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EFFECT OF SOURCE AND LEVEL OF DIETARY WATER HYACINTH ON NILE TILAPIA, *Oreochromis niloticus*, PERFORMANCE

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ABSTRACT

A feeding laboratorial trial in glass aquaria for 12 weeks, to replace graded levels of water hyacinth (WH) meal protein from two (polluted and not polluted) water sources instead of 0, 10, 20, 30 and 40% of soybean meal protein in Nile tilapia diets. Ten experimental diets were formulated to be isocaloric and isonitrogenous (26% crude protein) and offered daily at 2 meals, 6 days a week at 3% of fish biomass daily. Results indicated that rearing water did not influence fish by the tested treatments. Most tested heavy metals had higher levels in WH and diets especially those of polluted source. Iron levels of the WH and experimental diets were > those of Mn > Zn > Cu > Pb > Cd. The highest ether extract (EE) and nitrogen free extract (NFE) and the lowest ash contents were realized in diet contained 30% replacement with WH leaves protein from non-polluted source. Growth performance parameters differed significantly as affected by WH source and level, so the final body weights (FBW) in treatments contained 10, 20 and 30% replacement with WH levels meal protein from the polluted source were significantly lower than those of WH from the non-polluted source. Also, the pollution source for WH led to significantly lower other growth performance parameters than those of the unpolluted source for WH, whether for the bodyweight gain (BWG), survival rate (SR), or specific growth rate (SGR). Increasing level of WH leaves meal protein in the experimental diets led to significantly lower FBW, BWG, SR, SGR and condition factor. The pollution source of WH led to increases in the undeniable parts from the experimental fish (tissues' indices, hepato-somatic and female and male gonado-somatic indices), also more than 30% replacement negatively affected these indices. Contaminated source of WH decreased the feed conversion ratio (FCR) for the very low feed intake as well as for the low fish growth which led to apparent improvements in FCR, protein efficiency ratio (PER) and protein productive value (PPV). Increasing the substitution levels led to increased FCR and PPV but led to lower PER. All blood hematological and biochemical parameters of the tested fish significantly and negative influenced by source and level of WH in the experimental diets, except hemoglobin and total proteins' concentrations. Increasing level of WH leaves meal protein lowered blood total proteins in the fish as a result of lower quality of protein in such diets containing WH. Source and level of WH in the experimental diets significantly affected the chemical analysis of the whole fish body including CP, EE and ash contents. The CP decreased and both of EE and ash were increased by elevating the substation level or for dietary contaminated WH increased by elevating the substation level or for dietary contaminated WH inclusion. The increase in WH level in fish diets reduced the feed intake sharply particularly from the diets contained WH from the polluted source comparing with those contained WH from its non-polluted source. Although the low price of WH – included diets, particularly by increasing dietary WH levels; yet, the return from fish weight gain decreased, especially when WH was coming from its polluted source, which starkly reduced feed intake.

Keywords: Water hyacinth – Nile tilapia – Growth performance – Feed utilization – Economic evaluation.

INTRODUCTION

Tilapia is the third largest group of farmed finfish species, only after carps (10.37 x 10^6 mt) and salmonids (0.94 x 10^6 mt) (FAO, 1997), with an average annual growth rate of about 11.5%. In addition, Nile tilapia was the 6^{th} most cultured finfish species in the world in 1995 with a total production of 473,641 mt with an average compound growth rate of about 12% per annum since 1986. The global production of farmed tilapia has increased more than three-folds since 1984, from 186.544 mt to 659.000 mt, representing 4.48% of total farmed finfish in 1995, with a value of US$ 925 million (Tacon, 1997). About 650.000 mt or 98.6% of farmed tilapia were produced in developing countries in 1995, where Asia alone produced about 84% of this amount (FAO, 1997). EL-Sayed (2006) mentioned that Egypt produced 20% of the world tilapia capture and 12% of the world farmed tilapia. Recently, Bakeer (2009) cited that tilapia fish are among the ancient Egyptian fish of origin; yet, they became among the most outspreading fish species all over the world. They are cultured nowadays world wide , so their production exceeded 2.5 million tons year 2006, and Egypt now take the 2^{nd} position after China in the world production and the 1^{st} in Africa and middle East . He added that the local fish production is more than one million ton, from which the fish culture is about 63% (630 thousand tons) year 2007. About 80% of the culture production is tilapia (504 thousand tons).

Water hyacinth (*Eichhorinia crassipes,* Mart Solms) is a warm water aquatic plant which widespread in many countries, particularly during summer months with its highest growth in July **(**Sivakami and Ayyappan, 1991)**.** El-Sayed (2003) evaluated the effects of different fermentation methods on the nutritive value of water hyacinth (WH) for Nile tilapia fingerlings. Fresh dry hyacinth (FH), molasses – fermented hyacinth (MF), cow rumen content – fermented hyacinth (RF) and yeast – fermented hyacinth (YF) were incorporated into nine isonitrogenous (35% CP), isocaloric (450 kcal GE/100g) test diets as a replacement of dietary wheat bran at 10 and 20% substitution levels. These results indicate that fermentation of WH way only be necessary when incorporated into Nile tilapia diets at 20% inclusion levels. El-Sayed (2003) **s**howed that, the fermentation of water hyacinth only be necessary when incorporated into Nile tilapia diets at 20% inclusion levels.

To be environmentally friends as well as to overcome the fish culture main problem of aqua feed shortage, an attention may be gifted to use this weed "water hyacinth" in fish feeding. So, the aim of this thesis was to evaluate the possibility of feeding Nile tilapia fish for 12 weeks on graded levels of replacing soybean meal protein with water hyacinth leaves meal protein. The evaluation was carried out via studying the quality criteria of fish rearing water, growth performance and survival of fish, feed and nutrients utilization, blood picture, chemical composition and economic evaluation.

MATERIALS AND METHODS

An in-door feeding experiment was conducted for 12 weeks to study the effect of replacing soybean meal protein by 0, 10, 20, 30 and 40% water hyacinth (*Eichhorinia crassipes*) protein from two sources, either from clean

water or from polluted water, on growth performance, feed utilization, body composition, some blood parameters and preliminary economical evaluation of Nile tilapia (*Oreochromis niloticus*) fingerlings breeding.

