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CARBOHYDRATE UTILIZATION AND ITS EFFECT ON PERFORMANCE, DIGESTIBILITY AND METABOLIC PARAMETERS OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

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SUMMARY

Two experiments were carried out with Nile tilapia *O.niloticus* fingerlings. The first experiment was designed to evaluate the influence of seven levels dietary D-glucose (0,4,8,12,16,20 and 24%) on the performance, digestibility and metabolic parameter for *O.niloticus* fingerlings of 19,99 gm ± 0.21. The second experiment was including four-carbohydrate source glucose, maltose, sucrose and starch for *O.niloticus* fingerlings of 20.08 gm ± 0.59 to study its effect on performance, digestibility and metabolic parameter. Each of diets was fed to triplicate groups of *O.niloticus* for 8 weeks. The best weight gain and feed efficiency of *O.niloticus* were observed for fish fed D-glucose levels at 16 to 20%, while, fish fed starch > maltose > sucrose > glucose for best weight gain and feed efficiency. *O.niloticus* fed 24% and 16% D-glucose showed the best protein, lipid and energy digestibility respectively, while, dietary starch significantly increased apparent protein digestibility coefficient, moreover, lipid and energy digestibility did not show significant differences among the different kinds of soluble carbohydrate. Higher plasma triglycerol levels when the D-glucose was 16 % or more was noticed. Higher liver glycogen levels were observed in *O.niloticus* fed diets with 8% D-glucose. Normal plasma glucose levels (40-130mg/dl) were observed in fish fed diets with 0-24% glucose. *O.niloticus* fed the glucose diets had significantly ($p < 0.05$) higher plasma triglycerol and liver glycogen levels than that fed the other diets. Maximum plasma glucose levels of 130 and 107 mg/dl were observed in *O.niloticus* fed glucose and maltose, respectively.

Key words: carbohydrate, tilapia, mono, di-, and polysaccharides

INTRODUCTION

Natural diet of fish contains very little carbohydrate and thus their ability to utilize carbohydrate is generally very poor. Nevertheless, carbohydrates are including in fish feeds because they improve the physical quality of the feeds and provide an inexpensive energy source to the fish. Attempts to include high levels of highly digestible carbohydrates in fish feeds have met recently with some success (Kaushik et al., 1989).

Oreochromis niloticus, is the most important cultured species in Egypt with feeding costs of more than 40% of its production costs (Collis and Smitherman., 2002). Therefore it is of great importance to optimize feed composition and feeding strategies.

Fish generally don't utilize carbohydrate well as domestic animals, but utilization varies among fish species (Furuichi and Yone., 1981) and even between subspecies (Refstie and Austreng., 1981). To data, no requirement for dietary carbohydrate has been shown in fish (NRC, 1993), however, reduced growth rate have been observed in some species when they fed carbohydrate free diets (Degani et al., 1986). Alternatively, feeding excessive dietary carbohydrate to fish has been shown to adversely affect an array of morphometric and physiological parameters used to measure growth and nutrient utilization or physiological function (Dixon and Hilton., 1985).

Carbohydrates are the least expensive forms of dietary energy for man and domestic animals, but their utilization by fish varies and remains somewhat obscure. Bahler and Halver (1961) fed Chinook salmon with different carbohydrates and found that growth rate decreased with increasing carbohydrate molecular weight. Red Sea bream showed higher feed efficiency when fed the starch diet than when fed the dextrin and glucose diets. Furuichi et al. (1986) have shown that starch was better utilized than glucose by the Yellow tail.

There is a paucity of information on disaccharide utilization by fish, except for channel catfish (Wilson and Poe., 1987) and white sturgeon (Hung, 1991).

Channel catfish were unable to utilize mono and disaccharide efficiently, whereas white sturgeon utilized glucose and maltose more efficiently than fructose, sucrose, lactose, dextrin and starch. These studies, however, provide little information on the performance, digestibility and metabolic implications of long term feeding of high levels of highly carbohydrates to *O.niloticus*.

