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Arori MK
University of Nairobi, School of Biological Sciences, Nairobi, Kenya

Muthumbi AWN
University of Nairobi, School of Biological Sciences, Nairobi, Kenya

Mutia GM
South Eastern Kenya University, School of Water Resources Science and Technology, Kitui, Kenya

Nyonje B
Kenya Marine and Fisheries Research Institute, Mombasa, Kenya

Correspondence
Arori MK
University of Nairobi, School of Biological Sciences, Nairobi, Kenya

Potential of seaweeds (*Hypnea cornuta* and *Hypnea musciformis*) in Nile tilapia (*Oreochromis niloticus*) fingerlings diets

Arori MK, Muthumbi AWN, Mutia GM and Nyonje B

Abstract
The study was conducted to evaluate the potential of selected seaweeds in Nile tilapia *Oreochromis niloticus* fingerlings diets. Two species of seaweeds, *Hypnea cornuta*, and *Hypnea muscifomis* were sampled from the Kenyan coast and their chemical composition determined. They both had crude protein content above 20%. Five diets with crude protein of 35% were formulated with different levels of seaweed content of 0% seaweed (control), 20% *H. cornuta*, 30% *H. cornuta*, 20% *H. musciformis* and 30% *H. muscifomis* to partially replace the protein ingredient (fresh water shrimp). These diets were fed in triplicate to 450 tilapia fingerlings stocked in glass tank aquaria for a period of 60 days. The results showed significant comparison between *H. cornuta* diets and the control diet. This generally concluded that low inclusion of seaweed especially *H. cornuta* as protein source, can partially replace freshwater shrimp in Nile tilapia fingerling diet.

Keywords: *Hypnea musciformis*, *Hypnea cornuta*, *Oreochromis niloticus*, growth performance, partial replacement, protein source

1. Introduction
Aquaculture growth is positively correlated to the progressive use of quality feeds which have nutrients that meet requirements of the fish species under culture. However, fish feed is one of the major and costly inputs in aquaculture production and it has caused a great challenge to the development and growth of the aquaculture sector worldwide [8]. This problem is persistent and is majorly contributed by the cost of fish meal which is widely used protein ingredient in fish feeds. Therefore, it is important to seek other sources which are satisfactory alternative protein sources for fish feed and can provide similar nutritional benefit at lower cost. These alternative sources can totally or partially replace fish meal as protein source in fish feed so as to eventually cut down the cost of fish feed [16].

Studies done to determine potential of seaweed as a possible feed ingredient and alternative protein source for farmed fish [13] have shown that fish feeds with seaweed incorporated provide good quality lipids and proteins [12]. Total replacement of fish meal by algal meal has recorded very poor growth performance for *O. niloticus*. This may be caused by factors including low digestibility of plant materials [11]. Therefore, the use of moderate algal inclusion in fish feed has been recommended since it records good growth responses, good feed utilization, higher survival rate, improved immunity and improved carcass quality [11].

Several seaweed studies [21, 22, 20] and feeding trials have been done worldwide to assess seaweeds as fish feed [6, 1], but Kenya has not yet carried out such studies. Mwalugha *et al*, (2014) [21] have reported the nutrient composition of several seaweeds along the Kenyan coast. Most of them contained significant amount of crude protein and crude lipids among other nutrients that are essential for fish growth hence setting a basis for their potential inclusion in fish feeds.

Nile tilapia (*O. niloticus*) is the most commonly farmed fish species which accounts for 75% of the Kenyan aquaculture production [19]. The major problem that culture faces in the country is lack of affordable and quality feeds [23]. This fish species requires higher protein level in their diet during earlier stages of their life. The major source of protein used in Kenya fish feed is from the fresh water shrimps that are sourced from Lake Victoria and fish meal from freshwater and marine sources.

Due to the rise in aquaculture practise in the country, these two sources of protein are being overexploited and their stock in the natural system continues to decline hence increasing their prices in the market [24]. Therefore, the aim of this study was to assess the potential of selected species of seaweeds from Kenyan coast as Nile tilapia fish feed ingredients to partially replace fresh water shrimps and evaluate its effect on the fish growth.

