, % (BM)					
0	103.97[a]	1.81[a]	1.75[a]	25.12[a]	16.12[a]
25	104.42[a]	1.76[a]	1.78[a]	25.55[a]	16.15[a]
50	111.62[a]	1.85[a]	1.69[a]	24.66[a]	15.35[a]
75	109.42[a]	1.82[a]	1.71[a]	25.18[a]	15.75[a]
100	110.04[a]	1.72[a]	1.82[a]	26.99[a]	16.74[a]
Interaction $CrCl_3$ × BM					
Diets*					
1	108.35	1.62	1.94	28.16	17.87
2	106.78	1.75	1.79	25.78	16.09
3	107.12	1.74	1.79	26.25	16.21
4	111.39	1.66	1.87	27.57	17.02
5	116.23	1.79	1.74	25.89	15.78
6	99.58	2.01	1.56	22.08	14.38
7	102.05	1.77	1.77	25.31	16.22
8	116.12	1.97	1.59	23.08	14.50
9	107.45	1.99	1.56	22.79	14.49
10	103.85	1.64	1.91	28.09	17.70
$LSD_{0.05}$	10.90	0.21	0.22	3.52	2.15

Means in the same column within each item having different superscript are significantly different ($P < 0.05$).

*Diets 1, 2, 3, 4 and 5 contained 0, 25, 50, 75 and 100 % BM, respectively with $CrCl_3$ supplementation.

Diets 6, 7, 8, 9 and 10 contained 0, 25, 50, 75 and 100 % BM, respectively without $CrCl_3$ supplementation.

[1]Feed conversion ratio: total dry diet fed (g)/total wet weight gain (g).

[2]Protein efficiency ratio: wet weight gain (g)/amount of protein fed (g).

[3]Protein productive value (%): $(P-P_0)\ 100/P_i$ where P is protein content in fish carcass at the end of the experiment, P_0 is the protein content in fish carcass at the start of the experiment and P_i is the protein in feed intake.

[4]Energy utilization (%): $(E-E_0)\ 100/E_i$ where E is the energy in fish carcass (kcal) at the end of the experiment, E_0 is the energy in fish carcass (kcal) at the start of the experiment, and E_i is the energy in feed intake (Kcal).

Table (6): Linear regression of feed and nutrient utilization parameters (y) of dietary macaroni inclusion level (x) supplemented with or without $CrCl_3$.

Item	With $CrCl_3$	Without $CrCl_3$
Feed intake	$y = 105.9+0.081x$	$y = 102.991+0.056x$
FCR*	$y = 1.658+0.001x$	$y = 1.987-0.0021x$
PER*	$y = 1.888-0.0012x$	$y = 1.577+0.0019x$
PPV*	$y = 27.276-0.011x$	$y = 22.369+0.038x$
EU*	$y = 17.243-0.013x$	$y = 14.472+0.02x$

*Abbreviations as footnoted in Table 5.

Table (7): Proximate body composition and hepatosomatic index (HIS) of blue tilapia (*O. aureus*) fed different levels of broken macaroni with or without chromium chloride.

Item	Dry matter	On dry matter basis (%) Crude protein	Ether extract	Ash	Gross energy[1]	HSI[2]
Chromium chloride ($CrCl_3$)						
With	26.98[a]	53.75[a]	18.38[b]	27.87[a]	476.66[a]	2.72[a]
Without	27.16[a]	52.81[b]	19.29[a]	27.90[a]	479.95[a]	2.66[a]
Broken macaroni level, % (BM)						
0	27.15[a]	52.50[b]	19.67[a]	27.83[a]	481.83[a]	2.55[a]
25	26.88[a]	52.95[b]	19.25[a]	27.80[a]	480.36[a]	2.53[a]
50	27.05[a]	53.45[a]	18.50[b]	28.05[a]	476.10[a]	2.75[a]
75	27.13[a]	53.60[a]	18.53[b]	27.87[a]	477.18[a]	2.83[a]
100	27.15[a]	53.90[a]	18.23[b]	27.87[a]	476.04[a]	2.80[a]
Interaction $CrCl_3$ × BM						
Diets*						
1	27.2	53.05	19.25	27.70	480.92	2.55
2	26.7	53.50	18.85	27.65	479.69	2.55
3	27.0	53.70	18.20	28.10	474.68	2.75
4	27.1	54.00	17.95	28.05	474.01	2.75
5	27.0	54.50	17.65	27.85	474.00	3.05
6	27.1	51.95	20.10	27.95	482.74	2.55
7	27.1	52.40	19.65	27.95	481.04	2.50
8	27.1	53.20	18.80	28.00	477.52	2.75
9	27.2	53.20	19.10	27.70	480.36	2.85
10	27.3	53.30	18.80	27.90	478.09	3.00
$LSD_{0.05}$	NS	0.67	0.85	NS	NS	NS

