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EFFECT OF YUCCA (*YUCCA SHIDIGERA*) ON WATER QUALITYAND GROWTH PERFORMANCES OF NILE TILAPIA (*OREOCHROMIS NILOTICUS* L.) FINGERLINGS.

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Key words: *Yucca shidigera*, water quality, growth performance, Nile tilapia.

ABSTRACT

The effects of supplementation of *Yucca shidigera* in diets of Nile tilapia, *Oreochromis niloticus* (L.). Fingerlings were studied using the aquarium system, which allowed feeding and continuous measurement of water quality parameters. Three hundreds and sixty fish each weighing approximately 16.82 ± 0.09g were stocked in 24 glass aquaria (80 l each) at a rate of 15 fish per aquarium and were fed either control diet (C) or diets supplemented with Y250, Y500, Y750, Y1000, Y1250, Y1500 and Y1750 mg Yucca per kg diet. Diets were fed to fish at a rate of 3 % of body weight during the first 12 weeks then gradually reduced to 2% until the end of the experiment (18 weeks). The results of this study revealed that, when Yucca was added to the diets of fish, it caused a significant ($P < 0.05$) lower levels of ammonia and nitrite and higher levels of nitrate in the aquaria water. At the end of the experiment, the final average body weight (FBW), body weight gain (BWG), specific growth rate (SGR % day^{-1}), protein efficiency ratio (PER) and feed efficiency ratio (FER) of the Y750 and Y1000 fed groups were significantly ($P < 0.05$) higher than that of the control group and significantly different ($P < 0.05$) from other treatments. The best feed conversion ratio (FCR) was achieved with Y750 fed groups. Apparent digestibility coefficient (ADC) of protein and lipid were relatively high for most treated diets with Yucca, although groups fed Y1500 and Y1750 showed significantly higher ADC protein, lipid, energy, carbohydrate (CHO) and ash ($P < 0.05$) than other groups . Proximate composition of whole body moisture, protein, and lipid and ash contents was significantly influenced by adding Yucca to the diets.

From the present results, it can be concluded that adding of Yucca to the diets of Nile tilapia especially in intensive culture systems at a level of 750 mg/kg diet, could reduce ammonia and nitrite in water and act as growth stimulant for increasing growth performance and feed utilization.

INTRODUCTION

The increase of protein production either from farm animals or aquaculture especially by improving the metabolic efficiency in food utilization is at the frontier of agricultural development. Also water reuse or recirculation aquaculture system is receiving increased attention because they conserve water, and reduce pollution output. Accumulation of nitrogenous wastes (ammonia and nitrite) limits production intensity in water-recirculation aquaculture systems. The use of synthetic substances that were found to increase the efficiency of feed utilization by animals such as antibiotics and steroid hormones as animal feed additives are currently prohibited in several countries. In this context, search for natural, biologically active, and renewable plant products that could be used to replace hazardous synthetic growth stimulants are relevant. One group of such substances is saponins present in many wild plants and cultivated crops (Francis et al. 2002).

In other livestock industries, an extract of the *Yucca shadier* plant has shown to be promising in controlling ammonia accumulation. Jacques and Bastien (1989) reported that, ammonia average in manure of a bird not fed *Y. shidigera* extract was 29 ml/L and 2 ml/L from bird receiving extract. Suggested modes of action include urease inhibition, increased bacterial use of ammonia and direct binding of ammonia (Headon and Dawson, 1990).

Improved performance and increased efficiency have also been demonstrated or claimed when *Y. shidigera* extract was incorporated into feeds for poultry (Johnston et al. 1982), swine (Mader and Brumm, 1987), and channel catfish (Tidwell et al. 1992). Johnston et al. (1982) suggested that surfactant properties of components of *Y. shidigera* extract could aid nutrient absorption. However, because of the intimate contact fish have with their culture environment, any compound used in aquaculture system (and resulting metabolites) must be nontoxic to the fish at the levels required for efficacy.

This experiment was conducted to evaluate the effects of Yucca, *Yucca shadier* on water quality parameters, fish growth feed utilization and body composition, when incorporated into Nile tilapia feeds reared in aquaria.