2. Materials and Methods

2.1 Acquisition of Materials

The two species of seaweeds (*Hypnea cornuta* and *Hypnea musciformis*) which belong to the genus Rhodophyta (red algae) were collected during low tide at Mkomani beach along Nyali creek and Kanamai beach in Mtwapa during the months of October, November and December in the year 2017. After collection the seaweeds were placed in clean buckets and thoroughly washed with seawater then rinsed with fresh tap water before placing them on blotting paper to remove excess water. After which they were oven dried at 37 ^{o}C-39 ^{o}C for up to 72 hours to avoid protein denaturation and attain a crispy form for easier of grinding into powder. Freshwater shrimps (*Caridina nilotica*) used as control feed ingredient and wheat bran were bought from the local market, sorted out dirt, and dried then grinded into powder using a blender.

Tilapia monosex fingerling of size range 0.6cm-1.6cm length and 1.3g - 1.5g weight were purchased from green algae fish farm in Sagana and transported to University of Nairobi culture facility in oxygenated bags. They were acclimatized for two days while being feed on the control diet to satiation.

2.2 Nutritional Analysis

Proximate analysis of Triplicate samples of seaweeds (*Hypnea cornuta* and *Hypnea musciformis*) and freshwater shrimps was done according to the standard procedures given in association of official analytical chemists [3], to determine the following chemical composition.

2.3 Feed Formulation

Feed ingredients including freshwater shrimp, *Hypnea cornuta*, *Hypnea musciformis* and wheat bran were used in the formulation of the experimental feed with consideration to the Pearson Square method to make a complete fish feed. Freshwater shrimp was used in the formulation of the control diet and partially included in other feeds to make up to 35% protein content while wheat bran was used as the carbohydrate source in all the diets. The ingredients were mixed to form five different diets. The proportion of each component used (0%, 20%, 30%, freshwater shrimp and wheat bran) in the diet was determined by the protein content of each constituent.

2.4 Feeding Protocol

After fish acclimatization they were stocked in 15 separate tanks of 112,000 cm^3 (80x35x40cm) by volume. This contained three replicate tanks for each of the experimental diets with stocking density of 30 fish per tank. The fish were feed three times a day, at 9.00am, 1.00pm, and 4.00pm for 60 days. The feeds were distributed evenly in each tank for the fish to feed to satiation. During the first four weeks the fish were fed at 10% body weight and during the remaining four weeks the quantity was increased to 15% body weight.

2.5 Growth Parameters and Nutritional Utilization

The total length of fish was measured using a measuring board while its body weight was measured using a 0.01g Denver instruments XL-6100 sensitive weighing scale. The following growth and feed utilization parameters were calculated; Weight gained, Specific growth rate, Feed conversion ratio (FCR) and Condition factor.

2.6 Statistical Analysis

All data was presented as means ± SE (standard error). The data obtained was analysed using one-way Analysis of Variance (ANOVA) on a GENSTAT program version 15. Difference between the treatment means were considered significant at $p<0.05$ level. The effect between the different diet treatments on specific growth rate (SGR), total weight gained and survival rate (%) were analysed using one-way ANOVA followed by turkey's multiple range test to compare statistical difference among treatment means.

3. Results

3.1 Chemical composition of diet ingredient

Proximate analysis of two experimental seaweeds and the freshwater shrimps shows that the species varied in nutritional composition (Table 1). Freshwater shrimps had the highest percentage of crude protein, lipids and energy that significantly differed from that of both seaweeds. *Hypnea cornuta* had slightly higher percentages of crude protein, ash, lipids and energy content compared to *H. musciformis*. On the other hand, *H. musciformis* had significantly higher percentages of moisture content and crude fibre compared to *H. cornuta*.

