# COMPARATIVE ASSESSMENT OF ROSELLE (*Hibiscus sabdariffa* var. *sabdariffa*) SEED MEAL AND KENAF (*Hibiscus sabdariffa* var. *altissima*) SEED MEAL AS REPLACEMENT FOR SOYBEAN MEAL IN PRACTICAL DIETS FOR FINGERLINGS OF NILE TILAPIA, *Oreochromis niloticus*

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## Abstract

Apparent digestibility coefficient (ADC) values for crude protein and gross energy contents of mechanically-extracted meals derived from soybean meal, roselle (*Hibiscus sabdariffa* var. *sabdariffa*) and kenaf (*Hibiscus sabdariffa* var. *altissima*) seeds were determined using an inert marker in the diets and by faeces collection using the dissection method. Soybean, roselle seed and kenaf seed meals had similar ADC values for crude protein, but ADC value for gross energy content of soybean meal was higher ($P < 0.05$) than those of roselle seed and kenaf seed meals. Soybean meal was incorporated as protein source in a control diet (300 g crude protein, 100 g crude lipid and 18.5 MJ gross energy/kg diet), which was substituted in the test feedstuff diets with Roselle seed meal or kenaf seed meal. Differences ($P < 0.05$) occurred in water stability of pellets as the inclusion level of roselle seed meal or kenaf seed meal increased. The diets were later fed to Nile tilapia (*Oreochromis niloticus*) fingerlings (mean weight, 13.1 g) twice daily to apparent satiation for 70 days. Mortality was low (< 5%); growth and feed utilization indices and carcass composition were similar ($P > 0.05$) in *O. niloticus* fingerlings fed diets containing roselle seed meal providing up to 30% of total protein or kenaf seed meal providing 15% of total protein. High crude fibre content and lower energy digestibility of roselle seed meal or kenaf seed meal will almost certainly limit their use beyond these levels in *O. niloticus* diets. No physical abnormalities or deleterious effects emerged from the present study.

## Introduction

Soybean meal protein is the most commonly used plant protein in feeds for omnivorous fish species commonly used in African aquaculture, such as tilapias and catfishes (Lovell, 1988). It is palatable and is available at a cost much below fishmeal, but recently, it has become relatively expensive and scarce due to competitive demands in

poultry and livestock feeding (Rumsey, 1993); hence, alternative plant protein sources must be evaluated in fish nutrition. *Hibiscus sabdariffa* Linnaeus (Family Malvaceae), has two main varieties, of which the more important economically is kenaf, *H. sabdariffa* var. *altissima* Wester, and the other is roselle, *H. sabdariffa* var. *sabdariffa* Linnaeus. Both varieties are annual herbs extensively cultivated in tropical Africa, Asia, Central America and the Caribbean for the jute-like fibre or the red calyces surrounding the fruit; the basis of a popular red non-alcoholic drink, hams, jelly and colouring material for foods and beverages. The seeds of both varieties are sources of protein and lipid (Kalyane, 1986; El & Khalil, 1994; Rao, 1996) and are used for small-scale edible oil production. The resulting meals from this process contain low levels of antinutrients-tannin, α-amylase inhibitors, protease (chymotrypsin, trypsin) inhibitors, phytic acid, gossypol, phytic acid (Liener, 1975; Abu-Tarboush & Ahmed, 1996; Abu-Tarboush *et al*., 1997, Hansawadi & Kawabata, 2000).

Roselle seed meal is presently sold in Nigeria at one third of the cost of soybean meal, and hence justifies investigating its use in fish feeding. From the standpoint of economics, availability and nutritional value, roselle seed meal and kenaf seed meal represent attractive replacements for soybean meal in fish diets. One of the most important characteristics of feedstuffs is the bioavailability of nutrients, particularly digestible protein (DP) and digestible energy (DE), hence reliable data on the digestibility of different ingredients for each species might well be considered as a necessary prerequisite. This study evaluates the apparent digestibility of macronutrients and nutritive value of roselle seed meal and kenaf seed meal as alternatives to defatted soybean meal in dry practical diets for fingerlings of Nile tilapia, *Oreochromis niloticus* (Linnaeus).

