

**Effect of dietary replacement of yellow corn energy with culled sweet potato (as non traditional energy source) on growth performance, nutrients utilization and carcass traits of growing Nile Tilapia (*Oreochromis niloticus*)**

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**ABSTRACT**

The present study aimed to evaluate the effect of incorporation of culled inedible sweet potato root (as non-traditional energy source) to replace yellow corn energy in growing mono-sex Nile tilapia (*Oreochromis niloticus*) diets on the fish performance, nutrients utilization, whole body composition and carcass traits. The study was carried out in concrete ponds (7.5m length × 2.25m width × 0.70m water depth). Each pond was divided by fine nets into three equal parts (2.5 × 2.25 × 0.70m each) to represent four treatments; the control (CSP0); the 25 (CSP25); 50 (CSP50) and 100% (CSP100) culled sweet potato, respectively. Each dietary treatment was carried out in triplicates and the treatments were stocked with Nile tilapia fry (0.31 g initial weight) at a rate of 20 fish / m<sup>3</sup> i.e. 80 fish in each replicate. The experimental diets were formulated to be iso nitrogenous and iso caloric and contained about 33% crude protein and 4500 kcal GE/kg. The experimental diets were fed at daily rates of 30; 10; 6 and 4 % of the fish biomass for fish weight from start to 1g; 1-5g; 5-20g and 20g respectively till the end of the experiment after 22 weeks. The experimental diets were offered in equal portions at 9am; 11am; 1 pm and 3pm respectively. Results obtained are summarized in the following:

1- Culled sweet potato contained 92.5; 6.1; 1.0; 4.6; 3.87 and 76.93 % dry mater; crude protein; crude fat; ash; crude fiber and NFE, respectively. It contained 3671 kcal growth energy / kg.

2- Incorporation of culled sweet potato to replace 100% of yellow corn energy improved significantly final weight and weight gain compared to the 25 CSP and the control group. Replacement of yellow corn energy with CSP at all tested levels released no significant effects on condition factor and survival rate.

3- Incorporation of CSP at 50 and 100 % levels to replace yellow corn energy in Nile tilapia diets showed similar insignificant feed conversion ratio compared to the control group, however both levels improved significantly the protein efficiency ratio compared to the 25% replacement level. CSP at all tested levels had no significant effects on energy utilization compared to the control group.

4- Incorporation of CSP released significant effects on dressing; head; by-products and flesh percentages compared to the control group.

5- Replacement of yellow corn energy with CSP at 25; 50 and 100% levels had no significant effects on whole body chemical composition.

6- Replacement of yellow corn energy with CSP energy reduced the costs of one kg gain in weight by 4.67 and 1.24% for the CSP50 and CSP100 compared to the control group, respectively; while CSP at 25% level increased the production costs of one kg gain in weight by 5.72 % compared to the control group.

Based on the obtained results, it could be concluded that culled sweet potato can replace 50 to 100% of yellow corn energy without adverse effects on growth performance, feed utilization parameters with the advantage of reducing the costs of 1000 Kg gross energy.

**Keywords:** Nile Tilapia, *Oreochromis niloticus*, yellow corn, sweet potato, nutrients, growth

## INTRODUCTION

The type of feed and the ingredients which will be used depend on the species of the cultured fish, feed availability and its costs. The fish feed costs represent almost 65 to 70% of the intensive fish culture costs. Attempts have been done to reduce the feed costs by using cheaper alternative sources of protein and/or energy of what so called non- traditional ingredients or by-products which may be of great value in producing cheap fish diets (Abdel-Hakim *et al.*, 2003)

Also, it is well known that yellow corn grains forms the greatest share in Egyptian imported ingredients, accordingly, its cost continues to increase from time to time owing to its universal use as animal feed ingredient. Therefore, there is an urgent need to search for non-traditional feedstuffs or by-products which could be used as cheap sources of protein and energy to replace fish meal and yellow corn in formulating livestock and fish diets.

Sweet potato roots have several shortcomings as an animal feed. They contain little protein – where crude protein content commonly ranges from 1.3 - 4 per cent, though could run as high as 10 percent of dry matter (Li, 1974; Purcell *et al.*, 1976; Walter *et al.*, 1984) and up to 40 percent of the total nitrogen in sweet potato is non-protein nitrogen. Farmers overcome this constraint by supplementing a sweet potato-based diet with rice bran, fish meal, soy beans or residue, sweet potato and cassava leaves and, to a lesser extent, commercial supplement when these are available and affordable (Purcell *et al.*, 1976).

Middleton *et al.* (2001), found that extrusion co processing of culled sweet potatoes and poultry silage produce an acceptable feed ingredient for hybrid tilapia that can be included up to 33% of the diet without adversely affecting growth, market yield, sensory indices, or water quality as compared to

control diet. Olukunle (2006) evaluated the potential of sweet potato peel meal as a cheaper replacement for maize in the diet of *Clarias gariepinus*, at levels of 0% (control), 25, 50, and 75%, and he found that all the diets with sweet potato peel meal inclusion performed better than the control diet. The data indicated that *Clarias gariepinus* effectively tolerated diets containing sweet potato peel meal at low levels of concentration while fish growth performance and utilization decreased with the increase in the sweet potato peel meal inclusion. Also sweet potato peels meal based diets were cheaper than the control diet.

