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GROWTH PERFORMANCE, BLOOD CONSTITUENTS AND THYROID HORMONS IN NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FED DIETS CONTAINED CANOLA MEAL AND SUPPLEMENTED WITH YEAST STRAINS

(With 4 Tables & 3 Figures)

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النمو ومكونات الدم وهرمونات الغدة الدرقية فى البلطى النيلى الذى غذى على علائق احتوت على كسب الكانولا مع إضافة سلالات من الخميرة

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صممت تجربة عاملية (٤×٤) لتقييم تأثير استبدال مسحوق السمك بكسب الكانولا في العلائق المضاف إليها ثلاث عترات من الخميرة على النمو ومكونات الجسم وبعض مكونات الدم في البلطي النيلي. استخدم لهذه التجربة ٦٤٠ سمكة بمتوسط وزن ٣,٥٨ ±١,٣١جم وطول ٥,٧٦±٠,٧٠سم واستمرت التجربة لفترة ١٢ أسبوع. تم تكوين ١٦ علبقة تحتوى على ١٥، ٣٠، ٤٥، ٦٠% كسب الكانولا مع ثلاث عترات من الخميرة (Y- 7 ، G1 ، G4). تم وزن الأسماك كل على حدة وتم حساب الزيادة فى الوزن (BWG)، معدل تحويل الغذاء (FCR) ، معامل الحالة الجسمية (K-value) ، معدل النمو (SGR) . وبعد ١٢ أسبوع تم أخذ عينات دم من الأسماك تحت الدراسة وذلك لتقدير تركيز الهيموجلوبين والمكونات الخلوية في الدم ومحتويات السيرم من البروتين الكلى، والألبيومين، الجلوكوز، الكوليسترول، وأنزيمات الكبد (AST، ALT) وهرمونات الدرقية (T_3 و T_4). وتم تحليل مكونات الجسم من المادة الجافة من البروتين الخام، الدهن الخام، والرماد ودهن الكبد. وأوضحت النتائج أنه ليس هناك اختلافات معنوية في كل من الزيادة في الوزن ، معدل تحويل الغذاء ومعدل النمو (SGR) بين مجموعة الكنترول والمجموعات المغذاة على علبقة كسب الكانولا. وأن

التغذية بالخميرة أو الخميرة مع كسب الكانولا أدى إلى تحسين فى معدلات النمو والكفاءة التحويلية للغذاء.وجدير بالذكر أن استبدال مسحوق السمك بواسطة كسب الكانولا حتى مستوى ٦٠% ليس له تأثير معنوي على محتويات الجسم من المادة الجافة، البروتين الخام، الدهن الخام والرماد. في حين إن إضافة الخميرة في الغذاء أدت إلى زيادة ($P<0.01$) البروتين الخام ونقص ($P<0.01$) الدهن الخام في الجسم. وأيضا كان هناك تأثير معنوي لإضافة الخميرة مع كسب الكانولا على مكونات الجسم.بالإضافة إلى أن زيادة كسب الكانولا في العليقة أدت إلى زيادة ($P<0.01$) في الهيموجلوبين ومحتوى السيرم من البروتين الكلى، الجلوبيولين، الجليسريدات الثلاثية، انزيمات الكبد (ALT، AST) وهرمونات الدرقية (T_3 ، T_4). وأوضحت النتائج أيضا أن إضافة الخميرة إلى العليقة أدت إلى زيادة الهيموجلوبين ومحتوى السيرم من البروتين الكلى والجلوبيولين والجليسرايدات الثلاثية والجلوكوز وأنزيمات الكبد (ALT, AST) وهرمونات الدرقية (T_4 , T_3) . والخلاصة أن العلائق التي احتوت على كسب الكانولا بمستوى يصل الى ٦٠% من العليقة مع إضافة سلالة الخميرة (G4) ليس لها تأثير سلبي على النمو ومكونات الجسم أو مكونات الدم في البلطي النيلي.