Means in the same column within each item having different superscript are significantly different ($P < 0.05$).

*Diets 1, 2, 3, 4 and 5 contained 0, 25, 50, 75 and 100 % BM, respectively with $CrCl_3$ supplementation.

Diets 6, 7, 8, 9 and 10 contained 0, 25, 50, 75 and 100 % BM, respectively without $CrCl_3$ supplementation.

[1]Gross energy (Kcal/100 g dry matter), calculated on the basis of 5.64, 4.11 and 9.44 Kcal GE/g CP, NFE and EE, respectively (NRC, 1993).

[2]Hepatosomatic index: (liver weight / total body weight) ×100

Table (8): Linear regression of carcass composition parameters (y) of dietary macaroni inclusion level (x) supplemented with or without $CrCl_3$.

Item	With $CrCl_3$	Without $CrCl_3$
DM	y = 26.98 –7.207x	y = 17.06+0.002x
CP	y = 53.01– 0.014x	y = 52.11+0.014x
EE	y = 19.2– 0.016x	y = 19.92– 0.013x
Ash	y = 27.73+0.104x	y = 27.97–0.0014x
GE	y = 480.662– 0.08x	y = 481.945– 0.04x
HIS	y = 2.49– 0.0048x	y = 2.48+0.005x

Results of the simple economic evaluation in terms of feed cost (Dollar/ton feed), amount of feed/kg gain, cost of kg fish gain (Dollar) and changes in feed cost/kg gain (%) compared to the control group of blue tilapia (*O. aureus*) fed different levels of BM with or without $CrCl_3$ under concrete tanks culture are presented in Table 9. Fish fed diet containing 100% BM without $CrCl_3$ exhibited the highest change in feed cost/kg gain (-11.79%) followed by that fed diet containing 75% BM with $CrCl_3$ (-7.18%) compared to fish fed other diets. The lowest change in feed cost/kg gain (%) was in favor of fish group receiving diet containing 100% BM with $CrCl_3$ (-3.64%) compared to other treatments. Comparatively, the analyses indicated that the best profit margin would be achieved with diet containing 100% BM without $CrCl_3$ as well as 75 or 100% BM with $CrCl_3$ for production blue tilapia in concrete tanks.

Table (9): Cost of feed (Dollar/ton feed) required and change in feed cost/kg gain (%) compared to control for production one kg gain of blue tilapia (*O. aureus*) fed different levels of broken macaroni (BM) with or without $CrCl_3$ under concrete tanks culture.

Diets*	Feed cost (Dollar /ton feed)	Amount of feed/kg gain	Cost of kg fish gain (Dollar)	Change in feed cost/kg gain (%) compared to control
1	575.92	1.62	9.33	-
2	556.62	1.75	9.74	4.39
3	538.63	1.74	9.37	0.43
4	521.35	1.66	8.66	-7.18
5	502.10	1.79	8.99	-3.64
6	575.86	2.01	11.58	24.12
7	556.56	1.77	9.85	5.57
8	538.58	1.97	10.61	13.72
9	521.29	1.99	10.37	11.15
10	502.00	1.64	8.23	-11.79

Diet No. 1used as a base for calculation

*Diets 1, 2, 3, 4 and 5 contained 0, 25, 50, 75 and 100 % BM, respectively with $CrCl_3$ supplementation.

Diets 6, 7, 8, 9 and 10 contained 0, 25, 50, 75 and 100 % BM, respectively without $CrCl_3$ supplementation.

