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Utilization of Taro Leaves in Diet of the Nile Tilapia *Oreochromis nloticus*

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ABSTRACT

Eighty-four days feeding trial was conducted to address the growth performance, feeding efficacy rate, body indices, and biochemical parameters of the mono-sex Nile tilapia, when fed different substitution levels of soy and maize with dried taro (*Colocasia esculenta*) leaves, compared to a control diet. This trial was followed by a 14-days fish digestibility experiment. All treatments were duplicated by using two equal cement basins with 5 equal parts containing 100 fish per each with a recorded initial weight (23.39±0.43g). All growth responses were significantly affected, whether in the four examined fish groups or the control group ($P<0.05$). Compared to the control, the lowest muscle lipid and the highest muscle protein contents were recorded in fish fed diet 3, (20 % boiled soybean +40% yellow corn). A significant improvement was detected in the plasma total protein and the immunoglobulin ($p<0.05$) of the tilapia fed the four examined diets when compared to the control. Similarly, the highest protein digestibility was recorded for the 4 aforementioned fish groups ($p<0.05$). Meanwhile, an insignificant survival rate was observed for both groups; the treated and the control. Furthermore, the liver index and liver composition were significantly affected with regard to the tested fish groups when compared to the control. Results indicated that soy and corn substituted with taro leaves, which contain the important amino and fatty acids required for fish, can significantly promote growth and may provide the market with a low cost-effective and eco-friendly fish diet as well**.**

INTRODUCTION

Aquaculture is a considerable growing industry which enriches the world witha white protein source. Different trials have been organized to enhance feed efficiency and growth performance of the tilapia species.

Fishmeal is considered the most palatable animal protein source in aquatic feeds because of its balanced amino acid profile, high digestibility, in addition to its efficacy as a source of essential n-3 polyenoic fatty acids **(Hardy & Tacon, 2002)**. However, despite their lower percentage of plant protein, deficiency in amino acids and the antinutritional agents, plant protein feedstuffs have been used to replace fishmeal. Moreover, compared to fish meal, plant protein is more constantly available in lower costs, but its bad effect on the palatability and digestibility has been recognized **(Hardy, 2010)**. A deficiency in certain essential amino acids is one of the major issues associated with plant protein sources, when added to other ingredients **(Ogunji *et al.*, 2008)**. Better trials are recommended to examine the efficiency of partially or totally substituting fishmeal, soybean or any other expensive sources with less expensive and easily available plant protein sources. This step would reduce the high dependence on the afore- mentioned protein sources used for fish feed and simultaneously help increasing the nutritional feed quality.

Several studies were performed to evaluate the use of different plants as additives or replacements for fishmeal, soybean, and corn meal in aqua feeds **(Toan & Preston, 2010; Chhay *et al.*, 2010; Castillo & Gatlin, 2015; Raky *et al.*, 2021a, b, c)**.The nutritional values of some tubers and roots are not equivalent to the real values of their potential ability to supply people with specific nutrition; for instance, the low carbohydrate ingredients written on some items **(Carpenter *et al.*, 2001)**. Among the root crops, taro is one which contains a great amount (87%) of carbohydrates, fibre, and minerals in developing countries in Asia and Western Africa. Taro (*Colocasia esculenta*), a member of the Araceae family, is an ancient crop grown all over the humid tropics and is known for its edible corms and leaves, as well as its traditional ceremonial uses **(Wang, 1983)**. Though the taro corm lacks protein, fat, and most vitamins, itcontains a significant amount of dietary fibre and minerals **(Behera *et al.*, 2009)**.

Taro corm is served as boiled, but people are not aware of the importance of its leaves. The taro leaf is cooked and eaten as a vegetable in Asia and often in tropical Africa **(Akwee, 2015)**. The nutritional values are the main concern when a crop is being considered as a food source,thus informations on the nutritional contents of the root crops like taro are highly required **(Hang & Preston, 2009)**.

Taro leaves contain more values of beta-carotene (135μg), folic acid (3.28 mg) and iron (1.35 mg) **(Oueme & Winston, 1999)**. The protein content in taro leaves is high (21 % DM) and rich with most of the limited amino acids compared to other tropical root crops, cereals and legumes (**Ajijola *et al*., 2003)**. Taro leaves powder (*Colocasia esculenta*) is a significant protein supplement which can replace fish meal and soy meal due to its high protein digestibility and biological value **(Chhay *et al*., 2010)**.

It is very important to supply reared fish with the required amounts of essential amino acids (EAAs) for their high positive effectson the muscle deposition of the cultured fish and the feed cost **(Small & Soares, 1999)**. Thus, formulating effective diets with suitable cost that would meet EAAs requirement can be a target **(Kaushik & Seiliez, 2010)**. In this context, to meet those requirements, the use of high quality proteins associated with low price has been concerned **(El-Sayed, 2006; Webster & Chhorn, 2006)**.

