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Nutritional Value of *Prosopis juliflora* Pods in Feeding Nile Tilapia (*Oreochromis niloticus*) Fries

القيمة الغذائية لقرون نبات البروزوبيس جوليفلورا فى تغذية يرقات أسماك البلطى النيلى

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ABSTRACT: A feeding experiment was conducted to study the effect of different levels of supplemental *Prosopis juliflora* on growth performance, feed utilization and chemical composition of Nile tilapia (*Oreochromis niloticus*) fry (1.36 ± 0.04 g). Six isonitrogenous (30.46g 100g^{-1} crude protein) and isocalorific (0.018 MJ g^{-1}) diets were formulated. Diet 1 (control without supplementing *P. juliflora*), and diets 2, 3, 4, 5 and 6 were supplemented with different levels (20, 40, 60, 80 and 100 g kg^{-1}) of *P. juliflora*, respectively. The results revealed that harvested gain (g fish^{-1}) was significantly higher ($P\leq 0.05$) for fish fed 60g kg^{-1} *P. juliflora,* while the lowest value of harvested gain was achieved with fish fed free *P. juliflora* control diet. Despite that the fish fed diet (4) obtained the highest harvesting weight, weight gain, average daily gain and specific growth rate, no significant differences ($P\leq 0.05$) were observed in average daily gain (g fish^{-1} day^{-1}) between fish fed diet 3, 4, 5 and 6, and in specific growth rate (% day^{-1}) when inclusion level of *P. juliflora* was increased from 20 to 40 g kg^{-1} in diets 2 and 3 and from 80 to 100g kg^{-1} in diets 5 and 6, respectively. Feed intake was increased significantly ($P\leq 0.05$) with in increasing *P. juliflora* inclusion level in the experimental diets. No significant differences were observed between the experimental fish groups in FCR in spite of the occurrence of a slight decreasing up to 80g kg^{-1}, and PER. Protein productive value (PPV g 100g^{-1})) and energy utilization (EUg 100g^{-1}) were increased significantly ($P\leq 0.05$) with increasing *P.juliflora* inclusion level in the experimental diets up to 60g kg^{-1} and then decreased significantly ($P\leq 0.05$). Fish whole body composition of dry matter and protein were significantly ($P\leq 0.05$) affected by using *P. juliflora* in fish diets. Fish fed diet 4 achieved the highest values of dry matter and crude protein. The results suggested that diet supplemented with 60g kg^{-1} *P. juliflora* improved growth performances, feed and nutrients utilization, and whole body composition (dry matter, protein and energy content) in Nile tilapia fry.

Keywords: *Feeding, Tilapia, mesquite, Chemical composition.*

المستخلص: أجريت تجربة لدراسة تأثير إحلال مستويات مختلفة من مسحوق ثمار نبات البروزوبيس جوليفلورا محل الذرة الصفراء على كفاءة النمو والإستفادة من الغذاء والتركيب الكيميائى لصغار أسماك البلطى النيلى (1.36 ± 0.04 جرام). تم وضع الصيغ التكوينية وتصنيع عدد ستة أعلاف تجريبية متساوية فى المحتوى البروتينى (30.46%) والمحتوى من الطاقة (0.018

ميجاجول/جرام) تقريبا، هى العلف رقم 1 (الشاهد غير مضاف إليه مسحوق نبات البروزوبيس)، والأعلاف رقم 2، 3، 4، 5، 6 أضيف إليها مستويات 20، 40، 60، 80، 100 جرام/كجم علف من مسحوق نبات البروزوبيس، على التوالي. أوضحت النتائج أن الوزن المتحصل عليه (جرام/سمكة) فى المعاملات التى غذيت فيها الأسماك على العلف رقم 4 (يحتوى على 60 جرام بروزوبيس/ كجم علف) كان أعلى بدرجة معنوية عن باقى المعاملات بينما حققت الأسماك التى غذيت على العلف رقم 1 الشاهد الخالى من مسحوق البروزوبيس أقل وزن. ورغم أن الأسماك التى غذيت على العلف رقم 4 قد حققت أعلى قيم للوزن المتحصل عليه، إلا أنه لم تلاحظ أى فروق معنوية فى معدل الزيادة اليومية فى الوزن (جرام/سمكة/يوم) بينها وبين باقى المعاملات وكذلك معدل الوزن النوعى (النسبة المئوية للزيادة فى اليوم) عند زيادة مستويات إحلال مسحوق نبات البروزوبيس محل الذرة الصفراء فى الأعلاف رقم 2 و 3 (من 20 إلى 40 جرام/ كجم) وفى الأعلاف رقم 5 و 6 (من 80 إلى 100 جرام/ كجم) على التوالى. كذلك أوضحت النتائج الزيادة المعنوية فى المقدار المأكول من الأعلاف مع زيادة مستوى الإحلال لمسحوق نبات البروزوبيس فى الأعلاف التجريبية، ولم تلاحظ أى فروق معنوية بين الأسماك التجريبية فى معامل التحويل الغذائى رغم وجود إنخفاض بسيط فى قيم معامل التحويل الغذائى بزيادة مستوى إحلال مسحوق نبات البروزوبيس محل الذرة الصفراء حتى مستوى 80 جرام/كجم علف. أما كفاءة الإستفادة من البروتين ونسبة ترسيب البروتين ومعدل الإستفادة من الطاقة فإنها قد زادت بمقدار معنوى بزيادة معدل إحلال مسحوق نبات البروزوبيس فى الأعلاف التجريبية حتى مستوى 60 جرام/ كجم، وبعد هذا المستوى بدأت تنخفض بدرجة معنوية. وقد تأثرت قيم التحليل الكيميائى للحوم الأسماك خاصة محتوى المادة الجافة والبروتين الخام بإستخدام مسحوق نبات البروزوبيس فى أعلاف الأسماك، فالأسماك التى غذيت على العلف رقم 4 حققت أعلى القيم فى محتوى المادة الجافة والبروتين الخام بين المعاملات المختلفة. ويقترح إضافة مسحوق نبات البروزوبيس إلى أعلاف صغار أسماك البلطى النيلى بمعدل 60 جرام/ كجم علف لما لها من فائدة فى تحسين كفاءة النمو والإستفادة من الغذاء والطاقة وتحسين مواصفات لحوم الأسماك الكيميائية.