SUMMARY

A 4 x 4 factorial experiment was conducted to evaluate the effect of fish meal replacement by canola meal supplemented with different yeast strains on growth performance, body composition and blood constituents in *Oreochromis niloticus*. A total number of six hundred and fourty Nile tilapia, *O. niloticus* were used in a study lasted for 12 weeks. Averages body weight and length were 3.58 ± 1.31g and 5.76 ± 0.70 cm., respectively. Sixteen diets were formulated to contain 15, 30, 45 and 60% canola meal in combination with the strains of 0, Y-7, G1 and G 4 yeast strains (4 levels canola meal x 4 levels yeast). The fish were individually weighed biweekly and body weight gain (BWG), food conversion ratio (FCR), condition factor (K-value) and specific growth rate (SGR) were calculated. After 12 weeks, the fish were killed and blood samples were collected to determine hemoglobin concentration, packed cell volume (PCV), serum total protein, albumin, globulin, triglycerides, glucose, cholesterol, asparatic aminotransferase (AST), alanine aminotransferase (ALT) and thyroid hormones (T_3 and T_4). Fish body composition, dry matter, crude protein, crude fat, ash and liver fat were determined. There were no significant ($P>0.05$) differences in body weight gain (BWG), specific growth rate (SGR), food conversion ratio (FCR) and condition factor (K-value) between the control group and groups fed canola meal levels. Also, an improvement in these previous

parameters were significantly ($P<0.05$) achieved by yeast strains addition.The combination of both canola and yeast improved significantly ($P<0.05$) body weight gain, feed conversion ratio, condition factor and specific growth rate (SGR). Replacement of fish meal by canola meal had no significant ($P>0.05$) effect on fish body composition, dry matter, crude protein, crude fat and ash. However, dietary yeast increased significantly ($P<0.01$) crude protein and significantly decreased ($P<0.01$) crude fat percentage. Also, the interaction between canola meal and yeast was significant ($P<0.01$). Canola meal increased significantly ($P<0.01$) hemoglobin concentration and serum total protein, globulin, triglycerides, AST, ALT and thyroid hormones (T_3 and T_4) concentrations. Dietary yeast strains increased hemoglobin level and serum total protein, globulin, triglycerides, glucose, AST, ALT and thyroid hormones (T_3 and T_4) concentrations. It could be concluded that diets containing up to 60% canola meal supplemented with G4 yeast strain had no adverse effects on growth performance, body composition or blood constituents of *O. niloticus*.

Key words: performance, blood constituents, Nile tilapia, canola and yeast

INTRODUCTION

There is increasing interest in fish farming as means of producing high-quality human food. Tilapia production is expanding rapidly because of the fast growth, use of natural feeds, high reproductive rate and general hardiness characteristics of this species (Purdom, 1993 and Eldar et. al., 1995).

Fish meal is an important ingredient in aquaculture diets because of its high protein quality and palatability (Webster et al., 2000). However, good quality fish meal costs an amount of 40-60 % of total operating costs in the intensive aquaculture enterprises (FAO,1983). Partial or total substitution of more expensive fish meal with less expensive plant protein sources could be one approach to reduce the fish feed costs. In this respect, most of the researchers used soybean meal (SBM) for replacement of fish meal (Lovell, 1988; Kaushik et al., 1995).

Canola is the registered name given to genetically selected varities of rapeseed species that are low in both glucosinolates and erucic acid (Cheeke, 1991). Based on the essential amino acid index, Higgs et al., (1990) reported that the protein quality of canola meal (CM) is

equivalent to that of herring meal and higher than those for SBM and cottonseed meal (CSM). Global supplies of rapeseed/canola protein exceed those of fish meal (Higgs et al., 1996). Recently, the cost of canola meal is less than half that of premium quality fish meal on per kilogram protein basis (Forster et al., 1999). Nowdays there are more efforts to cultivate this plant in large scale in newland cultivation particullary in Toshka as source of oil (El- Morsi et al., 2000). Furthermore, there are some efforts to enhance nutritional value of canola meal as addition of enzymes (Buchanan et al., 1997), while this procedure is more expensive.

On the other side, the use of small amounts of live yeast has been used for more than six decades, it has only recently been based on sound scientific concepts. Dawson (1994) developed a model to explain the actions of yeast cultures in ruminant animals. However, this model may not be characteristic to all strains of *Saccharomyces cerevisiae*. In the past, little attention has been given to types of yeast included in various feed additives. It is clear from many studies on ruminants that responses to yeast are strain dependent, i.e., not all yeast strains have equal abilities to stimulate specific strains of ruminal bacteria. The American Type Culture Collection maintains a collection of over 1000 distinct strains of *Saccharomyces cerevisiae* which can be differentiated using specific biochemical or genetic techniques (Dawson, 1994).