Source of water hyacinth:

Water hyacinth was collected from two sources, the first source was from clean water (chanel) of the River Nile at Kafr El-Zayat. The second source was from polluted water (ditch) collected from a canal at Tanta, Manshiet Ganzor. The roots were removed and the rest of the plants were washed with running tap water to minimize the soil contamination, then dried under sunlight, and stored at room temperature until be used.

Experimaental fish:

The experimental fish (*Oreochromis niloticus*) were taken from the stock of Fish Research Laboratory in the Animal Production Department, Faculty of Agriculture, Kafrel-Sheikh University during January 2005. Prior to the start of the experiment, the fingerlings were placed in a fiberglass tank and randomly distributed into the experimental aquaria to be adapted to the experimental conditions until the start of the experiment. Fish were fed a control diet (without water hyacinth) for two weeks at a feeding level of 3% from the body biomass; during this period, healthy fish at the same weight replaced the died ones.

Experimental design of rearing fish:

A total number of 360 fish with 12.4 g average initial body weight were randomly distributed into 30 glass aquaria (70 L each, 12 fish in each). Each treatment was represented in three aquaria. Fresh tap water was stored in fiberglass tanks for 24h under aeration for dechlorination. One third of water aquaria was replaced daily and totally once every week after removing the wastes. The experimental aquaria were supplied with air by electerical small pumps and air stones. During the experimental period (12 weeks), each aquarium was suppled with electric heater and the water temperature was maintained on 26 ± 1^{0}C through the thermostat. Photoperiod was controlled to be 14h per day using florescent light. Fish feces and feed residue were removed daily by siphoning.

Experimental diets and feeding regime:

Prior to the start of the experiment, the fishes were adapted to a basal control diet (T_1, Table 1) containing about 26% crude protein and consisted of fish meal, soybean meal, yellow corn, wheat bran, sunflower oil and vitamin and minerals mixture for two weeks. Ten experimental diets were formulated from a basal diet to contain two sources of dried water hyacinth at a level of 0, 10, 20, 30 and 40% of soybean meal protein (diets No. 1, 2, 3, 4 and 5), respectively (from unpolluted water) and 0, 10, 20, 30 and 40% of soybean meal protein (diets No. 6, 7, 8, 9 and 10), respectively (from polluted water) as shown in Table (1). A basal diet was made from the commercial ingredients. The dry ingredients were finely ground and mixed by a dough mixer for 20 minutes for homogeneity. Oil was gradually added during the mixing. After homogenous mixture was obtained, forty ml water per hundred g diet was slowly added to the mixture. The diets were cooked on a water evaporator for 20 minutes. The diets were pelleted (3 mm) through fodder machine and the manufacture pellets were dried in a drying oven at 70^{o}C for

48 hours. The diets were collected, tagged and stored in refrigerator at 4^{o}C. Fish in all treatments were daily fed the experimental diets at a level of 3% of the fish biomass then weighed every week; accordingly, the amount of food (which was given twice daily at 8.0 a.m. and 3.0 p.m., six days a week for 12 weeks) was recalculated.

Table (1): Composition of the experimental diets.

Ingredients	Water hyacinth (clean water source)					Water hyacinth (polluted water source)				
	T_1 (0%)	T_2 (10%)	T_3 (20%)	T_4 (30%)	T_5 (40%)	T_6 (0%)	T_7 (10%)	T_8 (20%)	T_9 (30%)	T_{10} (40%)
Fish meal	10	10	10	10	10	10	10	10	10	10
Soybean meal	34.0	30.6	27.2	23.8	20.4	34.0	30.6	27.2	23.8	20.4
Yellow corn	41	36.23	31.46	26.68	21.92	41	36.23	31.46	26.68	21.92
Wheat bran	10	10	10	10	10	10	10	10	10	10
Sunflower oil	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Vit. and Min. premix*	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Water hyacinth	0	8.17	16.34	24.52	32.68	0	8.17	16.34	24.52	32.68
Total	100	100	100	100	100	100	100	100	100	100

*** Vitamins and minerals premix (product of HEPOMIX) each 2.5 kg contain: 12.000.000 IU Vit.A; 2.000.000 IU Vit. D3 ; 10 g Vit. E; 2g Vit. K3; 1g Vit. B1 5g Vit. B2; 1.5 g Vit. B6 ; 10g Vit.B12; 30 g Nicotinic acid ; 10 g Pantothenic acid ; 1g Folic acid; 50g Biotien; 250g Choline chlorid 50% ; 30g Iron; 10g copper; 50g Zinc; 60g Manganese; 1g Iodine; 0.1g Selenium and Cobalt 0.1g (local market).**

Water quality parameters:

Samples of water were taken from each aquarium daily to determine the values of pH, dissolved oxygen concentration and water temperature. The pH value of water was determined daily by using an electrical digital pH-meter. Concentrations of dissolved oxygen were measureed by using oxygen meter model 9060. Water temperature was determined by using a mercuric Celsius thermometer.

Chemical analysis:

Chemical analysis of ingredients, diets and fish samples were analyzed according to A.O.A.C. (1990) for dry matter, crude protein, ether extract, and ash. Gross energy contents of the ingredients, experimental diets and fish samples were calculated by using the energy values of protein, lipid and carbohydrates presented in NRC (1993), being 5.65, 9.45 and 4.22 kcal/g, respectively. Mineral analysis was carried out in the Chemical Analyses Lab., Regional Center, belonging to the General Authority for the Agricultural Budget Box, Ministry of Agriculture, Dokki, Giza.

Measurements of growth and feed utilization parameters:

Body weight of fish in each aquarium was measured at start and every week and total body length was measured at start, at 6th and 12th weeks during the experimental period (12 weeks). Growth parameters were average weight gain (AWG), average daily gain (ADG), total body length gain (TLG), relative growth rate % (RGR), specific growth rate %/day (SGR) and survival rate % (SR). Feed conversion ratio (FCR), protein efficiency ratio (PER) and

protein productive value % (PPV), were estimated at the end of the experimental period according to the equations given by Abdelhamid (2009-a).