Table 1: chemical composition of selected seaweeds and freshwater shrimps (%)

Parameters	*Hypnea cornuta*	*Hypnea musciformis*	freshwater shrimps
Moisture	8.36±0.386b	12.48±0.35a	1.23±0.0234c
Fat	1.24±0.005b	0.283±0.006c	4.64±0.0145a
Protein	22.4±0.072b	21.55±0.081b	48.53±0.0141a
Ash	26.72±0.017a	25.78±0.044a	3.43±0.0325b
Fibre	5.08±0.003b	6.25±0.026a	0.23±0.256c
CHO	36.19±0.373b	33.33±0.302c	41.93±0.0254a

Means (±se) values followed by the same letter in the same rows are not significantly different ($p<0.05$)

3.2 Growth performance of Tilapia fingerlings

There was observed a gradual increase in body weight of the fingerlings from average of 1.3g to average of 9.7g (figure 1) by the end of the experimental period. Tilapia fingerlings fed on 20% *H. cornuta* and 30% *H. cornuta* diets had high weight gain when compared to control, 20% *H. musciformis* and 30% *H. musciformis*. There was no significant variation in weight gained between fish fed on 20% *H. musciformis* and fish fed on control diet. The lowest weight gain was recorded in fish fed 30% *H. musciformis diet* (Table 2).

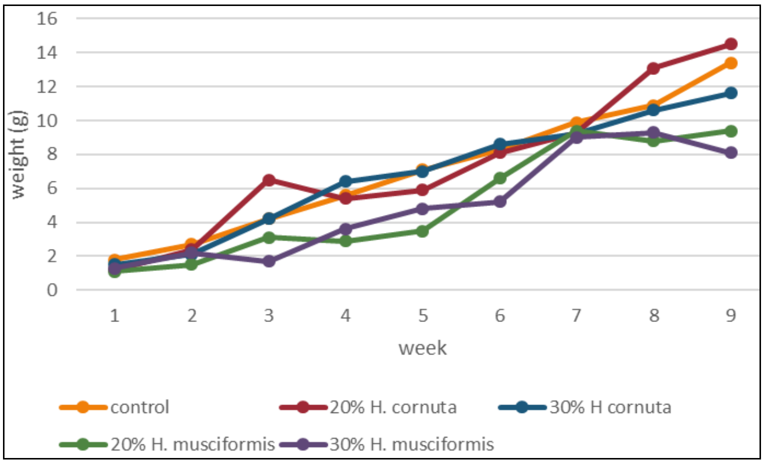

Fig 1: Weight of *O. niloticus* over the experimental period.

Specific growth rate**,** there was no significant variation in specific growth rate (SGR) of tilapia fingerling among the five treatment diets administered. The highest specific growth rate was observed in fish feed on 20% *H. cornuta* and the lowest was on feed fed on 30% *H. musciformis* (Table 2). Survival rate of fish among all diets was 100%. Food conversion ratio (FCR) was low in fish fed on control diet followed by 20% *H. cornuta*, 30% *H. cornuta*, 20% *H. musciformis* and highest in fish feed on 30% *H. musciformis* (Table 2). There was significant difference between control, 20% *H. cornuta*, 30% *H. cornuta*, 20% *H. musciformis* and the diet containing *30% H. musciformis.* Condition factor was high for fish fed on 30% *H. musciformis* diet followed by the 20% *H. musciformis*, 30% *H. cornuta*, and control. There was no significant difference between the diets containing *H. cornuta* and control and between the diets containing *H. musciformis* (Table 2).

Table 2: Growth performance and survival rate of tilapia fingerlings in different treatment diets during the two months study period

Diets	Initial weight	Final weight	Weight gain	% weight gain	SGR%(g day−1)	Survival (%)	Condition Factor	FCR
20% cornuta	1.52±0.076ab	10.83±0.251a	9.30±0.249a	611.8±36.327a	3.27±0.036a	100	1.22±0.032a	1.430±0.029a
30% cornuta	1.55±0.056a	10.83±0.232a	9.28±0.232a	598.7±26.417a	3.25±0.028a	100	1.35±0.025b	1.425±0.024a
20% musciformis	1.37±0.047b	9.49±0.161b	8.12±0.158b	592.7±38.490a	3.23±0.031a	100	1.07±0.054c	1.445±0.026b
30% musciformis	1.34±0.053b	8.46±0.222c	7.12±0.230c	531.3±33.771b	3.07±0.038a	100	1.84±0.031c	1.567±0.032c
Control Diet	1.33±0.064b	9.38±0.277b	8.05±0.286b	605.2±53.319a	3.26±0.064a	100	1.21±0.054a	1.420±0.054a

4. Discussion

4.1 Chemical Composition of diet ingredients (crude protein)

Chemical composition enables the balance of various nutritional components during fish feed formulation especially crude protein. The red seaweeds (Rhodophyta) have high nutritional value when compared to brown and green seaweeds [14]. Protein content is normally higher in Rhodophyta compared to other seaweeds [22]. This concurred with the above findings that *H. musciformis* and *H. cornuta* which are Rhodophytes had protein content of more than 20% (Table 1).

