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# Incorporating fodder beet *Beta vulgaris* cv. Majoral in Nile tilapia *Oreochromis niloticus* (L.) diet

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**Abstract:** Four approximately isoenergetic isonitrogenous diets containing 0, 150, 300 and 510 g $kg^{-1}$ fodder beet as a replacement for dietary corn in *Oreochromis niloticus* (Linnaeus) fingerling commercial feed were fed to triplicate groups (15 fish each) of fingerlings (2.46 g) for 9 weeks in a re-circulating system. Fish were fed three times a day to satiation. Tilapia weight gain, feed conversion, specific growth rate and protein efficiency ratio were similar in fish fed diets containing 0 (control), 150 and 300 g $kg^{-1}$ fodder beet ($P < 0.05$). Proximate carcass composition was affected ($P < 0.05$) by replacing dietary corn with fodder beet. As the level of fodder beet increased, fish body moisture was increased and fat reduced. Further increase in fodder beet inclusion to 510 g $kg^{-1}$ had a negative effect on fish growth performance. In conclusion, replacing corn with fodder beet in tilapia feed up to 300 g $kg^{-1}$ would produce growth parameters similar to those fed corn (control groups).

**Keywords:** Carbohydrates, fodder beet, fish, tilapia, feed**.**

## إدخال بنجر العلف *vulgaris* cv. في علائق أسماك البلطي *Oreochromis niloticus* (L.)

**إبراهيم الششتاوي حسن بلال**

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**الملخص**: تمت تغذية أربعة مجموعات (15 سمكة لكل مجموعة) إصبعيات أسماك البلطـي النيلـي فـي ثـلاث مكررات أربعة علائق متساوية في كل من محتوي الطاقة والبروتين تحتوي على نسب مختلفة (0، 150، 300 و 510 جرام لكل كيلو جرام) من بنجر العلف كإحلال لمحتوي الذرة في العليقة التجارية لإصبعيات أسماك البلطـي النيلي و ذلك لمدة تسعة أسابيع في نظام تدوير المياه. غذيت الأسماك ثلاث مرات يومياً حتـى الإشـباع. أشـارت النتائج إلى أن معدلات الزيادة في الوزن، التحويل الغذائي، المعدل المحدد للنمو و كفاءة تحويل البـروتين كانـت متشابه للأسماك التي تغذت على العلائق التي احتوت على 0، 150 و 300 جرام لكل كيلو جرام من بنجر العلف. ومن ناحية أخري فإن تحليل جسم تلك الأسماك أظهر أنها قد تأثرت معنويا بعملية إحلال الذرة ببنجر العلف حيـث وجد أنه كلما زادت نسبة الإحلال زادت نسبة الرطوبة في الجسم وقل الدهن. وقد وجد أنه عند ارتفاع نسبة الإحلال إلي 510 جرام لكل كيلو جرام نتج عن ذلك أثر معنوي سلبي علي كفاءة النمو. يستخلص من ذلك أنه يمكن إحلال جذور بنجر العلف محل الذرة في علائق البلطي بنسبة تصل إلى 300 جرام لكل كيلو جرام دون حدوث أي تغيير في كفاءة النمو بالمقارنة بالأعلاف التي تحتوي علي الذرة كمقارنة.

**الكلمات المفتاحية**: كربوهيدرات، بنجر العلف، أسماك البلطي، التغذية.

## Introduction

Fodder beet is a highly productive crop (6-7 tons dry top yield and 35-45 tons $ha^{-1}$ $year^{-1}$ dry root yield) that has been reported to be salt tolerant up to 11g $L^{-1}$ during the vegetative growth period (Niazi et al., 1999). Therefore, it is cultivated in many countries around the world. In terms of nutrient content fodder beetroot contains 700 g $kg^{-1}$ total carbohydrate, 73 g $kg^{-1}$ crude protein, 80 g $kg^{-1}$ ash, and 100-110 g $kg^{-1}$ crude fibers, 116 g $kg^{-1}$ nitrogen free extract and 45 g $kg^{-1}$ acid detergent fiber (De Barbander et al., 1999). Comparing fodder beet to typical analyses for yellow corn (NRC 1993), fodder beet root contains slightly less carbohydrates (as nitrogen free extract), crude protein, and fat than yellow corn. On the other hand fodder beet roots contain much more sugar (150-200 g $kg^{-1}$ sucrose), total ash and crude fiber than yellow corn. Therefore, fodder beet could prove to be a suitable alternative to cereal grains.