Organs indices:

All fish were killed at the end of the experiment, liver and gonads were removed and individually weighted. Hepatic somatic index (HSI) and gonado somatoc index (GSI) were calculated as described by Jangaard *et al*. (1967), Alabaster and Lioyed (1982), Tseng and Chan (1982) and Abdelhamid *et al*. (2004-a and b), respectively.

Blood Samples:

Blood samples were collected at the end of the experiment, fish in each aquarium were weighed and 5 fish were taken randomy for blood sampling. Blood samples were received in plastic tubes. Blood serum was isolated by centrifugation for 20 minutes at 4000 rpm. Serum samples were kept in deep freezer till the chemical analysis. Red blood cells (RBC_s x 10^6/mm), platelets and white blood cells (WBC_s x 10^3/mm) were counted by using a haemocytometer. Hemoglobin was determined using commercial colorimetric kit (Diamond Diagnostic, Egypt). Blood serum biochemical constituents were determined calorimetrically using commercial kits produced by Diagnostic System Laboratories, INC, USA. Total protein was determined as described by Tietz (1990). Albumin was determined according to Doumas *et al*. (1971). The concentration of serum globulin was obtained by subtracting the albumin from the total blood serum proteins concentration. Serum cholesterol was carried out according to the method described by Trinder (1969). Serum total lipids was determined according to the method of McGowan *et al*. (1983). Serum creatinine was estimated according to the method of Tietz (1986). Blood serum urea was determined according to Patton and Grouch (1977). Activity of alanin amino transferase (ALT) and activity of asparatate transferase (AST) were determined by the methods of Young (1990).

Economical evaluation:

Preliminary economical evaluation of the experimental diets has been calculated based on the cost of one kg fish weight gain produced (LE), using feed conversion rate and the price of the experimental diets. Costs were the price of feeds in local markets during 2005. Costs of 1 kg of fish meal, soybean meal, wheat bran, yellow corn, sunflower oil, vitamins and minerals premix, were 3.0, 1.5, 0.70, 1.0, 3.5, and 4 LE, respectively.

Statistical analysis:

The obtained numerical data were statistically analyzed using SAS (1996) for one-way analysis of variance. Differences between comparisons among treatment means were made by using Duncan multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Water quality criteria:

Table (2) illustrates some quality criteria measured in the fish rearing water as means (of the experimental whole period) for different experimental treatments (replacing levels by water hyacinth whether from clean or polluted

origins). Water temperatures range 26.4 – 27.5^{o}C, pH 7.15 – 7.20 and dissolved oxygen 5.01 – 5.30 mg/l. These ranges are ideal for rearing Nile tilapia fish according to Abdelhamid (1994, 1996, 2009-a & b).

Table (2): Averages of some physical and chemical parameters of fish rearing water during the feeding experimental period as affected by level and source of water hyacinth in the diets.

Treatments	Source of water hyacinth	Water temperature ^{o}C	Water pH	Dissolved oxygen mg/L
T_1	Clean water	27.50	7.20	5.30
	Polluted water	27.50	7.20	5.30
T_2	Clean water	27.40	7.15	5.00
	Polluted water	27.45	7.20	5.01
T_3	Clean water	27.00	7.15	5.01
	Polluted water	26.45	7.15	5.01
T_4	Clean water	26.85	7.15	5.02
	Polluted water	27.00	7.20	5.02
T_5	Clean water	26.50	7.20	5.04
	Polluted water	26.40	7.15	5.02

Trace and heavy metals:

Table (3) shows some trace elements and heavy metals of water hyacinth (WH) and diets used in the tested fish feeding. From this Table, it is clear that most of these elements were higher in the WH from polluted source than from clean source by 1160.7, 193/1, 373.6, 246.9, 25.0, and α% for Fe, Mn, Zn, Cu, Pb, and Cd, respectively. This consequently elevated the same elements in the diets containing polluted WH than in those containing the clean WH by 2217.3% (Fe), 221.8% (Mn), 379.6% (Zn), 181.0% (Cu), 500% (Pb) and 0.0% (Cd). However, the highest concentrations were for Fe > Mn > Zn > Cu > Pb > Cd, whether in WH or in the experimental diets. In this context, Abdelhamid and Gabr (1991-b) obtained higher Pb and Hg concentrations in ditch – WH than in channel – WH. Water hyacinth plant differs in its heavy metal concentrations from one part of the plant to the other parts of the same plant, since its leaves contain more aluminum (2.1%) than its steam (1,5%). Yet, ferrous is more concentrated in steams (0.354%) than in the leaves (0.255%). So, WH is used in reducing heavy metals toxicity for its spongy like properties in adsorption and accumulation of what is in the attached environment (James *et al*., 1992).

Table (3): Chemical composition of some metals of water hyacinth and manufactured diets as affected by the dietary water hyacinth (WH) source.

Items	Source of water hyacinth	Minerals (ppm)					
		Fe	Mn	Zn	Cu	Pb	Cd
Water hyacinth (WH)	Clean water	305	96.6	10.6	3.2	0.4	0.00
	Polluted water	3540	186.5	39.6	7.9	0.1	0.01
Diets including (WH)	Clean water	106.3	43.5	4.9	2.1	0.01	0.00
	Polluted water	2357	96.5	18.6	3.8	0.05	0.00

However, aquatic plants are spongy-like, i.e. they absorb different elements and metals from the ambient water and accumulate them in their tissues (Abdelhamid, 2009-b).