Cost in Dollar /ton: Fish meal: 1454.545, Soybean meal: 418.1818, Yellow corn: 236.3636, broken macaroni: 136.3636, Wheat bran: 218.1818, Vegetable oil: 909.0909 and Min. & Vit.: 363.6364 (Price of November, 2008).

The rapidly expanding aquaculture industry requires increasing amount of formulated feed. Currently, global feed production for farmed fish is approximately 13 million tons, and it is predicted that the world feed production will increase to over 37 million tons by the year 2010 (Barlow, 2000). To achieve the forecast production, a consistent supply of feed ingredients would be required (Tacon, 2003). Therefore, alternative feed ingredient sources for fish should be found. Plant sources have been identified to have the greatest potential to be used with wide percentages in fish feeds. However, plant ingredients contain significant quantities of carbohydrates (Stone, 2003 and Deng *et al.*, 2005). The ability of fish to utilize dietary carbohydrates as energy source to spare protein for growth varies, both among and within species (NRC, 1993). The present study was designed to move in two directions the first is to assess BM as alternative and cheaper carbohydrate source and the second is to maximize the utilization of this source by blue tilapia via adding $CrCl_3$to the experimental diet. The results indicated that adding $CrCl_3$ to blue tilapia diet enhanced growth performance and feed utilization. Chromium, an organic and low-toxicity form of trivalent chromium, is an essential element for optimum carbohydrate, lipid, protein and nucleic acid metabolisms (Anderson 1987; McCarty 1991 and Mertz 1993), as well as for activating certain enzymes. The primary role of Cr in metabolism is to potentiate the action of insulin (Steele *et al.* 1977 and Küçükbay *et al.*, 2006). It has been reported that dietary Cr leads to improved insulin binding, therefore normalizing blood glucose levels (Anderson *et al.* 1996). Dietary Cr supplementation has also a positive effect on growth rate and feed efficiency in rats and poultry (Anderson 1987; Cupo and Donaldson 1987; NRC 1997 and Lien *et al.* 1999). In addition, supplemental dietary chromium has also been reported to decrease mortality and alter glucose metabolism in fish (NRC 1997). The obtained results in this research are in partial agreement with these studies showing that chromium supplementation of diets resulted in significant ($P<0.05$) increases in weight gain, energy deposition, and liver glycogen in several fish species (CAN, 1997), and that chromium supplementation of blue tilapia diets had no effect on energy contents. Perhaps this variation may be due to fish species used in the mentioned study. However, the present results are in complete agreement with observations achieved by Shiau (1997), Shiau and Shy (1998) and Pan *et al.* (2003) on $CrCl_3$, chromic oxide and chromium picolinate, respectively. On the other hand, the present study reflected the ability of BM to replace yellow corn without any reduction in growth performance and feed utilization. This result might be attributed to the similarity of chemical composition of yellow corn and BM used in the present study (Table 1). Moreover, the growth performance of fish fed diet containing 100% BM surpassed that of control group. The surpassing of this level of BM upon yellow corn may due to the manufacturing process of macaroni that depends on exposing the ingredients to a considerably higher heat (extruded). Since, heat treatment is known to improve carbohydrate utilization by animals, and most fish species studied can utilize cooked carbohydrate better than raw (NRC, 1993; Hemre *et al.*, 2002; Venou *et al.*, 2003 and Zimonja and Svihus, 2008). Additionally, application of severe treatments such as extrusion may be beneficial for deactivation of alpha-amylase inhibitors and other anti-nutritional factors present in some feed ingredients (Saunders, 1975 and Barrows *et al.*, 2007). Extrusion improved also protein and lipid digestibility (Venou *et al.* 2003 and Sun *et al.*, 2006). Results of BM compared to diet free of BM are in accordance with observations by Francis *et al.* (2001) who found a positive effect of extrusion on digestibility of all nutrients and attributed that to the partial degradation of anti-nutritional factors present in some fish feed ingredients. As observed in the present study, the effect of different BM levels on feed and nutrient utilization was insignificant, these are incongruous with findings of Tran-Duy *et al.* (2008). Additionally, the results of the current study on the effect of $CrCl_3$ on blue tilapia carcass composition are in harmony with a study reported by Pan *et al.* (2003) on the effect of chromium picolinate on growth and carbohydrate utilization in tilapia, *O. niloticus* × *O. aureus*. In the current study fish receiving diets containing 50, 75 and 100 % BM gained higher protein and lower ether extract contents. Otherwise, carcass dry matter, ash, energy contents did not differ by different dietary BM treatments. These results are in partial agreement with observations reported by El-Husseiny *et al.* (1993). In relation to the interaction between $CrCl_3$ and BM, the combination of them resulted in higher fish growth performance and feed utilization. On the other hand, information on the effect of $CrCl_3$ and BM on growth performance, feed utilization and carcass composition need further investigation.