Therefore, this investigation aims at studying the impact of partial replacement of fish meal by canola meal in diets fortified by three strains of yeast on growth performance, body composition and blood constituents of Nile tilapia (*Oreochromis niloticus*).

MATERIAL and METHODS

Fish and Experimental Conditions:

Nile tilapia (*Oreochromis niloticus*) were collected from a culture pond belonging to Animal Production Dept., Faculty of Agriculture, Assiut University. A total of 640 healthy Nile tilapia (3.58 ± 1.31 g body weight, BW and 5.76 ± 0.70 cm. length) were allocated in a flow system consisted of 16 metalic barrels of 200 L capacity. Fourty fish were randomly stocked into each aquarium. The flow system was connected with running water at flow rate of 5 L/h. The experiment lasted for 12 weeks. Water temperature was measured three times daily

which ranged from 24 to 26°C during the experimental period. Fish mortality was also recorded daily.

Test Diets and Feeding Protocol:

Four experimetal diets were formulated from practical ingredients to contain various percentages of canola meal (CM) as partial replacement for fish meal. Canola meal was included at levels of 15, 30, 45 and 60% of the diet. Each diet was supplemented with three liquid cultures of yeast strains specific in vitamin B_6 production (Abd El-Latif, 1999), namely, Y-7, G1 and G4. The yeast cultures contained 689, 850 and 1530 µg B_6/ml for Y-7, G1 and G4, respectively. The combination between CM level (15, 30, 45 and 60%) and yeast supplementation (0, Y-7, G1 and G4) resulted in 16 experimental diets.

In preparing 1 kg of diet, dry ingredients were ground and thoroughly mixed. Five milliliter of each yeast culture was diluted by 50 ml of water, to ensure good dispensation of vitamin B_6, added to the other components of the diet and mixed thoroughly. Diets were left to dry at room temperature overnight. Corn oil was added immediately prior to storage. CM and test diets were subjected to proximate analyses according to the AOAC (1990) procedures. Composition and chemical analyses of CM and test diets are shown in Table 1. Available energy was calculated using the physiological values of 4, 4 and 9 kcal/g for carbohydrate, protein and lipid, respectively (Lee and Putnam, 1973; Garling and Wilson, 1977). Fish were adapted to the experimental conditions for two weeks on diet formulated according to Eid and El-Gamal (1996). After the adaptation period, the sixteen diets were assigned randomly to the sixteen aquaria. Feeding protocol was carried out at rate of 4% of the wet biomass in each aquarium per day in three equal portions at 09.00, 12.00 and 15.00 h.

Growth Performance and Feed Conversion Measurements:

Fish were weighed at the beginning, biweekly and at the end of the experiment. The amount of feed offered was readjusted biweekly according to the recorded weight. Growth performance was measured in terms of final weight (FW, g), conditional factor (K-value), body weight gain (BWG, g) and specific growth rate (SGR, %) and calculated as follows:

K-value = 100 X (body weight, g/total length^3, cm).

BWG (g)= final weight (FW) – Initial weight (IW).

SGR (%)=100 X [ln (FW)– ln (IW)/time between two successive weighings, days]

Table (1): Ingredients and proximate analysis of canola meal (CM) and tested diets fed to *O. niloticus*.

	Canola meal (CM)	Diet (% CM)			
		15	30	45	60
Ingredient :					
Ground yellow corn		40	34	28	22
Menhaden fish meal		31	22	13	4
Canola meal		15	30	45	60
Corn oil		5	5	5	5
Vitamins mixture		1	1	1	1
Minerals mixture		2	2	2	2
Cellulose		5	5	5	5
Carboxymethyl cellulose		1	1	1	1
Chemical analysis :					
Dry matter (%)	91.37	89.52	90.41	90.06	90.24
Crude protein (%)	32.41	34.05	31.11	29.88	26.69
Crude fat (%)	0.96	5.88	5.93	6.03	5.76
Crude fiber (%)	13.83	8.59	11.29	13.14	14.34
Ash (%)	6.56	10.44	9.31	8.30	7.89
Fiber fractions :					
NDF (%)	27.20	29.14	29.69	28.28	29.32
ADF (%)	23.00	10.88	13.13	17.16	19.44
ADL (%)	12.71	5.13	7.63	7.43	9.42
Cellulose (%)	10.29	5.75	5.50	9.73	10.02
Hemicellulose (%)	4.20	18.26	16.56	11.12	9.88
A.Energy (kcal / kg diet)	2809	3114	3089	3046	3008
P/E ratio	11.54	10.93	10.07	9.81	8.87

Feed conversion and feed utilization parameters were measured in terms of feed conversion ratio (FCR), protein efficiency ratio (PER) and protein retention value (PRV) and calculated as follow:

FCR = Total feed fed (g) / BWG (g).