MATERIALS AND METHODS

Feeds:

Eight experimental diets, a basal or control diet (C), and seven diets with added Yucca (Y250, Y500, Y750, Y1000, Y1250, Y1500, and Y1750) were prepared. The ingredients and chemical composition of the basal diet are shown in Table (1). The basal or control diet, was prepared in the fish research laboratory, Faculty of Agriculture, Minufiya University Shebin El-Kom then pelleted (about 1.0 mm diameter). The Yucca powder (YS, Sigma no. 0.9000.20.8; Sigma, St. Louis, USA), was first dissolved in alcohol then in distilled water and mixed thoroughly with the basal feed at levels of 250 mg kg^{-1} (Y250), 500 mg kg^{-1} (Y500), 750 mg kg^{-1} (Y750), 1000mg kg^{-1}(Y1000), 1250mg kg^{-1} (Y1250), 1500mg kg^{-1}(Y1500), and 1750mg kg^{-1}(Y1750). The moist pellets were dried and stored in a freezer at -18 ºC until use.

Experimental fish:

A total number of 370 Nile tilapia, *Oreochromis niloticus* (L.) fingerlings of about 16.82g initial average individual weight were obtained from a stock at the above mention fish research laboratory. The fish were starved for one day prior to the start of the experiment. Then fish were divided into 24 groups of 15 fish in each aquarium. The remaining 10 fish were killed, homogenized and frozen for determination the initial chemical composition. During acclimation in the aquarium, the fish were fed the basal diet containing approximately 321.5g kg^{-1} protein, 91.9g kg^{-1} lipid, 63g kg^{-1} ash and an energy content of 4.41 kcal g^{-1} on dry matter basis, for the first two weeks. At the start of the experiment, the eight experimental diets namely C, Y250, Y500, Y750, Y1000, Y1250, Y1500 and Y1750 were assigned each to triplicate groups.

The experimental set-up:

During the experiment, the aquaria were supplied with fresh declorinated water; about one third of water volume in each aquarium was daily replaced by aerated fresh water after cleaning and removing the accumulated excreta. All aquaria were supplied with compressed air. A photoperiod of 12h light, 12h dark (08:00 to 20:00h) was applied. The illumination was supplied by fluorescent ceiling lights. Each group of fish was weighed at the beginning and every two-week thereafter throughout the experimental period. The fish were fed six days a week at a rate of 3% of body weight during the first 12 weeks then gradually reduced to 2% until the end of the experiment at 18 weeks. At the termination of the experiment, five fish from each group were killed, homogenized and frozen. During the last month of the experiment, samples of feces were collected from each aquarium every morning before feeding. The feces were collected on filter paper for drying and subsequent chemical analysis. The apparent digestibility coefficients (ADC) for protein, lipid, ash and energy were calculated using the formula of Maynard and Loosli (1969).

ADC = 100 X {1-(% dietary Cr_2O_3 / fecal Cr_2O_3 X % fecal nutrient / % dietary nutrient)}.

Chemical analysis:

Analysis of samples were made on dry matter after desiccation in an oven (105 ^oC) for 24h), ash (incineration at 550 ^oC for 12h), crude protein (micro kjeldahl, N x 6.25), crude lipid (ether extract by Soxlhet method), crude fiber (AOAC, 1995) and gross energy (Ballistic bomb calorimeter, Gallenkamp, England). The chromic oxide in diets and feces was determined by the method of Furukawa and Tsukahara (1966).

Water quality:

Water temperature and dissolved oxygen were measured daily using an YSI oxygen meter (YSI Model 58 Yellow Springs, OH). Total ammonia, nitrite and nitrate were measured twice weekly using a DREL, 2000 spectrophotometer. pH was monitored daily using an electronic pH meter (pH pen; Fisher Scientific, Cincinnati, Ohio, USA).

Calculations and statistical analysis:

Calculations of growth parameters were conducted according to Cho and Kaushik (1985). Data were analyzed by analysis of variance (ANOVA) using the SAS ANOVA procedure (Statistical analysis system, 1988). Duncan's multiple range tests was used to compare differences among individual means. Treatment effect was considered significant at $P < 0.05$. All percentages and ratio were transformed to arcsine values prior to analysis (Zar, 1984).