Fodder beet has been utilized as feed for various animals, such as dairy cows (Roberts, 1987), beef cattle **(**MacDearmid and Kay, 1977; De Barbander et al. 1999); lamb (Fanagan, 1999), sheep (Hartnell et al., 2005), pigs (Jentsch et al., 1991) and broiler chickens (Rasdan and Pettersson, 1994). Presently, fodder beet plants are being used as an animal (camels, cows, and sheep) feed by local farmers in the Arabian Gulf. However, after reviewing the literature, no references were found on utilizing fodder beet roots as a feed ingredient for fish. This is probably because of its high fiber content and the extra efforts needed in processing. Some herbivorous fish, however, such as carp and tilapia, can utilize high levels of fiber and digested carbohydrates (Anderson et al., 1984; Teshima et al., 1987; El-Sayed and Garling, 1988). As carbohydrates represent both a critical energy source and a significant ingredient cost, their inclusion level and type should be optimized. Substituting yellow corn with low cost locally available fodder beet, (a locally more available carbohydrate source) could be of great importance for developing a more economical fish feed. The aim of this study was to evaluate growth, feed conversion, and body composition on *O. niloticus* when fed diets containing different levels of fodder beet as replacement for corn.

## Material and Methods

Culture condition

Groups of 10 of mixed sex fingerlings *O. niloticus* (average weight 2.46 g) were randomly stocked in twelve separate plastic circular tanks (60 L). Each tank was considered as an experimental unit; the tanks were part of a semi-closed water recirculating system using slow sand filters to remove solids, a fluidized sand bed acted as a biological filter to remove ammonia and nitrite, and a head tank to keep equal water pressure in each tank. Well water was filtered and aerated to remove solid particles, excessive iron and undesired gases such as hydrogen sulfide before being utilized. Water temperature was kept at (24±3$^{o}$C) throughout the experiment duration. Each group of fish was randomly assigned a test diet.

Fodder beet roots preparation

Three fodder beet roots with average weight 5kg each. They were immediately washed and chopped into small cubes (1-2 centimeter in length). A sub sample (2 kg) was dried in a vacuum oven for 24 hours at 60$^{o}$C and other proximate analyses were performed as described in AOAC (1990).

Experimental diet

Four experimental diets with 0, 150, 300 and 510 g $kg^{-1}$ fodder beet as a replacement for dietary yellow corn (on dry weight basis) were formulated (Table 2). The test diets contained the minimum requirement of all essential nutrients to satisfy the needs of *O. niloticus* as recommended by Jauncey (1998).

The diets were prepared as follows: all feed ingredients were ground in a commercial blender and then mixed in a kitchen mixer. Vitamin and mineral mixes were gradually added with continuous mixing. Distilled water (60$^o$C) was slowly added while mixing until the mixture began to clump. Then, the diet passed through a kitchen meat grinder and was dried for 24 hours at 60$^o$C in a vacuum drying oven. The dried diet was then chopped into pellets in a blender and then passed through laboratory test sieves (mesh 2 and 0.88 mm) to ensure homogenous particle size of sinking pellets and stored at -8$^o$C until used. The amount of waste (powder form) as a result of the pelleting process for every test feed was calculated separately as a percentage of the total amount of every feed. This was used as an indicator of weak (high percentage) or strong (low percentage) pellets.

Feeding trial

Each diet was fed twice a day to triplicate tanks of fish to satiation. Fish from each tank were weighed every seven days. The trial was continued for a period of nine weeks. At the end of the experiment, all the fish from each tank were separately weighed, sacrificed, ground in a commercial blender and stored at -8$^o$C for subsequent body composition analysis.

Feed efficiency parameters

Feed efficiency parameters including fish weight gain (WG), feed conversion ratio (FCR), specific growth rate (SGR), and protein efficiency ratio (PER) were calculated from the following equations:

1. WG = $w_2 - w_1$

Where $w_2$ = mean final weight (g) / fish, $w_1$ = mean initial weight (g) / fish

2. FCR = feed (dry) intake (g) / wet weight gain (g)

3. SGR = $\frac{\log w_2 - \log w_1}{T} \times 100$, where T = time in days

4. PER = $\frac{WG}{P\ in}$, where $P_{in}$ = protein intake

**Analysis**

Fodder beet roots and yellow corn analyses were done according to the methods described in AACC (1995). An atomic absorption spectrophotometer was used for mineral analyses. Total sugars and amino acids analyses were done using HPLC Model 1993 from Shimadzu, Japan. It contains a reagent box, PRR-2A with flow controller, two pumps- LC-6A with multiple terminal box-FCV-3Alsystem controller-Scl-6B, Auto injector-SIL-6B, Column oven-CTO-6A, Spectrofluometer Detector-RF-551, Shimadzu-SHIM-Pack Amino-Na-Column-ISC-30/50504, C-R7A Chromatopac.