كلمات مدخلية : *تغذية، أسماك البلطي، نبات البروزوبيس، التركيب الكيميائي.*

INTRODUCTION

The problem of insufficiency and expensiveness of raw materials involved in fish diet processing constitutes the most severe obstacle facing the activity of aquaculture. In light of the above, it becomes important that research be directed towards minimizing the cost with the specific objective of utilizing less expensive sources of raw materials for fish balanced rations formulation. *Prosopis juliflora*, one of the hardy nitrogen–fixer plants is used for rations, not only for cattle but also for poultry, goats, sheep, camels and horses (Mooney, *et al.* 1977; Shukla, *et al.* 1984; Silbert, 1988; Da Silva 1996). This plant is obtainable in Egypt and is not known as animal and fish feeding ingredient at a commercial level.

Tilapias are naturally accustomed to eating plant ingredients, and are typically considered strict herbivores once they reach maturity (Trewavas, 1983; Keenleyside, 1991). Currently, tilapia culture in Egypt has become uneconomical for most fish farmers because of the expensive dietary ingredients and/or commercial diets. This situation force the farmers to falsify the bulk of fish feeds with poultry offal. Moreover, during diet formulation for most of the commercial diets, there is a concentration on only one dietary nutrient which is crude protein without concern for other requirements especially energy. In that context, because protein is the single most expensive ingredient in fish diets, and the fact that high levels of dietary protein may lead to the consumption of protein for energy purposes, some studies had investigated the use of non-protein energy sources in fish diets such as carbohydrates and lipids (El-Sayed and Garling, 1988; De Silva, *et al.* 1991; Erfanullah Jafri, 1995). These studies reported that depending on feeding behavior, the utilization of carbohydrates and lipids by fish is species-specific, and that providing adequate energy from carbohydrates and lipids in fish diets can minimize the use of costly protein. Although lipids are well utilized by most fish, some studies reported that excessive levels may reduce fish growth or produce fatty fish (Chou and Shiau, 1996; Garling and Wilson, 1977; Takeuchi, *et al.* 1983). On the contrary, others reported that lipid-deficient diets may result in growth retardation and other physiological symptoms (Castell, *et al.* 1972; Takeuchi, *et al.* 1983).

Carbohydrates (starches and sugars) are the most economical and inexpensive sources of energy included in fish diets to reduce feed costs and for binding activity during feed manufacturing. Furthermore, dietary starches are useful in the extrusion manufacture of floating feeds, where cooking starch during the extrusion process makes it more biologically available to fish. Carbohydrates, stored as glycogen that can be mobilized to satisfy energy demands, are not used efficiently by fish (can extract about 1.6 kcal from 1 gram of carbohydrate) compared with mammals (can extract about 4 kcal of energy from the same amount of carbohydrate). On the other hand, up to about 20% of dietary carbohydrates can be used by fish (Craig and Helfrich, 2002).

The carbohydrate to lipid ratio (CHO/LIP) in fish diets has been investigated by a number of authors (Palmer and Ryman, 1972 in trout diets; Garling and Wilson, 1977 on channel catfish; Bieber and Pfeffer, 1987 on rainbow trout; El-Sayed and Garling, 1988 on *Tilapia zillii*; Nematipour, *et al.* 1992 on stripped bass; Shimeno, *et al.* 1993 on *Oreochromis niloticus* and Erfanullah Jafri, 1998 on *Clarias batrachus*)

The importance of *P. juliflora* arise from the followings: 1) Inexpensiveness of *P. juliflora* in comparison with other plant products; 2) High prices of yellow corn and rice bran, common plant energy sources in Egyptian fish farming; 3) good nutritional behavior of *P. juliflora* legumes and seeds as forage for livestock; (cattle, sheep, goats, camels and horses) (Vines, 1960; Martin and Alexander, 1974; Davis, *et al.* 1975; Duke, 1983), high protein content of seeds (Becker and Grosjean, 1980), amino acid profile of pod flour (FAO/WHO, 1973) carbohydrates of legumes (Harden and Zolfaghari, 1988), sugar of flowers (Skolmen, 1990) and gum (Simpson, 1977); and 4) crude protein and minerals concentration in *P. juliflora* improves low quality feed (Sargent, 1965).

The present study aims at investigating the effect of using different levels (0, 20, 40, 60, 80, and 100 g kg^{-1}) of *P. juliflora* pods, as plant energy source replacing yellow corn, in feeding Nile tilapia (*Oreochromis niloticu*) fry, on growth performance, chemical composition and feed utilization, in order to test the efficiency of *P. juliflora* pods in fish feeding.