MATEREIALS AND METHODS

Two experiments were conducted in the Fish laboratory belonging to the Animal Production Department, Faculty of Agriculture, Cairo University, Egypt to study the carbohydrate utilization in *O.niloticus*.

In the first experiment, *O.niloticus* fingerlings with an initial body weight of 19.99 + 0.21 were fed one of seven isonitrogenous diets containing from 0 , 4, 8, 12, 16, 20 to 24% D-glucose at 4% increments. Three replicate groups each containing 30 *O.niloticus* was fed 3.0% of their body weight/day of the calculated diets for 8 weeks.

In the second experiment, Nile tilapia fingerlings with an initial body weight (IBW), 20.08 + 0.59 were fed isonitrogenous diets containing 30%.The carbohydrate sources were glucose, maltose, sucrose and starch. Three replicate groups of 30 Nile tilapia fingerling were fed 3.0% % of their body weight/day twice a day at (9.00 a.m. and 12.00.p.m for 8 weeks.

Diet Preparation:

Locally available feed ingredients were used in formulating the diets isonitrogenous (38.4%CP) and isocaloric (4360Kcal/Kg) as fish meal, soybean oil, vitamin, mineral and carboxy methyl cellulose.Feed ingredients were finally ground then throughly hand mixed and pressed through a 2 mm diameter die by using an electrical meat mincer.The feed pellets were sun dried for 24 hr and stored at freezer The composition and proximate analysis (AOAC, 1984) of the experimental diets are given in Table 1 and 2.

Fish and diets:

990 *O.niloticus* with initial average weight given in (Table3 and 4), were obtained from a commercial hatchery and acclimated to laboratory conditions for one week in aquaria (80x50x40 cm) each. The fish were randomly and equally distributed into 33 aquarium 30 fish / aquarium (3 aquarium/treatment). Fish were weighed every two weeks, the aquarium was cleaned and one third of the water volume was replaced every three days. Water temperature range from 25°C in May 2002 to about 28°C in June 2002 at the end of the experiment.

Sampling:

Initially 10 Fish were randomly collected for whole fish analyses. At the end of the experiment 10 fish from each aquarium were randomly collected for whole fish analyses.

Growth performance and feed utilization:

Growth, as measured by the body weight gain (WG), feed conversion ration (FCR) and protein efficiency ratio (PER) were calculated as follows:
Weight gain (g/fish)= FBW- IBW.

Where:

FBW=Final body weight.
IBW=Initial body weight.
FCR= Feed intake (g)/ Weight gain (g).
PER=Weight gain (g)/ protein intake (g).

Digestibility trial:

At the end of the growth experiment, a digestibility trial was conducted to determine the apparent digestibility coefficient of crude protein (CP),

ether extract (EE), and energy. Feces from each aquarium were collected by siphon once a day at 10.00 O, clock before feeding. The collecting period was 14 days. To avoid fermentation, feces were kept in a deep freezer and analysis according to (AOAC, 1984). Chromic oxide was used as a marker. Apparent digestibility coefficient (ADC) were determined by using the following equation:

ADC%= 100-100 ((% marker in feed / % marker in feces) (%nutrient in feces / % nutrient in feed)

Analytical methods:

The chemical analysis of the experimental diets, whole fish body composition and feces were carried out to determined dry matter (DM), CP, EE, and ash content according to (AOAC, 1984). Gross energy was calculated using the calorific values 5.65, 9.45, 4.2 and 4.2 Kcal /g for protein, fat, fiber and carbohydrate, respectively (Jobling, 1983).

Blood Analysis:

Blood was sampled, centrifuged, and plasma was frozen according to Hung (1989). Plasma glucose and triglycerol were determined according to the Lorch and Gey method (1966). Liver was dissected, clamped, pooled from each, stored at freezer and glycogen levels determined aquarium (Murat and Serfaty, 1974).