PER = BWG (g) / protein fed (g).

PRV (%) = 100 X [retained protein (g) / protein fed (g)].

Blood Parameters and Body Composition:

At the end of the experiment, three replicates were taken from each treatment each replicate was five specimens. Blood was collected by cutting the caudal fin of the fish in two clean tubes. First one was heparinized for hemoglobin and packed cell volume (PCV, %) determinations. The packed cell volume (PCV%) and haemoglobin (Hb, g/dl) concentrations were determined immediately after blood collection. The PCV% was determined according to method of Stoskops (1993) while Hb level (g/dl) was measured spectrophotometrically using kits provided by Diamond diagnostic, Egypt. The other blood sample was contrifuged at 3000 rpm for 20 min. and blood serum was stored at –20 °C for biochemical analysis. Serum total protein (TP, g/dl), albumin (Alb, g/dl), asparatic aminotransferase (AST, U/L) and alanine aminotransferase (ALT, U/L) were measured by using kits from Diamond diagnostic, Egypt. Globulin (g/dl) concentration was determined mathematically by difference between serum T.protein and albumin levels. Glucose (mg/dl), total cholesterol (mg/dl) and triglycerides (mg/dl,) were measured by kits supplied by Bicon, Germany. Triiodothyronin (T_3, ng/ml) and Tetraiodothyronin (T_4, ng/ml) were measured by kits from Cal-TECH Diagnostics Inc. Chino, California, USA.

Fish of the three replicates, were eviscerated, oven-dried at 70 °C for 48 h and ground in a mincer. Proximate analysis of the carcass (body minus gills and gut) were performed according to the standard methods of AOAC (1990). Hepatosomatic index (H S I) was calculated as : H S I = 100 [liver weight (g)/gutted BW (g)].

Statistical Analysis:

All data were subjected to two-way analysis of variance (ANOVA) using the general linear model (GLM) procedure of SAS statistics package (SAS, 1987). Comparison of means was done by Duncan's method (Steel and Torrie, 1980) utilizing the same software package.

RESULTS and DISCUSSION

Growth Performance:

There were no significant differences (P>0.05) in body weight gain, specific growth rate, feed conversion ratio and condition factor between fish groups fed diets contained 15, 30, 45 and 60 % canola meal (Table 2). The insignificant differences in performance of fish group fed high levels of CM may be due to ability of *O. niloticus* to digest and retain CM nutrients. These results are supported by Higgs et al., (1988 and 1990) findings that the protein quality of canola is equivalent to that of herring meal and higher than for soybean meal and cottonseed meal based on essential amino acid index. Also, canola meal has relatively-balanced protein and it contained all the essential amino acids (El-Morsi et al., 2000) which may be required for optimum growth of *O.niloticus*. Also, the fish body weight gain increased significantly (P<0.05) with yeast supplementation (Table 2) which may be due to significantly (P<0.05) increase of protein retention value (PRV, Table 2). These results are supported by Webster et al. (1997) who attributed this increase in body weight gain of fish fed canola meal to protein retention values. Also, Leeson et al. (1987) recorded that the CM can replace 100% of dietary soybean meal without any adverse effects on feed intake, weight gain, feed efficiency and protein or fat in poultry. Indeed, there is a little informations in hand on the use of CM in tilapia diets but there is available data on the use of rapeseed meal (RM) in tilapia diets. Davies et al. (1990) showed that rapessed could be added to a level of 15% of the diet for tilapia. While 30% RM decreased the growth and they referred this decrease to the problems associated with imbalance in amino acid composition or reduced protein (amino acid) digestability in RM. Therefore, the newer varieties of canola do not exhibit the deleterious effects reported with older varieties of rapeseed (Leeson et al., 1987). However, there are some studies in using of canola meal in aquaculture diets but used lower level than the present study. The growth of channel catfish, *Ictalurus punctatus* and *Litopenaeus stylinostris* was not affected by the use of 25, 36 and 30% canola meal (Li and Robinson, 1994; Webster et al., 1997 and Cruz-Suarez et al., 2001), respectively.