Water quality parameters were measured once a week by the following tools and methods; dissolved oxygen, pH and water temperature using PSI DO meter, ammonia using Hatch Chemical Co. Model DR2010 water analysis kit, and phosphate using the methods described by Boyd (1980).

Each diet and fish sample was analyzed for moisture, crude protein, crude fat (ether extract), crude fiber (for feed samples only) and total ash content in triplicate. The methods of analysis were performed as described in AOAC (1990).

All data were analyzed by using the SAS ANOVA procedure (Statistical Analysis system, 1995). One-way analysis of variance (ANOVA) and Duncan's multiple range tests were used to compare treatment means (Snedecor and Conchran, 1981). Statements of significant differences are based on $P < 0.05$.

**Results**

Water quality parameters indicated that $DO_2$, $CO_2$, pH, water temperature, and the total ammonia nitrogen were within the following ranges $DO_2$ 8.2±.3 mg $L^{-1}$, $CO_2$ 2.4±.1 mg $L^{-1}$, pH 7.9± .1, total ammonia 1.03 to1.06 mg $L^{-1}$.

Table 1 shows the proximate composition, minerals, and total sugar content of both fodder beet and yellow corn. The figures show that corn has twice the crude fat level of fodder beet. It contains slightly higher dietary crude protein and carbohydrates than found in fodder beet. Fodder beet on the other hand, has much higher crude fiber (five times), total ash (seven times) and a much higher level of total sugars (nine times) than that in corn. Additionally, mangrove seeds contain much higher levels of all analyzed minerals (phosphorus, potassium, sodium, potassium, magnesium, manganese, copper, and iron) except for calcium. Corn has much more calcium (four times) than fodder beet.

**Table 1. Analysis of fodder beet[1] and corn seeds based on dry weight basis.**

| Type of analysis | Content | |
|---|---|---|
| | **Fodder beet** | **Yellow Corn** |
| Moisture(g $kg^{-1}$) | 72.3 | 102 |
| Crude protein | 74.1 | 99.2 |
| Crude fat | 1.90 | 4.1 |
| Crude fiber | 127.3 | 26.3 |
| NFE[2] | 690.4 | 817 |
| Total sugars | 176.3 | 19.1 |
| Total ash | 89.2 | 13.2 |
| Calcium (mg $kg^{-1}$) [1] | 178 | 800 |
| Phosphorus (mg $kg^{-1}$) [1] | 276 | 0.26 |
| Potassium (mg $kg^{-1}$) [1] | 3.1 | 0.25 |
| Sodium (mg $kg^{-1}$) [1] | 1.4 | 0.03 |
| Magnesium (mg $kg^{-1}$) [1] | 183 | 747 |
| Manganese (mg $kg^{-1}$) [1] | 11.2 | 4.40 |
| Copper (mg $kg^{-1}$) [1] | 6.9 | 2.14 |
| Iron (mg $kg^{-1}$) [1] | 161 | 25.0 |

[1] Performed using Atomic Absorption Spectrophotometer according to the AACC (1995)
[2] Nitrogen free extract

The dietary formulations and the proximate composition of the experimental diets are shown in Table 2. The proximate composition did not show variation in the nutrient levels of the various diets and agreed with the estimated values.

Good binding properties were noted with increasing levels of fodder beet in the experimental diet. The level of fines during the pelleting process decreased (340, 296, 220, 110 g $kg^{-1}$) for diets containing 0, 150, 300 and 510 g $kg^{-1}$ fodder beet, respectively, with very high correlation ($r^2 = 0.97, P < 0.05$).

Growth and feed efficiency parameters of *O. niloticus* are shown in Table 3. There was no significant difference among the initial weights of fish ($P > 0.05$). However, the final weight for some of the groups was significantly different ($P < 0.05$). This indicates that different diets produced different effects on the growth rate of the experimental fish. It was observed that fish fed diets containing 0, 150 and 300 g $kg^{-1}$ fodder beet grew similarly and were superior to those fed a diet containing 510 g $kg^{-1}$ fodder beet significantly ($P < 0.05$). Other growth and feed utilization parameters, namely; specific growth rate (SGR), feed conversion ratio and protein efficiency ratio followed the same pattern as weight gain. It was found that fish performed poorly as the level of fodder beet increased above 300 g kg $^{-1}$ relative to all other experimental feeds in terms of growth and feed efficiency.