Statistical Analysis:

Data were statistically analyzed by MSTAT program version 4 (1987). Treatment means were compared using the Duncanís multiple range test.

RESSULTS

Performance and feed utilization

In the first experiment final body weights and weight gain were significantly ($p< 0.05$) higher in O.niloticus fed diets containing from 16% to 20% dietary D-glucose compared with *O.niloticus* fed other diets (Table 3), The feed conversion ratio was significantly ($p<0.05$) ranging from an average of 2.11 in fish fed 16% D-glucose in the diet to 4.32 when fed 24% dietary D-glucose. There was a positive correlation (Table3) between increasing dietary D-glucose up to 16% and protein efficiency ratio. Mean PER values ranged between 0.77 when fed 24% D-glucose to 1.58 when fed 16% D-glucose

In the second experiment *O.niloticus* fed diet containing starch showed higher final body weights and weight gain compared with diets containing mono or di-saccharides (Table 4) Fish fed starch showed the best-feed conversion ratio (1.91), while fish fed glucose showed worst feed conversion ratio (3.82). PER in fish fed starch was significantly ($p<0.05$) higher than that in fish fed mono or di-saccharides (Table 4). The mean

PER was ranging from 0.87 for fish fed glucose to 1.75 for fish fed starch.

Apparent digestibility coefficient

In the first experiment, as shown in (Table 5) apparent protein digestibility had a significant ($p< 0.05$) positive correlation with increasing dietary D - glucose. Apparent lipid digestibility was significantly higher in fish fed 20 - 24% dietary D-glucose when compared with other treatments. Higher apparent energy digestibility (45.01- 45.91%) was found when diets containing 12% and 16% D-glucose were used.

In the second experiment fish fed starch had significant ($p<0.05$) higher apparent protein digestibility as compared with mono or di- saccharide. However, no such differences were found when fish fed mono, di and polysaccharides in lipid digestibility, which varied between 79.01% to 82.01%. Apparent energy digestibility ranged from 58.02% when fish fed sucrose to 62.01% for fish fed glucose with no significantly differences.

Chemical body composition

In the first experiment, the body lipid and the body protein were significantly affected by the dietary treatment (Table 6). Body lipid content was highest for fish fed 0%D-glucose (31.91%) while the lowest value for fish fed 24% D-glucose (26.01%). Body protein was highest in fish fed 24% D-glucose (57.28%), while the lowest value was observed for fish fed 4% D-glucose (51.97%). Body dry matter and ash were unaffected by the dietary treatment (Table 6).

In the second experiment, ash was unaffected by the different carbohydrate sources. Body lipid and dry matter were significantly affected by the dietary treatments (Table 6). Body lipid was highest in fish fed the starch and sucrose diet, followed by those fed the maltose and glucose diets. Dry matter was highest in fish fed the starch and maltose diet, followed by those fed the sucrose and glucose diets. Body protein was significantly affected by the carbohydrate sources. The body protein was highest in fish fed glucose diet, followed by those fed the maltose, sucrose and starch.

3.4 Blood parameters

In the first experiment, plasma triglycerol and plasma glucose concentrations of tilapia fed 24%D-glucose were significantly ($p<0.05$) higher than other diets (Table 7), liver glycogen of *O.niloticus* fed 8% D-glucose was significantly higher than other diets.

In the second experiment plasma triglycerol and liver glycogen were significantly affected by the dietary treatment (Table 7). Plasma triglycerol and liver glycogen were highest in fish fed glucose diet following by those fed maltose and sucrose diets, and finally the starch diet. Plasma glucose was highest for fish fed glucose diet, following by those fed maltose and starch, and finally the sucrose diet.