Similar results were recorded by (Mwalugha *et al*, 2015) [22], who found that *Hypnea* spp. (21.39%) and *H. musciformis* (19.79%) along the Kenyan coast had the highest protein content compared to other species of seaweeds he was studying. (Mwalugha, 2014) [21] Reported a crude protein 14.17% for *H. musciformis* in Kenyan coast. (Carneiro *et al*, 2014) [5] Reported protein content of 17.12% on *H. muscfiormis* found in Brazil. These were slightly lower compared to crude protein recorded in this study. There are no published chemical composition results for *H. cornuta*.

Freshwater shrimps used as control had the high crude protein (48.53%) as compared to the seaweeds. It is because of its protein content that has made it more preferred by farmers as an ingredient for animal feeds. Unfortunately, this has caused its overexploitation hence making it scarce and expensive therefore need to partially or totally replace it in feed so as to reduce feed cost [24].

4.2 Growth Performance

The Nile tilapia fingerlings in this study accepted the experimental diets and were fed to satiation hence good palatability of the diets. This can be explained by Nile tilapia being omnivorous hence readily consuming feeds with both animal and plant ingredients and showing increased growth performance with plant supplemented diets [1].

Growth performance of fish fed on diets with partial seaweed inclusions was comparable to the control diet. However, *H. cornuta* diet performed better compared to *H. musciformis* diet and diets with 20% seaweed inclusion performed better than those with 30% inclusion. Earlier studies have shown that inclusions at 20% or lower of various species of seaweeds tend to perform better than 30% inclusions and higher [6, 13]. These studies show that low algae inclusion in fish feed improve growth and digestive efficiency of feed [6]. This is observed under the growth performance of experimental diets with 20% seaweed inclusion. The decrease in fish growth and feed utilization when a feed has higher levels of seaweeds could be because of the existence of anti-nutritional factors like saponin, tannins and gossypols that occur in several plants [9]. These anti-nutritional factors interfere with digestion and absorption of food hence somehow supressing growth of fish [10]. This therefore compromises the feed conversion throughout the feeding period. There are studies on methods to eliminate or inactivate the anti-nutritional factors in feeds [10]. The more the fibre content in a feed, 30% *H. musciformis* diet (Table 1) seems to reduce the growth performance of the fish feed on that diet (Table 2). This is because increased fibre content in fish feed reduces feed digestibility [2].

4.3 Nutritional Utilization and Survival rate

Feed conversion ratio (FCR) is the rate that measures how efficient the feed given to fish is converted into fish flesh. In this study the FCR ranged between 1.4 and 1.5 (table 2), meaning for the fish to gain 1kg of flesh it will consume 1.4kg-1.5kg of the seaweed diet. Control diet, 20% *H. cornuta*, 30% *H. cornuta* and 20% *H. musciformis* had significantly low FCR as compare to 30% *H. musciformis*. This indicates that diet, *H. cornuta* diets and 20% *H. musciformis* diet gave FCR that is comparable to freshwater shrimp diets hence favourable as fish feed ingredient since the lower the FCR the higher the feed utilization efficiency and the higher the fish weight gain [27]. This also means that less feed is lost as waste into the pond hence less water pollution and greenhouse gas emissions during the culture period [25].

This study results concurs with [4] who found that Nile Tilapia showed low FCR when fed with seaweed diet hence recommended the diet as a partial substitute for fish meal. (Ergun *et al*, 2008) [7] Reported that Nile tilapia juveniles fed on ulva meal diet improved their FCR. (El-tawil, 2010) [6] Recorded best FCR in fish fed on 20% Ulva and it decreased with decrease in seaweed inclusion in the diet.