MATERIAL AND METHODS

The present experiment was designed to use *P. joliflora* in experimental diets formulation as plant source of energy concentrates instead of yellow corn in order to investigate the possibility of using *P. joliflora* in fish diets. The study had been carried out at the Department of Animal and Fish Production, Faculty of Agriculture (El-Shatby), Alexandria University. *P. juliflora* pods were harvested from mature trees in the Faculty of Agriculture, Alexandria University, and the samples were oven dried at 105°C (to remove anti-trypsin inhibitor activity) and stored for later analysis. Composition and proximate analysis (g $100g^{-1}$) of *P. juliflora* used in the experimental diets formulating and processing (on DM basis) and as reviewed by several authors are shown in Table (1).

Six experimental diets were formulated to be isonitrogenous and isoenergetic. Diet 1 (Control without adding *P. juliflora*) was formulated to be similar to a high quality commercial tilapia feed. Diets 2, 3, 4, 5 and 6 were formulated on the basis of replacing yellow corn with different levels (20, 40, 60, 80 and 100 g kg^{-1}) of supplemental *P. juliflora,* respectively. Ingredients were thoroughly mixed with water and then oven-dried at 105°C. Diets were offered to fish in pelleted form (0.3 mm diameter).

Twelve glass aquaria (30×40×100cm), each with capacity of 120L of fresh water, were used in the study. Each aquarium was allowed to contain 100L of dechlorinated tap water (using 10 crystals of Sodium thiosulphate for each aquarium when water exchange). All aquaria were supplied with air pumps for keeping dissolved oxygen level at 6 mg/l. Dissolved oxygen was measured every week using an YSI model 58 oxygen meter. Illumination was supplied by flourcent ceiling lights and adjusted at 12 hours light: 12 hours dark. Water temperature was measured twice daily, at 9 a.m. and 9 p.m. Total ammonia and nitrite were measured twice weekly using a DREL, 2000 Spectrophotometer. Total alkalinity and chloride were monitored twice weekly using the titration method and pH was monitored twice weekly using an electronic pH meter. Determined water quality parameters in the experimental glass aquaria were found as follow: Temperature (28 ± 0.5°C), dissolved oxygen (6.8 ± 0.6 mg L^{-1}), total ammonia (0.10 ± 0.12 mg L^{-1}), nitrite (0.05 ± 0.03 mg L^{-1}), total alkalinity (178 ± 38 mg L^{-1}), chlorides (570 ± 148 mg L^{-1}) and pH (8.3 ± 0.17).

Nile tilapia fry were obtained from one patch of reproduction from one female reproduced in the laboratory and reared for 21 days for the aim of acclimatization for experimental diets and water quality; mortalities were excluded immediately. From survive fry, ten Nile tilapia fry (average 1.36 ± 0.04 g) were stocked, after weighing, into each aquarium with two replicates per treatment. After stocking, to minimize stress of handling, all fish, in each aquarium, were weighed every 2 weeks till the end of the feeding experiment. At the end of the experiment survival rate was 100% between the experimental fish. All fries were fed twice daily at 8.00 a.m. and 16.00 p.m. for 112 days (6 days weekly) as follows: 15g $100g^{-1}$ of total body weight at the first month, 10g $100g^{-1}$ of total body weight at the second month, 5g $100g^{-1}$ of total body weight at the third month and then 4g $100g^{-1}$ of total body weights till the end of experiment. At the start and end of the feeding experiment, a number of fish were killed, decapitated, homogenized in a blender, stored in polyethylene bags, and frozen for subsequent protein (kieldahl), ether extract (Sochsilette), moisture and ash analysis.

Growth performance and feed utilization were measured in terms of final individual fish weight (g), final weight gain (g), average daily gain (g $fish^{-1}day^{-1}$), Specific growth rate (SGR%), Feed conversion ratio (FCR), protein efficiency ratio (PER), Protein productive value (PPV%), Energy utilization (EU%) according to Ballestrazi, *et al.* (1994).

Statistical analysis was performed according to Statistical Analysis System (1988); using a computerized Package Software (SPSS Version 10) and treatments were evaluated at the 0.05 probability. Analysis of variance, one-way ANOVA was used to evaluate the effect of different levels of supplemental *P. juliflora* on growth performance, chemical composition and feed utilization of Nile tilapia (*Oreochromis niloticus*) fry. The differences within treatments were evaluated using LSD at 0.05 probabilities (Steel and Torrie, 1980). All percentages and ratios were transformed to arcs in values prior to analysis (Zor, 1984).

Table 1. Composition (g $100g^{-1}$) of *Prosopis juliflora* used in the experimental diets (on DM basis) and as reviewed by several authors.

Part of the plant	Ingredient	g $100g^{-1}$	Reference
Pods	Crude protein	19.92	Present study
	Ether extract	1.41	
	Crude fiber	22.22	
	Nitrogen free extract	49.82	
	Ash	5.33	
	Gross energy (MJ $100g^{-1}$)	1.3825	
Fresh leaves	dry matter	41.2	Boyns (1947)
	crude protein	19.0	
	crude fiber	21.6	
	ash	8.5	
	ether extract	2.9	
	soluble carbohydrates	48.0	
Pods	Water	14.35	Simpson(1977)
	Oil	1.64	
	Starch	16.36	
	Glucose	30.25	
	nitrogenous material	0.85	
	tannin-like material	5.81	
	mineral salts	3.5	
	cellulose	27.24	
Pods	Protein	13.9	FAO (1980)
	Fat	3.0	
	Total carbohydrates	78.3	
	Fiber	27.7	
	Ash	4.8	
Leaves	Protein	19.0	
	Fat	2.9	
	Total carbohydrates	69.6	
	Fiber	21.6	
	Ash	8.5	