Table (1): Composition and chemical analysis of the experimental diets (Exp.1)

Item	Control	TI	T2	T3	T4	T5	T6
Fish meal	64	64	64	64	64	64	64
Soybean oil	15	13	11	9	7	5	5
Vitamin [1]	6	5	4	3	2	1	1
Mineral [1]	6	5	4	3	2	1	1
Cr203	1	1	1	1	1	1	1
Carboxy methyl cellulose	8	8	8	8	8	8	4
D-glucose	0	4	8	12	16	20	24
Chemical analysis (% DM basis)							
Dry matter	92.01	92.18	92.11	90.11	91.01	92.02	91.51
Crude protein	38.52	38.30	38.51	38.71	38.01	38.51	38.33
Ether extract	16.23	14.92	13.21	10.51	8.51	7.92	7.01
Crude fiber	8.22	7.95	8.11	8.00	8.42	8.51	4.50
Ash	10.56	10.23	10.11	9.98	10.32	10.11	10.54
NFE[2]	30.47	32.6	34.06	36.80	38.74	38.95	43.62

1) Vitamin and mineral premix (vitamin amount in Kg premix), A 4 800 000 IU, D3 800 000 IU, E 4.0g, K 0.8g, B1 0.4g B21.6 g B6 0.6g, Pantothenic acid, 4.0g, Nicotinic, 4.0g, Folic acid, 400 mg, Biotin, 20mg, Iodine, 12.0gm, Iron 12.0g, managanese 22.0gm.
2) Nitrogen free extract = 100 -- (CP+EE+CF+Ash).

Table (2): Composition and chemical analysis of the experimental diets (Exp.2)

Item	Glucose	Maltose	Sucrose	Starch
Fish meal	64	64	64	64
Soybean oil	5	5	5	5
Vitamin [1]	1	1	1	1
Mineral [1]	1	1	1	1
Cr203	1	1	1	1
Carboxy methyl cellulose	4	-	4	4
D-glucose	24	4	-	-
Maltose	-	24	-	-
Sucrose	-	-	24	-
Starch	-	-		24
Chemical analysis (% DM basis)				
Dry matter	92.01	90.11	93.11	92.51
Crude protein	38.21	38.22	38.01	38.31
Ether extract	7.21	7.00	7.11	6.99
Crude fiber	4.51	4.22	4.11	4.65
Ash	10.51	10.22	10.35	10.72
NFE[2]	39.56	40.34	40.42	39.33

1) Vitamin and mineral premix (vitamin amount in Kg premix), A 4 800 000 IU, D3 800 000 IU, E 4.0g, K 0.8g, B1 0.4g B21.6 g B6 0.6g, Pantothenic acid, 4.0g, Nicotinic, 4.0g, Folic acid, 400 mg, Biotin, 20mg, Iodine, 12.0gm, Iron 12.0g, managanese 22.0gm.
2) Nitrogen free extract = 100 -- (CP+EE+CF+Ash).

Table (3) :Performance for Nile tilapia fed different levels of D-glucose (Exp., 1).

D-glucose	IBW	FBW	WG	F CR	PER
0	20.01	44.65^{e}	24.64^{f}	4.28^{a}	0.78^{f}
4	19.92	49.04^{d}	29.12^{d}	3.98^{c}	0.84^{e}
8	20.01	52.49^{c}	32.48^{c}	3.21^{d}	1.04^{d}
12	20.15	54.13^{b}	33.98^{b}	2.91^{e}	1.15^{c}
16	19.90	60.78^{a}	40.88^{a}	2.11^{b}	1.58^{a}
20	19.89	59.21^{a}	39.32^{a}	2.19^{b}	1.52^{b}
24	20.11	43.11^{e}	23.00^{e}	4.32^{a}	0.77^{f}
Pooled					
s.e.d	2.19	3.71	2.75	1.22	0.11

S.e.d Standard error of difference.

Different superscripts indicate significant ($p < 0.05$) difference between fish fed carbohydrate.

Table (4): Performance for *O.niloticus* fed different carbohydrate sources (Exp., 2).

