Effect of dietary carbohydrate sources on the growth of *Oreochromis niloticus L:* A case of Kaaka fish farm, Namutumba district, Eastern Uganda

[1.] Mr Apollo, A. Musita [*], [2] Dr Otieno, A. Charles, [2] Dr Warkach, K. Tonui, & [2] Dr Naila, G. Napoo

[1.] Faculty of Agriculture, Science & Technology, Busoga University, P.O.Box 154, Iganga (U).

2. School of Humanities & Social Sciences, Jaramogi Oginga Odinga University of Science & Technology, P.O.Box 210-40610, Bondo (K).

Corresponding author[*]
Apollo, A. Musita
Faculty of Agriculture, Science & Technology,
Busoga University, P.O.Box 154, Iganga (U).

ABSTRACT
A 16-week field experiment was carried out at Kaaka fish farm in Namutumba district to investigate the effect of dietary carbohydrate sources on the growth performance of Nile tilapia, Oreochromis niloticus L Fish fry of an initial mean standard length (SL) of 2.4cm were randomly introduced into experimental 12 pond units. They were subjected to three different test feeds possessing different sources of dietary carbohydrate namely maize bran (MB), cassava peels (CP) and sweet potato peels (PP). Growth rate was dete4mined by Standard Length (SL) measurements. Results revealed a significant difference among the treatment Means ($p<0.001$). A Post-hoc analysis showed that it was the mean standard lengths of PP Vs CP and MB Vs CP that differed significantly ($p< 0.003$). The mean standard lengths of PP Vs MB did not differ significantly. The above results suggest that PP was the best performer when compared to other test feeds. The sweet potato-based feed should there fore be utilized to completely substitute the maize-based feed (MB) in diet of Nile tilapia.

Key words: amylase, dietary carbohydrate, fish feeds, fish species, starch, Nile tilapia

INTRODUCTION
Carbohydrates are molecules that generally conform to the empirical formula $(CH_2)_n$, hence the name 'hydrate of carbon ('Dyson,1978). They are found in various plant tissues such as seeds, fruits, stems and roots. Plant ingredients contain a lot of carbohydrates (Stone, 2003). A part from milk products, which contain the sugar lactose, nearly all the carbohydrates in animal diets originate from plants (Brody, 1988).

Carbohydrates generally include sugars, starch, cellulose, hemi cellulose and lignin (Guyer & Owen, 1998). The carbohydrate content of feedstuffs is divided into digestible carbohydrate and fiber (Jauncey, 1998). Digestible carbohydrates include mainly sugars and starch while fiber include mainly cellulose. The digestible carbohydrates can be further sub-divided into their constituent sugars as follows; monomers such as glucose, non-monomers such as maltose and polysaccharides such as starch. Most of the carbohydrate sources for animal feeds are dominated by starch.

Carbohydrates constitute the largest proportion of farm animal diets They are the main sources of dietary energy in most animal diets (Abro, 2014). Many authors agree that they are often regarded as cheap sources of dietary energy than proteins and lipids (Mollah & Alam, 1990). The two carbohydrate fractions commonly used in evaluating the carbohydrate content of a feed are crude fiber and nitrogen-free extracts (NFE) (Guyer & Owen, 1998). The NFE is the most digestible portion of a carbohydrate.

Appropriate amounts of carbohydrates should be provided for animal diets in order to promote effective nutrient utilization and growth. Fish species show reduced growth rates when fed on carbohydrate free diets (Wilson, 1994). Insufficient carbohydrate supply in fish diets also affects the utilization of other dietary energy nutrients especially dietary protein. Since carbohydrate is the major form of energy in most animal diets, a deficiency of dietary carbohydrate especially in herbivorous fish species can reduce growth rates. This occurs as the organism resorts to dietary protein instead of dietary energy, for metabolic activities.

The ability of fish to utilize carbohydrates as energy sources varies both among and with in species. Warm water fish exhibit a great potential of utilizing dietary carbohydrates for energy supply (Stone, 2003) and protein sparing (Azaz et al, 2003). Omnivorous fish species such as Nile tilapia which feed at low trophic levels can efficiently utilize higher levels of dietary carbohydrates (Enest et al, 2011). In aquaculture, utilization of dietary carbohydrates is therefore greater for the omnivorous fish species than other non-herbivorous fishes.