Omoregie *et al.* (2009) used incorporation of sweet potato peels in the diet of *Oreochromis niloticus* up to 25%, and they found that, no significant depression in growth or deleterious effects on health of the fish, which means to a lesser extent (15%) sweet potato peel was well tolerated by *Oreochromis niloticus*.

The aim of the present investigation was to study the effect of replacing yellow corn energy in Nile tilapia diets with culled sweet potato energy at different levels on growth performance, nutrient utilization and the costs of gain in weight of the tested fish.

## MATERIAL AND METHODS

The present study was conducted at Water Resources Research Station belonging to the National Institute of Oceanography and Fisheries at Baltim region, Kafr El-sheikh governorate, Egypt. The study started from 1st of June and lasted till 2nd of November 2006 for 22 weeks.

The study included a trail to substitute yellow corn energy with culled sweet potato (CSP) energy in Nile tilapia diet at 25, 50 and 100 % levels.

**Preparation of Culled sweet potato (CSP):** Culled sweet potato (CSP) was brought from Al-Oboor market, Cairo. The CSP was broken sweet potato and biggest or smallest ones not fit for human consumption. The CSP was cleaned and washed to remove the clime and dust, then left in air to dry. After that, CSP was cut into slices by a chipping machine then left in the sun for ten hour for primary drying. After that, it was dried in an oven at 105 °C for 24 hour. Then the CSP was grinded to make sweet potato powder for easy mixing and good distributing with other ingredients in experimental diets. After that CSP powder was stored in plastic bags kept away from wetness until used in formulating the experimental diet. Table (1) shows the chemical analysis of culled sweet potato (CSP) compared with yellow corn in dry matter basis.

Table (1): Proximate chemical analysis of culled sweet potato compared with yellow corn.

Ingredients	Culled sweet potato	Yellow corn
Moisture	7.5	10
Dry matter	92.5	90
Crude protein	6.1	8.5
Crude fat	1.0	4.1
Ash	4.6	2.06
Crude fiber	3.87	2.4
NFE*	76.93	72.94
G.E. K cal/kg**	3671	3881

\* Calculated by difference

\*\* Based upon the factor 5.65, 9.45, 4.0 and 4.0 Kcal/g of protein, ether extract, crude fiber and nitrogen free extract (Jobling, 1983)

The experiment included four dietary treatments; the first treatment served as a control and contained yellow corn as main dietary energy source. The second, third and fourth treatments contained CSP to replace yellow corn energy at 25 (CSP25), 50 (CSP50) and 100% (CSP100) levels respectively. All diets of this experiment were formulated to be iso nitrogenous and iso caloric (33 % CP and 4500 Kcal / Kg gross energy). The compositions of the experimental diets are given in Table (2).

Table (2): Composition of the experimental diets used in feeding experiment

Ingredient%	T1 control	Treatment		
		T2 CSP 25%	T3 CSP 50%	T4 CSP 100%
Fish meal (72%)	25	25	25	25
Yellow corn	30	22.5	15	—
Soybean meal (44 %)	25	25.9	26.6	28.4
Rice bran	12	10.2	8.8	5.6
Vegetable oil	6	6.5	6.8	7.4
Sweet potato	—	7.9	15.8	31.6
Vitamin mixture *	1	1	1	1
Mineral premix **	1	1	1	1
<b>Total</b>	100	100	100	100
<b>Calculated composition</b>				
Protein	33.09	33.09	33.07	33.14
Fat	11.25	11.28	11.13	10.89
Ash	8.21	8.26	8.35	8.51
G.E. Kcal/Kg***	4496	4504	4501	4500

\*Each gram of vitamin mixture contains 20.00 IU vit A 200 IU vit .,De, 400 vit E, 20mg Niacin 4.5 mg riboflavin, 3 mg pyridoxine , 0.013 mg vit B12, 100 mg chcholin chloride and 2 mg vit .k.

\*\*Each gram contains 0.83 Ca, 0.63 P .078Na. 0.018Mn , 0.011Zn and 0.001 Cu The Mixture was prepared by mixing 35 parts of dicalcium phosphate , 3 parts of mineral premix and 2 part of common salt.

\*\*\* Based upon the factor 5.65, 9.45, 4.0 and 4.0 Kcal/g of protein, ether extract, crude fiber and nitrogen free extract (Jobling, 1983)

**Experimental fish:** Apparently healthy mono-sex Nile tilapia (*Oreochromis niloticus*) fry (with sex reversed into males with hormone treatment) were purchased from a commercial private fish hatchery located at Kafr El-Sheikh Governorate were used as experimental fish. Fish were acclimated to the experimental water for 7 days before starting the experiment in four fiberglass tanks (1 m<sup>3</sup>) with small aeration pumps. After acclimation, the fish were randomly distributed into four groups that represented the dietary treatments cited before and stocked in the experimental ponds at a rate of 20 fish/ m<sup>3</sup> in three replicates each. The initial weight of the experimental fish was 0.31 g also chemical compositions of fish whole bodies at the start of experiments are showed in Table (3).