## Materials and methods

Roselle seed meal and kenaf seed meal were obtained from Arewa Oil Mills, Kano (northern Nigeria) while menhaden fish meal, soybean meal and other ingredients were obtained from commercial sources in Nigeria. The feedstuffs were separately milled, screened to fine particle size (< 250 μm), and triplicate samples were analysed for proximate composition (moisture, crude protein, crude lipid, crude fibre, total ash) according to AOAC (1990). Crude protein was determined using Kjeltec Auto 1030 Analyser after digestion with concentrated $H_2SO_4$ in a digester. Crude lipid was estimated by extracting in chloroform: methanol (2:1) using a Soxtec extraction HT6 unit. Crude fibre was determined using a Fibretec System 1020 Hot Extractor and ash content was determined by igniting at 550$^{o}$C in a muffle furnace for 12 hours. Protein feedstuffs were analyzed for calcium and phosphorus by digesting the samples with a mixture of nitric and perchloric acids. Calcium was measured using flame photometry (Black, 1965) while phosphorus was determined using a spectrophotometer (Golterman *et al*., 1978). Gross energy content was determined with a Gallenkamp adiabatic bomb calorimeter. Nutrient composition and energy content of the protein feedstuffs are presented in Table 1.

Table 1. Proximate composition (g $kg^{-1}$ dry wt) of protein feedstuffs.

| | Fish meal | Soybean meal | Roselle seed meal | Kenaf seed meal |
|---|---|---|---|---|
| Dry matter | 921 | 890 | 926 | 902 |
| Crude protein | 680 | 446 | 394 | 332 |
| Crude lipid | 104 | 46 | 61 | 90 |
| Crude fibre | 10 | 49 | 177 | 249 |
| Total ash | 204 | 58 | 114 | 106 |
| Calcium | 56.5 | 2.9 | 6.6 | 6.4 |
| Phosphorus | 31.6 | 6.8 | 6.8 | 6.9 |
| Gross energy (MJ $kg^{-1}$) | 18.69 | 17.78 | 17.21 | 17.13 |

The essential amino acids (EAA) content of the protein feedstuffs were determined using an LKB 4151 Alpha plus amino acid analyzer after treating samples with 6 mol $L^{-1}$ HCl under reflux for 24 hours at 110°C. Tryptophan content was determined colorimetrically after hydrolyzing samples in 4.2 mol $L^{-1}$ NaOH (Fischl 1960). The EAA profile of the feedstuffs is shown in Table 2.

Table 2. Essential amino acid composition (g $kg^{-1}$ protein) of protein feedstuffs.

| | Fish meal | Soybean meal | Roselle seed meal | Kenaf seed meal |
|---|---|---|---|---|
| Arginine | 61 | 71 | 96 | 92 |
| Histidine | 24 | 26 | 27 | 27 |
| Isoleucine | 47 | 61 | 47 | 45 |
| Leucine | 73 | 86 | 80 | 80 |
| Lysine | 77 | 65 | 59 | 57 |
| Methionine | 29 | 15 | 16 | 14 |
| Phenylalanine | 40 | 53 | 51 | 44 |
| Threonine | 41 | 40 | 34 | 34 |
| Tryptophan | 11 | 14 | 13 | 13 |
| Valine | 53 | 53 | 54 | 50 |

Apparent digestibility coefficients of crude protein and gross energy in soybean meal, roselle seed meal and kenaf seed meal were determined as follows: a purified reference diet (casein 32%, gelatin 8%, α-starch 40%, fish oil 10%, vitamin-mineral mix 9%, and chromium III oxide 1%) and a test feedstuff diet containing 70% of the reference diet mixture and 30% of soybean meal, roselle seed meal or kenaf seed meal was prepared as previously described by Fagbenro (1998). *O. niloticus* fingerlings were separately distributed in groups of 15 fish into 20-litre cylindrical plastic tanks supplied with aerated water. Each diet was assigned to duplicate tanks and *O. niloticus* fingerlings were fed to apparent satiation twice daily (8.30–9.00h and 16.0–16.30h) for 14 days. On the last day, faeces were collected from each anaesthetized *O. niloticus* fingerlings (2.5 ml quinaldine $L^{-1}$ of water) eight hours after feeding using the dissection method.