Diets composition:

Table (4) presents routine analysis of the experimental diets. They were almost isonitogenous and isocaloric (26.13 – 26.80% crude protein and 429 – 443 Kcal GE/100 g dry matter, respectively). Yet, EE, NFE and ash ranges were 4.35 – 5.05%, 58.1 – 61.4% and 7.34 – 11.03%, respectively. Treatment No. 4 containing clean WH was the highest in EE and NFE and the lowest in ash contents among all diets with different WH inclusion levels and sources. This is in agreement with the findings of Abdelhamid and Gabr (1991-a) who found that water hyacinth (WH) contains low organic matter although its crude protein content was high. Also, ash, K, and cell wall fractions were high. Thus, its intake, digestibility, feeding values and N-balance were low. Its high K content affected negatively serum analysis, water balance and kidney function. So, it may be used as an ingredient but not solely in animal feeding. Also, Abdelhamid and Gabr (1991-b) reported that WH from the ditch reflected higher contents of ether extract, crude protein, ash, acid detergent fiber (ADF), acid detergent lignin (ADL), cellulose and silica whereas most of the minerals (Ca, P, Pb and Hg) were lower than in WH from the chanel. The leaves contained more neutral detergent fiber (NDF), hemicelluloses, cellulose, total phenols and phenalic tannin, but stems were higher in ADF and ADL than leaves. Ca/P ratio was narrow in the whole plant than in leaves or stems. Digestibility of organic matter (*in vitro* gas production system, 58.4%) was closely to the *in vivo* estimated value (59.5%), although metabolizable energy was 6.35 MJ/Kg DM. They added that, inclusion of WH in the rations reduced feed intake. Digestibility and nutritive values decreased by increasing WH levels in the ration. They found also, that WH increased blood total protein, albumin, total lipids and cholesterol, and decreased creatinin, phospholipids, inorganic P and Ca, so WH may not be offered as a sole feed but it could be replace up to 50% of the diet's concentrates. So, El-Sayed (1999) presented alternative dietary protein sources for tilapia with emphasis on aquatic plants.

Table (4): Chemical analysis of the experimental diets on dry matter basis (%) and calculated* gross energy content (Kcal/ 100 g) as affected by the dietary source and level of water hyacinth (WH).

Treat.	DM		CP		EE		Ash		NEF		GE	
Source of WH	C	P	C	P	C	P	C	P	C	P	C	P
T_1	59.0	59.0	26.5	26.5	4.73	4.70	8.60	8.60	60.2	60.2	439	438
T_2	59.4	60.2	26.5	26.4	4.40	4.83	11.03	8.60	58.1	60.1	442	440
T_3	59.8	60.2	26.4	26.8	5.02	4.83	8.46	8.56	60.2	59.8	429	439
T_4	61.2	60.6	26.2	26.1	5.05	4.35	7.34	8.63	61.4	60.9	443	437
T_5	66.7	59.4	26.4	26.3	4.98	4.70	7.72	7.90	60.9	61.1	442	441

*** After NRC (1993), C: clean and P: polluted sources**

Also, El-Ebiary *et al*. (2004) recommended using WH at a level up to 50% of tilapia diets. Abdelwareth (2006) found that WH contains 34% CP, 6% EE and 6.5% crude fiber and recommended its use at 20 – 30% level from dietary fish meal for Nile tilapia. Moreover, El-Sayed (2006) referred to water hyacinth as unconventional feedstuff that can be used in semi-intensive culture of tilapia in Egypt. He gave its chemical composition as 21.1% CP, 1.0% EE, 19.0% CF, 18.2% ash and 40.7% NFE to be fed at 10 – 20% of the fish diet.

Growth performance:

From Tables (5 and 6), initial body weight of the tested fish did not differ between clean and polluted WH included diets nor among levels (treatments) of the WH in the fish diets. Yet, final body weight of T_2, T_3 and T_4 polluted WH were significantly lower than those of clean WH. Since polluted WH inclusion and increasing WH levels led to significantly lower final body weight, total body weight gain, average daily gain and survival rate. Also, specific growth rate (SGR) took the same trends, i.e. it decreased by elevating WH inclusion level in the fish diet as well as by polluted WH than clean WH source. Also, increasing WH dietary inclusion levels led to lower condition factor (K) (Table 7). In accordance with the present results, El-Ebiary *et al*. (2004) reported lower growth performance parameters of Nile tilapia fry by increasing the level of replacement with WH to more than 50%. Abdelhamid *et al*. (2006) came to the same conclusion, thus they recommended to use WH protein at a level up to 20% of soybean protein in a diet for feeding Nile tilapia fingerlings.

Table (5): Growth performance and survival rate/aquarium of the experimental fish throughout the experimental period as affected by the dietary level and source of water hyacinth (WH).

Treat-ment	Initial weight (g)		Final weight (g)		Average total weight gain (g)		Average daily gain (g/ day)		SGR (%/day)		Survial rate (%)	
Source of WH	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water
T_1	147.00	149.00	187.33 ab	188.17 a	40.33 ab	30.17 a	0.42 ab	0.41 a	0.289	0.278	83.00 b	83.00 b
T_2	147.67	149.33	184.00 bA	174.27 bB	36.33 bA	24.94 bB	0.38 bA	0.26 bB	0.262	0.184	100.00 a	100.00 a
T_3	146.67	149.00	188.00 aA	169.50 bB	41.33 abA	20.50 bB	0.43 abA	0.21 bB	0.291	0.153	97.33 a	94.33 a
T_4	147.33	149.33	189.67 a	170.00 b	42.34 aA	20.67 bB	0.44 aA	0.22 bB	0.301	0.154	97.00 a	91.00 a
T_5	147.33	149.00	175.33 a	175.00 b	28.00 c	26.00 b	0.29 c	0.27 b	0.207	0.191	91.38 abA	81.83 bB
MSE*	0.34	0.46	1.44	2.00	1.55	2.09	0.02	0.03	-	-	1.93	1.96

a, b and c means in the same rows bearing different letters significantly at 0.05 level.
A and B means in the same columns bearing different letters differ significantly at 0.05 level.
*** Mean square of error from the analysis of variance.**

Table (6): Average weight gain (g/fish) and average daily gain (mg/fish) as affected by the dietary level and source of water hyacinth (WH).