Table (3) chemical composition of fish at the start

Item	Moisture	Protein	Fat	Ash
%	79.19	60.19	14.65	25.16

**Experimental ponds and stocking rate** :Four rectangular cement ponds were used in these experiments with dimensions  $7.5 \times 2.25$  and 1.1 meter depth for each pond. All ponds were divided into three partitions with sheet of screen with fine mesh size, where every pond had three replicates for one treatment. The experimental ponds before being stocked with fish were drained completely; where bottoms were exposed to sun radiation for one week and treated with potassium permanganate ( $\text{KMnO}_4$ ). Then the ponds were filled after cleaning up with brackish water to 70 cm height from underground well by electrical pump for lifting water through pipes and valves to the beginning of ponds. A screen with fine mesh size was used for each pond to prevent escaping of the stocked fishes during the drainage process of water at the end of pond.

The volume of each partition (replicate) was about  $4 \text{ m}^3$  ( $2.5 \times 2.25$  and 0.7 m water depth) stocked by 80 mono-sex of Nile tilapia fry ( $20 \text{ fry} / \text{m}^3$ ).

During the experimental period; water was changed and renewed at a rate of 20% of the water column daily to obtain a good water quality and ponds were drained every two weeks for cleaning the ponds.

Aeration of water was supplied by rotary lobe blower through a plastic pipe and then to a 16 mm perforated pipes which were laid 50 cm below the water level.

**Feeding rate:** The experimental diets were fed in unpelleted powder form during the whole experimental period. The diets were offered for thirteen days every two weeks to allow the cleaning of experimental ponds for one day and to record the fish weight in fish samples for readjusting the new feeding rate according to the rates presented in Table (4). The daily feed amount was distributed daily by hand in four equal portions at 9am, 11am, 1pm and 3pm according to Kubaryk (1980) (Table 4).

Table (4): Feeding rate of Nile tilapia throughout the experimental period.

Weight (g)	start – 1	1 - 5	5 - 20	20 - end
Feeding rate (% of b. wt.)	30	10	6	4
Daily feeding times	Four meals(9 am, 11 am, 1pm, 3 pm)			

**Fish samples and measurements:** The initial body weight was recorded and the chemical composition of fry whole bodies was carried out at the beginning of the experiments.

Random samples of fish (90 fish / treatment as  $30 \text{ fish} \times 3$  replicates) were taken once every two weeks during the whole experimental period to record its weight and to calculate the new biomass and adjust feed amounts accordingly. Fish were collected by using nylon net early in the morning and the fish of each pond were kept in a separate plastic tank ( $1\text{m}^3$ ) filled with water from the corresponding pond to avoid any stress on the fish, thereafter the fish were returned to their experimental ponds after recording the data.

At the end of experimental period, individual body weight and total length of fish were recorded for each treatment.

According to the data of body weight and length, the following parameters were estimated:

**Growth performance:**

1- Body weight gain =  $W_2 - W_1$

Where:  $W_2$  = Final body weight;  $W_1$  = Initial body weight

2- Average daily gain =  $(W_2 - W_1) / \text{period in day}$

3- Specific growth rate SGR =  $(\ln W_2 - \ln W_1) \times 100/t$ .

Where:  $\ln = (\log 10x)^{3.303}$

4- Condition factor (K) =  $[\text{weight (g)} / \text{length}^3 \text{ (cm)}] \times 100$

5- Survival Rate (%) =  $N_1 / N_0 \times 100$

Where:  $N_1$  = Total number of fish survival in pond at end of experiments.

$N_0$  = Total number of fish in tank at the beginning of experiments.

**Feed utilization:**

1- Food conversion ratio (FCR) =  $\text{total feed consumption (g)} / (W_2 - W_1)$

2- Protein efficiency ratio (PER) =  $(W_2 - W_1) / \text{protein intake (g)}$

3- Protein productive value

(PPV) =  $\text{Protein retained in tissue (g)} / \text{protein intake (g)} \times 100$

4- Energy utilization % (EU) =  $(E_1 - E_0 / EI) \times 100$

Where:  $E_1$  = energy content in fish carcass (Kcal) at the end of experiment

$E_0$  = energy content in fish carcass (Kcal) at the start of experiment

$EI$  = energy intake (Kcal)

**Carcass characteristics**

The samples (15 fish/ treatment) were taken randomly after harvesting for carrying-out the carcass characteristics. Body weight, length of each fish in the sample were recorded at first, then the scales and viscera were removed also head and fins were cut then skin was removed, bones were obtained by dipping rest of the body in boiling water. All parts were weighted and recorded to calculate the following.