Crude protein content was analysed in triplicate samples of diets and faeces using AOAC (1990) methods and gross energy was determined by bomb calorimetry. Chromium content of diets and faeces was determined spectrophotometrically (Bolin *et al*., 1952). Apparent digestibility coefficient (ADC) of crude protein and gross energy in the diets were

calculated as: ADC = $10^2$ – [$10^2$ x ($I_d/I_f$ x $N_f/N_d$)], where: $N_d$ = nutrient in diet, $N_f$ = nutrient in faeces; $I_d$ = $Cr_2O_3$ in diet; $I_f$ = $Cr_2O_3$ in faeces. The ADC $_{\text{crude protein/gross energy}}$ in test feedstuff was calculated as: ADC $_{\text{crude protein/gross energy}}$ = 100/30 (ADC $_{\text{test diet}}$ – 70/100 ADC $_{\text{reference diet}}$).

Based on the nutrient composition of the protein feedstuffs (Table 1), seven isoproteic and isocaloric diets (300 g crude protein/kg, 100 g crude lipid/kg and 18.5 kJ digestible energy/g dry matter) were formulated as presented in Table 3 and all diets satisfied the macronutrient requirements of *O. niloticus* (Jauncey, 2000). A control diet (S45) contained soybean meal as the plant protein source, and six test feedstuff diets contained roselle seed meal or kenaf seed meal as replacement for soybean meal in the control diet (Table 3), providing 15%, 30% or 45% of total protein. Lipid content of all diets was adjusted with corn oil and cod liver oil while gelatinized corn starch was supplemented to adjust gross energy content. Carboxymethyl cellulose was added at 10 g $kg^{-1}$ as a non-nutritive binder. All the feedstuffs were blended in a Hobart A120 food processor and the resultant mash was moistened and pressed without steam through a 3-mm die. The resulting strands were oven-dried at 45°C for 24 hours, broken into pellet lengths of 1 cm, and stored in air-tight plastic containers at ambient temperature (25°C). Triplicate samples of diets were analysed for proximate composition, gross energy content and EAA composition as described above. Water stability of pellets was determined in triplicate samples (Wood, 1987).

Table 3. Ingredients composition (g $kg^{-1}$ dry matter) of the experimental diets.

| | Control diet | Test feedstuff diets | | | | | |
|---|---|---|---|---|---|---|---|
| | | Roselle seed diets | | | Kenaf seed diets | | |
| | S45 | R15 | R30 | R45 | K15 | K30 | K45 |
| Menhaden fish meal | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| Soybean meal | 450 | 350 | 250 | 150 | 350 | 250 | 150 |
| Roselle seed meal | - | 115 | 230 | 345 | - | - | - |
| Kenaf seed meal | - | - | - | - | 135 | 270 | 405 |
| Cod liver oil | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Corn oil | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Corn starch | 305 | 290 | 275 | 260 | 270 | 235 | 200 |
| Vitamin-mineral mix[1] | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Dicalcium phosphate | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Carboxymethyl cellulose | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

[1]Fish pre-mix, Colborne Dawes Nutrition Ltd., UK g $kg^{-1}$ diet: vitamin A, 1600 IU; vitamin D, 2400 IU; vitamin E, 160 mg; vitamin K, 16 mg; thiamin, 36 mg; riboflavin, 48 mg; pyridoxine, 24 mg; niacin, 288 mg; panthotenic acid, 96 mg; folic acid, 8 mg; biotin, 1.3 mg; cyanocobalamin, 48 mg; ascorbic acid, 720 mg; choline chloride, 320 mg; calcium 5.2 g; cobalt, 3.2 mg; iodine, 4.8 mg; copper, 8 mg; iron, 32 mg; manganese, 76 mg; zinc, 160 mg; Endox (antioxidant) 200 mg.

*O. niloticus* fingerlings were acclimated to experimental conditions for 14 days prior to the feeding trial. Seven groups of 20 *O. niloticus* fingerlings (mean weight, 13.1 ± 0.5 g) were randomly stocked into each of 15 plastic circular tanks (50-litre capacity) in an indoor recirculating system with a water flow of 1 L $min^{-1}$; pH, 6.6-7.5; temperature, 25-28°C; dissolved oxygen, 6.2-8.5 mg $L^{-1}$; total ammonia, 0.098-0.125 mg $L^{-1}$; total nitrite, 0.029-0.033 mg $L^{-1}$. Water quality analyses followed the methods outlined by APHA (1980). Water temperature and dissolved oxygen were measured daily using a combined digital YSI