RESULTS

Chemical Analysis of Diets

Proximate chemical analysis (g $100g^{-1}$) of *P. juliflora* pods, obtained in the present study, compared with different references, and as shown in Table (1), revealed that the pods of *P. juliflora* contained 19.92g $100g^{-1}$ crude protein; 1.41g $100g^{-1}$ ether extract; 22.22g $100g^{-1}$ crude fiber; 5.33g $100g^{-1}$ ash; 49.82g $100g^{-1}$ nitrogen free extract; and 1.3825 MJ $100g^{-1}$ DM gross energy. The composition and proximate analysis (g $100g^{-1}$) of the six experimental diets are shown in Table (2). Experimental diets were formulated to be isonitrogenous and isoenergetic, and to contain about 30.46g $100g^{-1}$ crude protein and 0.018MJ g^{-1} gross energy. The average value of protein to energy (P:E) ratio in the tested diets was 0.294mg protein MJ^{-1} gross energy.

Growth Performance

The results in Table (3) demonstrate that highest final weight was obtained with fish group fed with diet (4) supplemented with 60g kg^{-1} *P. juliflora*. The smallest final weight was recorded with fish group fed control diet. Slightly significant differences ($P \leq 0.05$) were observed among the experimental fish in Average Daily Gain, where fish fed control diet was the lowest in ADG, while the best ADG was observed in fish fed diet (4) and differences between fish fed diets 3, 4, 5 and 6 were not significant ($P \leq 0.05$). Specific growth rate (SGR%) was not significant ($P \leq 0.05$) between fish fed diets 2, 3, 5 and 6 and the highest value of SGR was obtained with fish fed diet (4), while the lowest value was obtained with fish fed control diet. Weight gain was increased with increasing *P. juliflora* inclusion level in experimental diets up to 60g kg^{-1} (diet 4), and then decreased. On the other hand, it was found that increasing *P. juliflora* inclusion level more than 60g kg^{-1} in Nile tilapia fry diet leads to a decrease in growth rate.

Feed Utilization

Table (4) shows that feed intake increased with increasing *P. juliflora* levels in fish diets up to 100g kg^{-1} and no significant differences were observed in feed intake when inclusion of *P. juliflora* was increased from 40 to 60 g kg^{-1} and from 80 to 100 g kg^{-1} in the experimental diets. In spite of the slight improvement of Feed Conversion Ratio with increasing inclusion level of *P. juliflora* up to 80g kg^{-1}, no significant differences ($P \leq 0.05$) were observed between all fish groups in FCR.

The results of the present study also revealed that no significant differences were observed in Protein Efficiency Ratio (PER) between all experimental fish, but the best PER was obtained with fish fed diet (4). Protein Productive Value (PPV%) and Energy Utilization (EU%) were increased significantly ($P \leq 0.05$) with increasing the inclusion level of *P. juliflora* in the experimental diets up to 60g kg^{-1} and then decreased. The best PPV% and EU% were obtained with fish fed diet (4) while the lowest values were obtained with fish fed control diet.

Carcass Chemical Composition

Fish whole proximate composition at the termination of the feeding experiment, as shown in Table (5), revealed that Dry Matter (DM) and Crude Protein (CP) were increased with increasing *P. juliflora* inclusion levels in experimental diets up to 60g kg^{-1} and then decreased up to 100g kg^{-1}. On the other hand, Ether Extract (EE) and Ash had shown a reversible trend. Energy content (MJ $100g^{-1}$) was significantly ($P \leq 0.05$) increased at the end of the experiment for all treatments.

DISCUSSION

Maximizing the utilization of protein for growth by supplying adequate amounts of alternative dietary of none protein energy sources such as lipids and carbohydrates is an aim in fish feeding; in particular protein is the most expensive source of energy and carbohydrates (starches and sugars) are the most economical and inexpensive sources of energy for fish diets. The use of carbohydrates as a protein sparing energy source has less attention than the use of lipids and there is still some dissension about the level of dietary carbohydrates that should be included in commercial fish rations, especially Tilapia. Different studies (Brett and Groves, 1979; Chow and Halver, 1980) stated that the ability of fish to utilize carbohydrates as a source of energy depends on its enzymatic capacity to degrade carbohydrate. The authors added that α-amylase activity is the highest in herbivorous fish, followed by omnivorous and carnivorous fish, respectively, and therefore, herbivorous and omnivorous fish can utilize carbohydrate as a source of energy more than carnivorous fish. In addition, Anderson *et al.* (1984) found that *O. niloticus* can utilize both simple and complex carbohydrates and the growth of Nile tilapia was improved as the level of glucose, sucrose, dextrin and starch was increased from 0 to 40%.

Table 2. Composition and Proximate analysis (g $100g^{-1}$) of experimental diets with different inclusion levels of *Prosopis juliflora* pods supplementation.