Treatment	AWG (g/fish)		ADG (mg/fish)	
	Clean water	Polluted water	Clean water	Polluted water
T_1	0.5315^{B}	1.6810^{A}	5.7730^{aA}	0.8125^{ab}
T_2	0.2881^{B}	0.8480^{A}	0.3001^{bB}	2.1455^{bA}
T_3	0.1304^{B}	1.0398^{A}	0.8640^{ab}	0.9385^{c}
T_4	0.0425^{B}	0.6738^{A}	1.2199^{a}	2.0439^{b}
T_5	0.4384^{B}	1.8199^{A}	0.6561^{abB}	5.4847^{aA}

Table (7): Data of fish final weight (g), total length (cm) and condition (K) factor at the end of the experimental period as affected by the dietary level and source of water hyacinth (WH).

Treatment	Final weight		Total length (L)		K- factor	
Source of WH	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water
T_1	15.69	18.85	10.30	10.60	1.435	1.500
T_2	15.84	14.60	14.13	12.91	0.560	0.71
T_3	15.40	15.00	11.97	12.27	0.897	0.812
T_4	12.72	15.94	11.17	11.23	0.911	1.122
T_5	20.23	15.94	11.60	12.17	1.296	0.884
MSE*	2.43	1.83	0.47	0.35	0.01	0.02

a, b and c means in the same rows bearing different letters significantly at 0.05 level.
A and B means in the same columns bearing different letters differ significantly at 0.05 level.
*** Mean square of error from the analysis of variance.**

Internal organs' indices:

The polluted WH diets increased significantly the inedible parts, i.e. hepato-somatic index and gonado-somatic index of both females and males than the other source (clean) of WH (Table 8). Up to 30% replacement improved these indices, but higher than 30% affected negatively these indices. However, Abdelhamid *et al*. (2006) reported that dietary WH inclusion did not significantly influence HSI nor GSI (in female) but there were significant differences among treatments concerning GSI (male).

Table (8): Effect of level and source of dietary water hyacinth (WH) on organs indices of fish at the end of the experiment.

Treatment	HIS		GSI (Female)		GSI (Male)	
Source of WH	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water
T_1	0.5315^{B}	1.6810^{A}	0.9075^{ab}	0.2153^{bB}	5.7730^{aA}	0.8125^{ab}
T_2	0.2881^{B}	0.8480^{A}	0.3341^{bB}	2.3058^{aA}	0.3001^{bB}	2.1455^{bA}
T_3	0.1304^{B}	1.0398^{A}	0.5911^{b}	0.6083^{b}	0.8640^{ab}	0.9385^{c}
T_4	0.0425^{B}	0.6738^{A}	1.4500^{ab}	1.3428^{ab}	1.2199^{a}	2.0439^{b}
T_5	0.4384^{B}	1.8199^{A}	0.7708^{ab}	0.2004^{b}	0.6561^{abB}	5.4847^{aA}
MSE*	0.19	0.21	0.17	0.24	0.34	0.48

a, b and c means in the same rows bearing different letters significantly at 0.05 level.
A and B means in the same columns bearing different letters differ significantly at 0.05 level.
*** Mean square of error from the analysis of variance.**

Feed conversion and protein utilization:

Table (9) show that feed conversion ratio was lower on polluted-WH diets than on clean – WH diets throughout all dietary inclusion levels. This may be due to lower bodyweight gain in fish fed the polluted-WH diets (Table 7) as well as to very low feed intake (Table 13) resulting in apparently better feed conversion, protein efficiency ratio (PER), and protein productive value (PPV%) as illustrated in Table (9). However, FCR and PPV% increased and PER decreased by increasing level of WH replacement.

Table (9): Feed conversion ratio (FCR), protein efficiency ratio (PER), and protein productive value (PPV%) throughout the entire period of the experiment as affected by the dietary level and source of water hyacinth (WH).

Treatment	FCR		PER		PPV %	
Source of WH	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water
T_1	2.76^{b}	0.85^{c}	1.39	4.50^{b}	22^{b}	22.09^{b}
T_2	3.60^{a}	1.53^{b}	1.06	2.51^{B}	31^{a}	42.84^{a}
T_3	3.00^{a}	1.79^{b}	1.27	2.14^{B}	28^{a}	22.50^{b}
T_4	2.93^{b}	1.78^{b}	1.31	2.13^{B}	27^{a}	34.36^{a}
T_5	3.92^{a}	1.28^{b}	0.97	2.98^{A}	23^{b}	20.22^{b}

a, b and c means in the same rows bearing different letters differ significantly at 0.05 level.
A and B means in the same columns bearing different letters differ significantly at 0.05 level.

In agreement with these results, El-Ebiary *et al*. (2004) registered that PPV and energy utilization by fish decreased by increasing the level of replacement with WH to more than 50%. Thus, they recommended using WH at a level up to 50% of diets containing a mixture of fish meal and soybean meal for feeding Nile tilapia fingerlings. Moreover, Abdelhamid *et al*. (2006) mentioned that PPV and PER of fish were decreased by increasing the level of replacement with WH more than 20%.

Blood profile:

Significant differences were recorded among treatments of both groups fed on diets included WH whether from clean or polluted sources, concerning all tested hematological and biochemical parameters, with one exception in Table 10 (total proteins) and Table 11 (hemoglobin). There was a general decreasing trend in values of uric acid, urea, total protein, albumin, globulin, cholesterol, hemoglobin, and red blood cells in the fish fed clean WH including diets, but there was a general increasing trend in levels of transaminases, white blood cells and platelets (Table 10). Similar trends were recorded in Table (11) except for uric acid, urea, and transaminases which took the opposite trend (decrease). In this context, increasing the plasma total protein indicates the improvement in the nutritional value of the diet. In the present investigation, total protein was lowest when fish fed a diet where 30% (T_4, Table 10) or 40% (T_5, Table 11) of soybean meal protein were substituted by WH protein and this is due to inferior the protein quality of these diets.

10

11

Generally, anemia causes lower Hb concentration and RBC_s count; bacterial infection, acidosis, and leucosis lead to higher WBC_s count; liver diseases are responsible for lower concentration of blood urea, uric acid, and proteins, as well as transaminases' activity; malabsorption syndrome is a causative for lower level of blood lipids; and not infrequently lower cholesterol concentrations are obtained in pernicious anemia (Merck, 1976 and Varley, 1978).