RESULTS

Water quality:

Inclusion of *Y. shidigera* in Nile tilapia feeds caused significant decreases ($P < 0.05$) in total ammonia, nitrate, nitrite, and dissolved oxygen (Table2). Results in table (2 & Fig 1) ,revealed that levels of water total ammonia in aquaria of fish groups fed on diets containing Yucca shidigera extract powder (Y250, Y500, Y750 andY100) were significantly ($P =0.05$) lower than that of the control groups after two weeks of the experiment start. Also, it was found that ammonia concentration decreased by continuous feeding with *Y. shidigera*. Nitrite concentrations were significantly lower ($P < 0.05$) than control values in all aquaria receiving treated feed (Table 2 & Fig 2). After eight weeks, aquaria fed with *Y. shidigera* had significantly ($P < 0.05$) higher nitrate, than groups fed control diet (Table 2 & Fig 3). Dissolved oxygen after two weeks was significantly ($P < 0.05$) higher in aquaria with fish fed *Y. shidigera* than control one. There were no significant differences ($P =0.05$) among treated and untreated groups (Table 2 & Fig. 4).

Growth rate:

Results of table (3) revealed that groups Y750and Y1000 showed significantly (*P=0.05),* higher FBW, BWG and SGR compared to the control and other treatment groups. This may indicate that incorporation of *Y. Shidigera* into tilapia diets at levels of 750 to 1000 mg /kg diet is sufficient to obtain the maximum growth results.

Feed conversion and efficiencies:

Concerning feed conversion (FCR), the best results were obtained by the Y750 group followed by the other groups and the worst were obtained by the control group. The differences in the average values of FER and PER through the diets treated with Yucca, were not statistically different, while control diet was significantly ($P < 0.05$) lower than other diets.

Apparent digestibility coefficients (ADC):

The results of ADC of protein, fat, energy and ash for Nile tilapia fed diets untreated with yucca (control diet C) and treated with different levels of yucca (Y250, Y500, Y750, Y1000, Y1250, Y1500 and Y1750) are presented in Table (4). ADC of protein, fat, energy, carbohydrate and ash were significantly ($P < 0.05$) higher for most diets treated with *Yucca shidigera* when compared with the control diet. The highest values of ADC of protein, fat, energy, carbohydrate and ash were recorded with groups of fish fed diet (Y1750) which contained 1750 mg/kg of yucca while, the lowest values were recorded with groups of fish fed the control diet (C).

Whole body composition:

The results of body composition analysis on wet basis % are shown in Table (5). Significant differences ($P < 0.05$) were observed in the moisture, crude protein, crude fat, and crude ash in the groups of fish fed diets with different levels of Yucca. Whole body crude protein and fat contents were inversely related and the increase in the yucca concentration resulted in decreased protein and fat contents in the whole fish body. On the other hand, moisture and ash contents exhibited the opposite trend and increased with the increasing of Yucca concentrations in the Nile tilapia feeds.

DISCUSSION

An extract of *Yucca shidigera* plant has a promising effect in the control of ammonia with various terrestrial livestock animals. It is not known if the reduction is due to urease inhibition, increased use of ammonia (Jacques and Bastien 1989), or direct binding of ammonia (Headon and Dawson 1990). Previous studies (Tidwell et al., 1992) utilized channel catfish and