Item	Diet No.					
	1	2	3	4	5	6
Ingredient **(g $100g^{-1}$)**						
Fish meal	20	20	20	20	20	20
Soybean meal	25	25	25	25	25	25
Wheat bran	20	20	20	20	20	20
Yellow corn meal	30	28	26	24	22	20
Prosopis juliflora	0	2	4	6	8	10
Sunflower oil	3	3	3	3	3	3
Premix*	2	2	2	2	2	2
Total	100	100	100	100	100	100
Proximate analysis (% dry weight)						
Dry matter	94.60	93.43	93.61	93.90	94.20	94.45
Crude protein	30.13	30.35	30.57	30.80	30.42	30.46
Ether extract	4.33	4.29	4.25	4.21	4.16	4.12
Crude fiber	4.50	4.88	5.27	5.66	6.05	6.43
Ash	5.83	5.91	5.98	6.06	6.14	6.21
NFE	55.21	54.57	53.93	53.27	53.23	52.78
Gross energy** (MJ g^{-1})	0.018	0.018	0.018	0.018	0.018	0.018
P/E ratio (mg MJ^{-1})	0.288	0.291	0.295	0.298	0.296	0.298

* Premix supplied the following vitamins and minerals (mg or IU) / kg of diet, vit. A, 8000 IU; vit. D3 4000 IU; vit. E, 50 IU; vit K_3, 19 IU; vit. B_2 25 mg; vit. B_3, 69 mg; Nicotinic acid, 125 mg; Thiamin, 10 mg; Folic acid, 7 mg; Biotin, 7 mg; vit. B_{12}, 75 mg; Cholin, 400 mg; vit. C, 200 mg; Manganese, 350 mg; Zinc, 325 mg.

** Gross energy (GE MJ g^{-1} diet) calculated according to NRC (1993) using the following calorific values: 5.64, 9.44 and 4.11 Kcal/g diet of protein, ether extract and carbohydrates, (0.02359776, 0.03949696 and 0.01719624 MJ), respectively.

Table 3. Effect of different inclusion levels of *Prosopis juliflora* on growth performance of Nile tilapia *(Oreochromis niloticus)* fry.

Diet* No.	Live weight (g/fish)		Weight gain (g/fish)	ADG** (g/fish/day)	SGR*** (% day)
	Initial	Final			
1	1.35^{a}	43.45^{f}	42.10^{f}	0.38^{b}	3.09^{b}
2	1.37^{a}	49.49^{e}	48.12^{e}	0.43^{ab}	3.20^{ab}
3	1.35^{a}	57.93^{d}	56.58^{d}	0.51^{a}	3.36^{ab}
4	1.36^{a}	62.78^{a}	61.42^{a}	0.55^{a}	3.42^{a}
5	1.37^{a}	60.56^{b}	59.19^{b}	0.53^{a}	3.38^{ab}
6	1.35^{a}	59.58^{c}	58.23^{c}	0.52^{a}	3.38^{ab}
$\bar{X}\pm$ SE	0.05±0.01	0.31±0.06	0.29±0.06	0.11±0.03	0.28±0.08

* Diet 1(control), diets 2, 3, 4, 5 and 6 containing different levels (20, 40, 60, 80 and 100 g kg^{-1}) of *Prosopis juliflora*, respectively.

** ADG: Average daily gain.

*** SGR%: Specific growth rate.

a, b, c: Means bearing the same letters within each column do not differ significantly (P≤ 0.05).

Table 4. Effect of different inclusion levels of *Prosopis juliflora* on feed and nutrient utilization of Nile tilapia (*Oreochromis niloticus*) fry.

Diets* No.	Feed utilization		Protein utilization		Energy utilization (g/100g^{-1})
	FI	FCR	PER	PPV%	
1	72.83 ^{d}	1.73 ^{a}	1.92 ^{a}	22.74 ^{e}	15.10 ^{e}
2	80.84 ^{c}	1.68 ^{a}	1.96 ^{a}	24.30 ^{d}	16.10 ^{d}
3	93.36 ^{b}	1.65 ^{a}	1.58 ^{a}	25.86 ^{c}	17.16 ^{c}
4	93.36 ^{b}	1.52 ^{a}	2.14 ^{a}	30.43 ^{a}	19.80 ^{a}
5	97.66 ^{a}	1.40 ^{a}	1.99 ^{a}	27.16 ^{b}	17.84 ^{b}
6	97.83 ^{a}	1.67 ^{a}	1.95 ^{a}	26.14 ^{c}	17.43 ^{c}
$\bar{X}\pm$ SE	0.30 ±0.06	0.34±0.05	0.64±0.19	0.39±0.07	0.39±0.07

*Diet 1(control), diets 2, 3, 4, 5 and 6 containing different levels (20, 40, 60, 80 and 100 g kg^{1}) of *Prosopis juliflora*, respectively.
FI: Feed intake (not seen on the table)
FCR: Feed conversion ratio
PER: Protein efficiency ratio
PPV: Protein productive value%
a, b, c: Means bearing the same letters within each column do not differ significantly (P≤ 0.05).

Table 5. Effect of different inclusion levels of *Prosopis juliflora* on chemical composition of Nile tilapia (*Oreochromis niloticus*) fry.

T	DM	On DM basis (g 100g^{-1})			Energy content (MJ 100g^{-1})
		CP	EE	Ash	
At start:	20.37	54.12	19.34	26.54	2.04876
At end:					
1	20.49 ^{e}	57.79 ^{b}	24.41 ^{a}	17.68 ^{ab}	2.04876 ^{a}
2	21.19 ^{d}	58.30 ^{b}	23.82 ^{b}	17.88 ^{a}	2.336754 ^{a}
3	22.04 ^{c}	58.92 ^{ab}	23.57 ^{bc}	17.51 ^{ab}	2.329614 ^{a}
4	23.30 ^{a}	60.82 ^{a}	22.50 ^{e}	16.68 ^{c}	2.330202 ^{a}
5	22.67 ^{b}	59.89 ^{ab}	23.03 ^{d}	17.08 ^{bc}	2.331756 ^{a}
6	22.45 ^{bc}	59.37 ^{b}	23.33 ^{c}	17.30 ^{abc}	2.331378 ^{a}
$\bar{X}\pm$ SE	0.48±0.09	2.03±0.39	0.29±0.05	0.64±0.012	0.26±0.06

*Diet 1(control), diets 2, 3, 4, 5 and 6 containing different levels (20, 40, 60, 80 and 100 g kg^{1}) of *Prosopis juliflora*, respectively.
**DM: Dry matter, CP: Crude protein, and EE: Ether extract.
a, b, c: Means bearing the same letters within each column do not differ significantly (P≤ 0.05).