Fish body composition:

The chemical composition at the experimental begin was 26.07% dry matter, 54.30% crude protein, 9.0% fat and 14.0% ash, on DM basis. From Table (12) of the chemical analysis (% dry matter basis) of the whole fish body at the end of the experiment, it is clear that both of WH sources and dietary inclusion levels affected significantly each of crude protein (CP), ether extract (EE) and ash contents. Where, CP decreased but EE and ash increased by elevating the substitution level and inclusion of polluted WH. This refers to the bad feed utilization by increasing WH substituting level, particularly from polluted source, may be for its inclusion on some heavy metals and also may be attributed to the low DM content of the tested rations. Also to that WH contains saponin as a toxic substance, and ca. 45 Kg of this aquatic plant could be converted into 1 Kg of fish. Moreover, WH is rich in crude fiber and ash contents leading to low nutritive value (Jian, 1985). However, Lim and Dominiy (1989) cited that replacing fish meal either partially or totally with less expensive plant proteins in practical diets of various warm water fish species had varying degrees of success. It is generally observed that plant proteins have a lower nutritive value than fish meal and high levels of inclusion of plant proteins usually result in reduced growth and feed efficiency. The ability of fish to utilize plant proteins also differs; results obtained by different researchers are sometimes contradictory. Despite the poor utilization of plant protein as compared to fish meal (for the presence of anti-nutritional factors or toxic substances, improper balance of essential nutrients, high fiber and carbohydrates content, decreased palatability and reduction of pellet quality), practically the plant proteins are being used to some extent in commercial warm water fish feeds.

Table (12): Chemical analysis (% DM basis) of the fish body at the end of the experimental period as affected by level and source of dietary water hyacinth (WH).

Treatment	Dry matter		Crude protein		Ether extract		Ash	
Source of WH	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water	Clean water	Polluted water
T_1	25.72	28.78	60.81^{abA}	58.83^{B}	19.27^{b}	20.77	19.63	19.60
T_2	28.01	25.85	60.17^{ab}	58.86	18.43^{b}	20.74	19.17	20.03
T_3	25.81	26.19	62.27^{aA}	58.17^{B}	20.35^{ab}	21.77	19.87	20.03
T_4	24.97	26.93	56.77^{c}	58.50^{cB}	21.27^{a}	21.67	20.30-	19.83
T_5	25.41	25.61	59.70^{b}	58.23^{B}	20.17^{ab}	21.63	20.03	20.14
MSE*	0.48	0.52	0.55	0.19	0.32	0.21	0.30	0.20

a, b and c means in the same rows bearing different letters differ significantly at 0.05 level.
A and B means in the same columns bearing different letters differ significantly at 0.05 level.
*** Mean square of error from the analysis of variance.**

The facts of the negative relationship between CP and EE from one side and the between dry matter (DM) and CP on the other side were realized in this study. Also, there was a positive relationship between DM and EE contents. These relationships confirm those reported before since a negative relationship was noticed between CP and EE contents of fish body but a position relationship between CP and ash contents was recorded too (Abdelhamid *et al*., 2000; and El-Saidy and Gaber, 2002). There was a positive correlation between crude protein and fat contents of the fish, also Abdelhamid *et al*. (2004-a & b and 2005-a & b), Magouz *et al*. (2002-a & b), El-Ebiary and Zaki (2003), Abdelhamid and El-Katan (2006-a & b) and Abdelhamid *et al*. (2009) found a negative correlation between protein and fat contents of the fish.

Economic evaluation:

Elevating WH level reduced the feed intake, particularly from polluted source to about 30% of that consumed from clean-WH including diets (Table 13). Dietary inclusion of WH reduced the feed price gradually by increasing the level of WH substitution. Yet, total fish body gain decreased, especially by using WH from polluted source; so, the feed cost/Kg bodyweight gain increased by increasing WH level of dietary inclusion but not be using the polluted WH because of the very low of feed intake. Similarly, Abdelhamid *et al*. (2006) found that same trend in their results.

Table (13): Data of economic evaluation of feeding process as affected by level and source of dietary water hyacinth (WH).

Treatment	Feed Intake (g)		Cost (L.E) of one Ton diet		Decrease in feed cost (%)		Total gain (g/Fish		Feed cost/gain* L.E)	
Source of WH	Clean	Polluted	Clean	Polluted	Clean	Polluted	Clean	Polluted	Clean	Polluted
T_1	111.40	33.49	2765.0	2765.0	-	-	40.33	39.17	7.63	2.36
T_2	131.08	38.19	2625.4	2625.4	139.6	139.6	36.33	24.93	9.47	4.02
T_3	124.34	36.88	2425.9	2425.9	339.1	339.1	41.33	20.50	7.29	4.36
T_4	124.24	36.82	2346.2	2346.2	418.8	418.8	42.33	20.67	6.88	4.17
T_5	109.97	33.48	2206.8	2206.8	558.2	558.2	28.00	25.00	8.66	2.84

*** Feed cost/Kg gain (L.E) = Feed intake (g) x cost (L.E) of one Kg feed / total gain (g).**

Conclusively, it is not to recommend using water hyacinth from polluted water sources in feeding fish. In emergency cases only and in case of feed shortage, water hyacinth from non-polluted water sources could be used up to 30% not more as a substitute level in fish diets instead of soybean meal protein. In conclusion, the histological examination cleared no pathological lesions in liver and kidney or pathological effects on gills and the dorsal muscles when fish were fed diets in which protein of soybean meal was replaced by up to 20% water hyacinth from clean source or 10% water hyacinth from polluted source.