Compared to the corn, the amino acid and fatty acids composition of taro leaf were higher. Meanwhile, taro leaf has been considered as a good source of essential amino acid and fatty acid **(Temesgen *et al.*, 2017)** and also, there is high ambivalence between the lysine, tryptophan, and methionine requirements for the tilapia. **Mmanda *et al*. (2020)**

reported that several local feed ingredients have the potential to supply the EAA required for proper fish growth and health.

In addition, **El-Tawil *et al.* (2020)** assessed that, growth performance parameters of the Nile tilapia, *Oreocromis niloticus*, improved ($p<0.05$) with the increasing the percentage used of taro leaves in case of substituting taro leaves meal for soybean meal in fish diets. The previous authors added that the values of feed efficiency measurements were increased significantly in fish; the highest values were recorded with fish fed up to 20% taro leaves. Results cleared that fish proximate analysis affected ($p<0.05$). Moreover, the supplementation of taro leaves in the fish diet reduced the cost of one kg diet compared the control.

Principal objective

Substitute expensive diet ingredients by unconventional plant materials, which are uneaten by people, are good trials to reduce cost of production and increase supply of protein and carbohydrate in fish diet.

The study aimed to investigate the effect of partial replacement of the two ingredients (soy and corn) by dried taro leaves in diets for the mono sex Nile tilapia.

Specific objectives

1- To investigate nutrient (% DM basis), amino acid, and fatty acid of taro leaf meal.

2- To investigate dry matter intake, protein intake, digestibility, protein efficiency, mean weight gain, and feed conversion efficiency of fish fed diets containing different substitution levels.

3- To determine the nutrient composition, biochemical properties, and fish health indicators after use of taro leaf meal.

MATERIALS AND METHODS

1. Taro leaves powder preparation

Fresh taro leaves (*Colocasia esculenta L.*) were obtained from local market, washed and air dried. The dried samples were powdered into particle size of 1.6mm and packaged in polythene bags to formulate the diets for various feed chemical analyses.

The nutritional composition of taro leaves and other main ingredients of fish ration are showed in Table (1).

2. Experimental design and Preparation of diets

Four diets containing different percentages of substitution of boiled soybean meal (BSM) and yellow corn (YC) with 30, 45, 60, and 75% taro leaves meal (TM) were performed as follow: D1 (10% BSM+20% YC); D2 (15 % BSM +30% YC); D3 (20 % BSM +40% YC), and D4 (25 % BSM +50% YC).

Feed ingredients were formulated for test diets and chemically analyzed (Table 2& 3).

Fish were acclimated under optimal conditions for a week before starting the trial. The mono-sex Nile tilapia, with mean initial body weight of 23.39 ± 0.43g, were fed twice a day at 10 am and 3 pm for 84 days. Fish weight was calculated biweekly in order to adjust feeding rate (3%). The water was changed twice a week.

Table 1. Main ingredient composition (%)

Chemical composition	Fish meal	Taro leaves	Yellow corn	Soybean meal
Crude Protein (CP)	59.02	26.2	7.5	41.44
Ether extract (EE)	8.91	5.9	3.5	0.5
Crude fiber (CF)	0.96	18.5	8.8	7.0
Ash	18.8	19.1	5.5	6.0
Nitrogen free extract (NFE)	4.31	30.3	55.1	35.06
Dry matter (DM)	92	18.3	86	92
Gross energy (GE)*	18.5	17.14	16.0	17.4

*GE= (CP*5.65+EE*9.65+CF*4.2+NFE*4.2)*4.182/100

Table 2. Experimental diet formulations

	Examined diets				
	Control	**D1**	**D2**	**D3**	**D4**
Fish meal	15	15	15	15	15
Corn gluten meal	5	5	5	5	5
Boiled soybean	30	27.0	25.5	24.0	22.5
Yellow corn	30	24.0	21.0	18.0	15.0
Taro leaves	0	9.0	13.5	18.0	22.5
Wheat bran	16.5	16.5	16.5	16.5	16.5
Sunflower oil	2	2	2	2	2
Premix*	1	1	1	1	1
Cr_2O_3	0.5	0.5	0.5	0.5	0.5

*One kg premix contained:

Vitamins: 48×10^5 I.U (A), 6×10^2 mg (B_6), 20 mg (biotin), 8×10^5 I.U. (D_3), 144 mg (E), 400 mg (B_1), 1600 mg (B_2), 4×10^3 mg (pantothenic acid), 4 mg (B_{12}), 4×10^2 mg (niacin), 2×10^5 mg (choline chloride), and 400 mg (folic acid).

Minerals: 12×10^3 mg iron, 16×10^3 mg manganese, 12×10^2 mg copper, 120 mg iodine, 80 mg cobalt, 40 mg selenium, and 16×10^3 mg zinc.