two different commercial sources of *Y. shidigera* extract. These extracts can contain at least three steroid saponins (Kaneda et al., 1987), but the exact extraction procedures utilized by different companies conceivably can result in significantly different levels of active compounds in the end products. Specifically, it appears that saponin component of the extract can be removed without eliminating its ammonia reduction capabilities (Headon, university college, Galway, Ireland, personal communication to Tidwell et al. ,1992). Accordingly, the extract used in the Kelly and Kohler study may prove highly useful in reducing N content in tilapia feces. Moreover, the long intestinal tract of Nile tilapia compared to channel catfish may be more conductive for N reduction. In the present study, the addition of *Y. shidigera* in Nile tilapia feed reduced ammonia concentration in the aquaria water. These results agree with those of Tidwell et al., (1992), who stated that addition of *Y. shidigera* extract to in vitro ammonia solutions reduced ammonia concentrations. Also, Headen and Dawson (1990) reported that reduction of ammonia could be due to either binding of ammonia with some fraction of *Y. shidigera* or by conversion of ammonia to another compound. The present study supports the theory of conversion. In fish groups fed on diets supplemented with Yucca, the water of aquaria showed increase nitrate concentration as ammonia levels declined, subsequently, nitrite concentrations decreased. These indicate the action of either chemical oxidation or nitrifying bacteria. In aquatic systems, bacteria of the genus *Nitrosomonas* oxidize ammonia to nitrite which is oxidized to nitrate by bacteria of the genus *Nitrobacter*. Microbial or chemical nitrification is also supported by concurrent declines in oxygen levels, because these are oxygen-consuming reactions.

Previous studies have shown that addition of *Y. shidigera* to formulated channel catfish diets reduced ammonia accumulation and decreased fish growth performance (Tidwell et al., 1992). In our study on Nile tilapia, a reduction in ammonia production or accumulation was demonstrated when *Y. shidigera* was incorporated into prepared Nile tilapia feeds. Also, increased growth and decreased feed conversion values with *Y. shidigera* incorporation indicate increased feed consumption or utilization, which agree with the positive growth responses reported for cattle (Goodall and Matsushima ,1980), swine (Foster ,1983), and poultry (Johnston et al. 1981).

The present study indicated that added Yucca to Nile tilapia feeds at a level of 750 mg/kg diet caused a 35.5 % increase in the final average weight over control. The values of other parameters such as FCR, FER, and PER, were also statistically differing from control and the best values were observed in Y750 fed groups. Lipid deposition in the whole fish body was decreased as Yucca concentration increased. This is in agreement with the finding of Hardwood et al. (1993), who reported a lower serum cholesterol level due to Yucca feeding.

In the present study, the ADC of nutrients was improved when *Y.shidigera* was incorporated into prepared Nile tilapia feeds. Serrano et al. (1998) and Francis et al. (2002) have shown that the Quillaja saponin mixture, when presented in the diet of carp, stimulated some gut and liver enzymes. The activity of the gut enzymes trypsin and amylase were significantly stimulated at 300 and 400 mg/kg levels and that of the liver enzymes, cytochrome c-oxidase (CO) and lactate dehydrogenase (LDH) were significantly higher at 150 mg/kg QS. These results indicate actions of Quillaja saponin both at the intestinal and general metabolic levels. The higher feed conversion ratio of the Y750 group in our study could be attributed to the increased digestion and absorption of food nutrients. Onning et al. (1996) have previously reported that saponins significantly increased passage of macromolecules across rat intestine in vitro.

From the above results, it can be concluded that adding of *Yucca shidigera* to the diets of Nile tilapia especially in intensive culture systems at a level of 750 mg/kg diet could reduce ammonia and nitrite in water and act as growth stimulant for increasing growth performance and improving feed utilization.

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Table 1Composition and proximate analysis of the basal diet fed to Nile tilapia.

Ingredients (%)	Basal diet
Fish meal (66%C.P.)	38
Wheat bran (15%C.P.)	26
Yellow corn meal	26
Oil	4
Molasses	2
Premix[1]	4
Total	100
Proximate Analysis (%)	
Moisture	10.11
Crude protein	32.15
Crude lipid	9.19
Crude fiber	6.51
Crude ash	6.3
NFE[2]	35.74
Gross. Energy.(kcal/g)	4.41

[1]Prepared after (.Xie, et al., 1997)
[2]NFE (nitrogen free extract) =100- (moisture crude proteien+crude lipid+crude fiber+ash)