The body weight gain (BWG), length, feed conversion ratio (FCR) and specific growth rate (SGR) of the fish groups fed canola meal (15, 30, 45 and 60%) and supplemented with Y-7 and G1 yeast strains had insignificant (P>0.05) difference as compared with control group

(Table 2). While, the addition of G4 yeast strain led to significant improvement in BWG, FCR and SGR (Table 2). This effect may be due to its high content of vitamin B_6 (1530 µg/ml as compared with 689 and 850 for Y-7 and G1, respectively).

Several investigators (Abd-El Halim et al., 1989; Omar et al., 1989 and Kobeisy and Hussein, 1995) on the same fish species reported that the addition of live yeast to the diet of tilapia led to significant ($P<0.01$) increase in its growth performance. Also, Giri et al. (1997) stated that the Vit. B_6 (200 mg/kg diet) improved weight gain and feed efficiency of *Penaeus japonicus* where Vit. B_6 is related to dietary protein and amino acid metabolism in the fish. However, the improvement in growth performance of the fish due to dietary yeast addition may be attributed to: 1) yeast is a source of protein which led to the improvement in growth performance (De Silva, et al., 1989), 2) it acts as a source of some enzymes (amylase, protease and lipase) which may improve food utilization (Giri et al., 1997), 3) yeast as a source of Vit. B_6 which stimulated growth hormone and Vit. B_6 (Pyridoxal 5-phosphate, PLP) act as a coenzyme of dopa decarboxylase enzyme, and dopamine stimulates GH secretion and 4) also, yeast is a source of B_6 may increase the level of B_6 in red blood cells and consequently increase the O_2 affinity to hemoglobin (Mc Coy, 1986), which leads to high O_2 uptake. Moreover, both high level of GH and O_2 uptake stimulates metabolism and growth.

Table 2 showed that there is significant ($P<0.01$) increase in hepatosomatic index (H S I) with the increase of dietary canola meal. This incresae may be due to significant ($P<0.01$) increase of liver fat content (Table 3). Moreover, Proudfoot and Hulan (1987) stated that the diets containing high levels of canola meal resulted in a significant increase in the incidences of fatty liver syndrome (FLS) among treatments in chickens.

The decrease in fish length with the increase of CM level may be due to decrease of P/E ratio (Table 1).

The mortality rate was not affected either by increasing canola meal levels or addition of yeast culture strains.

Body Composition

Crude protein percentage in whole body was not affected by increasing CM level except the group fed 45% CM, while, fat percentage significantly increased ($P<0.01$) in the same group (Table 3). This increase in fat percentage in this fish group may be due to the increase of

serum cholesterol and triglycerides concentrations in the treated fish groups (Table 4).

Also, crude protein percentage was improved significantly ($P<0.01$) in fish groups fed various CM levels and supplemented with yeast (Table 3). This improvement in crude protein may be due to Vit. B_6 content of the yeast. Rogerson and Singsen (1976) stated that Vit. B_6 had a highly significant effect on carcass protein. Also, Giri et al. (1997) showed that the addition of 200 mg Vit. B_6/kg diet increased whole body protein content of *Penaeus japonicus*, muscle glutamate oxaloacetate transaminase activity and protein retention in B_6 treated groups. The fat percentage decreased significantly ($P<0.01$) with yeast addition (Table 3). Similar, results were found by Abd El-Halim et al. (1989) and Kobeisy and Hussein (1995) in the same fish.

There was no significant ($P>0.05$) effect of increasing the dietary levels of CM on ash percentage (Table 3). These results are in agreement with those of Leeson et al. (1987) who showed that ash percentage was not affected by increasing CM in the diets which attributed to the calcium, phosphorus or magnesium content were not affected by CM percentage. Also, ash percentage was not affected by yeast addition. This result is in harmony with the findings of Abd El-Halim et al. (1989).