Table 3. Nutritional composition of experimental diets

Nutritional parameter	Experimental diets				
	Control	**D1**	**D2**	**D3**	**D4**
DM	89.19	82.98	79.87	76.76	73.66
CP	29.62	29.95	30.12	30.28	30.45
EE	5.30	5.60	5.76	5.91	6.06
CF	4.07	5.43	6.10	6.78	7.46
Ash	6.13	7.45	8.11	8.77	9.43
NFE	42.80	40.14	38.82	37.49	36.16
GE	17.37	17.34	17.33	17.32	17.30

3. Experimental fish measurements

Fish were weighed biweekly to calculate mean weight gain (MWG), daily weight gain (DWG), and specific growth rate (SGR). In addition, feed intake (FI) and protein intake of feed were recorded to determine protein efficiency and feed conversion ratios (PER & FCR) and protein productive value (PPV) according to **Cho and Kaushik (1985)** as the following:

MWG, g /fish = [final body weight (g) - initial body weight (g)]

DWG, g /fish /day = [BWG (g) / Experimental period (days)]

SGR, %g/day = [Ln final weight - Ln initial weight] / Experimental period (day)*100

FCR = feed intake (g) / body weight gain (g)

PER = gain in weight (g) / protein intake in feed (g)

PPV, % =100 [protein gain in fish (g) / protein intake in feed (g)]

Survival rate % = 100 [Initial number of fish stocked-Mortality] / Initial number of fish stocked.

Apparent protein digestibility (APD) was measured by using the method of **Furukawa and Tasukahara (1966).** The uneaten diet and faeces were collected by siphoning once daily in the last 15 days of the trial. Feed or faeces was carefully collected before first feeding. After about 30 min of feeding, uneaten feed was collected. Faeces were collected separately after 2 hours then filtered and dried at 60ºC and stored to determine the chemical composition.

4. Water quality parameters

During the experimental period, water quality parameters (water temperature, dissolved oxygen and pH (measured daily); total ammonia, nitrite, and nitrate) were weekly measured. The unionized ammonia (UIA) was calculated according to the method of **Zhang *et al.* (2018)**.

5. Laboratory analysis

5.1. Chemical composition

Samples of feed ingredients, fish diets and fish muscles were analyzed for crude protein (CP), ether extract (EE), crude fibre (CF) and ash using the **AOAC (2012)** reference methods.

5.2. Biochemical analysis

5.2.1. Fatty and Amino acids composition

Taro leaf was processed as a powder prior to the analysis. The leaf samples were tested for fatty acid and amino acid composition by using the method recommended by **Li and Watkin (1998)** that was applied for the determination of fatty acid and amino acids. This method was evaluated by **Tidwell *et al.* (1993)**.

5.2.2. Liver analysis

At the end of the trial, liver samples of 15 fish were taken randomly from each pond, then liver tissues were homogenized with 5 ml distilled water to determine the following parameters; liver glycogen was determined (g/100 g fresh tissue) by the formula, using modified method of **Handle (1965**).

Glycogen = (Absorbance sample/Absorbance standard) x Conc. of standard x (V. of dil. factor/ Wt. of tissues).

The total liver lipid was extracted with a mixture of 2 chloroform:1 Methanol following the description in the study of**Bligh and Dyre (1959)**, then 0.5 ml sulphuric acid was added to the dried lipid extract by using the method of **Zollner and Kirsch (1962)**.

Lipid = (Absorbance sample/Absorbance standard) x Conc. of standard x (V. of dil. factor/ Wt. of tissues).

Total liver protein was homogenated in trichloroacetic acid to 0.2 ml of tissue, centrifuged 1008 x*g*, using the formula of **Gornall *et al.* (1949)** as follows:

Protein = (Absorbance sample/Absorbance standard) x Conc. of standard x (V. of dil. factor/ Wt. of tissues).

6. Physiological parameters

6.1. Body indices

Livers and guts of the experimental fish were taken at the end of the feeding trial and weighed to calculate liver and gut (HSI &GSI respectively) as follows:

HSI = (liver weight/ fish total weight)×100;

GSI = (gut weight/ fish total weight)×100.

6.2. Blood parameters

At the end of the trial, blood samples were collected from the fish caudal veins. Blood was centrifuged at 1008 x*g* for 15 min. Samples were subjected to the determination of plasma protein (PTP) according to method of **Armstrong and car (1964)**. The Immunoglobulin's (IgM and IgD) were measured by using the method of **Feinstein *et al.* (1985)**.

7. Data analysis

The data were subjected to analysis of variance (ANOVA) using general linear models (GLM) procedure, and the software used was SPSS (Version 16.0) **(SPSS, 1997)**. Duncan's multiple range tests **(Duncan, 1955)** were used to compare between means of the control and treated groups.