Proximate composition is shown in Table 4. *O. niloticus* body composition was affected (P< 0.05) by replacing dietary corn with fodder beet. As the level of fodder beet incorporation increased in the diet, body moisture was increased, while body fat was gradually reduced. Total ash and crude protein were not affected by the level of fodder beet in the test diet.

**Table 2. Composition and proximate analysis of the test diets.**

| **Feed ingredients** | **Fodder beet content in diet (g kg$^{-1}$)** | | | |
|---|---|---|---|---|
| | **0[1]** | **150** | **300** | **510** |
| Fish meal[2] | 387 | 387 | 387 | 387 |
| Yellow corn | 510 | 360 | 210 | 000 |
| Fodder beet | 000 | 150 | 300 | 510 |
| Corn oil | 23 | 23 | 23 | 23 |
| Carboxy methyl cellulose | 20 | 20 | 20 | 20 |
| Vitamins Premix[3] | 20 | 20 | 20 | 20 |
| Minerals premix[4] | 20 | 20 | 20 | 20 |
| Dicalcium phosphate | 20 | 20 | 20 | 20 |
| Proximate analysis | | | | |
| Crude protein | 318 | 315 | 312 | 314 |
| Crude fat | 87 | 83 | 80 | 71 |
| Crude fiber | 20 | 26 | 39 | 58 |
| Total ash | 128 | 169 | 183 | 192 |
| NEF[5] | 447 | 407 | 386 | 365 |
| Energy [6] (kJ g$^{-1}$) | 187 | 179 | 172 | 165 |

[1] Control
[2] Peruvian fish meal, 120 g kg$^{-1}$ crude fat, from Nutris Co., S.A., 3 Rue, Rosenwald, 75015, Paris, France.
[3] As reported by Jackson et al. (1982)
[4] As reported by Jackson et al. (1982)
[5] Nitrogen-Free Extract, determined by difference
[6] Gross energy was calculated based on 23.67, 17.17 and 39.79 kJ g$^{-1}$ protein, carbohydrate and lipid, respectively.

**Table 3. Growth, feed utilization and feed conversion values.**

| Fodder beet content in diet ($g\ kg^{-1}$ dry wt) | Mean initial wt. ($g\ fish^{-1}$) W1 | Mean final wt. ($g\ fish^{-1}$) W2 | Weight gain ($g\ fish^{-1}$) W2-W1 | Feed intake ($g\ fish^{-1}$) | FCR[1] | SGR[2] | PER[3] |
|---|---|---|---|---|---|---|---|
| 0 | $2.56^a$ | $12.78^b$ | $10.22^b$ | $13.18^c$ | $1.29^b$ | $1.61^b$ | $2.58^a$ |
| 150 | $2.44^a$ | $13.12^b$ | $10.68^b$ | $13.04^c$ | $1.22^b$ | $1.68^b$ | $2.73^a$ |
| 300 | $2.37^a$ | $12.25^b$ | $9.88^b$ | $11.47^b$ | $1.16^b$ | $1.43^b$ | $2.87^a$ |
| 510 | $2.50^a$ | $7.44^a$ | $4.94^a$ | $8.92^a$ | $1.81^a$ | $0.68^a$ | $1.83^b$ |
| SEM[4] | 0.10 | 0.7 | 0.24 | 0.72 | 0.23 | 0.20 | 0.34 |

[1] FCR, Feed conversion ratio (feed intake/average weight gain per fish for the nine week period)
[2] SGR, specific growth rate = [ (In W2- In W1)/time in days) x 100]
[3] PER, protein efficiency ratio = average weight gain (g)/average weight of protein fed (g).
[4] Pooled standard error of means = $\frac{SD}{\sqrt{n}}$
each value is a mean of three observations
Values in the same row with different subscripts are significantly different ($P < 0.05$)

**Table 4. Whole body composition of *O. niloticus*[5] fed the experimental diets.**

| Type of analysis | Fodder beet content in diet ($g\ kg^{-1}$) | | | | |
|---|---|---|---|---|---|
| | 0 | 150 | 300 | 510 | SEM[6] |
| Moisture | $706^a$ | $711^a$ | $728^b$ | $737^c$ | 3.1 |
| Crude protein | $171^a$ | $168^a$ | $165^a$ | $163^a$ | 4.4 |
| Crude fat | $66^c$ | $63^c$ | $52^b$ | $44^a$ | 2.1 |
| Total ash | $58^a$ | $57^a$ | $57^a$ | $55^b$ | 1.9 |