Nutritional Value of *P. juliflora*

Proximate chemical analysis of *P. juliflora* varies in different studies due to agriculture location, soil characteristics, and *Prosopis* species (Imperial Bureau of Animal Nutrition, 1936; Habit and Saavedra, 1988). In terms of nutritional value, different studies have been made to illustrate the benefits that could be obtained from *P. juliflora* in animal feeding. In feeding trials with sheep, Felker and Bandurski (1979) concluded that protein digestibility coefficient for mesquite pods was 15% higher than for alfalfa hay. In India, Shukla, *et al.* (1984) reported that whole pods *P. juliflora* were found to provide 7g 100g^{-1} digestible crude protein and 75g 100g^{-1} total digestible nutrients on a dry matter basis; the digestibility of crude protein from *P. juliflora* pods was 50-60g 100g^{-1}; ether extract 70g 100g^{-1}; crude fibre 80g 100g^{-1}; nitrogen free extract 79g 100g^{-1} and organic matter 74g 100g^{-1}. On the other hand, Talpada (1985) found that the sugar content of *P. juliflora* pods varied from 13 to 20 g 100g^{-1} in different seasons and years, showing a strong environmental effect on pod composition. Other studies concluded that the fruit (pods) produced by *Prosopis* is high in sugars, carbohydrates and protein (Oduol, *et al.* 1986; Galera, *et al.* 1992; Anttila, *et al.* 1993). Furthermore, Bravo, *et al.* (1994) found that nitrogen and calcium balances in *Prosopis* species were positive, but the phosphorus balance was negative suggesting that pods should be fed with a phosphorus rich feed supplement. However, the Indian Council for Forestry Research and Education (ICFRE, 1994) reported that *P. juliflora* has a great value as fodder, and that value lies in its pods which are very palatable and provide good nutritive value to cattle, sheep, goats, camels and horses.

Growth Performance

In concept, using *Prosopis* pods in animal feeding could substitute or reduce, at much lower cost, the use of maize, soybeans, and wheat, all of which could be produced on only a very limited scale in semi-arid areas. *Prosopis* has higher protein content than all common feeds from arid regions (Da Silva, 1996). Fish fed diet supplemented with 60g kg^{-1} *P. juliflora* realized the highest final weight in the present study. Some studies had investigated plant ingredients other than *P. juliflora* in fish feeding. Lovell (1988) illustrated that Peanut meal can replace 250g kg^{-1} of fishmeal in the diet of *O. mossambicus* without affecting growth performance. In addition, Fagbenro (1998) concluded that the legume seed meals were suitable for tilapia diets. Furthermore, Fontainhas-Fernandes, *et al.* (1999) suggested that in fish feeds there is a possibility of partial replacement of fishmeal with plant ingredients that have high apparent digestibility coefficients such as extruded pea seed meal, defatted soyabean meal, full-fat toasted soyabean, and micronized wheat.

Abdelgabbar (1986) in feeding trials, indicated that rations for goats, sheep, beef cattle and dairy cattle can give very good weight gains and/or milk production when about 600g kg^{-1} of the diet consisted of ground *Prosopis* pods. Other studies (Michelson, 1960; Goldschmeding and Jager, 1973; Takel, 1976; Harada and Kawasaki, 1982; Harada, 1987; Harada *et al.*, 1993) reported the same results of using *P. juliflora* in livestock feeding with precautions. Furthermore, Silbert (1996) illustrated that suitable amendments such as urea, cottonseed meal or molasses must be included in the animal feed at using *Prosopis* as an ingredient in the diet. The decrease of growth rate of tilapia fry in the present study consequent to increasing *P. juliflora* level more than 60g kg^{-1}, may be attributed to the high level of fiber content (22.22g $100g^{-1}$) of *p. juliflora* as shown in Table (1), or the inflammatory effect of the alkaloidal fractions of *P. juliflora* (*Julifloricine and juliflorine*), which appears to affect skin at level of 50g kg^{-1} (Aqeel, *et al.* 1995). Moreover, high content of cellulose in *P. juliflora* pods may affect digestibility and absorption of involved dietary ingredients retrogressively.