Carbohydrate	IBW	FBW	WG	F CR	PER
Glucose	20.11	42.91^{c}	22.80^{c}	3.82^{a}	0.87^{d}
Maltose	20.23	56.29^{b}	36.06^{b}	2.12^{b}	1.57^{b}
Sucrose	19.97	51.53^{b}	31.56^{b}	2.51^{b}	1.33^{c}
Starch	20.01	84.41^{a}	64.40^{a}	1.91^{c}	1.75^{a}
Pooled s.e.d	2.19	4.72	3.11	0.19	0.11

S.e.d Standard error of difference.

Different superscripts indicate significant ($p < 0.05$) difference between fish fed carbohydrate.

Table (5): The apparent digestibility coefficients (ADCs) for *O.niloticus* fed different carbohydrates or different levels of D-glucose.

% D-glucose	Experiment (I)			Experiment (II)			
	Protein ADC	Lipid ADC	Energy ADC	Carbohydrate	Protein ADC	Lipid ADC	Energy ADC
0	72.01^{d}	82.11^{c}	37.01^{b}	Glucsoe	74.92^{b}	82.01^{a}	62.01^{a}
4	72.51^{d}	82.01^{c}	38.51^{b}	Maltose	75.01^{b}	80.51^{a}	61.08^{b}
8	72.53^{d}	87.01^{b}	38.21^{b}	Sucrose	82.01^{a}	81.73^{a}	58.02^{a}
12	74.51^{c}	83.02^{c}	45.01^{a}	Starch	83.21^{a}	79.01^{a}	58.52
16	80.01^{b}	88.91^{b}	45.91^{a}	Pooled s.e.d	1.43^{b}	1.54	1.02
20	83.11^{b}	90.21^{b}	44.22^{a}				
24	81.11^{a}	94.51^{a}	36.11^{c}				
Pooled s.e.d	2.51	1.82	1.92				

S.e.d Standard error of difference.

Different superscripts indicate significant (p 0.05) difference between fish fed carbohydrate.

Table (6): Body composition for *O.niloticus* fed different carbohydrates or different levels of D-glucose

% D-glucose	Experiment (I)				Experiment (II)				
	DM	ASH	EE	EE	Carbohydrate	DM	ASH	CP	EE
0	36.01	16.01	52.08^{b}	31.91^{a}	Glucsoe	28.21^{b}	16.71	51.11^{a}	32.18^{b}
4	35.92	16.21	51.97^{b}	31.82^{a}	Maltose	32.11^{a}	16.31	49.98^{b}	33.71^{b}
8	35.61	15.92	52.97^{b}	31.11^{a}	Sucrose	30.12^{b}	16.51	48.21^{b}	35.28^{a}
12	35.78	16.00	53.75^{b}	30.25^{b}	Starch	33.11^{a}	15.99	47.11^{bc}	36.90^{a}
16	34.11	16.72	52.98b	30.30^{b}	Pooled s.e.d	0.92	1.01	1.28	1.64
20	33.01	15.82	54.97^{b}	29.21^{b}					
24	31.11	16.72	57.28^{a}	26.01^{c}					
Pooled s.e.d	0.54	0.99	0.96	1.32					

S.e.d Standard error of difference.

Different superscripts indicate significant ($p < 0.05$) difference between fish fed carbohydrate.

Table (7): Blood parameters for *O. niloticus* fed different carbohydrates or different levels of D-glucose.

% D-glucose	Experiment (I)			Experiment (II)			
	Plasma triglycrol (mg/dl	Liver glycogen (mg/g)	Plasma glucose (mg/g)	Carbohydrate	Plasma triglycrol (mg/dl	Liver glycogen (mg/g)	Plasma glucose (mg/g)
0	800^{c}	17^{d}	40^{e}	Glucsoe	1200^{a}	92^{a}	130^{a}
4	620^{d}	52^{c}	65^{d}	Maltose	1107^{a}	85^{a}	107^{b}
8	900^{c}	85^{a}	89^{c}	Sucrose	800^{b}	60.72^{b}	69^{c}
12	820^{c}	74^{ab}	109^{b}	Starch	720^{b}	50.11^{c}	82^{d}
16	1000^{b}	59^{c}	122^{ab}	Pooled s.e.d	15.21	4.25	7.02
20	1100^{ab}	76^{ab}	125^{ab}				
24	1250^{a}	64^{bc}	130^{a}				
Pooled s.e.d	20.12	7.01	652				

S.e.d Standard error of difference.