The model of analysis was as follows:

$$\mathbf{Y_{ij} = \mu + T_i + E_{ij}}$$

μ = the overall mean;

T_i = the effect of treatment;

E_{ij} = the random error.

RESULTS AND DISCUSSION

Water quality

The mean values of water quality (±SD) are recorded in Table (4). All water quality parameters are within the acceptable ranges for rearing the tilapia **(Makori *et al.*, 2017)**.

Table 4. Water physico-chemical parameters

Water parameter	Value
Temperature °C	27.4 ± 1.14
Dissolved oxygen (mg/L)	5.9- 6.6 ± 0.21
pH	7.3 ± 0.15
Total ammonia nitrogen (mg/L)	0.023 ± 0.00
Nitrate (mg/L)	0.72 ±0.03
Nitrite (mg/L)	0.022±0.010

Biochemical investigation

Analysis of essential amino acid and fatty acid composition of taro, soy and corn are important variables considered in the present study (Table 5&6) and (Fig. 1).

The present results recorded that, taro leaves powder had a rich source of mainly essential amino and fatty acids which are highly important for fish health, especially the three amino acids (methionine, lysine, and tryptophan) and the unsaturated fatty acids, which compensate methionine deficiency in soy and corn **(Raky, 2001; Temesgen *et al.*, 2017; Lyu *et al.*, 2019)**. Additionally, **Jiang (1999)** reported that taro leaves are rich in essential amino acids and its protein content is approximately 23%. .

Table 5. Essential amino acids of taro leaves, soy and corn (g/100g)

Essential amino acids %	Taro leaves	Soybean	Yellow corn
Histidine	2.61	1.2	1.30
Threonine	4.75	1.88	1.31
Valine	6.02	1.12	1.51
Methionine	2.34	0.65	1.93
Cysteine	1.91	0.65	0.92
Phenylalanine	6.02	2.64	2.44
Arginine	1.66	3.21	2.53
Isoleucine	4.85	2.41	2.27
Lysine	5.94	3.11	1.27
Leucine	8.95	3.57	3.82
Tryptophan	3.25	1.01	0.84

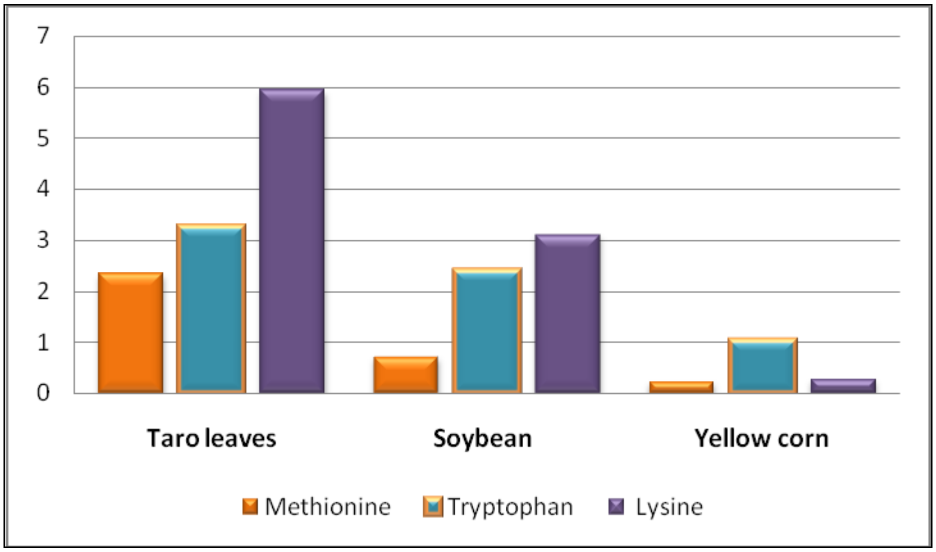

Fig. 1. Taro leaves rich in the EAA (%) relative to soy and corn

The total unsaturated fatty acids (314.91g/100g**)** were the dominant acids recorded in the present study. Similarly, **Temesgen *et al.* (2018)** stated that the high levels of unsaturated fatty acids in the taro are nutritionally rich **(**322.98 ±.55 g/100g).

