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EFFECT OF PARTIAL OR COMPLETE REPLACEMENT OF SOYBEAN MEAL WITH LEAF PROTEIN CONCENTRATE MEAL IN NILE TILAPIA DIETS ON GROWTH PERFORMANCE AND BLOOD CONSTITUENTS

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ABSTRACT: The current trial was conducted to study the effects of partial replacement of soybean meal (SBM) with leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves in Nile tilapia diets on growth performance, body composition and blood biochemical parameters. Three diets were formulated by replacing 0, 50 and 100% of protein from SBM with LPCM (control, LPCM50, and LPCM100, respectively). Each diet was fed to three replicate groups of fish (initial body weight: 5.03 ± 0.01 g) for 12 weeks. Results showed that dietary LPCM substitution significantly decreased final weight, weight gain, specific growth rate, and feed intake of juvenile tilapia. No significant differences in feed conversion ratio and survival rate were observed among the experimental groups. Condition factor significantly increased in fish groups LPCM50 and LPCM100 compared with those in control. Fish fed LPCM50 and LPCM100 diets had lower crude lipid content than the control group. Regarding all blood biochemical and hematological parameters, no significant differences were observed among all groups. However, the relative margin was increased by 12.83% in LPCM100 group, while decreased by 5.88% in fish group LPCM50 compared with the control one. These findings demonstrated that partial or complete replacement of SBM protein with LPCM has impaired growth performance of *O. niloticus*, without any negative effect on blood constituents. In addition, the relative margin was increased significantly in *O. niloticus* fed LPCM100 diet.

Key words: Leaf protein concentrate, Nile tilapia, growth performance, blood biochemistry.

INTRODUCTION

Global aquaculture production in 2016 included 80.0 million tonnes of food fish and 30.1 million tonnes of aquatic plants, as well as 37900 tonnes of non-food products (**FAO, 2018**). Aquaculture is considered one of the main sources to provide the animal protein for human consumption in the whole world (**FAO, 2016**). A major determinant of successful growth and intensification of aquaculture production is aqua feed. Feed comprises the major cost in fish production and accurate supply of the nutritional requirements increases the efficiency of production. Ideally, the nutrient requirements and nutrient concentration of a feedstuff should be expressed in units of availability so that least-cost formulations can optimize the nutrient requirements minimizing the cost of feeds or of production (**Sklan *et al*., 2004**).

Several plants contain appreciable quantity of protein with good amino acid profile that can be used during aqua feed formulation (**Gatlin *et al*., 2007; Azaza *et al*., 2008**). Plant-based protein sources may be the only solution to reduce high feed costs in aquaculture (**Hlophe *et al*., 2011**). The results showed great variation in the degree of success for using plant protein in fish diets depending on the species of fish under culture, feeding strategy and the ingredients available (**Gatlin *et al*., 2007; Koumi *et al*., 2009**). Plant products contain huge amount protein, different amino acid and fatty acids

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which are not available in animal protein. In fish feed industry grasses, vegetables, aquatic weeds, plant's leaves, stems, seeds and seed extracts are commonly used (**Mondal and Payra, 2015**). The use of leaf protein concentrates as dietary feed ingredients has great potential because of the feasibility of producing good quality protein from tropical and subtropical plant leaves (**Vinconneau, 1979**). The leaf protein concentrate contains high crude protein (48.9%) and crude fat (14.5%). Apart from the relatively high mineral and protein contents, it has an amino acid profile which in most cases compares with those of fishmeal. Leaf protein concentrate has been reported to enhance growth rate when it replaced soybean (**Agbede, 2000**).

Therefore research into the utilization of plant protein ingredients in aquafeed will more likely continue. The present study aimed to investigate the effects of partial or complete replacing soybean meal with leaf protein concentrate in a formulated feed on the growth performance, carcass proximate and economic efficiency of Nile tilapia (*Oreochromis niloticus*).

MATERIALS AND METHODS

The present study was carried out at the Wet Laboratory of the Animal Production Department, Faculty of Agriculture, Zagazig University, Egypt. The experimental period lasted 84 days from May to August, 2019. In a complete randomized design, all fish were randomly distributed into 9 glass aquaria (35 × 70 × 40 cm - 0.074 m^3 of water) in 3 treatments (3 replicates per treatment). The first group fed the control diet (control; T1), the second group was fed on diet replaced 50% of soybean meal with 25% carrot leaf protein concentrate and 25% sugar beet leaf protein concentrate (25% CLPC+25% SLPC; T2) and the third group was fed on diet replaced 100% of soybean meal with 50% carrot leaf protein concentrate and 50% sugar beet leaf protein concentrate (50% CLPC+50% SLPC; T3). The test diets were formulated as shown in Table 1.