1- Dressing percentage =  $((\text{body weight} - \{\text{head} + \text{fins} + \text{viscera} + \text{scales}\}) / \text{body weight}) \times 100$

2- Head percentage =  $(\text{head weight} / \text{body weight}) \times 100$

3- By-product percentage =  $(\{\text{head} + \text{fins} + \text{viscera} + \text{scales} + \text{skin} + \text{bones}\} / \text{body weight}) \times 100$

4- Flesh percentage =  $(\{\text{body weight} - \text{by-product}\} / \text{body weight}) \times 100$

**Chemical analysis of fish**

Proximate chemical analysis (moisture, protein, fat and ash) of whole fish body was carried out according to the methods described by AOAC (1990) and Lovell (1981)

**Water quality:**

Quality of ponds water was checked once per two weeks to determine temperature ( $^{\circ}\text{C}$ ), dissolved oxygen (DO), transparency Secchi disk visibility (SD), hydrogen ions concentration (pH), Ammonia ( $\text{NH}_3$ ) and Total dissolved salt (T.D.S).

All measurements were carried out according to the standard methods of American Public Health Association (APHA 1985) and Boyd (1992)

1- Water temperature (°C) and dissolved oxygen (DO): According to Boyd (1992), tests of temperature and dissolved oxygen were taken between 7 am and 8 am by inserting the probe of the oxygen meter (YSI 57, USA) by dripping it few centimeters below the water surface (approximately 5 cm)

2- Secchi disk visibility (S.D) (cm): Estimates of Secchi disk visibility were made on each sampling date. Measurements were made at the same location in each pond according to Boyd (1992).

3-Hydrogen ions (pH): According to Boyd (1992), pH value was measured by using pH meter (Coming Co. pH meter model 345) as soon as samples of water were collected.

4- Ammonia (NH<sub>3</sub>): Ammonia (mg/l) was calculated from the results of total ammonia according to the following equation:

Ammonia concentration (mg/l as NH<sub>3</sub>) = A/ 100 x 1.2 x total ammonia.

Where: A is a coefficient related to water pH and temperature at the time of testing (Boyd, 1992).

5- Total dissolved salt (T.D.S): Total dissolved salt was measured by using refractometer (Abbe Model AR-001).

#### **Statistical analysis:**

Statistical analysis was performed using the one-way analysis of variance (ANOVA) and Dauncan (1955). Multiple Range Test was done to determine differences between treatment (mean at significance level of P<0.05). Standard errors were also estimated. The software used for the statistical analysis was Spss ver. 14 for WINDOWS Xp.

#### **Economical evaluation:**

The Economic evaluation of experimental treatments were done to determine the cost of feed required to produce one Kg of fish weight gain. The cost of the experimental diets has been done in L.E. for market prices in 2006. Accordingly, the cost of producing one Kg gain = amount of feed used to produce 1 Kg fish gain × cost of one Kg feed. The cost of 1000 kcal gross energy from CSP and from yellow corn was also calculated.

## **RESULTS AND DISCUSSION**

**Water quality:** Water quality parameters including water temperature (°C), dissolved oxygen (DO) concentration (mg / l), water transparency (cm), pH (degrees), ammonia (NH<sub>3</sub>) (mg / l) and total dissolved salts (T.D.S) (mg / l) are presented in Table (5). Water quality parameters were measured every two weeks during (June, July, August, September and October) the course of the experiment. As presented in this table, water temperature ranged between 24 to 30.9 °C, DO concentration ranged between 6.3 and 9 mg / l, transparency 37 to 52 cm, pH 7.3 to 7.9 degrees, NH<sub>3</sub> 0.022 to 0.033 mg / l and TDS between 8610 and 9580 mg / l and all tested water quality parameters were within the

optimal levels required for growth and development of Nile tilapia and were in accordance with the levels of APHA (1985)

Table (5) Monthly average water quality parameter during the experimental period in the cement ponds.

Month	Parameters					
	Temperature (°C)	DO. (mg/l)	Transp. (Cm)	pH	NH3 (mg/l)	TDS (mg/l)
June	25.1	9	52	7.9	0.025	8720
July	28.5	8.2	43	7.8	0.029	8610
August	30.9	7.5	45	7.5	0.022	8670
September	29.2	6.8	42	7.3	0.031	9580
October	24	6.3	37	7.7	0.033	8800

**Growth performance:** Growth performance parameters of Nile tilapia as affected with replacement of yellow corn with sweet potato as energy source at levels 25; 50 and 100% (as energy) including final weight (FW); total weight gain (TWG); daily weight gain (DWG); specific growth rate (SGR); condition factor (K) and survival rate (SR), are presented in Table (6).

Results of the same table indicate that average initial weights at the experimental start were found to be 0.31 g for all dietary treatment groups.