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تاثير مصدر ومستوى ورد النيل فى عليقة البلطى النيلى على أداءه

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فى تجربة غذائية معملية فى أحواض زجاجية لمدة 12 أسبوعاً، حل فيها بروتين مسحوق ورد النيل (من مصدرين مختلفين، ملوث وغير ملوث) بنسب صفر، 10، 20، 30، 40% محل بروتين مسحوق فول الصويا فى علائق أسماك البلطى النيلى، كُونت العلائق العشرة التجريبية متساوية البروتين (26%) والطاقة، وقدمت للأسماك بمعدل 3% من وزن الجسم يومياً لمدة 6 أيام/أسبوع وذلك على وجبتين يومياً. أمكن

تلخيص النتائج فى أن خواص جودة المياه لتربية الأسماك لم تتأثر بالمعاملات. زادت تركيزات معظم العناصر الثقيلة فى العلائق المحتوية على ورد نيل من مصدر ملوث (181 – 2217.3%) عنها فى العلائق المحتوية على ورد نيل من مصدر غير ملوث، وذلك لارتفاعها فى مسحوق أوراق ورد نيل ملوث المصدر عنها فى ورد النيل من مصدر غير ملوث. كانت تركيزات الحديد > المنجنيز > الزنك > النحاس > الرصاص > الكادميوم سواء فى مسحوق أوراق ورد النيل أو فى العلائق التجريبية. أعلى العلائق فى المستخلص الإيثيرى والمستخلص خالى الآزوت والأقل فى محتوى الرماد كانت عليقة رقم 4 (المحتوية على 30% إحلال ببروتين أوراق ورد النيل غير ملوث المصدر). اختلفت قياسات أداء نمو الأسماك باختلاف مصدر مسحوق أوراق ورد النيل (ملوث وغير ملوث)، فكانت الأوزان ا لنهائية للأسماك فى المعاملات أرقام 2، 3، 4 (10، 20، 30%) إحلال ببروتين مسحوق أوراق ورد النيل من مصدره الملوث)، أدنى معنويا من تلك المغذاه على العلائق ذات ورد النيل من مصدر غير ملوث. كما أدى تلوث مصدر ورد النيل إلى خفض معنوى لقياسات النمو الأخرى كذلك عن ورد النيل من مصدره الآخر غير الملوث، سواء بالنسبة للزيادة فى وزن الجسم، والحياتية، ومعدل النمو النوعى. أدت زيادة مستوى بروتين أوراق ورد النيل فى العلائق إلى انخفاض معنوى فى كل من وزن الأسماك النهائى، الزيادة فى وزن الجسم، الحياتية، معدل النمو النوعى، معامل الحالة. تلوث ورد النيل زاد من الأجزاء غير المأكولة من الأسماك فى صورة دلائل الأنسجة (كبد ومناسل ذكور وإناث)، كما أن نسب إحلال أعلى من 30% أثرت سلبياً على هذه الدلائل. إنخفض معدل تحويل الغذاء بتلوث مصدر ورد النيل لانخفاض إستهلاك العلف بشدة وكذا ضعف نمو الأسماك مما أدى لتحسن ظاهرى فى تحويل الغذاء وفى نسبة كفاءة البروتين وقيمة البروتين الإنتاجية. أدت زيادة مستوى الإحلال إلى زيادة معدل التحويل الغذائى ونسب قيمة البروتين الإنتاجية، لكن انخفضت نسبة كفاءة البروتين. أثر كل من مصدر ومستوى الإحلال ببروتين أوراق ورد النيل معنوياً على صورة الدم (هيماتولوجياً وبيوكيماوياً) للأسماك، باستثناء تركيزات كل من الهيموجلوبين والبروتين الكلى، فقد انخفضت قيم كل من حمض اليوريك واليوريا والبروتين الكلى والألبيومين والجلوبيولين والكوليسترول والهيموجلوبين وعدد كرات الدم الحمراء فى الأسماك المغذاه على علائق ورد النيل غير الملوث، مع زيادة عامة فى مستويات إنزيمات نقل الأمين وعد كرات الدم البيضاء والصفائح الدموية. انخفضت البروتينات الكلية فى دماء أسماك المجموعتين المحتويتين على 30% بروتين ورد نيل من مصدر غير ملوث و40% بروتين ورد نيل من مصدر ملوث، لانخفاض جودة بروتينات مثل هذه العلائق. أثر معنوياً كل من مصدر مستوى الإحلال بورد النيل على كل من محتوى الجسم للأسماك من البروتين الخام والمستخلص الإيثيرى والرماد، حيث انخفض البروتين وزاد الدهن والرماد بزيادة مستوى الإحلال أو لاحتواء العلائق على المصدر الملوث لورد النيل، وهذا راجع ربما لرداءة الإستفادة الغذائية بزيادة مستوى الإحلال خاصة من المصدر الملوث لورد النيل، وقد يرجع لانخفاض المادة الجافة لهذه العلائق المختبرة. أدت زيادة مستوى ورد النيل فى العلائق لإنخفاض إستهلاك الغذاء خاصة من العلائق المحتوية على ورد النيل من مصدر ملوث إلى 30% فقط من المستهلك من العلائق ذات ورد النيل من مصدره غير الملوث. ورغم انخفاض أسعار العلف المحتوى على ورد النيل تدريجياً بزيادة مستوى ورد النيل، إلا أن العائد من زيادة وزن الجسم تنخفض خاصة لو كانت التغذية على علائق بها ورد نيل من مصدره الملوث (الذى يخفض بشدة من استهلاك العلف). لذا لا يوصى باستخدام ورد النيل (من مصادر ماء ملوث) فى تغذية الأسماك، وفى حالة الإضطرار فقط ونقص الأعلاف فيستخدم ورد النيل من مصادر غير ملوثة وبحد أقصى لا يتعدى 30% من بروتين فول الصويا فى العلائق.

قام بتحكيم البحث

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Table (10): Data of blood hematological and biochemical parameters of the experimental fish at the end of experimental period as affected by the dietary level of water hyacinth (WH) from the clean source.