Table 2.Water quality parameters as affected with dietary Yucca supplementation

	Variable[1]					
Diets	Temperature (^{o}C)	Dissolved oxygen (mg/L)	pH	T. ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)
0.0mg/kg	26.2 ± 0.1 ^{a}	4.20 ± 0.1 ^{b}	7.4 ± 0.1 ^{a}	0.39 ± 0.02 ^{a}	0.55 ± 0.01 ^{a}	0.48 ± 0.01 ^{c}
250mg/kg	26.2 ± 0.1 ^{a}	4.30 ± 0.2 ^{b}	7.5 ± 0.1 ^{a}	0.18 ± 0.01 ^{b}	0.30 ± 0.01 ^{b}	0.62 ± 0.02 ^{a}
500mg/kg	26.2 ± 0.1 ^{a}	4.60 ± 0.1 ^{ab}	7.5 ± 0.1 ^{a}	0.14 ± 0.02 ^{b}	0.24 ± 0.01 ^{c}	0.56 ± 0.02 ^{b}
750mg/kg	26.1 ± 0.2 ^{a}	4.64 ± 0.2 ^{a}	7.5 ± 0.1 ^{a}	0.12 ± 0.01 ^{c}	0.20 ± 0.01 ^{c}	0.57 ± 0.02 ^{b}
1000mg/kg	26 1 ± 0.1 ^{a}	5.10 ± 0.2 ^{a}	7.5 ± 0.1 ^{a}	0.11 ± 0.01 ^{c}	0.20 ± 0.01 ^{c}	0.57 ± 0.02 ^{b}
1250mg/kg	26.2 ± 0.1 ^{a}	5.10 ± 0.2 ^{a}	7.5 ± 0.0 ^{a}	0.10 ± 0.01 ^{c}	0.20 ± 0.01 ^{c}	0.57 ± 0.01 ^{b}
1500mg/kg	26.1 ± 0.2 ^{a}	5.10 ± 0.1 ^{a}	7.5 ± 0.1 ^{a}	0.10 ± 0.01 ^{c}	0.20 ± 0.01 ^{c}	0.57 ± 0.01 ^{b}
1750mg/kg	26.2 ± 0.1 ^{a}	5.10 ± 0.1 ^{a}	7.5 ± 0.0 ^{a}	0.10 ± 0.01 ^{c}	0.20 ± 0.01 ^{c}	0.57 ± 0.01 ^{b}

[1]**.**. Means within a column having different letters were significantly different ($P < 0.05$).

Table 3.

Table 4 . Nutrient digestibility coefficients of experimental diets with different levels of *Y.shidigera*fed to Nile tilapia.

Diets	Variable[1]				
	ADC protein	ADC fat	ADC energy	ADC CHO	ADC ash
0.0mg/kg	78.67 ± 0.21^{g}	64.57 ± 1.66^{e}	67.97 ± 0.57^{g}	61.35 ± 0.70^{d}	43.23 ± 9.38^{c}
250mg/kg	82.95 ± 0.05^{f}	64.56 ± 2.38^{e}	69.33 ± 0.40^{f}	64.13 ± 2.84^{c}	44.08 ± 1.02^{c}
500mg/kg	84.39 ± 0.12^{e}	67.80 ± 0.70^{cd}	71.24 ± 1.02e	64.71 ± 0.43^{c}	49.36 ± 2.41^{bc}
750mg/kg	85.25 ± 0.25^{d}	66.67 ± 0.61^{d}	72.83 ± 0.38^{d}	66.44 ± 0.70^{bc}	57.70 ± 2.16^{a}
1000mg/kg	85.77 ± 0.67^{c}	67.70 ± 0.28^{cd}	74.04 ± 0.05c	67.47 ± 0.61^{b}	56.03 ± 0.81^{ab}
1250mg/kg	86.60 ± 0.10^{b}	69.12 ± 1.06^{bc}	75.69 ± 0.02^{b}	71.94 ± 1.21^{a}	48.99 ± 1.93^{bc}
1500mg/kg	87.07 ± 0.12^{ab}	70.42 ± 0.71^{ab}	75.88 ± 0.14^{b}	71.45 ± 1.11^{a}	55.77 ± 4.13^{ab}
1750mg/kg	87.19 ± 0.06^{a}	71.72 ± 0.57^{a}	76.79 ± 0.30^{a}	72.00 ± 0.96^{a}	62.61 ± 3.96^{a}

_Means in the same column bearing different superscript letters differ significantly at 0.05 levels.
[1]Values are mean ± SD[1]

Table 5. Initial[1] and final whole body composition (wet weight basis %) of Nile tilapia fed experimental diets with different levels of *Y.shidigera*.