Averages of final weight (FW) for the control (CSP0); culled sweet potato at level 25 % (CSP25); 50% (CSP50) and 100% (CSP100), were 81.39; 78.83; 88.15 and 93.05 g respectively. Analysis of variance for FW indicate that the group CSP100 recorded significantly ( $p < 0.05$ ) the highest final weight followed in a significant ( $p < 0.05$ ) decreasing order by CSP50 and both CSP0 and CSP25, respectively. The same trend was observed in TWG where the group CSP100 recorded the highest ( $p < 0.05$ ) value followed by the CSP50 and the CSP0 and 25 groups, respectively. Concerning averages of SGR; results of the same table show that SGR values for the CSP0; CSP25; CSP50 and CSP100 were 3.62; 3.6; 3.67 and 3.7, respectively. The results indicate also that groups CSP100 and CSP50 had significantly ( $p < 0.05$ ) higher SGR values compared to the CSP0 and CSP25 groups. Results of Table (6) indicate that K values ranged between 1.82 and 1.84 with insignificant differences among the dietary treatment groups which reveal that the fish in all groups grow almost equal in weight in relation to length. Results also show that survival rates ranged between 89.63 % (CSP25 group) and 92.96 % (group CSP50) with insignificant differences among the treatment groups. In general, results concerning growth performance as affected with replacing yellow corn with sweet potato as dietary energy source indicate that yellow corn energy in growing Nile tilapia diets can be completely replaced with sweet potato or partially at 50 % replacement level

These results are in accordance with the findings of Olukunle (2006) who reported that replacing the energy of yellow corn with energy with sweet potato peel (SPP) at 25; 50 and 75 % improved growth performance parameters of African catfish compared to the control group and the improvement in growth



parameters was more pronounced at 25% replacement levels. The author added that the percentages of weight gain for the control; 25; 50; and 75 % groups were 101.54; 150.77; 132.31 and 127.6 %, respectively. Also, Soltan *et al.* (2005) incorporated potato by-product meal (PBM) to replace 10; 20; 30; 40 and 50% of yellow corn in common carp diets. They reported that the higher replacing level (50%) of yellow corn by (PBM) in carp diets significantly decreased BW, WG and SGR. Furthermore, Ghazalah *et al.* (2002) found that, replacing 25 or 50% of YC with PBM did not significantly changed BW, WG and SGR of Nile tilapia (*O. niloticus*). On the other hand, Shouqi *et al.* (1997) concluded that as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*) diets, final BW and SGR significantly decreased and mortality increased.

Table (6): Growth performance of Nile tilapia fed on Culled Sweet Potato as non-traditional energy feedstuffs place corn in diet

Parameter	control	CSP		
		25%	50%	100%
Initial weight (g)	0.31 <sup>a</sup> ±0.00	0.31 <sup>a</sup> ±0.00	0.31 <sup>a</sup> ±0.00	0.31 <sup>a</sup> ±0.00
Final weight (g)	81.39 <sup>c</sup> ±1.27	78.83 <sup>c</sup> ±1.64	88.15 <sup>b</sup> ±1.3	93.05 <sup>a</sup> ±1.21
Total weight gain (g)	81.08 <sup>c</sup> ±1.27	78.52 <sup>c</sup> ±1.64	87.84 <sup>b</sup> ±1.3	92.74 <sup>a</sup> ±1.21
Daily Weight gain (g)	0.53 <sup>b</sup> ±0.01	0.51 <sup>b</sup> ±0.01	0.57 <sup>a</sup> ±0.01	0.6 <sup>a</sup> ±0.01
SGR	3.62 <sup>b</sup> ±0.01	3.6 <sup>b</sup> ±0.01	3.67 <sup>a</sup> ±0.01	3.7 <sup>a</sup> ±0.01
Condition factor	1.82 <sup>a</sup> ±0.01	1.84 <sup>a</sup> ±0.01	1.84 <sup>a</sup> ±0.0	1.83 <sup>a</sup> ±0.0
Survival Rat %	91.3 <sup>a</sup> ±1.03	89.63 <sup>a</sup> ±1.03	92.96 <sup>a</sup> ±1.21	90.56 <sup>a</sup> ±0.85

a, b, c...etc.: Means within row with different superscripts are significantly different ( $P < 0.05$ )

In this connection, Saleh (2001) reported that yellow corn can be substituted by either 25% date stone (DSM) or up to till 50% potato by-product meal (PBM) in Nile tilapia diets without harmful effect on the growth performance and feed utilization of fish. Furthermore, Ufodike and Matty (1988) fed the rainbow trout (*Salmo gairdenii*) fingerlings on diets containing 10; 20 and 30% corn or potato waste. They found that nutrient digestibility and growth results indicate that the increase either in dietary corn or potato waste yield greater weight gain and better SGR, PER and apparent net protein utilization (NPU). On the other hand Degani *et al.* (1986) found that potato starch had less effect on growth than wheat meal, bread meal or soluble corn starch by European eels. Also, Omoregie *et al.* (2009) incorporated sweet potato peel (SPP) in Nile tilapia diets (0.46 - 0.48 g initial weight) at levels of 0; 5; 10; 15; 20 and 25 percent in iso nitrogenous (31.22 % crude protein) diets and found that the greatest increase in body weight (1.30±0.07 g) of the fish was achieved with the control diet ( $p < 0.05$ ). This was followed by fish fed diet with 5% of the peel (0.90±0.09 g) while the least increase in body weight (0.46±0.01 g) was obtained in the fish fed diet with 25% of the peel ( $p < 0.05$ ).

The disagreement among results of the present study (Table 6) and the results of Omoregie *et al.* (2009) may be due to the fact that they used SPP,

while in the present work the whole sweet potato roots were used which contain more starch and sugars available as energy source.