CONCLUSION

The incorporation of BM as carbohydrate source, as a replacement of yellow corn, with $CrCl_3$ supplementation in practical fish diet offers a potential to maximize growth and feed utilization of blue tilapia culture in concrete tanks.

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تأثير كلوريد الكروميوم على الاستفادة من كسر المكرونة فى عليقة البلطى الحسانى

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اجريت تجربة عاملية ٥ × ٢ بمكررتين لكل معاملة على اسماك البلطى الحسانى (ذات وزن ابتدائى ٨,٤±٠,٣ جم/سمكة) لمدة ١٢ أسبوع في ٢٠ حوض أسمنتي ذو أبعاد ٣ × ١ × ١ متر وذلك بغرض تقييم استخدام كسر المكرونة كمصدر للكربوهيدرات عند خمس مستويات وقد تم إضافة كلوريد الكروميوم بمستويين. تم تكوين خمس علائق حيث كانت متساوية فى الطاقة الكلية (٤٥٣,٦٢ كيلو كالورى/١٠٠ جم من المادة الجافة للعليقة) وأيضا فى نسبة البروتين (٣٢ ٪) وتحتوى على مستويات مختلفة من كسر المكرونة هى صفر (معاملة معيارية) و٢٥ و٥٠ و٧٥ و١٠٠ ٪ مع المعاملة أو بدون المعاملة بكلوريد الكروميوم. غذيت الأسماك بمعدل ٣ ٪ من الوزن الحى لمدة ستة أيام أسبوعيا خلال ١٢ أسبوع هى مدة التجربة. وقد أشارت النتائج إلى التأثير الإيجابى لكلوريد الكروميوم على كفاءة النمو والاستفادة من الغذاء فى الأسماك مقارنة بالتغذية على العلائق التى لا تحتوى على كلوريد الكروميوم. وبغض النظر عن إضافة كلوريد الكروميوم، فقد أظهر كسر المكرونة أيضا مردود إيجابى كمصدر للكربوهيدرات فى العليقة على النمو والاستفادة من الغذاء. أما فيما يتعلق بالتداخل بين مستويات كسر المكرونة وكلوريد الكروميوم، فقد حققت الأسماك التى غذيت على علائق تحتوى على ١٠٠ ٪ من كسر المكرونة بدون إضافة كلوريد الكروميوم وجميع مستويات كسر المكرونة التى تم إضافة كلوريد الكروميوم لها أفضل النتائج حيث حازت هذه الأسماك على مستويات افضل من النمو والاستفادة من الغذاء مقارنة بالأسماك التى تم تغذيتها على العلائق الأخرى. وقد تأثر جوهريا محتوى جسم الأسماك من البروتين والدهون، بينما لم تتأثر باقى مكونات جسم الأسماك نتيجة المعاملات المختلفة. وقد أظهر التقييم الإقتصادى أن افضل العلائق اقتصاديا تلك التى تحتوى على ١٠٠ ٪ من كسر المكرونة بدون إضافة كلوريد الكروميوم وتلك التى تحتوى ٧٥ أو١٠٠ ٪ من كسر المكرونة مع إضافة كلوريد الكروميوم. وأخيرا اقترحت النتائج إمكانية استخدام كسر المكرونة كمصدر للكربوهيدرات مع إضافة كلوريد الكروميوم بدون إحداث نتائج عكسية على كفاءة النمو والاستفادة من الغذاء فى علائق البلطى الحسانى المستزرع فى أحواض أسمنتية.