T	Uric mg/dl	Urea mg/dl	T. Prot. g/dl	Albu g/dl	Glob g/dl	T. mg/dl Lipid	Cholost. Mg/dl	AST u/l	ALT u/l	RBC x 10^6	WBC	Plat.	Hb g/dl
T_1 (Zero)	0.95 ± 0.03^{a}	16.20 ± 0.20^{a}	2.93 ± 0.03$^{N.S}$	0.88 ± 0.03^{b}	2.05 ± 0.05^{a}	147.25 ± 0.25^{a}	202.50 ± 0.50^{a}	64.50 ± 0.50^{b}	61.00 ± 1.00^{b}	4.38 ± 0.03^{a}	1525.0 ± 25.00^{c}	100.0 ± 0.00^{b}	11.50 ± 0.00^{a}
T_2 (10)	0.75 ± 0.05^{b}	16.10 ± 0.30^{a}	2.65 ± 0.25	0.70 ± 0.10^{b}	1.95 ± 0.05^{a}	148.00 ± 0.00^{a}	192.50 ± 2.50^{b}	64.00 ± 1.00^{b}	61.50 ± 0.50^{b}	4.25 ± 0.05^{a}	1850.0 ± 50. 0^{b}	130.00 ± 5.00^{a}	11.00 ± 0.20^{ab}
T_3 (20)	0.67 ± 0.04^{bc}	11.15 ± 0.25^{b}	2.90 ± 0.10	1.85 ± 0.05^{a}	1.05 ± 0.05^{b}	132.70 ± 0.70^{c}	159.00 ± 1.00^{c}	80.00 ± 1.00^{a}	77.50 ± 0.50^{a}	3.45 ± 0.05^{c}	2050.0 ± 50.0^{a}	120.50 ± 0.50^{a}	9.75 ± 0.75^{b}
T_4 (30)	0.55 ± 0.05^{c}	13.20 ± 0.30^{b}	2.05 ± 0.05	1.50 ± 0.30^{a}	0.55 ± 0.25^{b}	139.50 ± 0.50^{b}	156.50 ± 0.50^{c}	76.50 ± 2.50^{a}	77.00 ± 1.00^{a}	3.85 ± 0.05^{b}	1875.0 ± 25.0^{b}	127.50 ± 2.50^{a}	10.50 ± 0.50^{ab}
T_5 (40)	0.75 ± 0.05^{b}	15.20 ± 0.40^{a}	2.70 ± 0.60	0.766 ± 0.14^{b}	1.89 ± 0.41^{a}	147.20 ± 0.00^{C}	160.00 ± 0.00^{C}	64.00 ± 0.00^{b}	64.00 ± 0.00^{b}	4.25 ± 0.05^{a}	1050.0 ± 50.0^{d}	122.50 ± 2.50^{a}	10.75 ± 0.25^{ab}
Mean	0.73 ± 0.05	14.37 ± 0.65	2.65 ± 0.14	1.138 ± 0.16	1.50 ± 0.21	142.89 ± 1.99	174.10 ± 6.49	69.80 ± 2.37	69.80 ± 2.37	4.04 ± 0.12	1670.0 ± 118.6	120.10 ± 3.65	10.70 ± 0.24

a, b, c and d means in the same column bearing different letters differ significantly at 0.05 level.
N.S. not significant at P > 0.05.

Table (11): Data of blood hematological and biochemical parameters of the experimental fish at the end of experimental period as affected by the dietary level of water hyacinth (WH) from the polluted source.

T	Uric mg/dl	Urea mg/dl	T. Prot. g/dl	Albu g/dl	Glob g/dl	T. mg/dl Lipid	Cholost. Mg/dl	AST u/l	ALT u/l	RBC x 10^6	WBC	Plat.	Hb g/dl
T_1 (Zero)	0.45 ± 0.05^{cd}	12.75 ± 0.45^{b}	1.70 ± 0.20^{ab}	0.88 ± 0.08^{b}	0.83 ± 0.13^{a}	138.00 ± 0.00^{bc}	222.50 ± 2.50^{ab}	76.50 ± 1.50^{ab}	73.50 ± 0.50^{ab}	4.28 ± 0.03^{c}	1275.0 ± 25.00^{c}	115.00 ± 5.00^{bc}	10.70 ± 0.00$^{N.S}$
T_2 (10)	0.82 ± 0.02^{b}	13.15 ± 0.05^{b}	2.05 ± 0.05^{a}	1.20 ± 0.00^{a}	0.85 ± 0.05^{a}	146.45 ± 2.85^{a}	232.50 ± 7.50^{a}	65.00 ± 1.00^{c}	65.50 ± 0.50^{c}	4.48 ± 0.03^{a}	1350.0 ± 50. 0^{bc}	104.00 ± 2.00^{c}	10.80 ± 0.80
T_3 (20)	0.65 ± 0.05^{bc}	15.15 ± 0.35^{a}	1.90 ± 0.06^{ab}	0.95 ± 0.05^{b}	0.92 ± 0.03^{a}	134.50 ± 1.50^{c}	240.00 ± 1.00^{a}	79.00 ± 0.00^{a}	75.00 ± 0.50^{a}	4.38 ± 0.02^{b}	1275.0 ± 25.0^{c}	105.00 ± 0.50^{c}	11.00 ± 0.00
T_4 (30)	1.30 ± 0.01^{a}	12.05 ± 0.05^{c}	1.45 ± 0.15^{b}	0.85 ± 0.05^{b}	0.55 ± 0.05^{b}	144.15 ± 2.55^{ab}	237.50 ± 2.50^{a}	77.50 ± 0.50^{ab}	65.50 ± 1.50^{c}	4.33 ± 0.03^{bc}	1475.0 ± 25.0^{b}	125.00 ± 5.0^{ab}	11.40 ± 0.50
T_5 (40)	0.30 ± 0.05^{d}	15.00 ± 0.30^{a}	0.90 ± 0.05^{c}	0.38 ± 0.03^{c}	0.50 ± 0.00^{b}	134.50 ± 1.50^{C}	209.00 ± 9.00^{b}	75.50 ± 0.50^{a}	71.50 ± 1.50^{a}	4.00 ± 0.00^{d}	1750.0 ± 25.0^{a}	130.00 ± 0.00^{a}	11.05 ± 0.25
Mean	0.70 ± 0.12	13.62 ± 0.42	1.60 ± 0.14	0.85 ± 0.09	0.73 ± 0.06	139.52 ± 1.77	228.30 ± 4.21	74.70 ± 1.69	70.20 ± 1.36	4.29 ± 0.05	1425.0 ± 60.61	115.90 ± 3.61	10.99 ± 0.15

a, b, c and d means in the same column bearing different letters differ significantly at 0.05 level.
N.S. not significant at P > 0.05.