Table 6. Fatty acids (FA) composition of taro leaves (soy and corn) replacer

Fatty acid ratios (g/ 100g)							
Saturated FA		**Mono unsaturated FA**		**Unsaturated FA**		**Poly-unsaturated FA**	
C14:0	2.50±0.11	C14:1	0.32±0.03	C18:1(n-9)	223.61±2.1	C18:2(n-6)	54.01±1.00
C15:0	0.30±0.01	C16:1(n-7)	15.31±0.30	C18:2(n-6)	55.11±1.00	C18:3(n-3)	0.32±0.21
C16:0	203.58±2.4	C17:1	0.32±0.01	C18:3(n-3)	0.34±0.21	C20:1(n-9)	0.32±0.03
C17:0	0.32±0.01	C18:1(n-9)	220.61±2.1	C20:1(n-9)	0.34±0.03	C20:2(n-6)	0.32±0.01
C18:0	100.81±1.1	C20:1(n-9)	0.32±0.03	C20:2(n-6)	0.34±0.01	C20:3(n-6)	0.31±0.04
C22:0	0.30±0.03	C22:1(n-9)	0.313±0.01	C20:3(n-6)	0.34±0.04	C20:4(n-6)	26.22±0.01
C24:0	0.32±0.02	C24:1(n-9)	0.313±0.02	C20:4(n-6)	27.32±0.01	C20:3(n-3)	0.31±0.03
				C20:3(n-3)	0.32±0.03	C22:1(n-9)	0.30±0.01
				C22:1(n-9)	0.313±0.01	C22:6(n-3)	5.80 ±0.02
				C22:6(n-3)	5.85 ±0.02	C24:1(n-9)	0.31±0.02
				C24:1(n-9)	0.33±0.02		
Total	**308.22**		**237.51**		**314.91**		**88.03**

Growth performance of *Oreochromis niloticus*

The results of growth and feed utilization parameters as shown in Table (7) and Figs (2 - 5) improved principally for fish fed D3, (20% soy +40% corn) followed by fish fed D4, (25% soy + 50% corn) which were replaced by taro leaves. These results may be due to the fact that taro leaf is rich with essential amino acid, unsaturated fatty acid, carbohydrates, and other nutritional components **(Jiang, 1999; Oueme & Winston, 1999; Ajijola *et al*., 2003; Chhay *et al*., 2010; Temesgen *et al*., 2018)**.

Table 7. Growth response parameters of fish fed examined diet

Growth parameter	**Experimental diets**				
	Control	**D1**	**D2**	**D3**	**D4**
Initial weight (g)	23.18 ±0.45	23.15 ±0.51	23.33±0.43	23.72±0.35	23.55 ±0.32
Final weight (g)	98.71^{d}±1.28	99.38^{c}±1.14	100.18^{bc}±1.22	103.76^{a}±1.01	101.20^{b} ±.92
MWG (g)	75.53^{d}±0.77	76.23^{c}±0.82	76.85^{c} ±64	80.04^{a} ±0.70	77.65^{b}±0.65
DWG (g/day)	0.90^{c} ±0.02	0.91^{b}±0.01	0.91^{b}±0.01	0.95^{a}±0.04	0.92^{ab}±0.02
SGR (%)	1.72^{c}±0.04	1.73^{c}±0.02	1.74^{b}±0.04	1.76^{a}±0.05	1.74^{b}±0.03
FI (g)	125.07^{d}±0.7	125.65^{d}±0.8	126.65^{c}±0.82	130.54^{a}±1.62	127.92^{b}±1.11
SR%	97.00	98.00	97.00	98.00	100.00

Values in the same row with different superscripts are significantly different ($P<0.05$)