Diets	Variable[2]			
	Moisture	Crude protein	Crude fat	Crude ash
0.0mg/kg	70.04 ± 0.31^{c}	17.08 ± 0.13^{a}	5.56 ± 0.14^{a}	4.97 ± 0.14^{abc}
250mg/kg	72.93 ± 0.63^{ab}	15.48 ± 0.40^{c}	4.16 ± 0.29^{bc}	4.43 ± 0.12^{c}
500mg/kg	73.50 ± 0.48^{a}	15.48 ± 0.36^{c}	4.16 ± 0.12^{bc}	4.47 ± 0.49^{bc}
750mg/kg	72.57 ± 1.39^{ab}	16.03 ± 1.32^{bc}	4.81 ± 0.99^{b}	4.36 ± 0.61^{b}
1000mg/kg	71.75 ± 0.03^{b}	16.69 ± 0.11^{ab}	4.63 ± 0.13^{bc}	5.10 ± 0.47^{abc}
1250mg/kg	73.24 ± 0.07^{ab}	16.97 ± 0.01^{bc}	4.47 ± 0.14^{bc}	5.41 ± 0.15^{a}
1500mg/kg	74.24 ± 0.11^{a}	15.37 ± 0.72^{c}	4.16 ± 0.17^{bc}	5.14 ± 0.41^{ab}
1750mg/kg	74.40 ± 0.27^{a}	14.32 ± 0.07^{d}	3.98 ± 0.22^{c}	4.91 ± 0.04^{abc}

[1] The values of initial whole body composition were as following: Moisture 84.8 ± 045, crude protein 7.18 ± 0.25, crude fat 5.64 ± 0.17, ash 2.22 ± 0.06 and energy 93.83 ± 2.96 kcal /100g.
[2]Values are mean ± SD
Means in the same column bearing different superscript letters differ significantly at 0.05 levels.

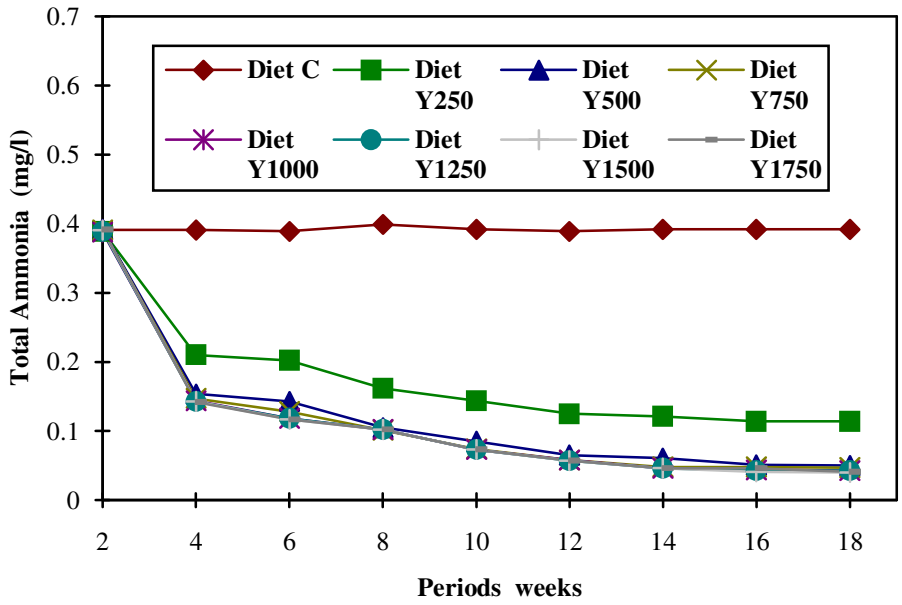

Fig. 1. Effects of different levels of *Yucca shidigera* concentration supplemented to the diets of Nile tilapia on concentration (mg/L) of ammonia-nitrogen during 18 weeks growth trial.