In this respect, considerable research has been undertaken on the use of milled pods in livestock rations, particularly in India (Shukla, *et al.* 1984) and Brazil (Habit and Saavedra 1990). Shukla, *et al.* (1984) found that consumption of rations containing up to 450g kg^{-1} *P. juliflora* pods was 15g kg^{-1} of cattle body weight, with acceptable live weight gains and good animal performance. Other studies have indicated that cattle rations containing less than 500g kg^{-1} *P. juliflora* pods lead to no adverse effects on consumption, digestibility, nutrient balance and animal health. However, there are several records of pods causing ill effects in livestock when used alone as a feed (Alder, 1949), and these were assumed to be attributed to the regression of rumen bacterial cellulase activity resulted from the high sugar content of the pods. In addition, Silva (1990) recommended rations containing *Prosopis* pods for lactating animals, where milk production improved as pods included in the ration and he noted no effects on milk flavour at less than 500g kg^{-1} pods in the ration. On the other hand, Silbert (1988) reported that mesquite is particularly beneficial for increasing milk yields when dairy cows fed 750g kg^{-1} mesquite flour with 150g kg^{-1} bran and 100g kg^{-1} corn. The author added that for good growth and production in high yielding dairy cows, mesquite's crude fiber must be balanced with a feed high in crude protein such as cottonseed meal or soy paste. Furthermore, Tewari, *et al.* (2000) reported that *Prosopis* cattle feed has increased milk yield by more than 20%.

On the other hand, Habit and Saavedra (1988) in Brazil, reported that *P. juliflora* pod flour could replace up to 600g kg^{-1} of wheat flour in rations for lactating cows and that DM intake, weight gain, and milk production increased with increasing proportion of pod flour. They added that total replacement of wheat flour by ground pods was also favorable for beef cattle. In addition, Habit and Saaverda (1988) in Mexico, reported that trials with sheep showed that replacement of sorghum flour with *P. juliflora* pod flour, up to 450g kg^{-1} but less than 600g kg^{-1}, increased weight gain, while in Brazil, replacement of sugarcane molasses with *P. juliflora* pods at 0, 150, 300, 450 and 600 g kg^{-1} was most effective in terms of weight gain at the 300 and 450 g kg^{-1} levels. In addition, Riveros (1992) reported that *P. juliflora* flour was used to replace up to 100% of wheat bran in rations for chickens with no effect on intake, FCR, or egg weight. Furthermore, Da Silva (1996) reported that the introduction of up to 100g kg^{-1} of bran from *Prosopis* pods can substitute other normal food without affecting the productivity of chickens and other birds raised for meat, and up to 300g kg^{-1} of the food of cattle, horses, goats, sheep can be furnished by *Prosopis* bran.

Lim and Dominy (1989) reported that Tilapia can digest carbohydrates in feedstuffs relatively well. Furthermore, Osman (1991) found that Tilapia hybrid fingerlings body weight gain, SGR, FCR, and NPU were improved when fish fed a diet containing 25% protein with 62% total carbohydrates. In confirmation to these results, Shiau and Peng (1993) stated that tilapia well utilized the highest carbohydrate level of 41%, and that the optimum P:E ratio for tilapia fry and small fish up to 2.5g, is ranging from 28 to 35.5 mg protein/kJ ME, while the adult fish have a P:E ratio ranging from 21.5 to 30 mg protein/kJ ME. In the present study, P:E ratios in the experimental diets were higher than recommended ratios by Shiau and Peng (1993), which may be the cause of obtaining insignificant results between treatments in some growth performance parameters, feed intake and feed conversion ratio. On the other hand, Craig and Helfrich (2002) concluded that up to about 20% of dietary carbohydrates can be used by fish. These differences in determination of the optimal carbohydrate level may be attributed to differences in the experimental environmental conditions and the form of carbohydrates used in feeding trial.

Feed Utilization

Improving feed conversion ratio (FCR), in the present study, from 1.73 to 1.52, indicates increasing feed intake with increasing *P. juliflora* level in fish diet from 20 to 60g kg^{1}. On the other hand, increasing feed intake with increasing *P. juliflora* levels in fish diets up to 100g kg^{-1} indicates its attractive effect and palatability, but lead to a negative effect on FCR (1.68), which indicates that increasing *P. juliflora* to more than 60g kg^{-1} in the diet of Nile tilapia (*Oreochromis niloticus*) fry had lead to decreasing the beneficial effect of using the *P. juliflora* supplemented diet in producing one unit of fish.

The highest values of protein efficiency ratio (PER), protein productive value (PPV %) and energy utilization (EU %) recorded for fish fed diet (4) may be attributed to: 1) taking into consideration that crude protein values in experimental diets were approximately similar, weight gain in fish fed diet (4) recorded the highest value; 2) *P. juliflora* contains many miscellaneous compounds in the form of monosacharides, disaccharides and amino acids (Da Silva, 1996), which attract tilapia to increase its appetite and feed palatability (Simpson, 1977); and 3) tilapia utilize disaccharides better than glucose (Shiau and Chen, 1993).

Carcass Chemical Composition

Increasing experimental fish's energy content (MJ $100g^{-1}$) at the end of the experiment for all treatments is a normal result for increasing protein and fat contents. Increasing crude protein in fish, at the end of the experiment, with increasing *P. juliflora* levels in the diet up to 60g kg^{-1} reflects the role of *P. juliflora*, as a moderate source of plant protein and rich source of carbohydrates, in replacing yellow corn (energy source) for protein retention in the fish and saving rich protein sources (fishmeal and soybean meal) for growth. The decrease in ether extract content with increasing *P. juliflora* level may be attributed to: 1) low fat content in *P. juliflora; and* 2) *Prosopis* flour requires longer time to digest than those from most other grains, e.g., 4 to 6 hours compared to 1 to 2 hours for wheat (Choge, *et al.* 2006), which means expending more energy in *Prosopis* digestion, with energy expenditure increasing as

Prosopis level increased in the ration.