Healthy fingerlings; sex-reversed (all-male) of Nile tilapia (*Oreochromis niloticus*) provided by the Fish Hatchery of Central Laboratory for Aquaculture Research at Abbassa, Sharkia Governorate, Egypt. One hundred and thirty five fingerlings (weighing approximately 5.02±0.019 g after adaptation period for three weeks under normal laboratory conditions) were randomly distributed into the glass aquaria. The system installed in an environmental-controlled laboratory with a photoperiod of 12 hr., light and 12 hr., darkness. Continuous aeration was provided by an air blower. Fish were fed at the rate of 3% of live body weight and it offered two times at 8.00 and 15.00 hours. The fish in each aquarium were weighed biweekly, and the feed weight was adjusted after each fish weighing. About 25% of the water in the aquarium was daily replaced by aerated freshwater. Each aquarium was supplied with air pump to supply fish with oxygen. The glass aquariums were supplied with well–aerated and dechlorinated tap water from storage tank. Air was compressed to each aquarium via air stones by air pumps during the experimental period. The diet remains and fish wastes of each aquarium were removed by siphoning using plastic tube before the second daily feeding to further analysis and minimize leaching. Every second day, each aquarium was partially cleaned, including the fish feces and the water partially changed (about 50%).

The experimental diets were analyzed to determine moisture, protein, lipid, fiber, and ash contents. Also, the proximate composition, including crude protein, crude fat, crude ash and moisture of body composition was determined using the standard procedures of **AOAC (2005)**. Fish were weighed to the nearest 0.1 g at the beginning of the experiments and every 15 days and the amount of feed given was adjusted in accordance with the new measured biomass. Body weight gain was calculated by subtracting the two successive live weights at different experimental periods (weight gain (g/fish) = final weight-initial weight). Specific growth rate (SGR) was calculated according the following equation: SGR = [ln (final fish weight) – ln (initial fish weight)] × 100 / period (day).

The proximate composition, including crude protein, crude fat, crude ash and moisture of body composition was determined using the standard procedures of **AOAC (2005)**. At the end

Table 1. Formulation and proximate chemical composition of trial diets

Ingredient (%)	Control (T1)	50% LPCM (T2)	100% LPCM (T3)
Fish meal	12	12	12
Soybean meal	35	17	0
Corn grain	22	21	19
Wheat bran	20	20	20
Corn gluten	6	7	7
Vegetable oil	2	2	2
CLPC[1]	0	8	15
SLPC[1]	0	10	22
Dicalcium phosphate	1	1	1
Vitamin mixture [2]	1	1	1
Minerals mixture [3]	1	1	1
Chemical composition (%)			
Crude protein	32.19	32.00	32.05
Ether extract	6.04	6.07	6.10
Crude fiber	4.89	3.84	2.81
Nitrogen free extract	42.49	41.06	39.48
Gross energy (kcal/kg)[4]	4136	4069	4010
Price per kg (LE)	8.66	7.50	6.33

1 LPCM, leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves
2 Each one Kg of mineral mixture contained: Zinc 1.23g, manganese 930 mg, Iron 630 mg, Copper 105 mg and selenium 2.1mg.
3 Each one Kg of vitamin mixture contained: Vitam. A 72000 IU, Vitam. B1 6 mg, Vitam. B3 12000 IU, Vitam. B6 9 mg, B12 0.06 mg, Vitam. E 60 mg, Vitam. K 12 mg, Pantothenic acid 60 mg, Nicotinic acid 120 mg, Folic acid 6 mg, Biotin 0.3 mg and Choline chloride 3mg.
4 Calculated according **to NRC (1993)**.