Dietary carbohydrates are usually dominated by starch. Some scientists have it that the tilapias, among the omnivorous fish exhibit a greater potential to utilize starch (Amirkolaice et al, 2006). It should therefore be noted that future development of plant-based sources of dietary carbohydrates, lays among the tilapias especially the Nile tilapia. Carbohydrate digestibility in tilapias varies with the nature of carbohydrate, its level in the feed and the dietary fibre (Barash et al, 1984).

Most fish species are unable to utilize dietary carbohydrates due to lack of adequate gut micro biota especially amylase that digests starch (Abro, 2014). The superiority of omnivores as compared to carnivores in terms of carbohydrate utilization is due to presence of higher levels of amylase. Amylase is the digestive enzyme involved in the metabolism of starch (Mizutani, et al, 2012). Fish species show different abilities to digest and metabolize alternative dietary carbohydrate components (Abro, 2014).

On most the farms where fish culture is integrated with crop plants, a lot of the crop by-products and wastes are rarely fully utilized. Through processing, plant-based products can be made more useful as pond in-puts (Muir, 1987). The incorporation of currently discarded wastes from traditional food crops, will lead to low feed costs for tilapia culture (King&Ibrahim, 2006). However, these non-conventional feed stuffs, should be subjected to research in order to determine their usefulness as fish feeds (Devendra, 1995).

Maize bran is widely used and is the basic feed ingredient in semi-intensive aquaculture (Balirwa, 2006). It is a by-product of processing of maize (*Zea mays*) grains and is currently the conventional source of dietary carbohydrate for Nile tilapia. Maize bran can be scarce because of the stiff competition between farmed fish, other livestock and human beings (Mataka & Kagambe, 2007). Limited success in the utilization of other alternative plant-based products has been partly attributed to the persistence utilization of maize bran despite its high cost and variability in supply.

A variety of by-products and wastes from crop plants can provide alternative sources dietary carbohydrates to supplement or substitute maize bran in aqua feeds. According to Odong *et al,* (2002) sweet potato is the third most produced food crop in Uganda after bananas and cassava. Sweet potatoes (*Ipomea batatus*) and cassava can produce large quantities of by-products with a high potential for transformation into aqua feed ingredients.

Odong *et al*, (2002) add that generally, sweet potatoes are cheap and available most of the year. Bashasha (1995) observes that sweet potatoes are commercially grown in the eastern and central parts of Uganda. Kapinga et al (2005) asserts that the transformation of sweet potatoes into a market-oriented commodity while maintaining its status as a food security crop is its undoing.

A part from the recognition of cassava as a key food security crop in Sub-Saharan Africa, its utilization is still limited despite its high energy content (Engoru, 2005). It’s the large amounts of starch accumulated in the roots that make cassava an important source of energy (Jose & Maybre, 1982). This makes cassava a potential ingredient for animal feeds utilization. Livestock feeding on cassava remains marginal with the exception of its peels which are included in the diets of sheep and goats (Bokango, 1998). Dry and processed products of cassava have gained acceptance as animal feed ingredients. This therefore makes cassava now common for diets of poultry and pigs (Goozens, 2004). Besides that cassava has already been included in the diets of certain fish species particularly the pond-raised shrimp (Sarma, 1991). This therefore makes a cassava-based diet specifically targeting the commonly cultured Nile tilapia a priority. According to Goozens, (2004), one of the high priorities related to this development is the production of a cassava-based feed which is 20-30% cheaper than the maize-based feeds.

AREA OF STUDY

Kaaka Fish Farm is located in Magada sub-county, Namutumba district (Figure 1.1). It was selected for the experiments because of its suitability for fish culture such as high soil water levels, light soils for pond excavation with high capillarity and experienced labour force in Tilapiine fish culture. The area and its surroundings are dominated by flat low lands (3830-4100ft) that alternate with valleys where wetlands are located.

Figure 1 Lay-out of earthen ponds at the study site located at Kaaka Fish Farm, Namutumba district Source: Researchers' field photos 2014.

MATERIALS AND METHODS

The research adopted an experimental design where; the test diets acted as treatments and were replicated 4 times i.e. MB (T_1-T_4), CP (T_5-T_8) and (PP) (T_9-T_{12}). Treatments constituted the columns of the block. The 1st, 2nd and 3rd columns were therefore served with MB, CP and PP respectively. The 4th Colman consisted of 4 water reserve ponds. There were 4 rows per column, thus producing a total of 16 treatments per block. 12 out of the 16 ponds at the experimental site were experimental ponds.