Blood Constituents:

Serum total protein concentration was not significantly ($P>0.05$) differ among the fish groups fed 15, 30 and 45% CM (Table 4). While, 60% CM level led to significant ($P<0.01$) increase in serum total protein concentrations. Such increase was mainly due to the increase in serum globulin concentration rather than albumin (Table 4). The increase in serum total protein concentration may be attributed to the increase of protein synthesis which referred to high essential amino acids content of CM (El-Morsi et al., 2000). This result supports the high growth rate in the treated groups (Table 2). Moreover, the significant ($P<0.01$) increase in serum globulin concentration of the treated fish groups with canola meal (Table 4) may be due to the fact that globulins were the most abundant protein fraction and accounted 68.4% followed by albumins (15.8%) of the total protein in CM (El-Morsi et al., 2000).

The data also showed a significant ($P<0.01$) improvement in serum total protein of the fish groups fed CM and yeast strains (Table 4). These results may be due to, as mentioned before, yeast is a source of Vit. B_6 (Mc Dowell, 1989) which is required for the synthesis of all L-amino acids (Tryfiates, 1986). As well as, B_6 is essential cofactor for the

transaminases enzymes which are also known as amino transferases (Edwards and Hassal, 1980). Moreover, B_6 is required in amino acids metabolism where B_6 prevented the catabolism of most amino acids (Giri et al., 1997).

Serum triglycerides concentration tended to increase significantly in fish groups fed CM while, the cholesterol concentration was not significantly ($P>0.05$) affected by CM level (Table 4). Leeson et al. (1987) reported that there was no significant ($P>0.05$) effect of CM on fat retention. Also, Goulding et al. (1983) stated that fish meal was hypercholesterolemic while plant sources decreased serum cholesterol levels. The data in Table 4 showed that serum triglycerides concentrations improved significantly ($P<0.01$) while the cholesterol concentrations insignificantly decreased ($P>0.05$) with the yeast addition. Similar results were found by Kobeisy and Hussein (1995).

Serum glucose concentration was insignificant increase with the increase of CM (Table 4). This result is coincied with the findings of El-Morsi et al., 2000 who showed that CM contains 2.7% raffinose family sugar. However, serum glucose concentration inceased significantly in the fish group treated with Y-7 yeast strain (Table 4). Similar result was obtained by Kobeisy and Hussien (1995) who stated that the glucose level elevated with the increse of the yeast supplementation in the same fish.

Serum AST and ALT activities were significantly elevated in the fish groups fed CM as compared with the control group (Table 4). These elevations of AST and ALT may be due to its requirement for the synthesis of all L-amino acids (Tryfiates, 1986). Also, serum AST and ALT were improved significantly ($P<0.01$) in the treated groups with CM and yeast (Table 4). These results are supported by the findings of Rogerson and Singsen (1976) who stated that Vit. B_6 improved serum aminotransferase activity. Also, Giri et al. (1997) showed that the activity of AST may be due to the difference between levels of pyridoxal phosphate (PLP) and pyridoxamine phosphate (PMP) in the hepatopancreas where amino transferase require PLP as a coenzyme.

The hemoglobin concentrations were elevated significantly ($P<0.01$) in the fish groups treated with 30 and 45% CM. while, PCV% was insignificant increase ($P>0.05$) in the fish groups treated with CM (Table 4). Similar trend was achieved when yeast supplementation was employed.This improvement in Hb concentration may be due to the effect of vitamins B in yeast where Hb level decreased with the deficiency of Vit. B_6 (Mc Coy, 1986).

Figures 1, 2 and 3 show that T_3 , T_4 and T_3/T_4 ratio were significantly improved ($P<0.05$) either with the use of CM only or CM supplemented with yeast strains. These elevations in T_3 and T_4 are required for increase protein synthesis. These results are supported by the findings of Webster et al. (1997) who showed that thyroid gland was normal in channel catfish fed 48% CM.

CONCLUSION :

It is concluded from this study that *O. niloticus* can utilize diets contained 15, 30, 45 and 60% canola meal with or without yeast without adverse effect on the growth performance (BWG, FCR and SGR), body composition and blood constituents. The fish groups fed 15, 30, 45 and 60% canola meal and supplemented with G4 yeast strain showed a satisfactory results. Therefore, the canola meal could be included in the diet of *O. niloticus* as a competitive ingredient to other plant protein sources.

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Table (2) : Effect of canola meal and yeast culture on *O. niloticus* performance.