dissolved oxygen meter (YSI Model 57 YSFI; Yellow Springs, Ohio); pH was monitored weekly using a pH meter (Metler Toledo-320, Jenway, UK). Each diet was fed to *O. niloticus* fingerlings in triplicate tanks per treatment to apparent satiation twice daily (09.00 hours and 16.00 hours) for 70 days. Fish mortality was monitored daily. Individual fish in each tank was weighed at the start and every 14 days to monitor growth and feed utilization using the appropriate indices (Steffens, 1989). At the end of the growth trial, five *O. niloticus* fingerlings were randomly selected from each tank, and frozen (-20$^{o}$C) for subsequent carcass analyses. The livers of another batch of five *O. niloticus* fingerlings per treatment were removed, weighed and used to estimate the hepatosomatic index (HSI). Samples of liver tissues were fixed in 10% neutral-buffered formalin, stained with hematoxylin and eosin and periodic acid-Schiff (PAS) for histological examination.

All data obtained were subjected to one-way ANOVA test ($P < 0.05$). When ANOVA revealed significant differences, Duncan's multiple-range test (Zar, 1996) was applied to characterize and quantify the differences between treatments using Statgraphics 5 Plus package for Windows (Manugistics Inc. and Statistical Graphics Corp, Maryland, US.).

## Results and discussion

The $ADC_{crude\ protein}$ of soybean meal, roselle seed meal and kenaf seed meal were similar ($P > 0.05$) while $ADC_{gross\ energy}$ of roselle seed meal and kenaf seed meal were lower ($P < 0.05$) than those of soybean meal (Table 4). Differences ($P < 0.05$) occurred in water stability of pellets as the inclusion level of roselle seed meal or kenaf seed meal increased (Table 5). The present results are a clear evidence for the varied degree of digestibility depending on the nature, source and composition of test feedstuffs. Differences ($P > 0.05$) in $ADC_{gross\ energy}$ values for roselle seed meal and kenaf seed meal compared with the value for soybean meal are attributable to the high crude fibre and total ash contents in the diets (De Silva *et al.,* 1990) and from relative quantities of their digestible energy content (Shiau, 1989). Similarly, lower energy digestibility in sunflower meal, brewery draff and palm kernel meal fed respectively to *O. mossambicus* and *O. niloticus* was attributed to their high crude fibre content (Jackson *et al*., 1982, Poumogne *et al*., 1992, Omoregie & Ogbemudia, 1993, Fagbenro & Davies ,2000).

Table 4. Apparent digestibility coefficient (ADC) for crude protein and gross energy in protein feedstuffs.

| | Fish meal[1] | Soybean meal | Roselle seed meal | Kenaf seed meal |
|---|---|---|---|---|
| ADC crude protein (%) | 92.8 | 86.9a | 86.8a | 86.2a |
| ADC gross energy (%) | 85.1 | 77.4a | 71.9b | 70.1b |
| Digestible protein[2] ($g.kg^{-1}$) | 631.0 | 387.6a | 342.1b | 286.2c |
| Digestible energy[2] (MJ $kg^{-1}$) | 15.91 | 13.76a | 12.73b | 12.36b |

a, b, c, - Values in the same row with similar letters are not significantly different ($P > 0.05$)
[1]Values previously determined for Menhaden fish meal by Fagbenro (1998)
[2]Calculated values

The digestible protein contents of diets were apparently similar ($P > 0.05$) in the diets, the calculated digestible energy content of the diets decreased ($P > 0.05$) as roselle seed meal or kenaf seed meal levels in the diet increased (Table 5). The decrease in digestible energy might be responsible for the depressed growth and poor performance of *O. niloticus* fingerlings fed diet K30 as well as diets R45 and K45 containing the highest levels of roselle seed meal or kenaf seed meal. Similar increases in fibre content of diets containing various fibrous feedstuffs elicited negative effects on weight gain, growth response and protein utilization values from fingerlings of several cultured fish species e.g. American channel catfish - *Ictalurus punctatus* (Leary & Lovell, 1985), grass carp - *Ctenopharyngodon idella* (Mgbenka & Lovell 1987), rainbow trout - *Salmo gairdneri* (Hilton *et al*., 1983; Yamamoto *et al*., 1994), Asian catfish, *Clarias macrocephalus* (Saad *et al*., 1994), hybrid Asian-African catfish, *Clarias macrocephalus* x *C. gariepinus* (Ng & Chen, 2002), clariid catfish hybrid and Mozambique tilapia – *O. mossambicus* (Jackson *et al*.; 1982, Pouomogne *et al*., 1992), and Nile tilapia (Omoregie & Ogbemudia, 1993). Fibre level of 100g $kg^{-1}$ is ideal for omnivorous fish species, above which reduced feed efficiency and digestibility have been reported (Leary *et al*., 197; Anderson *et al*., 1984). Higher dietary fibre could result in dilution of nutrients, thereby evoking poor fish growth (Hilton *et al*., 1983; Mgbenka & Lovell, 1987; Shiau, 1989).