of the feeding trial, blood samples were collected *via* caudal vein. Whole blood was collected in a small sterile vial having anticoagulant (EDTA). The collected samples were used to measure the hematological parameters including total red blood cells (RBCs), hemoglobin (Hb), hematocrit (HCT), mean cell volume (MCV), mean corpuscular hemoglobin concentration (MCHC), total leukocytes (WBC), and lymphocytes were evaluated according to **Feldman *et al.* (2000)**. Other blood samples were collected without adding EDTA, centrifuged (SIGMA 2-3, Osterode, Germany) at 3000 rpm for 20 min, and stored at –20°C until analyses. The collected serum were used to measure biochemical parameters including serum total protein, albumin (**Sundeman, 1964**), creatinine, urea-N (**Henery, 1974**) and plasma transaminase enzymes AST; aspartate amino transferase and ALT; alanine amino transferase (**Reitman and Frankel, 1957**) were determined using the commercial kits from Diamond Diagnostics Company, Egypt. Fractionation of serum proteins was done using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-

PAGE) technique for determination of serum alpha (α), beta (β) and gamma (γ) globulins according to the technique described by **Ornstein (1964)**. Serum cholesterol and triglycerides were determined according to the method of **Kaplan *et al.* (1987) and Bucolo and David (1973)**, respectively. High–density lipoprotein cholesterol (HDL-C) concentration was carried out according to **Vassault *et al.* (1986)**. Low–density lipoprotein cholesterol (LDL-C) and very low–density lipoprotein cholesterol (VLDL-C) concentrations were calculated according to **Ahmadi *et al.* (2008)**.

Water quality control was measured biweekly analysis before replacing the water in the aquarium during the experimental period. All the water quality parameters were within the acceptable ranges for fish growth (**Boyd, 1990**). Water temperature was measured in each aquarium daily using a mercury thermometer of 0 to 100ºC range. Dissolved oxygen was measured directly by using oxygen meter apparatus (XSI model 58, Yellow Spring Instrument Co., Yellow Springs, Ohio, USA). Ammonia (NH_4-N mg/l), Nitrate (NO_3 -N mg/ l), Nitrite (NO_2–Nmg/l) and pH were measured by using the Hach kit model HI 83205 (Multipurameter Bench Photometer, Hanna Instruments, Romania). Continuous aeration was provided by an air blower.

The economic assessment was determined according to the equation of **Ayyat *et al.* (2018)**. Profit is the difference between the income from body gain and feed costs. Relative profit = survival rate (%) × final margin. Assuming the rest of the other costs remains constant. The price of selling of one kg of fish was 25.0 LE (Egyptian pound equal to 0.064 US$). The price of the diets was shown in Tables 1.

The data were statistically analyzed by a completely randomized design with **SAS (2004)** in relation to the following model: $Y_{ij} = \mu + T_i + E_{ij}$. Where μ is the overall mean, T_i is the fixed effect of i^{th} treatments, and E_{ij} is the random error. Differences between treatments were statistical tested by Duncan's multiple range test (**Duncan, 1955**).

RESULTS AND DISCUSSION

All tested water quality criteria were suitable for rearing Nile tilapia (*O. niloticus*) fingerlings. Water temperature, oxygen, pH, ammonia and nitrite (overall mean) were 27.53°C, 7.07 mg/l, 7.43 mg/l, 0.087 mg/l and 0.114 mg/l, respectively. Ranges of water quality parameters within the acceptable ranges required for normal growth of tilapia as mentioned by **Boyd (1990)**.

Final body weight of Nile tilapia fish significantly (P<0.01) decreased as the replacement of soybean meal with the leaf protein concentrations. Final body weight decreased by 8.52 and 6.80% in fish group 25% CLPC + 25% SLPC (T2) and 50% CLPC + 50% SLPC (T3) when compared with the control group (Table 2 and Fig. 1). Daily body gain, specific growth rate and daily feed intake of Nile tilapia fish significantly (P<0.05 or 0.01) affected with the replacement of soybean meal with the leaf protein concentrations at 4-8 and 0-12 weeks of the experimental period, except at 0-4 and 8-12 weeks of the experimental period insignificantly affected (Table 2). The fish group fed diet replaced 50% of soybean meal with leaf protein (T2) recorded the lower daily body gain at 0-12 weeks than the other groups. When compared the experimental groups with the control group, daily body gain decreased by 11.17 and 9.04%, respectively in fish group fed diets 25% CLPC + 25 SLPC and 50% CLPC + 50% SLPC, while the same trend for the specific growth rate were 8.52 and 6.80%, respectively (Fig. 1). Feed conversion of Nile tilapia fish insignificantly affected with the replacement of soybean meal with the leaf protein concentrations at 8-12 and 0-12 weeks of the experimental period, while at 0-4 and 4-8 weeks significantly (P<0.05) affected (Table 2). Fish group fed the control diet (T1) or 50% CLPC + 50% SLPC (T3) recorded the best values of feed conversion, while fish fed 25% CLPC + 25% SLPC (T2) recorded the bad feed conversion ratio (Fig. 1). The obtained growth performance results may be indicated that Soybean meal can partially or completely replacement with leaf concentrate protein from carrot and sugar beet. The results of **Paray *et al.* (2020)** showed that the oak leaf