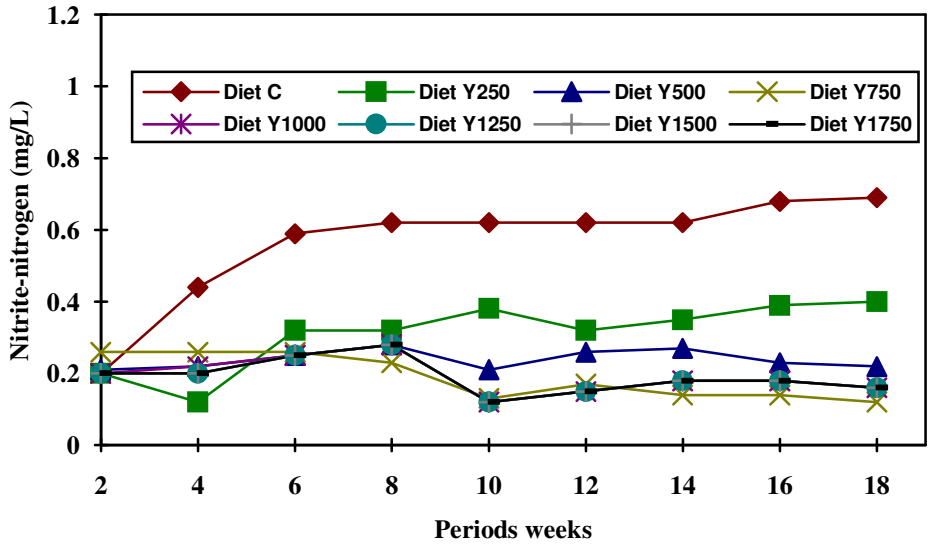

Fig. 2. Effects of different levels of *Yucca shidigera* concentration supplemented To the diets of Nile tilapia on concentration (mg/L) of Nitrite -nitrogen During 18 weeks growth trial.

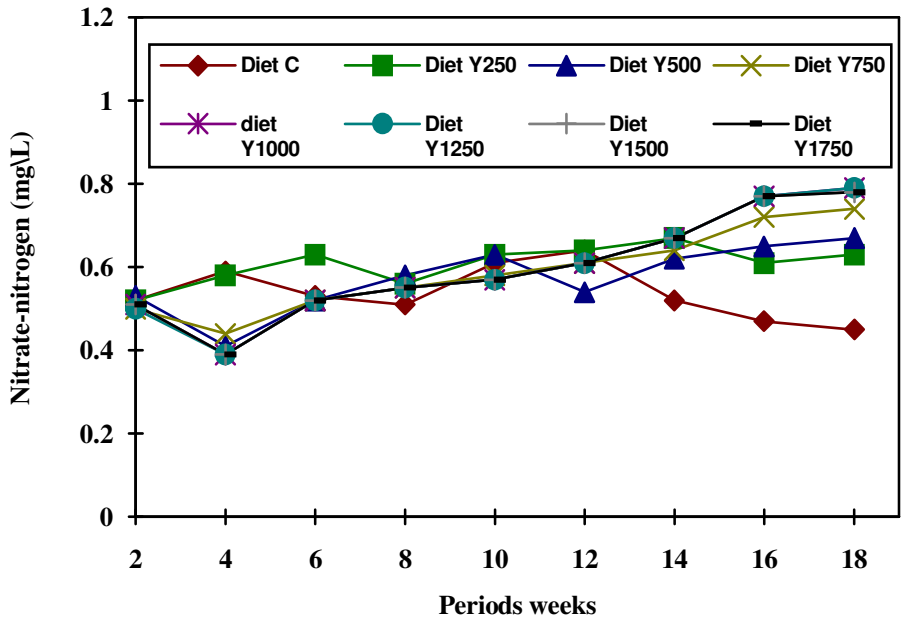

Fig. 3. Effects of different levels of *Yucca shidigera* concentration supplemented To the diets of Nile tilapia on concentration (mg/L) of Nitrate-nitrogen During 18 weeks growth trial.