The decrease in growth performance and feed utilization occurred in fish fed more than 60g kg^{-1} of *P. juliflora* supplemented diets may be attributed to the increase of fiber content, despite that the values are within the tolerable range for tilapia species. It was reported in the "Summary Reports" of European Commission (1999) that *Prosopis* fibres did not have any adverse effect in rat and human experiments, and their most remarkable physiological effect is related to their strong bulking and laxative effects.

The carbohydrate to lipid (CHO/LIP) ratio in fish diets has been investigated by a number of authors. Palmer and Ryman (1972) suggested that there may be an optimum carbohydrate to lipid ratio value in trout diets which could maximize the metabolism of glucose through hepatic glycolysis and the overall efficiency of glucose use. Acceptable carbohydrate to lipid ratios for channel catfish diets have been reported to be between 0.45 and 4.5 (Garling and Wilson, 1977). Bieber and Pfeffer (1987) observed a better growth rate and enhanced protein and energy retention in rainbow trout (*Salmo gairdneri* R.) when the diets consisted of both fat and starch as compared to diets containing either only fat or starch. El-Sayed and Garling (1988) reported that *Tilapia zillii* can efficiently utilize both carbohydrates and lipids as energy sources and that these can be substituted at a rate of 1/2.25 commensurate with their physiological fuel values. Nematipour, *et al.* (1992) reported that hybrid stripped bass efficiently utilize both carbohydrates and lipids as energy sources but suggested that lipids be partially replaced with carbohydrates to improve fish quality and productivity. Erfanullah Jafri (1998) observed that the growth of walking catfish (*Clarias batrachus*) fed diets containing varying CHO/LIP ratios (0.02 to 43.00) differ significantly.

NRC (1993) revealed that no specific dietary requirement for carbohydrates has been demonstrated in fish. On the other hand, Steffens (1989) and Wilson (1994) reported that an appropriate level of carbohydrates in fish diets is required to avoid any disproportionate catabolism of proteins and lipids for the supply of energy and metabolic intermediates. In addition, Andrews (1979) stated that it is very important to provide the exact amount of energy in diets for fish, and dietary excess or deficiency of useful energy can reduce growth rate, because energy is needed for maintenance and voluntary activity. The diet containing excess energy can restrict food consumption and thus prevent the intake of necessary amounts of protein and other nutrients for maximum growth. Furthermore, Lovell (1989) reported that excessively high energy/nutrient ratios can also lead to a deposition of large amounts of body fat (fatty fish) and dietary protein will be used for energy when the diet is deficient in energy in relation to protein.

In the present study, based on Lovell (1989), increasing inclusion level of *P. juliflora* instead of yellow corn up to 60g $100g^{-1}$ increased protein deposition significantly ($P \leq 0.05$). Any increase beyond that level lead to a decrease in protein deposition, which may be attributed to the imbalance in dietary energy/nutrient ratios. Simultaneously, body fat was decreased up to 60g $100g^{-1}$ inclusion level and then began to deposit in fish body, may indicates that energy/nutrients ratios became higher than required ratio for experimental fish.

Moreover, increasing feed intake with increasing inclusion level of *P. juliflora* up to 60g $100g^{-1}$, in the present study, may indicate that dietary energy in diet (4) was the optimal level for *O. niloticus* fry under the present experimental conditions, which is reflected in achieving the best average daily gain and specific growth rate.

Lochmann and Phillips (1977) stated that weight gain of warm water omnivorous fish improved with increasing complexity of the carbohydrates: starch, dextrin, sucrose, and glucose, respectively. In the present study, both yellow corn and *Prosopis juliflora* were involved in experimental diets as starch. In spite of being higher than yellow corn in fiber content, which hinders dietary nutrients absorption, *P. Juliflora* inclusion in the experimental diets improved growth and feed utilization parameters slightly up to 60g $100g^{-1}$ in the present study. On the other hand, reducing growth performance parameters with increasing *P. Juliflora* beyond that inclusion level, instead of yellow corn in fish diets, may be attributed to: 1) the higher fiber content of *P. Juliflora;* 2) P:E ratio may be higher than experimental fry requirements; and 3) increasing phytic acid (hexaphosphate of myoinositol) concentrations in *P. Juliflora* with increasing inclusion level which reduced protein and mineral bioavailability (Davies and Gatlin, 1991; Hossain and Jauncey, 1990; NRC, 1993) due to the absence of the enzyme phytase within the digestive tract of fish (Lovell, 1989).

CONCLUSION

The current study is the first under-publication experiment on using *Prosopis juliflora* in fish feeding. It concentrated on investigating and studying the effect of different levels of supplemental *Prosopis juliflora* on growth performance. There is a need for further experiments and dissemination of information on using *Prosopis* in fish feeding, particularly in investigating: 1) the tolerable level of *P. juliflora* in fish feeds; 2) thermal, chemical and biological treatments of anti-nutrients involved in *P. juliflora*; and 3) economical evaluation of using *P. juliflora* in fish feeds.

Based on the results of this study, it is recommended to use *Prosopis juliflora* pods powder, as a complementary ingredient, not as a sole ingredient diet, to tilapia feeds at 60g kg^{-1} level during fry and fingerlings stages in order to stimulate roughage consumption and to maintain dietary protein for growth as a source of energy. Furthermore, it is recommended that Phytase enzyme must be added to diet when using *P. Juliflora* in feeding Nile tilapia; *P. Juliflora* could be used in Nile tilapia fry feeds as a source of energy; a combination of different plant origin energy sources could be used in tilpia fry feeds, and more trials need to be carried out to investigate the potentiality of *P. Juliflora* as energy source in tilapia feeds.

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