Table 2. Growth performance of Nile tilapia as affected by dietary replacement of soybean meal protein by leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves

Item	Control (T1)	50% LPCM (T2)	100% LPCM (T3)	Significant
Body weight (g) at				
Initial weight	5.011±0.013	5.027±0.008	5.022±0.014	NS
4 Week	7.238±0.373	6.313±0.094	6.282 ± 0.214	NS
8 Week	11.238±0.481	11.548±0.123	10.690 ±0.207	NS
12 Week	20.821±0.417 [a]	19.047±0.104 [b]	19.405±0.167 [b]	**
Daily weight gain (g/day) at				
0-4 Week	0.080±0.014	0.046±0.004	0.045±0.007	NS
4-8 Week	0.143±0.008 [b]	0.187±0.007 [a]	0.157±0.012 [ab]	*
8-12 Week	0.342±0.031	0.268±0.008	0.311±0.008	NS
0-12 Week	0.188±0.005 [a]	0.167±0.001 [b]	0.171±0.002 [b]	**
Specific growth rate at				
0-4 Week	1.303±0.194	0.813±0.057	0.796±0.111	NS
4-8 Week	1.575±0.091 [b]	2.157±0.085 [a]	1.901±0.153 [b]	*
8-12 Week	2.207±0.214	1.788±0.055	2.130±0.068	NS
0-12 Week	1.695±0.021 [a]	1.586±0.008 [b]	1.609±0.008 [b]	**
Daily feed intake (g feed/day) at				
0-4 Week	0.168±0.003	0.164±0.002	0.159±0.001	NS
4-8 Week	0.247±0.013 [a]	0.214±0.002 [b]	0.208±0.004 [b]	*
8-12 Week	0.406±0.009	0.397±0.003	0.381±0.004	NS
0-12 Week	0.274±0.008 [a]	0.258±0.002 [ab]	0.250±0.002 [b]	*
Feed conversion (g feed/g gain) at				
0-4 Week	1.182±0.065 [a]	0.878±0.026 [b]	1.024±0.076 [ab]	*
4-8 Week	1.739±0.127 [a]	1.149±0.045 [b]	1.335±0.104 [b]	*
8-12 Week	1.209±0.133	1.486±0.053	1.227±0.042	NS
0-12 Week	1.457±0.076	1.548±0.022	1.457±0.009	NS

Values in each row with different superscripts have significant differences ($p < 0.05$).
NS = Not significant, * = $P<0.05$, and **=$P<0.01$.