**Feed utilization:** Results of total amount of feed consumed (g / fish); total gain in weight; feed conversion ratio, (g. feed required for each g. gain in weight); protein efficiency ratio (PER); protein productive value (PPV) and energy utilization (EUR) are illustrated in Table (7).

Results in this table reveal that total feed intake (per fish) increased as the level of CSP in Nile tilapia diets increased. The same trend was observed with total gain in weight except for the CSP25 group.

Averages of FCR for the CSP0; CSP25; CSP50 and CSP100 groups were found to be 2.04, 2.15, 1.94 and 2.01. Analysis of variance for FCR indicates that the CSP0, CSP50 and CSP100 groups had significantly ( $p < 0.05$ ) better (lower) FCR compared to the CSP25 group. These results indicate that the CSP25 group consumed more diet but gained less weight compared to the other groups. Averages of PER for the CSP0; CSP25; CSP50 and CSP100 groups were 1.49; 1.41; 1.56 and 1.51, respectively and the highest ( $p < 0.05$ ) values were obtained by CSP50 and CSP100 compared to the CSP25 group; however differences among the CSP0 group and CSP50 and CSP100 in PER were insignificant. Averages of PPV ranged between 24.87 (CSP25 group) and 26.14 (CSP100 group) with insignificant differences among the dietary treatments groups; which indicate that replacing yellow corn energy with sweet potato energy resulted in an insignificant effect in protein utilization. As indicated in Table (7), EUR % for groups CSP0, CSP25, CSP50 and CSP100 were 16.44, 16.56, 16.94 and 17.15%; respectively with insignificant differences among the treatment groups; however EUR% tended to increase with each increase in CSP replacement level.

In this respect, Olukunle (2006) reported that the highest feed conversion efficiency (FCE) and (PER) were observed in African catfish with diets containing 25% sweet potato peel (SPP) compared to diets contained 50 or 75 % SPP in replacement with yellow corn. Soltan *et al.* (2005) reported that replacement of yellow corn with potato by-products meal at 50% level significantly improved FCR and PER compared to higher or lower replacement level in common carp diets. Also Saleh (2001) substituted yellow corn by date stone meal (DSM) or potato by-products meal (PBM) at 25, 50 and 75% levels in Nile tilapia diets. She reported that yellow corn energy can be substituted by either 25% DSM or up to 50% PBM without harmful effects in nutrients utilization.

Recently, Omoregie *et al.*, (2009) incorporated sweet potato peel (SPP) in Nile tilapia diets at 0, 5, 10, 15, 20 and 25% levels and found that PER, apparent net protein utilization values were 2.14, 1.88, 1.59, 1.70, 1.45 and 1.13 for PER and 27.14, 33.55, 30.42, 23.24, 31.79 and 14.04 for ANPU respectively. The same authors reported that the best FCR value 1.49 and 1.71 were recorded

by the control and SPP5 groups; respectively, while that of the other groups (SPP20 and SPP25) were significantly higher (worse).

Table (7) Feed utilization of Nile tilapia fed on Culled Sweet Potato as non-traditional energy feedstuffs place corn in diet

Parameter	Control	CSP		
		25%	50%	100%
Total feed intake g/fish	165.25	168.88	170.58	186.82
Total weight gain g/fish	81.08	78.52	87.84	92.74
FCR	2.04 <sup>b</sup> ±0.02	2.15 <sup>a</sup> ±0.02	1.94 <sup>b</sup> ±0.04	2.01 <sup>b</sup> ±0.03
PER	1.49 <sup>ab</sup> ±0.02	1.41 <sup>b</sup> ±0.02	1.56 <sup>a</sup> ±0.04	1.51 <sup>a</sup> ±0.02
PPV	25.06 <sup>a</sup> ±0.27	24.87 <sup>a</sup> ±0.27	25.96 <sup>a</sup> ±0.6	26.14 <sup>a</sup> ±0.4
EUR	16.44 <sup>a</sup> ±0.18	16.56 <sup>a</sup> ±0.18	16.94 <sup>a</sup> ±0.39	17.15 <sup>a</sup> ±0.26

a, b, c...etc.: Means within row with different superscripts are significantly different ( $P < 0.05$ )

**Carcass traits:** Averages of carcass traits (as percentage of body weight) are presented in Table (8). Averages of dressing percentage (fish body without head; fins; viscera and scales) for the groups CSP0, CSP25, CSP50 and CSP100 were found to be 59.92, 62.33, 62.03 and 62.91 percent respectively. Results of dressing percentage revealed that replacement of yellow corn energy with sweet potato at 25, 50 or 100% levels improved significantly ( $p < 0.05$ ) this trait compared to the control group. On the other hand the CSP0 and CSP50 groups recorded the highest head percentages compared to the CSP100 group. Averages of by-products (body weight - flesh weight) percentage were 48.05, 46.97, 47.17 and 46.18% for the CSP0, CSP25, CSP50 and CSP100 respectively. Results revealed that the CSP100 group recorded the lowest ( $p < 0.05$ ) by-products percentages while the CSP0 group recorded the highest ( $p < 0.05$ ) value. Concerning flesh% results of table (8) group CSP100 recorded the highest flesh percentage followed in a significant decreasing ( $p < 0.05$ ) order by the CSP50 and the control groups; however differences among CSP100 and CSP25 in flesh percentage were insignificant.