During the feeding trial, the ranges of the water quality parameters were: temperature 26 -28$^{o}$C, dissolved oxygen concentration 6.5-8.1 mg $L^{-1}$, total ammonia 0.1-0.25 mg $L^{-1}$ and pH 6.8-8.2. No critical values were detected for $NO_2$ and $NO_3$. These values were within the acceptable range for tilapia culture (Beveridge & McAndrew, 2000). The proximate composition of the protein feedstuffs are presented in Tables 1 and 5, respectively. Both roselle seed meal and kenaf seed meal had higher crude lipid, crude fibre and ash contents than soybean meal (Table 1). Phosphorus content was similar in soybean meal, roselle seed meal and kenaf seed meal but the calcium content of soybean meal was lower than those of roselle seed meal and kenaf seed meal.

Table 5. Proximate composition (g $kg^{-1}$ dry matter) and digestible contents of diets.

| | S45 | R15 | R30 | R45 | K15 | K30 | K45 |
|---|---|---|---|---|---|---|---|
| Crude protein | 301.7 | 302.3 | 301.9 | 302.0 | 301.7 | 300.9 | 302.4 |
| Crude lipid | 102.3 | 101.7 | 104.6 | 105.2 | 105.9 | 110.1 | 120.7 |
| Crude fibre | 34.8 | 47.4 | 63.5 | 79.0 | 61.3 | 90.6 | 111.3 |
| Total ash | 83.1 | 89.7 | 98.9 | 105.1 | 93.0 | 108.4 | 109.5 |
| Gross energy (MJ $kg^{-1}$) | 18.65 | 18.65 | 18.65 | 18.64 | 18.64 | 18.63 | 18.63 |
| Digestible protein[1] (g $kg^{-1}$) | 269.1a | 269.7a | 270.2a | 270.8a | 269.0a | 268.8a | 268.7a |
| Digestible energy[1] (MJ $kg^{-1}$) | 15.99a | 15.84a | 15.69b | 15.54b | 15.74b | 15.46bc | 15.19d |
| Pellet water stability[2] (LDM, %) | 98.2a | 96.0a | 94.4a | 90.8b | 95.7a | 90.5b | 89.7b |

a, b, c, d, - Values in the same row with similar letters are not significantly different ($P > 0.05$)

[1] calculated from ADC values of protein feedstuffs in Table 4

[2] loss of dry matter = % of dry solid retained after 10 min in water

Essential amino acids (EAA) composition of the protein feedstuffs and diets are presented in Tables 2 and 6, respectively. Arginine and histidine contents of roselle seed meal and kenaf seed meal were higher than that of soybean meal. Isoleucine, leucine, lysine

and threonine contents of both roselle seed meal and kenaf seed meal were lower compared with soybean meal (Table 2) and correspondingly reflected in the diets (Table 6). The individual EAA contents of the experimental diets were similar and comparable and in many cases, they were higher in diets containing roselle seed meal or kenaf seed meal.