In this study, there was 100% survival rate of fish among all the experimental diets (Table 2). This may be due to the provision of optimum physico- chemical water parameters and complete feed that favoured the survival and general growth of fish [17]. These results concurred with (Khalafalla *et al*, 2015) [15] and (Hussein, 2017) [13] who recorded 100% survival rate during the entire experimental period in all experimental units after feeding Nile tilapia a feed supplemented with brown seaweed (*Ascophyllum nodosum*) meal, *Ulva rigida, Pterocladia capillaceaas* and *Taonia atomaria* seaweed species respectively. This may suggest that seaweed diets are palatable to Nile tilapia hence attaining 100% survival rates.

The condition factor of the experimental fish also suggests that they were provided a favourable condition and were in good health. This is because the condition factor range in all experimental diets was above one giving an indication that their growth was isomeric [18]. This study concurs with (Shahabuddin *et al.*, 2015) [26], who recorded condition factor range 1.2-1.7 on Nile tilapia juveniles fed on diets containing *Pyropia spheroplasts* seaweed. (Younis *et al.*, 2018) [28] Recorded a constant condition factor of 1.6 on Nile tilapia fed on diets containing red algae, *Gracilaria arcuate.* This therefore suggests that diet containing seaweed have no effect on the growth condition and health of Nile tilapia during culture.

5. Conclusion

This research concludes that some sea weeds have significant amount of crude protein that can be used in fish feed formulation. However, the research also shows that small inclusions of the seaweeds in diet have significant growth performance. This potentially suggests that partial replacement of seaweeds in *O. niloticus* juvenile diet can give a quality and inexpensive feed in the fish feed market.

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7. References

1. Abdel-Warith AWA, Younis EMI, Al-Asgah NA. Potential use of green macroalgae *ulva lactuca* as a feed supplement in diets on growth performance, feed utilization and body composition of the African catfish *Clarias gariepinus*, Saudi Journal of Biological Sciences. 2016; 23:404-409.
2. Anderson J, Jackson AJ, Matty AJ, Capper BS. Effects of dietary carbohydrate and fibre on the tilapia *Oreochromis niloticus* (Linn.). Aquaculture. 1984; 37(4):303-314.
3. AOAC. Official methods of analysis of AOAC international, 20th edn, *Association of official analytical chemist*. Washington, DC. USA, 2000, 24-7.
4. Bindu MS, Sobha V. Conversion efficiency and nutrient digestibility of certain seaweed diets by laboratory reared *Labeo rohita* (Hamilton). Indian Journal of Experimental Biology. 2004; 42:1239-1244.
5. Carneiro JG, Rodrigues JAG, Teles FB, Cavalcante ABD, Benevides NMB. Analysis of some chemical nutrients in four Brazilian tropical seaweeds. *Acta Scientiarum.* Biological Sciences. 2014; 36(2):137-145.
6. El-Tawil NE. Effects of green seaweeds (*Ulva* sp.) as feed supplements in red tilapia (*Oreochromis* sp.) diet on growth performance feed utilization and body composition. Journal of the Arabian Aquaculture Society. 2010; 5(2):179-194.
7. Ergun S, Tekesoglu H, Yigit M. Effects of dietary natural zeolite levels on ammonia excretion rates in young Rainbow trouts (*Oncorhynchus mykiss*). Fresenius Environmental Bulletin. 2008; 17:245-248.
8. FAO: Food and Agriculture Organization. Report of the FAO Expert Workshop on on-farm feeding and feed management in aquaculture. Manila, the Philippines. FAO Report No. 949. Rome, FAO. 37, 2010.
9. Francis G, Makkar HPS, Becker K. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture Elsevier, 2001; 199:197-227.
10. Hajra A, Mazumder A, Verma A, Ganguly DP, Mohanty PB, Sharma PA. Antinutritional factor in plant origin fish feed ingredients. The problems and probable remedies. Advances in Fish Research. 2013; 5:193-202.
11. Hasan MR, Chakrabarti R. Use of algae and aquatic macrophytes as feed in small-scale aquaculture: a review. FAO Fisheries and Aquaculture Technical Paper No. 531. Rome, FAO. 123, 2009.
12. Henry EC. The use of algae in fish feeds as alternatives to fish meal. International Aquafeed, 2012, 10-19.
13. Hussein MEE. Effect of seaweed supplemented diet on Nile Tilapia *Oreochromis niloticus* performance. International Journal of Fisheries and Aquatic Studies. 2017; 5:2205-210.
14. Ito K, Hori K. Seaweed: Chemical composition and potential foods uses. Food Reviews International. 1989; 5:101-144.
15. Khalafalla MM, El-Hais AEM. Evaluation of Seaweeds *Ulva rigida* and *Pterocladia capillaceaas* Dietary