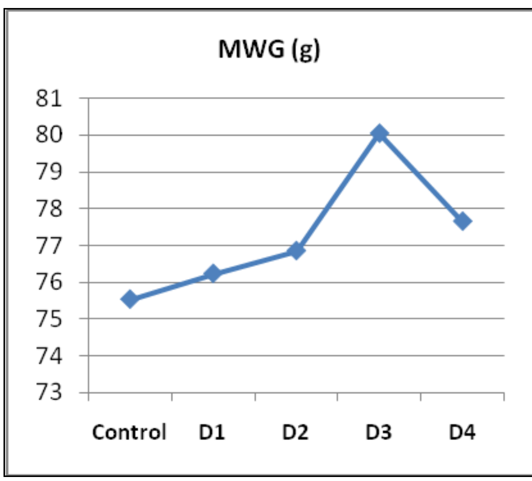

Fig. 2. Mean weight gain

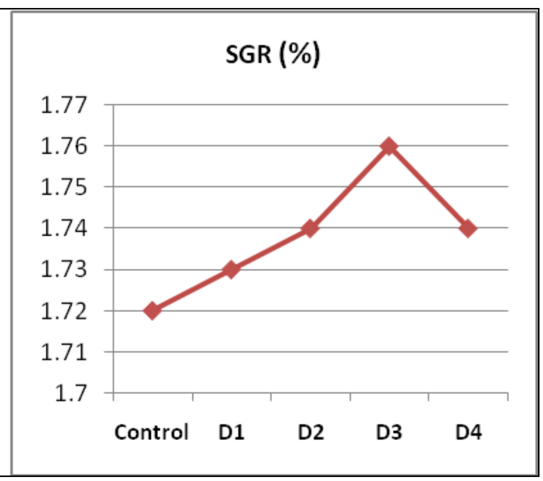

Fig. 3. Specific growth rate

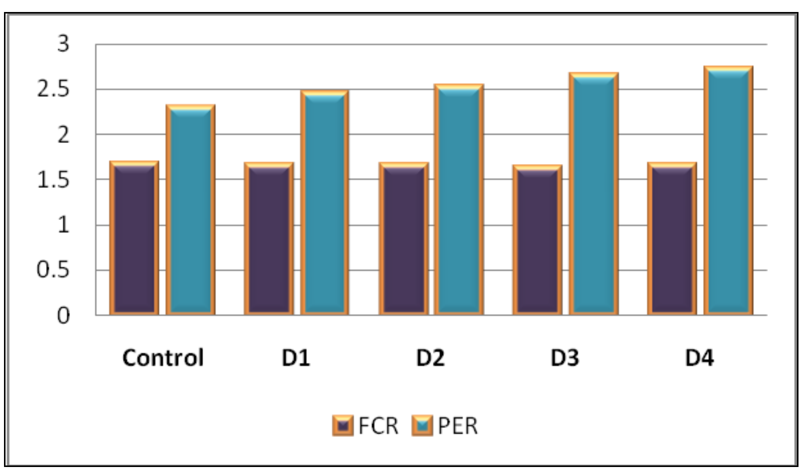

Fig. 4. Diet efficiency ratios

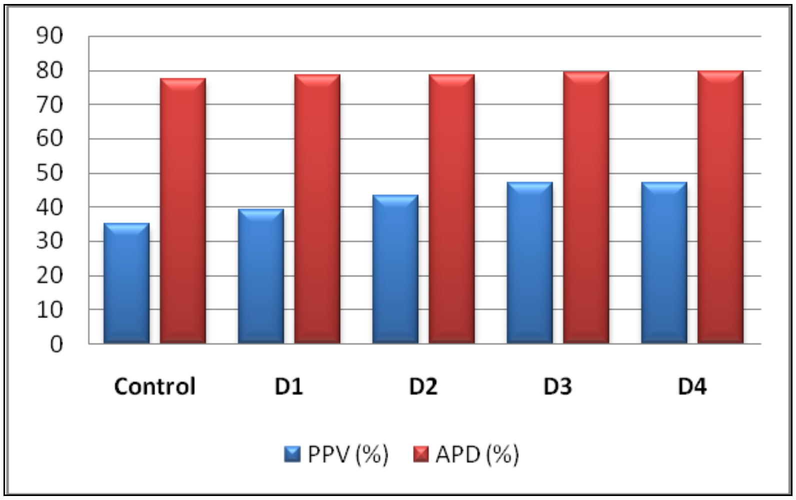

Fig. 5. Protein utilization

Moreover, **El-Tawil *et al*. (2020)** used taro leaves meal to substitute soybean meal in fish diets and deduced that the growth parameters of *Oreochromis niloticus* improved significantly with the increasing levels of taro leaves. They also found that feed efficiency measurements enhanced for the fish fed up to 20% taro leaves.

The present result agree with that of **Mathia and Fotedar (2012)** who used taro leaves as a complete replacement of shrimp meal protein in the tilapia diets and recorded an insignificant specific growth rate, survival rate, and apparent food conversion ratio. **Wee and Wang (1987)**, **Richter *et al.* (2003)** and **El-Saidy and Saad (2008)** suggested that a complete replacement of plant protein may have some assorted effects on the growth performance. The replacement of soybean meal by taro leaves powder up to 25% may have an adverse effect on growth performance (**El-Tawil *et al.*, 2020)**.

Acceptable ranges of essential amino acid requirement for the tilapia diet were 1.43–1.62% for lysine, 0.17–0.6% for tryptophan, 0.53–1.13% for methionine, and 0.53–2.1% for cysteine **(El-Sayed, 2004)**. The current findings indicate that taro leaves have the potential to supply the EAA required for fish growth and health.

Biological parameters

Biological composition in the present study revealed that fish indices fluctuated insignificantly within the four test diets, while diet 3 (20% soy + 40% corn) replaced by taro leaves gave the lowest indices compared to the control (Fig. 6 &7).