Criterion	Canola				Yeast culture				P-value		
	15	30	45	60	0	Y-7	G-1	G-4	Canola	Yeast	Canola x Yeast
Initial wt. (g)	3.60ab ±0.11	3.67a ±0.11	3.73a ±0.11	3.28b ±0.12	3.95a ±0.11	3.49b ±0.11	3.41b ±0.12	3.43b ±0.12	0.0367	0.0021	0.0119
Final wt. (g)	7.90ab ±0.26	8.34a ±0.27	7.57ab ±0.27	7.16b ±0.29	7.31b ±0.27	7.65ab ±0.27	7.69ab ±0.28	8.41a ±0.28	0.0286	0.0653	0.0832
Initial length (cm)	5.77a ±0.06	5.76a ±0.06	5.83a ±0.06	5.53b ±0.07	5.93a ±0.06	5.68b ±0.06	5.63b ±0.06	5.68b ±0.06	0.0048	0.0029	0.0165
Final length (cm)	7.79a ±0.09	7.89a ±0.09	7.47b ±0.09	7.35b ±0.10	7.48b ±0.09	7.65ab ±0.09	7.58ab ±0.09	7.83a ±0.09	0.0001	0.0988	0.1023
Initial K-value	1.85a ±0.03	1.88a ±0.03	1.82a ±0.03	1.82a ±0.03	1.83a ±0.03	1.86a ±0.03	1.84a ±0.03	1.84a ±0.03	0.3029	0.9400	0.0004
Final K-value	1.60c ±0.01	1.62c ±0.01	1.73a ±0.01	1.69b ±0.01	1.66a ±0.01	1.64a ±0.01	1.66a ±0.01	1.66a ±0.01	0.0001	0.6139	0.0018
T feed (g)	19.78a ±1.02	18.75ab ±0.98	17.32ab ±0.39	16.22b ±0.89	18.01a ±1.63	17.75a ±0.72	17.86a ±0.46	18.44a ±1.39	0.1188	0.9611	----
BWG (g)	4.37a ±0.44	4.74a ±0.31	3.84a ±0.37	3.96a ±0.49	3.43b ±0.29	4.17ab ±0.29	4.34ab ±0.44	4.96a ±0.29	0.2064	0.0379	----
F C R	4.62a ±0.34	4.06a ±0.52	4.62a ±0.36	4.24a ±0.39	5.25a ±0.13	4.32ab ±0.37	4.23b ±0.38	3.72b ±0.19	0.4756	0.0321	----
S G R	0.96a ±0.07	1.01a ±0.09	0.84a ±0.07	0.94a ±0.09	0.76b ±0.04	0.94a ±0.05	0.98a ±0.08	1.08a ±0.05	0.2138	0.0116	----
P E R (g/g)	0.65 c ±0.05	0.83ab ±0.09	0.74bc ±0.06	0.90a ±0.08	0.63b ±0.03	0.79ab ±0.08	0.80a ±0.08	0.90a ±0.07	0.0217	0.0227	----
P R V (%)	47.5c ±3.76	59.4ab ±6.25	51.2bc ±4.79	65.1a ±5.48	43.6b ±2.11	56.6a ±5.74	58.3a ±5.47	64.7a ±4.85	0.0107	0.0054	----
H S I	3.90c ±0.16	3.91c ±0.15	4.49b ±0.30	5.05a ±0.20	4.07b ±0.25	4.69a ±0.18	4.43ab ±0.27	4.25b ±0.26	0.0000	0.0182	0.0000

Means within rows differ (P<0.05) when the letter(s) differ.

Table (3) : Effect of canola meal and yeast culture on body composition of *O. niloticus*.

Component	Canola				Yeast culture				SEM	P-value		
	15	30	45	60	0	G-4	Y-7	G-1		Canola	Yeast	Canola x Yeast
Dry matter (%)	24.83c	25.21b	26.05a	25.76a	25.35	25.51	25.44	25.56	0.17	0.0000	0.6586	0.5105
Organic matter (%)	85.33	85.04	84.86	84.50	84.99ab	85.61a	84.96ab	84.19b	0.62	0.5977	0.1695	0.0221
Crude protein (%)	73.35a	71.95a	69.18b	72.00a	69.19b	72.11a	72.18a	73.01a	1.11	0.0060	0.0093	0.0003
Crude fat (%)	11.25b	11.16b	13.54a	11.47b	13.76a	11.66b	11.46b	10.55b	0.62	0.0013	0.0001	0.0011
Ash (%)	14.67	14.96	15.14	15.50	15.01ab	14.39b	15.04ab	15.81a	0.62	0.5977	0.1695	0.0221
Liver fat (%)	26.16 c	29.78 a	29.76 a	28.01 b	29.20 ab	27.08 c	29.78 a	27.66 bc	0.74	0.0004	0.007	0.0001

Means within rows differ (P<0.05) when the letter(s) differ.