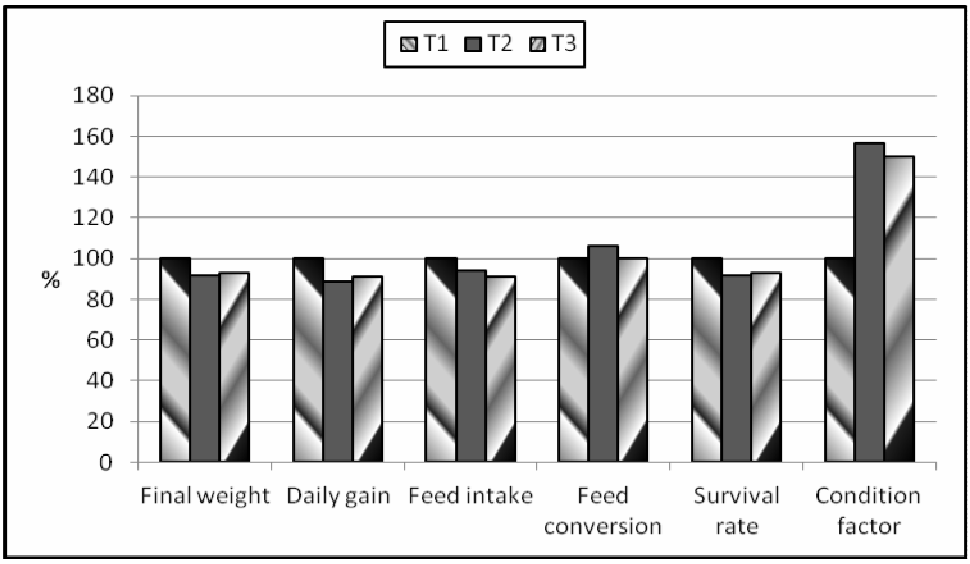

Fig. 1. Final body weight, daily gain, feed conversion and survival rate index of Nile tilapia fish as affected by substituting dietary soybean meal by leaf protein concentrations, when the values of the control group considered as 100%

extract had no significant effects on the common carp fish growth performance. Also, the results of **Osman *et al.* (1996)** indicated that weight gain, specific growth rate, feed conversion ratio and protein utilization parameters were significantly increased by the higher percentage of dried or cooked leucaena leaf meal in tilapia diets.

In the experiment of **Soares *et al.* (2001)** Nile tilapia diets were formulated with 0.00, 33.33, 66.67 and 100.00% levels of soybean meal protein replacement by the canola meal protein, corresponding to 0.00, 24.50, 49.00, and 73.50% dietary canola meal inclusion in the diets. Feed gain ratio and protein efficiency rate were not affected by the treatments. It was concluded that canola meal can be included at 35.40% of diets, substituting 48.17% of soybean meal protein in diets for Nile tilapia in the growing phase. **Da Silva *et al.* (2017)** studied the replacement levels of 0, 25, 50, 75 and 100% of soybean meal digestible protein by peanut meal for Nile tilapia diets. The feed conversion ratio was significantly affected when the soybean meal was totally replaced by peanut meal. The protein efficiency ratio, protein retention and whole-body protein content significantly decreased in fish fed diets containing peanut meal levels above 25% of peanut meal. Therefore, peanut meal can replace up to 25% of soybean meal without impairing juvenile Nile tilapia growth performance, feed efficiency, and body composition.

Survival rate of Nile tilapia insignificantly affected with the feed treatments. Condition factor significantly ($P<0.01$) increased as affected with the replacement of soybean meal with the leaf protein concentrations (Table 3). Condition factor increased by 56.47 and 49.96%, respectively in fish group fed diets 25% CLPC + 25 SLPC and 50% CLPC + 50% SLPC when compared with the control group (Fig. 1). **Gupta and Tripathi (2017)** indicated that better body condition is correlated with high values of condition factor and poor body condition is obtained when the values of condition factor is less.

Body crude protein and crude lipids significantly ($P<0.01$) decreased as affected with the replacement of soybean meal with the leaf protein concentrations (Table 3). **El-Saidy and Saad (2011)** find that up to 41.25% cottonseed meal can be used to replace 75% of soybean meal protein in diets for male Nile tilapia fingerlings without any adverse effects on the body composition.

Liver and kidney functions indicators, serum protein profile, lipid profile and hematological parameters of Nile tilapia insignificantly affected with the replacement of soybean meal with the leaf protein concentrations (Tables 4 and 5). **El-Saidy and Saad (2011)** find that up to 41.25% cottonseed meal can be used to replace 75% of soybean meal protein in diets for male Nile tilapia fingerlings without any adverse effects on the hematological indexes.

The economic visibility of Nile tilapia as affected by substituting dietary soybean meal by different levels of leaf protein concentrate from carrot or sugar beet are shown in Table 6. Feed cost of Nile tilapia decreased with the replacement of soybean meal with the leaf protein concentrations, while the return from body gain decreased. Replacement 100% of soybean meal with the leaf protein concentrates recorded the best final margin and relative margin than the other groups. When compared the experimental groups with the control group, the obtained results showed that the relative margin increased by 12.83% in fish group fed diets 50% CLPC + 50 SLPC, while fish fed 25% CLPC+25% SLPC the relative margin decreased by 5.88% (Fig. 2).

In conclusion, this study represents the first approach to assess the effects of the replacement of SBM protein with LPCM in Nile tilapia diets. The findings proved that partial or complete replacement of SBM protein with LPCM has reduced fish growth, but did not have any adverse effects on feed utilization and blood biochemical parameters. However, fish fed LPCM100 diet showed higher final and relative margin than other treatments.