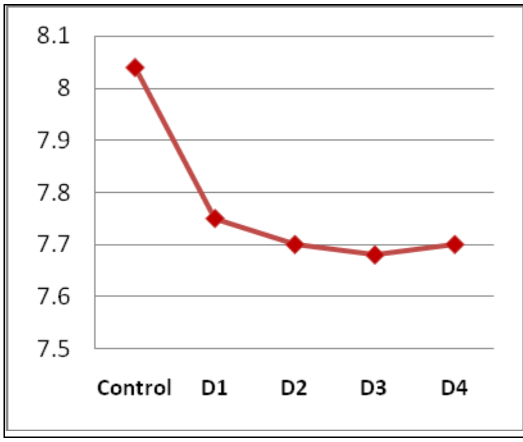

Fig. 6. Gastro-somatic index

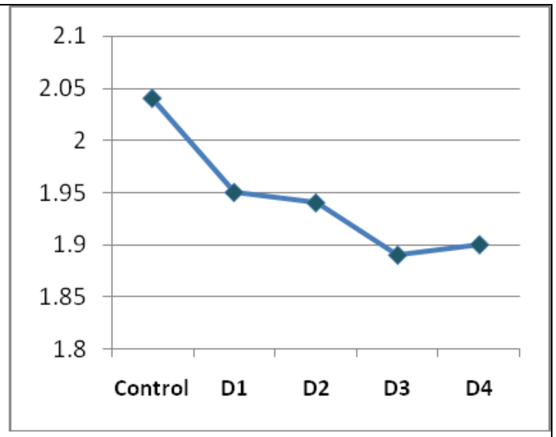

Fig. 7. Hepato-somatic index

Robaina *et al.* (1995) reported that the deficiency of some important essential amino acids in soy and corn (e.g. methionine) may havealmost occurred, particularly in plant sources amino acids resulting in increasing liver weight. This may explain why hepato-somatic index were lower in fish fed the diets containing taro leaves.

Muscle and liver composition of examined fish

Present results in Table (8) show that, muscle protein content increased ($p<0.05$) with increasing the levels of taro leaf, while lipid content decreased, compared to the control.

The quality of feed protein highly effects on the protein composition of final products such as meat **(Osek *et al.*, 2011**), also **Melesse *et al.* (2011)** proved that the quality of protein and amino acid contents of feed enhanced muscle protein.
El-Tawil *et al.* (2020) recorded that fish protein content increased ($p<0.05$) with increasing taro levels accompanied with lipid decrease.

Table 8. Muscle composition of mono-sex tilapia at the end of the trials

Chemical composition	Experimental diets				
	Control	D1	D2	D3	D4
DM	$24.25^{c}\pm0.91$	$24.60^{c}\pm0.87$	$25.70^{b}\pm0.92$	$26.57^{a}\pm0.68$	$26.38^{a}\pm0.74$
CP	$63.01^{c}\pm1.02$	$65.17^{b}\pm0.96$	$66.42^{ab}\pm0.58$	$66.81^{a}\pm0.85$	$65.95^{ab}\pm1.01$
EE	$19.73^{a}\pm0.52$	$18.90^{b}\pm0.46$	$18.70^{c}\pm0.67$	$18.04^{d}\pm0.39$	$19.01^{b}\pm0.40$
Ash	$13.05^{c}\pm0.27$	$13.80^{b}\pm0.19$	$13.90^{ab}\pm0.28$	$14.09^{a}\pm0.31$	$13.94^{ab}\pm0.12$
NFE	$4.21^{a}\pm0.02$	$2.13^{b}\pm0.04$	$0.98^{d}\pm0.01$	$1.06^{c}\pm0.03$	$1.10^{c}\pm0.01$
Moisture	$75.75^{a}\pm0.90$	$75.40^{b}\pm0.80$	$74.30^{c}\pm1.13$	$73.43^{d}\pm$o.75	$73.62^{d}\pm0.16$

The results of liver metabolites shown in Table (9) and Fig. (8) reveal that, the fish fed test diets showed an increased trend for liver protein ($p<0.05$) and glycogen ($p>0.05$), while hepatic lipid exhibited an opposite trend ($p<0.05$).

Table 9. Liver metabolites g/100 tissue

liver parameter	Experimental diets				
	Control	**D1**	**D2**	**D3**	**D4**
Hepatic protein	$22.79^{c} \pm 1.00$	$22.93^{c} \pm 0.90$	$23.92^{b} \pm 1.00$	$24.33^{a} \pm 1.01$	$23.95^{b} \pm 0.95$
Hepatic lipids	$7.15^{a} \pm 0.12$	$7.04^{b} \pm 0.15$	$7.00^{ab} \pm 0.13$	$6.51^{d} \pm 0.10$	$6.72^{c} \pm 0.05$
Hepatic glycogen	$4.23^{d} \pm 0.09$	$4.54^{b} \pm 0.08$	$4.67^{a} \pm 0.08$	$4.73^{a} \pm 0.10$	$4.45^{c} \pm 0.09$