Test diets

Complete diets containing all essential nutrients were prepared. The complete diets were equipped with minimum contents of all the essential nutrients to satisfy the needs of Nile tilapia as recommended by Jauncey & Ross (1982). The test diet composition was as follows; Carbohydrate source (30%), Fish meal (60%), feed binder (8%), minerals (1%) and vitamins (1%). The above ingredients apart from the carbohydrate sources were kept constant. The test diets therefore included; maize bran (MB), cassava peels (CP), and sweet potato peels (PP).

The feed ingredients were sun dried, grounded and hand pelleted and stored for at least 4 weeks before any supply of fresh feed.. The fish were fed at 9.00 am and 5.00 pm on a daily basis and at a daily feeding ration (DFR) of 5% of the live body weight as recommended by Belal (1999). The DFR was adjusted every two weeks after sampling in order to cater for the increasing weight gain.

Sampling method

A sample size of 1500 Nile tilapia fish fry were obtained from a hatchery of Muso-Fish Farm in Luuka, Iganga District. Simple random sampling (SRS) was utilized to select 576 fish for stocking as guided by Schefler, (1979) as follows; 12 plastic bowels (PB's) were each packaged with 48 fish of a mean Standard Length of 2.4 cm. 12 paper cards (PC's) corresponding to the number of experimental ponds were marked with figures 1-12. These PC's were reshuffled several times before assigning them to a row of the 12 PB's. The first PB of the raw was served with the top most PC and so on. PB's with PC's marked with figures 1-4 were used for stocking the first column of 4 ponds. PC s, of figures 5-8 stocked the second column. Those that were marked 8-12 stocked the last column of experimental ponds.

Data collection and analysis

Fish sampling began 2 weeks after stocking. During sampling, samples of 30 fish per pond unit were temporarily removed for measurement of standard lengths (SL). A total of 360 fish were measured during each sampling. Sampling was carried out after every 2 weeks for 5 weeks. A total of 5 samples were collected during the experiment. During sampling, a transparent ruler sensitive up to one millimeter (0.1cm) was used for SL measurements. Data was Log transformed to satisfy normality and a One-way analysis of variance (ANOVA) was utilized to test for significance between the treatment means. Later, Fisher's Post-hoc analysis was used to reveal significant differences between particular means.

RESULTS AND DISCUSSION

Table 1 and figure 1 (box plot) show descriptive statistics of the Standard Length (SL, cm) of fish subjected to different test diets during the experiment. The Sweet potato-based feed (PP) had the highest mean of SL (8.99cm) followed by the maize bran-based feed (MB) of (8.85cm) and the least was the cassava–based feed (CP) of (8.48cm

Table 1 Summary statistics for the 3 test diets for Nile tilapia

Statistic	C P	MB	PP
N	2160	2160	2160
Median	8.5	8.8	8.6
Sum	18325.4	19108.2	19423.5
Mean	8.5	8.8	9.0
S.Dev.	2.5	4.7	6.1
S. E. M	0.1	0.1	0.1
C.V.	0.3	0.5	0.7

Source: Researchers' field data, 2014

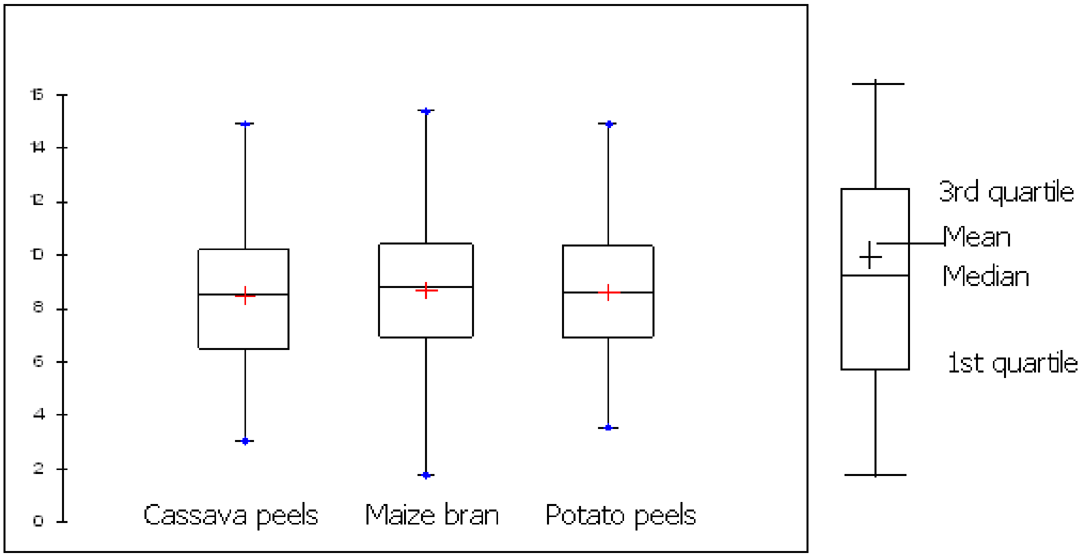

Fig.1. Box plots comparing growth performance (SL) performance of different test diets.
Source: Researchers' field data, 2014.