Table 6. Essential amino acid composition[1] (g $kg^{-1}$ protein) of diets.

| | S45 | R15 | R30 | R45 | K15 | K30 | K45 |
|---|---|---|---|---|---|---|---|
| Arginine | 41.1 | 45.0 | 49.0 | 52.9 | 46.4 | 51.7 | 57.1 |
| Histidine | 15.3 | 15.8 | 16.3 | 16.8 | 16.3 | 17.4 | 18.4 |
| Isoleucine | 34.5 | 33.8 | 33.1 | 32.4 | 34.5 | 34.5 | 34.4 |
| Leucine | 49.7 | 50.3 | 50.9 | 51.5 | 51.9 | 54.1 | 56.3 |
| Lysine | 40.8 | 41.1 | 41.4 | 41.7 | 42.0 | 43.2 | 44.4 |
| Methionine | 11.1 | 11.4 | 11.8 | 12.1 | 11.5 | 11.9 | 12.3 |
| Phenylalanine | 29.9 | 30.4 | 31.0 | 31.5 | 30.5 | 31.1 | 31.8 |
| Threonine | 24.2 | 24.1 | 24.0 | 23.9 | 24.7 | 25.3 | 25.9 |
| Tryptophan | 8.0 | 8.0 | 8.1 | 8.2 | 8.3 | 8.7 | 9.0 |
| Valine | 31.8 | 32.7 | 33.6 | 34.5 | 33.3 | 34.7 | 36.2 |

[1]Calculated from EAA values of protein feedstuffs in Table 2.

During the feeding trial, acceptance of the diets was good and Nile tilapia fingerlings became accustomed to the diets within the first week. Mortality was low (< 4%) in all diet treatments (Table 7) and morphological defects were not seen in all tilapias. Results of indices of weight gain, growth response, feed efficiency and protein utilization by Nile tilapia fingerlings are presented in Table 7, which shows that the best growth response was obtained in Nile tilapia fingerlings fed with the control diet (S45). Nile tilapia fed with diets R15, R30 or K15 showed no significant differences ($P > 0.05$) in weight gain, specific growth rate (SGR), feed gain ratio (FGR), protein efficiency ratio (PER) and protein productive value (PPV) compared with *O. niloticus* fingerlings fed the control diet S45 (Table 7). However, the values obtained for weight gain, SGR, FGR, PER and PPV were reduced ($P < 0.05$) for *O. niloticus* fingerlings fed with diets R45, K30 and K45.

Table 7. Growth and protein utilization of Nile tilapia fingerlings fed diets for 70 days.

| Diets | Mean wt. (g) | | WG[1] | SGR[2] | FGR[3] | PER[4] | PPV[5] | Mortality |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | (% fish$^{-1}$) | (% day-$^{1}$) | | | (%) | (%) |
| S45 | 13.2 | 58.4a | 342.4a | 2.12a | 1.6a | 1.70a | 37.19a | 1.67 |
| R15 | 13.1 | 57.2a | 336.6a | 2.11a | 1.7a | 1.68a | 36.95a | 3.33 |
| R30 | 13.0 | 54.8a | 321.5a | 2.06a | 1.7a | 1.66a | 36.88a | 3.33 |
| R45 | 13.0 | 49.1b | 277.7b | 1.90b | 2.1 | 1.32b | 30.92b | 1.67 |
| K15 | 13.2 | 55.9a | 323.5a | 2.06a | 1.8a | 1.67a | 36.76a | 1.67 |
| K30 | 13.1 | 48.3b | 268.7b | 1.86b | 2.3b | 1.26b | 30.83b | 3.33 |
| K45 | 13.1 | 46.4b | 254.2b | 1.81b | 2.5b | 1.20b | 30.24b | 1.67 |

a, b, - Values in the same column with similar letters are not significantly different (P > 0.05)
[1]weight gain = [(final wt. – initial wt.)/initial wt.)] x 100
[2]specific growth rate = [(ln final wt. – ln initial wt.)/no of days] x 100
[3]feed gain ratio = feed intake (g)/body weight gain (g)
[4]protein efficiency ratio = body wt. gain (g)/protein intake (g)
[5]protein productive value = [protein gain (g)/protein intake (g)] x 100

Reduced weight gain, depressed growth response and poor feed utilization in various aquaculture species fed with diets containing high levels of plant proteins have been explained by sub-optimal amino acid balance, low levels of phosphorus, inadequate energy, low feed intake caused by poor palatability or presence of endogenous anti-nutrients (Jauncey, 1998). The EAA composition of the experimental diets were similar and comparable (Table 6) and no deficiencies in EAA contents of diets R45, K30 and K45 relative to control diet S45 were apparent; and was therefore not responsible for the poor performance (low weight gain, retarded growth, poor protein utilization) of *O. niloticus* fingerlings fed with diet K30. Both roselle seed meal and kenaf seed meal would contain residual amount of antinutrients (Abu-Tarboush *et al*., 1997) that are characteristic of members belonging to the plant family Malvaceae. High levels of these antinutrients reduce lysine bioavailability and cause depressed appetite and loss of body weight. Toxicity was however light in this study and did not manifest histological abnormalities in the liver. Phosphorus requirements for tilapia would have been met in the diets with calcium phosphate supplementation.