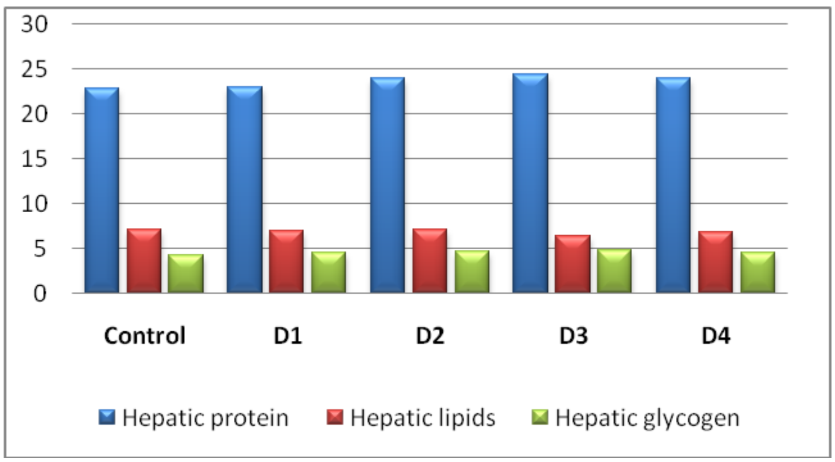

Fig 8. Liver metabolites (g/100g) tissue of mono-sex *O. niloticus*

Haematological investigations

The present study demonstrated that, when taro leaves wre evaluated as substitution of corn and soy, the plasma total protein (PTP), albumin, globulin (Table 10), and immunity indicator (IgM & IgD) levels were significantly enhanced (Fig. 9 & 10). Those results may be due to the bioactive compounds found in taro leaves **(Pereira *et al.*, 2018)**.

Plasma total protein is important to evaluate the nutritional state of the fish health condition **(Olaniyi 2010, Pratriche *et al.*, 2011)**. Extremely total protein and albumin have been reported to be directly responsive to protein intake and quality **(Onifade & Abu, 1998)**.

Table 10. Biochemical blood analysis

Parameter	Experimental diets				
	Control	D1	D2	D3	D4
Plasma protein	$3.12^{c} \pm 0.07$	$3.35^{b} \pm 0.06$	$3.59^{ab} \pm 0.02$	$3.71^{a} \pm 0.07$	$3.69^{a} \pm 0.06$
Plasma Albumin	$1.80^{a} \pm 0.02$	$1.53^{b} \pm 0.03$	$1.44^{c} \pm 0.03$	$1.32^{d} \pm 0.02$	$1.35^{d} \pm 0.01$
Plasma Globulin	$1.32^{e} \pm 0.06$	$1.82^{d} \pm 0.07$	$2.15^{c} \pm 0.05$	$2.39^{a} \pm 0.09$	$2.34^{b} \pm 0.06$

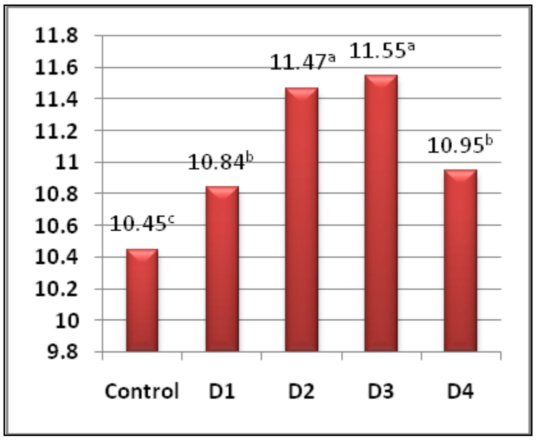

Fig. 9. IgM level

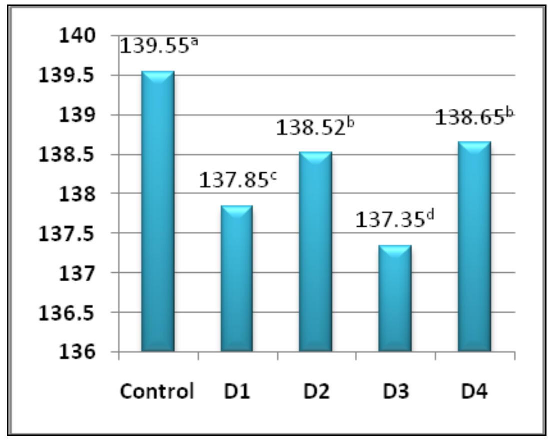

Fig. 10. IgD level

Profit index study

Regarding dietary amino acid and fatty acid of taro dried leaves, the effect of taro can be used as a possible alternative feed ingredient. In this regard, the use of cheap and readily available feed ingredient is important in maximizing nutritious and economic value **(Tion & Adeka, 2000)**.

For the analyses of both cost and benefits, taro leaf proved to beof low cost effectiveness when used as replacement of soybean meal in the diet of the tilapiafish **(El-Tawil *et al.*, 2020)**.

Substitute expensive yellow corn and soybean meal by unconventional source of raw materials, as taro leaves which are uneaten by people, is a good trial to reduce cost of production and increase the supply of protein and carbohydrate in fish diet.

The present results showed that dried taro leaf is low cost effective when used as replacement of expensive and conventional meal (soy and corn) in the Nile tilapia rations. Therefore, using taro leaf meal as a good source of nutrients for fish diet is recommended for the low cost and high benefits.

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