These results are in partial accordance with the findings of Soltan *et al.* (2005) who reported that incorporation of potato by-product meal (PBM) in replacement of yellow corn at up to 30% level did not significantly affect the percentages of dress out and flesh in carp carcass; while the percentages of fish by-products increased significantly with increasing the replacing level of YC by PBM in carp diets. However; diet PBM50 released the highest (56.34) percentage of by-products compared to the control diet which recorded the lowest value (51.92%).

In this respect, Soltan (2002) found that replacing YC by PBM up to 40 and 70% did not significantly affect the percentages of dress-out and flesh in tilapia carcass. Also results of El-Garhy (2003) are in partial agreement with the results in Table (8) where he stated that wastes of potato chippsy could be incorporated in Nile tilapia diets up to 50% in replacement with yellow corn without any adverse effects on growth performance, carcass characteristics and meat quality.

Table (8): Carcass parameters of Nile tilapia fed on Culled Sweet Potato as non-traditional energy feedstuffs place corn in diet

Ingredient	Control	CSP		
		25%	50%	100%
DRESSING %	59.92 <sup>b</sup> ±0.32	62.33 <sup>a</sup> ±0.33	62.03 <sup>a</sup> ±0.29	62.91 <sup>a</sup> ±0.28
HEAD %	19.6 <sup>a</sup> ±0.23	19.31 <sup>ab</sup> ±0.18	19 <sup>bc</sup> ±0.16	18.63 <sup>c</sup> ±0.19
BY-PRODUCT %	48.05 <sup>a</sup> ±0.33	46.97 <sup>bc</sup> ±0.37	47.17 <sup>ab</sup> ±0.3	46.18 <sup>c</sup> ±0.29
FLESH %	51.95 <sup>c</sup> ±0.33	53.03 <sup>ab</sup> ±0.37	52.83 <sup>bc</sup> ±0.3	53.82 <sup>a</sup> ±0.29

a, b, c...etc.: Means within row with different superscripts are significantly different ( $P < 0.05$ )

**Whole body chemical composition:** Results of whole body chemical composition as percentage on dry matter basis for crude protein, fat and ash of Nile tilapia as affected with culled sweet potato (CSP) incorporation in the diet to replace yellow corn as energy source are presented in Table (9). Results of this table reveal that dry matter (DM) contents in whole fish bodies ranged between 27.11 and 29.24%, protein contents ranged between 60.18 and 61.22 %, fat contents ranged between 20.95 and 21.91% and ash contents ranged between 17.72 and 18.87 % with insignificant differences in all of these parameters among the dietary treatments. These results indicate that incorporation of CSP in Nile tilapia diets to replace 100 % of the yellow corn as energy source released no significant effects on whole body composition of Nile tilapia.

Table (9): Chemical composition of Nile tilapia fed on Culled Sweet Potato as non-traditional energy feedstuffs place corn in diet

Ingredient	Control	CSP		
		25%	50%	100%
Moisture	72.32 <sup>a</sup> ±1.13	70.76 <sup>a</sup> ±0.03	72.89 <sup>a</sup> ±0.53	71.17 <sup>a</sup> ±0.73
Dry matter	27.68 <sup>a</sup> ±1.13	29.24 <sup>a</sup> ±0.03	27.11 <sup>a</sup> ±0.53	28.83 <sup>a</sup> ±0.73
Protein	60.8 <sup>a</sup> ±0.47	60.25 <sup>a</sup> ±0.31	61.22 <sup>a</sup> ±0.58	60.18 <sup>a</sup> ±0.58
Fat content	21.11 <sup>a</sup> ±0.35	21.91 <sup>a</sup> ±0.28	21.06 <sup>a</sup> ±0.23	20.95 <sup>a</sup> ±0.49
Ash content	18.09 <sup>a</sup> ±0.48	17.84 <sup>a</sup> ±0.41	17.72 <sup>a</sup> ±0.71	18.87 <sup>a</sup> ±0.19

a, b, c...etc.: Means within row with different superscripts are significantly different ( $P < 0.05$ )

In this respect, Soltan *et al.* (2005) reported that inclusion of potato by-product meal (PBM) in common carp diets in replacement with yellow corn at 0; 10; 20; 30; 40 or 50 % levels released insignificant effects on moisture contents of the whole fish body. They added that incorporation of PBM in carp diets at highest level (50%) significantly decreased the protein contents of the fish body and the opposite trend was observed for the ash contents. The same authors added that all replacing levels of yellow corn by PBM significantly decreased fat contents in fish bodies compared to the control group. Results of Table (9) disagree with the findings of Soltan (2002) who found that increasing the inclusion level of PBM up to 50% in tilapia diets did not significantly change the protein content but the higher inclusion levels (60, 70 or 80%) significantly decreased protein and ash contents of tilapia bodies. Shouqi *et al.* (1997) reported that, CP content of fish decreased ( $p < 0.05$ ) as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*)