Table 3. Survival rate, Condition factor and whole body chemical composition of Nile tilapia as affected dietary replacement of soybean meal protein by leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves

Item	Control (T1)	50% LPCM (T2)	100% LPCM (T3)	Significant
Survival rate (%)	95.555±2.222	93.333±0.000	93.333±0.000	NS
Condition factor (%)	1.229±0.020 [b]	1.923 ±0.029 [a]	1.843±0.120 [a]	**
Whole body composition (% on dry matter basis)				
Moisture	74.513±0.723	73.337±0.306	73.813±0.252	NS
Crude protein	56.303±0.356 [a]	55.253±0.184 [ab]	53.837±0.634 [b]	*
Crude lipid	25.253±0.133 [a]	22.923±0.194 [b]	21.623±0.384 [c]	**
Ash	17.453±0.668	16.817±0.176	18.017±0.303	NS

Values in each row with different superscripts have significant differences (p < .05).

NS = Not significant, * = P<0.05 and **=P<0.01.

Table 4. Blood biochemical of Nile tilapia as affected by dietary replacement of soybean meal protein by leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves

Item	Control (T1)	50% LPCM (T2)	100% LPCM (T3)	Significant
Creatinine (mg/dl)	1.070±0.021	1.030±0.026	1.037±0.057	NS
Urea (mg/dl)	16.767±0.219	16.033±0.788	16.400±1.069	NS
ALT (U/L)	16.567±0.657	16.267±0.549	16.900±0.981	NS
AST (U/L)	29.567±1.277	29.200±1.193	29.433±0.696	NS
Total protein (g/dl)	5.867±0.233	5.800±0.252	5.800±0.173	NS
Albumin (g/dl)	2.930±0.125	2.903±0.124	2.877±0.118	NS
α1 glob (g/dl)	1.340±0.051	1.223±0.057	1.210±0.087	NS
α2 glob (g/dl)	1.577±0.067	1.270±0.173	1.397±0.151	NS
β glob (g/dl)	1.000±0.026	0.973±0.038	1.010±0.050	NS
γ glob (g/dl)	1.240±0.231	1.163±0.113	1.073±0.052	NS
Total glycerides (g/dl)	109.000±1.732	106.333±2.963	106.333±1.453	NS
Cholesterol (g/dl)	182.667±12.991	168.667±11.724	161.333±3.667	NS
HDL-C (g/dl)	41.000±1.528	40.000±1.528	40.667±1.856	NS
LDL-C (g/dl)	125.867±2.258	125.067±4.570	122.200±5.147	NS
VLDL-C (g/dl)	9.133±0.406	9.100±0.351	9.167±0.240	NS

NS = Not significant

Table 5. Hematological parameters of Nile tilapia as affected by dietary replacement of soybean meal protein by leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves

Item	Control (T1)	50% LPCM (T2)	100% LPCM (T3)	Significant
RBCs ($10^6 \times \mu L$)	3.300±0.138	3.290±0.135	3.233±0.073	NS
Hb (g/dL)	10.900±0.153	10.767±0.517	10.633±0.176	NS
HCT (%)	36.667±1.856	36.333±0.667	36.000±1.528	NS
MCV (fL)	106.730±0.038	103.677±3.243	105.143±1.672	NS
MCHC (g/dL)	31.873±1.219	29.290±2.095	31.320±1.913	NS
WBCs ($10^5 \times \mu L$)	5.620±0.114	5.627±0.589	5.027±0.251	NS
Lymphocyte ($10^5 \times \mu L$)	3.237±0.091	3.263±0.520	2.730±0.394	NS

NS = Not significant

Table 6. Economic visibility of Nile tilapia as affected by leaf protein concentrate mixture (LPCM) from carrot and sugar beet leaves.