Table (4) : Effect of canola meal and yeast strains on blood constituents of *O. niloticus*

Blood parameter	Canola				Yeast culture				SEM	P-value		
	15	30	45	60	0	G-4	Y-7	G-1		Canola	Yeast	Canola x Yeast
T.Protein (g/dl)	6.25b	6.67b	6.67b	10.50a	4.83c	9.36a	7.53b	8.36ab	0.80	0.0002	0.0002	0.0119
Albumin (g/dl)	2.64a	1.96b	2.43a	1.82b	2.27a	2.56a	2.28a	1.74b	0.22	0.0046	0.0131	0.5667
Globulin (g/dl)	3.61b	4.71b	4.24b	8.68a	2.57b	6.80a	5.25a	6.62a	0.85	0.0001	0.0004	0.0112
Triglycerides (mg/dl)	247.80b	304.40b	375.00a	371.70a	256.50b	330.40a	372.80a	339.10a	29.46	0.0013	0.0084	0.0591
Glucose (mg/dl)	95.80b	121.00a	118.60ab	107.80ab	93.50b	136.60ab	128.20a	105.00ab	11.10	0.1336	0.0359	0.1875
T.Cholesterol (mg/dl)	147.80	151.80	146.20	165.30	159.00	152.60	148.60	151.00	13.16	0.4742	0.8756	0.2487
Hb (g/dl)	7.06b	8.41a	9.28a	6.43b	6.37b	8.37a	8.36a	8.08a	0.60	0.0009	0.0119	0.0070
PCV%	22.50	25.30	24.00	23.50	22.00	24.80	24.80	23.80	1.55	0.3831	0.2797	0.8709
AST(U/L)	47.75c	51.00b	51.00b	55.88a	38.75d	48.63c	66.38a	51.88b	1.31	0.0001	0.0000	0.0000
ALT(U/L)	26.00b	27.75b	32.25a	34.25a	22.50c	28.88b	31.00b	37.88a	1.82	0.0010	0.0000	0.0004

Means within rows differ (P<0.05) when the letter(s) differ.

Fig. (1): Triiodothyronin (T3) of O.niloticus fed canola meal supplemented with yeast strains.

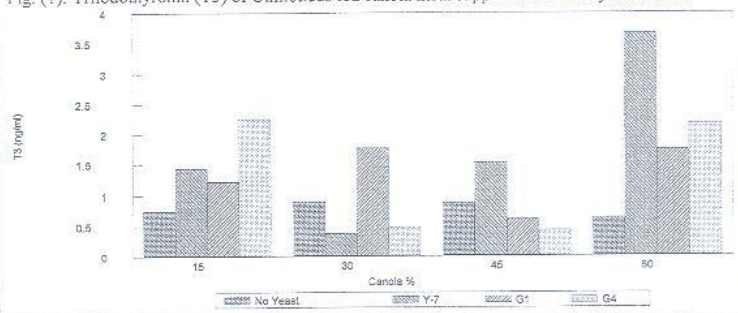

Fig. (2): Tetraiodothyronin (T4) of O.niloticus fed canola meal supplemented with yeast strains.

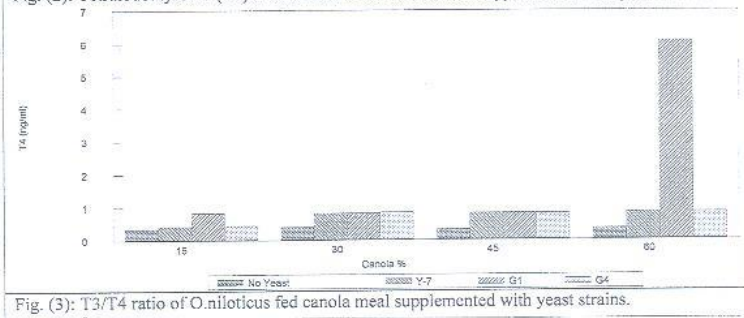

Fig. (3): T3/T4 ratio of O.niloticus fed canola meal supplemented with yeast strains.