[5] Expressed as a $g\ kg^{-1}$ of fish wet weight
[6] Pooled standard error of means = $\frac{SD}{\sqrt{n}}$
Values in the same row with different subscripts are significantly different ($P < 0.05$)

## Discussion

The semi closed recirculating culture system used in the experiment was capable of keeping water quality parameters (DO, $CO_2$, pH and total ammonia) of the water within the adequate range for raising the experimental fish. Wheatons et al. (1994)

Dietary carbohydrate sources (maize, sorghum, wheat, rice, barley, and fodder beet as well as some of their by-products wheat bran, rice bran, etc) are important sources of dietary energy for herbivorous fish such as carp and tilapia, as they can utilize high levels of digested carbohydrates (Anderson et al. (1984); Teshima et al. (1985); El-Sayed and Garling 1988).

Our test diets had different types of carbohydrates as fodder beet contains mainly simple sugars while yellow corn contains starch. It was shown by Belal& Al-Jasser (1997), and Belal (1999), (2002) and (2004) that *O. niloticus* fed diets containing different mixing ratios of carbohydrate sources (dates, barley or mangrove seeds) with corn grew similar to those fed corn as the only carbohydrate source (a basal diet). However, the authors added that at a certain mixing ratio (3 dates: 1 corn ), ( 2 barley: 1

corn), (2 mangrove seeds: 1 corn) and (2 rice bran to 3 corn) tilapia growth was superior to all fish fed other mixing ratios including the diet containing corn as the only carbohydrate source. In other words, when carbohydrate sources are mixed at specific ratios, fish growth and energy balance were improved. This was supported by studies in poultry by Kamel et al. (1981) and Najib, Al-Yousef, & Hemeidan, (1994). The results obtained from the present study did not support the above finding fully. It was indicated that the incorporation of fodder beet in tilapia feed as a replacement for corn at 0 , 150 and 300 g $kg^{-1}$ levels has not affected growth rate, feed conversion, specific growth rate and protein efficiency ratio. However, the present study did not find a mixing level that has a synergistic effect on tilapia growth parameters as the previous studies indicated.

Fodder beet contains lower levels of complex carbohydrates than yellow corn while it has more simple carbohydrates (sucrose) than yellow corn. Digestion of sucrose (glucose release) of fodder beet by fish is much higher than that of starch of yellow corn. This makes up for the difference in their carbohydrates content. Consequently, tilapia grew similarly with increasing the level of fodder beet up to 300 g $kg^{-1}$. On the other hand, when *O. niloticus* were fed a diet containing fodder beet roots alone (510 g $kg^{-1}$ of the test diet), they grew poorly as compared to fish fed a diet containing corn-fodder beet mixed as a carbohydrate source up to 300 g $kg^{-1}$. This was probably due to by the following: (1) The effect of a high level fodder beet diet on increasing binding ability of the test pellets which would probably reduce their digestibility. As several researchers indicated that increasing pellets binding could reduce digestibility of protein and lipids. (Gabaudan1979 and Storebakken1985), (2) Lower feed intake as compared to all other test diets (Table 4), (3) Higher levels of crude fiber that caused negative effects on digestibility of the test diets. Teshima et al. (1987) found that *O niloticus* fed semipurified test diets decreased with increasing dietary cellulose from 20 to 170 g $kg^{-1}$. Additionally, Buddingtons (1979) observed that cellulose and chitin of complex polysaccharides of plant fiber were poorly digested by three tilapia species, *O. aureus*, *O mossambicus* and *O niloticus*. Additionally, De Silva and Gunasekera (1989) reported a significant reduction in food conversion in O. niloticus fed diets containing test plant ingredients, possibly caused by poor nutrients availability and high fiber content. Body composition analysis of *O niloticus* indicated that as fodder beet incorporation level in the feed increased, body moisture and protein deposition were increased and body fat was decreased. This may be explained by an improvement in the protein sparing effect of the dietary carbohydrates during protein synthesis as indicated from the percentages of protein deposition. On the other hand, higher moisture content reflects a reduction in percentage body fat. Additionally, higher levels of fodder beet may have reduced digestibility by producing physically strong pellets. This resulted in an increase in body moisture and a reduction in fat deposition and growth rate. In conclusion, replacing corn with fodder beet in tilapia feed up to 300 g $kg^{-1}$ would produce growth parameters similar to those fed corn (control groups). Total replacement of corn with fodder beet at 510 g $kg^{-1}$ would have a negative effect on growth parameters. A less costly and more efficient fish diet could be produced using fodder beet. This is because the fodder beet plant is highly productive and irrigated with readily available higher salinity well as compared to costly fresh water for many countries around the world.

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