Item	Control (T1)	50% LPCM (T2)	100% LPCM (T3)
Feed cost (LE/fish)	0.199	0.163	0.133
Return from gain (LE/fish)	0.395	0.351	0.359
Final margin (LE/fish)	0.195	0.188	0.226
Relative margin (LE/fish)	0.187	0.176	0.211

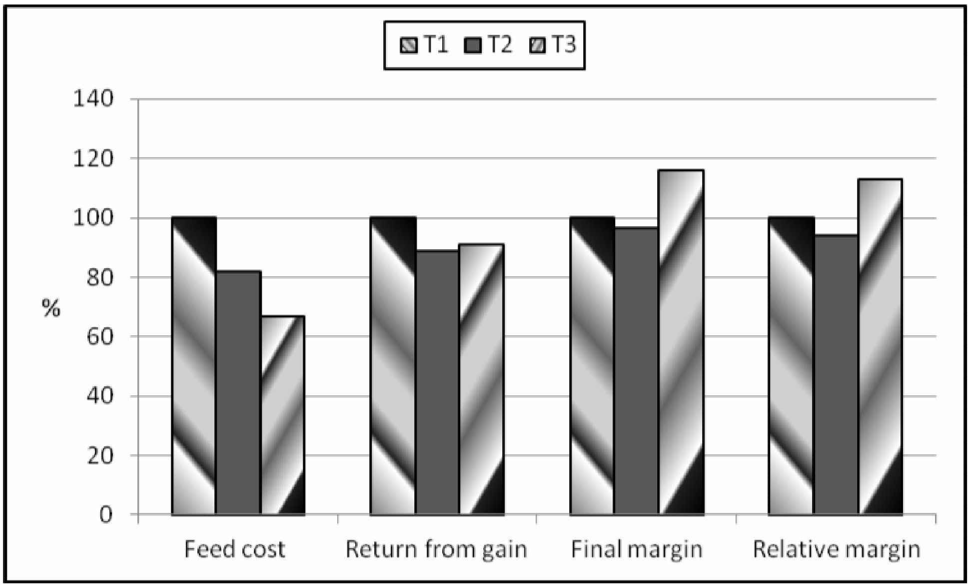

Fig. 2. The economic assessment index of Nile tilapia fish as affected by substituting dietary soybean meal by leaf protein concentrations, when the values of the control group considered as 100%

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تأثير الإستبدال الجزئي أو الكلى لكسب فول الصويا ببروتين الأوراق المركز فى علائق البلطى النيلى على أداء النمو ومكونات الدم

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أجريت التجربة الحالية لدراسة تأثير الإحلال الجزئى أو الكلي لبروتين كسب فول الصويا بمخلوط مركز بروتين أوراق الجزر وبنجر السكر (LPCM) فى علائق البلطى النيلى على أداء النمو وتركيب الجسم والقياسات البيوكيميائية فى الدم، تم تكوين ثلاث علائق موزعة على ٣ مجموعات تجريبية بحيث تم إستبدال صفر (مجموعة الكنترول)، ٢٥% (مجموعة LPCM50) و٥٠% (مجموعة LPCM100) من بروتين فول الصويا بمخلوط مركز بروتين ورقى، احتوت كل المجاميع التجريبية على ٣ مكررات (بمتوسط وزن البداية : ٥,٠٣ ± ٠,١ جم) وتمت التغذية لمدة ١٢ أسبوعًا، أظهرت النتائج أن إستبدال LPCM أدى إلى إنخفاض معنوى في وزن الجسم النهائى والزيادة فى الوزن ومعدل النمو والغذاء المأكول لأسماك البلطى، لم تظهر أى فروق معنوية بين جميع المجاميع التجريبية فى نسبة تحويل الغذاء ومعدل البقاء، زاد ت قيمة معامل الحالة بشكل معنوى فى المجموعات LPCM50 و LPCM100 بالمقارنة مع مجموعة الكنترول، إنخفض محتوى الدهن الخام فى الأسماك المغذاه على LPCM50 و LPCM100 بالمقارنة بمجموعة الكنترول، لم يلاحظ أى إختلافات معنوية فى كل قياسات الدم البيوكيمائية والهيماتولوجية، ومع ذلك فقد زاد هامش الربح النسبى فى مجموعة LPCM100 بنسبة ١٢,٨٣% بينما قل بنسبة ٥,٨٨% فى مجموعة LPCM50 بالمقارنة بمجموعة الكنترول، وتظهر هذه النتائج أن الإستبدال الكلى أو الجزئى لبروتين كسب فول الصويا بـLPCM قد أدى إلى تراجع معدل النمو بدون أى تأثير سلبى على مكونات الدم، بالإضافة إلى ذلك فقد زاد هامش الربح النسبى بشكل معنوى فى الأسماك المغذاة على LPCM100.

المحكمـــــون:

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