Different superscripts indicate significant (p 0.05) difference between fish fed carbohydrate.

DISCUSSION

Growth and nutrient utilization

In the first experiment, a level of 16% D-glucose appeared better suited for *O.niloticus* fingerlings compared to other diets based on feed and protein efficiency values. Similar results were obtained with sunshine bass (Hutchins et al., 1998).

Generally, good growth was achieved in the present experiment showing best final body weight (FBW) and weight gain (WG) at 16% D-glucose. Reduced feed intake and less weight gain were found in fish fed diets free or with high inclusion of D-glucose. These results indicate a growth promotion effect exerted by low to moderate levels of dietary carbohydrate, as reported in other herbivorous fish species (Hemre et al., 1992).

The superior growth of O.niloticus fed 16% D-glucose as compared to other diets, may be attributable to the lower metabolism of *O. niloticus* in high levels of D-glucose or resulting in more energy being available for growth (45.91%) (Table 5) which spare protein for growth, according to (Woods et al., 1995).

The best feed conversion and protein efficiency were observed when fish fed 16% D-glucose, which indicated a positive correlation with improve PER and FCR and that is due to a protein- sparing effect. Similar result has been reported for Rainbow trout by Bergot (1979) and

for eel by Degani et al. (1986). When the dietary carbohydrate concentration exceeded 16% the feed utilization was reduced, similar to what was found in Cod (Hemre et al., 1992). The results confirm a protein sparing effect of glucose.

In the second experiment, the utilization of di- saccharide by *O.niloticus* was higher than maltose and sucrose but lower than starch. Great growth of fish in the starch - fed group than in the glucose fed group is in accordance with finding by (Shi and Jei 1995). The reason for poor glucose utilization by fish is still not clear. It has been hypothesized that glucose is rapidly absorbed in the gut (Piefer and Pfeffer 1980). The rapid absorption of glucose would mean that considerable amounts of glucose enter the body before sufficient elevation of the activities of carbohydrate metabolic enzyme. This in turn could possibly restrict the use of the absorbed glucose (Furuichi and Yone 1982).

The best FCR and PER were obtained for *O.niloticus* fed diet containing starch due to the slower absorption of the starch that may be cleared from circulation before cells can utilize it efficiently (Hilton and Atkinson 1982) or due to the increasing activity of the glycolytic and pentose pathways that may explain the positive relationship between carbohydrate complexity and growth performance (WG, FCR and PER). Shiau and Liang (1995) observed an increased phosphofructokinase activity and a decreased glucose-6-phosphate activity in hybrid tilapia with increasing carbohydrate complexity in the diet. Subsequently, the activities of malic enzyme, glucose-6-phosphate dehydrogenase and phosphogluconate dehydrogenase also were positively related to carbohydrate complexity in the diet of hybrid tilapia (Lin and Shiau 1989).

DIGESTIBILITY COEFFICIENTS:

Digestibility is an important parameter in fish feed evaluation (Mundheim and Opstued 1989).

In the first experiment a significant increase was measured in protein, lipid and energy digestibility for the diets containing 24% and 16% dietary carbohydrate. The increase in lipid digestibility caused by feed high dietary D-glucose may be due to the low fiber effect (Storebakken 1985). The increase in protein digestibility from 72.01% to 83.51% accompanied by increased D-glucose consumption from 0-24%, would lead to a protein-sparing effect of D-glucose which maximize protein utilization (Hemre et al., 1995). Increased energy digestibility by increasing D-glucose up to 16% due to increasing lipid and protein digestibility or would lead to decrease in faecal starch, nitrogen and lipid losses when feeding the 0% diet to 16% D-glucose. However, it could be interpreted carefully as the total environmental impacts include several other factors including feed waste and metabolic losses, data agree with finding by Hemre et al., (1989).