diets. Also, Xie and Jokumsen (1997) cleared that incorporation of potato protein concentrate in diets of rainbow trout significantly increased ash contents of fish body. Furthermore, Olukunle (2006) reported that incorporation of sweet potato peel (SPP) meal in African catfish diets at levels of 0, 25, 50 and 75% in replacement to maize had no significant effects on carcass composition of African catfish at the end of the feeding trail, which is in partial agreement with results of the present results. Recently, Omoregie *et al.* (2009) replaced yellow corn in Nile tilapia diets with SPP at 0, 5, 10, 15, 20, and 25% levels in iso nitrogenous diets (31.23% protein) for 10 weeks. They reported that carcass of fish fed on diet containing SPP25 had the lowest protein content, which was significantly different from the other diets except SPP15. The ash content was nearly constant, as there was no significant difference among the six experimental diets. Fish fed diet SPP0 recorded the highest level of lipid deposit which was significantly different from the other dietary treatments.

**Economical evaluation:** Average costs of one kg formulated diet for T1, 25, 50 and 100% CSP groups were found to be 2.966, 2.972, 2.968 and 2.963 LE; respectively. Results revealed that the costs of the experimental diets were almost similar to that of the control group. This may be due to the use of higher level of soybean meal and oil in the formulation of CSP diets to adjust the protein and energy contents which results in iso caloric iso nitrogenous experimental diets. Averages of feed costs for each kg gain in weight in LE for the same groups cited above were 6.045, 6.391, 5.763 and 5.97 LE; respectively (table 10). As presented in the same table average percentages of feed costs based of the costs of the control group (100%) were found to be 105.72, 95.33 and 98.76% for the CSP25, CSP50 and CSP100 groups respectively. Furthermore; results of table (11) show that costs of 1000 Kcal from CSP was 0.168 LE, while that of yellow corn was 0.229 LE which show that 1000 Kcal from CSP is about 26.63% lower than that of yellow corn.

In this connection, Olukunle (2006) incorporated sweet potato peel SPP in African catfish diets at levels of 25, 50 and 75 % in replacement with maize; and found that the SPP meal based diets were cheaper than the control diet. The same author reported also that the gain in weight costs can be reduced with SPP, while maintaining a high yield. Also Soltan *et al.* (2005) incorporated potato by-products meal (PBM) in practical diets of common carp to replace yellow corn and found that it reduced the feed costs for one kg gain in weight to 83.47, 89.07, 87.47, 77.60 and 86.40% of the control group when PBM was incorporated at 10, 20, 30, 40, and 50 % levels in replacement with yellow corn as cheaper energy source.

Results of Saleh (2001) revealed that incorporation of PPM in Nile tilapia diets at 25 and 50% levels to replace yellow corn reduced the feed costs required for each kg gain in weight by 1.35 and 6.22% respectively while at 75% replacement level increased the costs of feed to produce one kg gain in weight by 1.08 compared to the yellow corn control group.

Table (10) feed cost (L.E) for one Kg weight gain produced by fish fed on Culled Sweet Potato as non-traditional energy feedstuffs place corn in diet (2006)

Treatment	Control	CSP		
		25%	50%	100%
Feed intake g/fish	165.25	168.88	170.58	186.82
Cost (L.E) of one Kg of feed	<b>2.966</b>	<b>2.972</b>	<b>2.9677</b>	<b>2.964</b>
Total weight gain g/fish	81.08	78.52	87.84	92.74
Feed cost/Kg gain L.E	6.045	6.391	5.763	5.97
Percentage decrease in feed cost to produce one Kg fish gain	<b>100</b>	<b>105.72 (+5.72)</b>	<b>95.33 (-4.67)</b>	<b>98.76 (-1.24)</b>

Table (11) Price comparison for 1000 K calories between culled sweet potato and corn (2006)

item	CSP	Yellow corn
1 ton cost (L.E.)	618	890
K cal / Kg	3671	3881
1000 K cal. cost (L.E.)	<b>0.168</b>	<b>0.229</b>

Results of Table (10) are in partial agreement with the findings of El-Garhy (2003). Who incorporated potato by-products (PB), macaroni by-products waste MP or a mixture of both (50% PB + 50%MP) to replace 25 or 50% of yellow corn energy in Nile tilapia diets. He found that incorporation of PB or MP or in combination in tilapia diets reduced the feed costs by about 7.35, 5.39 and 3.43% compared to the control corn diet. He attributed the reduction in diet costs to lower prices of PB and MP compared to yellow corn at the time of his study. The author found that feed costs required for production of one kg gain in weight for control, PB, PB + MP and MP groups respectively. The reduction in the costs to produce one kg gain in weight compared to the control group for PB, PB + MP and MP groups were 23.11, 19.92 and 19.52% respectively.

Based on the obtained results in this experiment yellow corn growing in Nile tilapia diet could be completely replaced by culled sweet potato without any adverse effects on fish growth performance, nutrients utilization or feed and production costs. The advantages of using CSP as dietary energy source may rely on the fact that CSP is locally produced in low price compared to the imported and not always available yellow corn

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