Supplements in Nile Tilapia Fingerlings. Journal of Aquatic Resource Development. 2015; 6(312):2.
16. Kumar S, Kumar M. Innovative outdoor fish farming technologies and technical solutions-applicable to low investment farming opportunities. NARIC-HAKI, 2015.
17. Makori AJ, Abuom PO, Kapiyo R, Anyona DN, Dida OG. Effects of water physico-chemical parameters on tilapia (*Oreochromis niloticus*) growth in earthen ponds in Teso North Sub-County, Busia County. Journal of Fisheries and Aquatic Sciences. 2017; 20:30.
18. Migiro KE, Ogello OE, Munguti JM. The Length-Weight Relationship and Condition Factor of Nile Tilapia (*Oreochromis niloticus L*.) Broodstock at Kegati Aquaculture Research Station, Kisii, Kenya. International Journal of Advanced Research. 2014; 2:777-782.
19. Munguti JM, Musa S, Orina SP, Charo-karisa H, Ogello OE. An overview of current status of Kenya fish feed industries and feed, management practices challenges and opportunities. International Journal of Fisheries and Aquatic Studies. 2014; 1(6):128-137
20. Muraguri EN, Wakibia JG, Kinyuru JN. Chemical Composition and Functional Properties of Selected Seaweeds from the Kenya Coast. Journal of Food Research. 2016; 5(6):114.
21. Mwalugha H. Preliminary studies on the proximate composition of some selected seaweeds from Mkomani and Kibuyuni, Kenya. In Scientific Conference Proceedings, 2014.
22. Mwalugha HM, Wakibia JG, Kenji GM, Mwasaru MA. Chemical Composition of Common Seaweeds from the Kenya Coast. Journal of Food Research. 2015; 4(6):28.
23. Neira I, Engle CR, Ngugi C. Economic and risk analysis of tilapia production in Kenya. Journal of Applied Aquaculture. 2009; 21(2):73-95.
24. Ogello EO, Munguti JM, Sakakura Y, Hagiwara A. Complete Replacement of Fish Meal in the Diet of Nile Tilapia (*Oreochromis niloticus L*.) Grow-out with Alternative Protein Sources. International Journal of Fisheries and Aquatic Studies. 2014; 2(8):962-978.
25. Robb DH, MacLeod M, Hasan MR, Soto D. Greenhouse gas emissions from aquaculture: A life cycle assessment of three Asian systems. FAO Fisheries and Aquaculture Technical Paper, 2017, 609.
26. Shahabuddin AM, Khan MND, Saha D, Ayna E, Wonkwon K, Murray WW *et al*. Length-weight relationship and condition factor of juvenile Nile Tilapia *Oreochromis niloticus* (Linnaeus 1758) Fed Diets with *Pyropia spheroplasts* in closed recirculating system. Asian Fisheries Science. 2015; 28:117-129.
27. Usaid. Harvest: Feed conversion ratio; Technical bulletin#7https://pdf.usaid.gov/pdf_docs/PA00K8MQ.pdf .2011
28. Younis ESM, Al-Quffail AS, Al-Asgah NA, Abdel-Warith AWA, Al-Hafedh YS. Effect of dietary fish meal replacement by red algae, *Gracilaria arcuata*, on growth performance and body composition of Nile tilapia *Oreochromis niloticus*. Saudi Journal of Biological Sciences. 2018; 25(2):198-203.