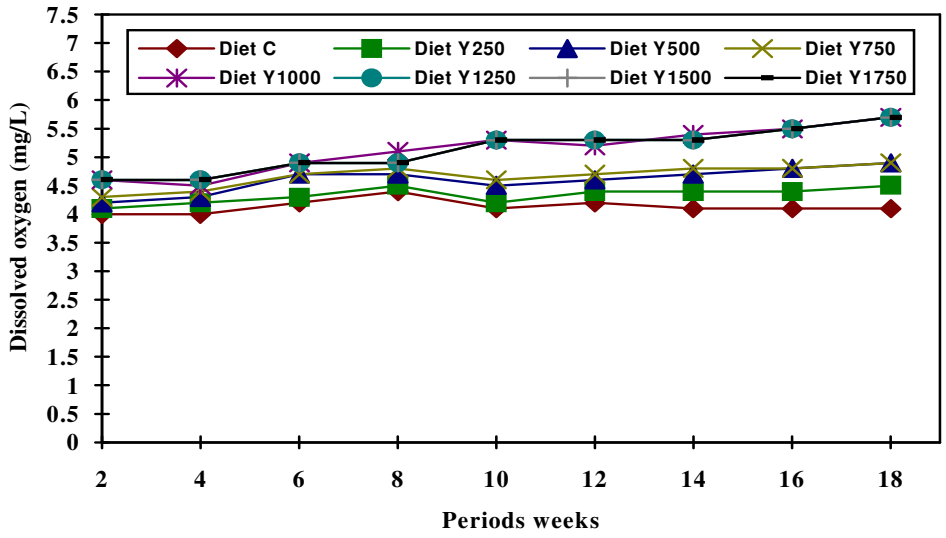

Fig. 4. Effects of different levels of *Yucca shidigera* concentration supplemented To the diets of Nile tilapia on concentration (mg/L) of dissolved oxygen During 18 weeks growth trial.

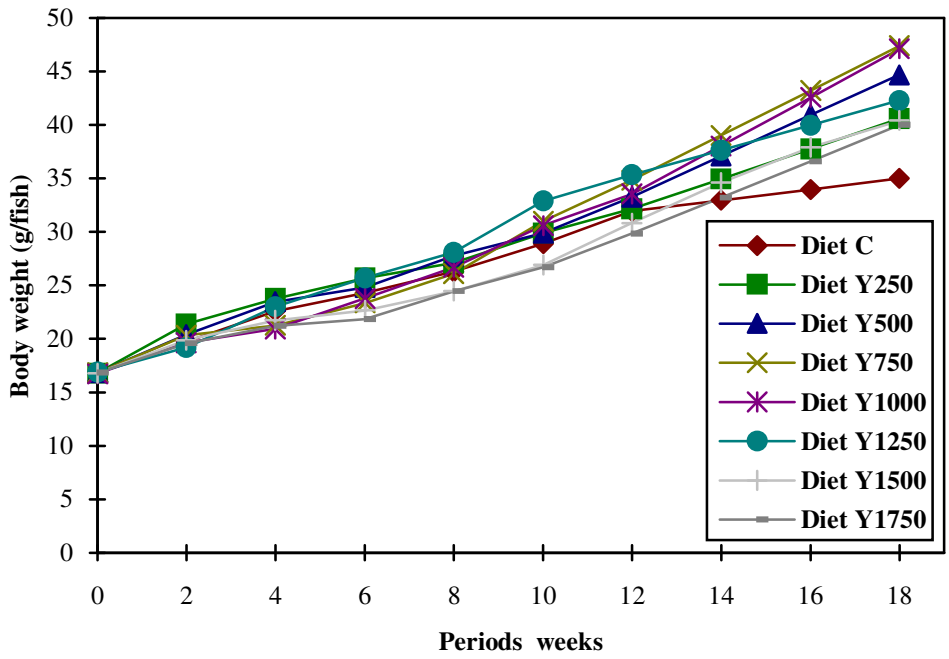

Fig. 5. Changes in average body weight of Nile tilapia fed diets supplemented with different levels of *Yucca shidigera* for 18 weeks.