n the second experiment, dietary carbohydrate sources did not have significant influence on lipid and energy digestibility. The relationship observed between protein digestibility and carbohydrate complexity in the diet of *O.niloticus* agreed with previous reports that protein digestibility is little affected by carbohydrate source (Bergot, 1993), extruded (Takeuchi et al., 1990) or semi purified (Furuichi and Yone, 1971). On the other hand, Herold et al. (1995) observed that protein digestibility, and lipid digestibility, varied with the addition of glucose, maltose, sucrose and starch to the diet without significant differences to the diet of white sturgeon agree with the present data. The low DE coefficients obtained for *O.niloticus* fed sucrose and the high DE coefficients obtained for fish fed glucose are similar to values obtained for practical high-carbohydrate feeds stuff (50 - 60%) with Palametto bass (Sullivan and Reigh, 1995) and for wheat (62%) with red drun (Gaylord and Gatlin,1996). Higher body protein in fish fed 24% D-glucose than other diets, while higher body fat was observed in fish fed diets containing from 0% to 8% dietary D-glucose the present study is agreement with finding by Hutchins et al. (1998).

Higher body fat and dry matter in fish fed the starch diet than those fed the glucose diet in the present study is agreement with previous studies (Shi and Jei 1995) but in disgreement with finding by (Shiau and Pin 1993). Fish feed the disaccharide-containing diet had intermediate levels of body fat and DM. Body fat in the fish fed maltose and sucrose diets was similar (Table, 6). The storage of body fat is an indication of carbohydrate utilization. Higher body protein in fish fed the glucose diet is in agreement with finding by (Shiam and Lin 1993). Fish fed the disaccharide-containing diet had intermediate levels of body protein.

Blood parameter

In the first experiment, plasma glucose levels (40-130mg/dl) were significantly affected by the dietary D-glucose. Peak concentrations of plasma glucose were found to be very high but similar to earlier studies were Atlantic salmon (Hemre et al., 1995). The dietary D- glucose levels also significantly affected plasma triacylglycerol levels in *O.niloticus*. *O.niloticus* fed diets with 24% D-glucose had 1.5 times higher plasma triacyglycerol levels than those fed diet with 0 to 12% D-glucose (Table, 6). The present data agreed with finding by (Hung, 1991) in Sturgeon. Low plasma triacylglycerol concentrations found during this experiment can be related to fish size at sampling than the level of carbohydrates (Lie et al., 1988). Liver glycogen levels were significantly affected by the dietary D- glucose, data agreement with (Hemre et al., 1995).

In the second experiment, there was a significant difference in plasma glucose levels. (69-130 mg/dl) in *O.niloticus* fed diet with different carbohy-

drates, but they were within the normal range in Nile tilapia (Shiau and Liang, 1995). Glucose and Maltose diets have high plasma glucose may be due to diffuse glucose through the cell or through the cell - to- cell junctions easily in Sturgeon gastrointestinal mucosa so the level of glucose was increased (Hung, 1991). The dietary carbohydrates significantly affected plasma triacylglycerol, the most pronounced effect, however, was observed in the plasma triacylglycerol levels. *O.niloticus* fed the glucose or maltose diets had twice the amount of plasma triacylglycerol when compared with those fed the other diets (Table, 7). The different carbohydrates significantly affected liver glycogen levels. O.niloticus fed glucose and maltose were significantly higher than other diets. Data with agreement with (Dixon and Hilton, 1985) which observed that feed on high levels of dietary glucose and other high digestible carbohydrate to rainbow trout has also been shown to increase liver glycogen.

In conclusion, D-glucose could be added in diets up to 16% without negative effects on performance and digestibility and starch considered suitable source of carbohydrate for *O.niloticus*.

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