As *O. niloticus* fingerlings in all treatments readily accepted the diets, palatability did not seem to pose a problem. These then leave high crude fibre content of both roselle seed meal and kenaf seed meal, hence low energy digestibility as the causes of poor growth of *O. niloticus* fingerlings in diet K30 treatment and at the highest dietary inclusion levels of roselle seed meal (diet R45) or kenaf seed meal (K45), respectively, which provided 45 % of total dietary protein. The poorer protein utilization in diets K30 and K45 was also due to the lower digestible energy content of kenaf seed meal (Table 1), which could indicate that more protein would have been used to produce energy. If this is true, the metabolic use of kenaf seed meal protein at high dietary inclusion levels could be improved by increasing the digestible energy level in the diet through gelatinized starch supplements. HSI values did not show any trend relating to diet treatment (Table 8) and histological examination of the livers of the *O. niloticus* fingerlings fed the different experimental diets revealed no alterations or any lesions suggestive of nutritional disorders. Carcass composition of tilapia at the start and end of the feeding trial are presented in Table 8. Generally, Nile tilapia fingerlings fed with

test feedstuff diets containing roselle seed meal or kenaf seed meal had higher moisture and ash contents as well as lower crude protein and crude lipid contents after the feeding trial compared with Nile tilapia fingerlings in the control diet treatment. However, no clear trend was observed in relation to roselle seed meal or kenaf seed meal levels in the diets (Table 8).

Table 8. Carcass composition of Nile tilapia fingerlings fed diets for 70 days.

| Diets | HSI[1] (%) | Carcass composition | | | |
|---|---|---|---|---|---|
| | | Moisture | Protein | Lipid | Ash |
| Initial fish sample | 1.79a | 74.7b | 13.1c | 2.9a | 2.1a |
| S45 | 1.77a | 76.9a | 16.8a | 2.7a | 1.5b |
| R15 | 1.79a | 77.2a | 16.3b | 2.3b | 1.8a |
| R30 | 1.76a | 77.3a | 16.2b | 2.2b | 1.9a |
| R45 | 1.78a | 77.2a | 16.3b | 2.2b | 1.8a |
| K15 | 1.76a | 77.4a | 16.4b | 2.3b | 1.9a |
| K30 | 1.77a | 77.5a | 16.3b | 2.3b | 1.8a |
| K45 | 1.79a | 77.3a | 16.3b | 2.2b | 1.9a |

a, b, - Values in the same column with similar letters are not significantly different ($P > 0.05$)
[1]Hepatosomatic index = (liver wt./body wt.) x 100

Roselle seed meal replaced peanut meal with no adverse effects on growth of broiler chicks and laying hens (Mohammed & Idris, 1991; Backeit *et al*., 1994). Roselle seed meal was also included in broiler diet up to 300 $g.kg^{-1}$ diet without lowering growth response or feed utilization (Cortés *et al*.; 1996, Jínez *et al*., 1998). In *O. niloticus* diets, roselle seed meal could not replace 75% of soybean meal protein without affecting growth and protein utilization, because of low nutrient digestibility (Fagbenro & Davies, 2000). However, this study reports the first evaluation of kenaf seed meal in complete diets for *O. niloticus* fingerlings. Results from this study show that roselle seed meal and kenaf seed meal can provide up to 30% and 15% of total protein respectively, in practical diets for *O. niloticus* fingerlings without compromising growth and nutrient utilization.

Considering the absence of any histological change in livers of *O. niloticus* fingerlings and its economic advantage in the cost of tilapia nutrition, roselle seed meal or kenaf seed meal may be recommended as alternatives to soybean meal as a dietary protein source, provided they do not replace > 30% or 15% of soybean meal protein, respectively. Their high crude fibre content and lower energy digestibility will almost certainly limit the use beyond this level in tilapia diets. Although no physical abnormalities or deleterious effect emerged from this study, long-term growth and histopathological studies are required over a complete growing cycle in ponds.

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