The test diets performance compared using box plots as indicated in fig.1 reveal the minimum, 1st quartile, median, mean and 3rd quartile together with both limits for each test diet. The trend for the mean and median showed that the performance from best to worst was in the order; PP > MB > CP. When the performance of test diets was compared for significant differences, there was a significant difference among the treatment groups. This was because the calculated value of 6.549 was greater than the F (3, 16) value of 3.24. Fisher's Post-hoc analysis specifically revealed that it was only the performances of PP Vs CP and MB and CP that differed significantly. The performance of PP and MB did not differ significantly as shown in the table below.

Table 2. Fisher's analysis of mean differences between test diets at a confidence interval of 95%

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
PP vs. CP	0.013	3.264	1.960	0.001	Yes
PP vs. MB	0.001	0.275	1.960	0.783	No
MB vs.CP	0.012	2.986	1.960	0.003	Yes

Source: Researchers' field data tabulations, 2014.

Discussion

The superior performance of MB as compared to CP for both was probably due to high protein content. Dietary protein is the feed component that greatly influences fish growth (El-Sayed 2006)). This explains the cause of fast growth of fish subjected to diets with higher levels of dietary protein. Maize contains two major proteins namely Zein and Glucelin while cassava and its products contain very low protein estimated at 30g/kg (Donald & Edwards, 1991). Sarma (1991) has it that cassava can only substitute course grains in livestock feeds when combined with protein supplements. Approximately four parts of dry cassava and one part of Soya bean can substitute five parts of maize in animal rations (Nweke et al, 2002). .

The crude protein content based on dry matter for sweet potatoes is 39g/ kg while that of cassava is 30g/kg (Donald & Edwards, 1991).The protein content of sweet potato and its products is higher than that of cassava which explains the significantly better performance of PP as compared to CP. A part from its lower protein content, the poor performance of CP as compared PP can be further explained by its higher starch content. Sweet cassava cultivars provide 50-70% of dry weight starch (Esechi, 1987). In all non-ruminants, including fish, starch can be hydrolyzed in their guts to produce only glucose. A high concentration or rate of release of glucose is known to inhibit the transport of amino acids at absorption sites in fish gut membranes which leads to a low protein retention (Hokozono *et al*, 1979).

There was no significant difference in the performance of PP and MB. Although MB contains more starch than PP, surprisingly, this did not affect its performance. Two major factors could have compensated for the above limitation; firstly, the presence of thiamine (Vitamin B_{12}) in maize-based products stimulates growth and carbohydrate utilization in animals. MB is a good source of thiamine (Williamson & Payne, 1987) essential for carbohydrate metabolism (Jauncey, 1998) and stimulates rapid growth in fishes (Swift, 1985). Secondly, MB contains a lot of less digestible fiber or cellulose. Nile tilapia usually feeds on undigested remains that remain suspended for long on the water column. Although these remains are of a low nutritive value, the micro organisms that normally adhere to them contain high amounts of protein (Shroeder, 1993).

According to the above results, the sweet potato-based feed (PP) which was the best performer should be regarded as a complete substitute for the conventional maize-based feed (MB) in the diet of Nile tilapia.

CONCLUSION AND RECOMMENDATIONS

There's a high potential for promotion of Nile tilapia culture fish once alternative and accessible dietary carbohydrate sources are formulated especially for small scale or semi- intensive pond culture systems. Rural fish farmers have the greatest chance of utilizing such diets because of the availability of a diversity crop product wastes.

The researchers therefore recommended that sweet potato peels should be utilized as an alternative source of carbohydrate for Nile tilapia diets. This shall solve the problem of relying on only maize bran, which is competitive, and some times scarce. The large amounts of sweet potato peels accumulated in almost every household are likely to make this feed ingredient accessible and cheaper to utilize than maize bran. The use of maize bran can still maintained since its performance was as good as that of potato peels especially in areas where it's cultivated intensively. However, further research is still required to establish the cost-effectiveness of such dietary adjustments.

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