www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 11: 185-190 (2011) DOI: 10.4194/trjfas.2011.0202

Evaluation of Cooked and Mechanically Defatted Sesame (*Sesamum indicum*) Seed Meal as a Replacer for Soybean Meal in the Diet of African Catfish (*Clarias gariepinus*)

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Received 16 September 2010
Accepted 29 November 2010

Abstract

A 56-day feeding trial was conducted to assess the replacement value of cooked and mechanically defatted sesame seed meal as dietary replacement of soybean meal in diets of *Clarias gariepinus*. All diets were prepared to be isonitrogenous, (40% crude protein), isolipidic (12% lipid) and isoenergetic (18 Mj/g). Cooked and mechanically defatted sesame seed meals were used to replace soybean meal at a rate of 0, 25, 50, 75, 100% respectively. The performance of the fish fed sesame seed meal-based test diets was compared to fish fed a soybean meal-based control diets containing 40% crude protein. Each treatment had three replicates using 15 catfish fingerlings per tank with mean initial body weight of 6.37±0.21 g. There was no significant difference (P>0.05) in protein productive value, feed intake; specific growth rate, % weight gain and crude deposition between fish fed control diets and fish fed diets containing 25% sesame. Similarly there was no significant difference (P>0.05) in protein productive value, feed intake; specific growth rate, % weight gain and crude deposition between fish fed fish fed diets containing 25% sesame and fish fed diets containing 50% sesame. However, a significant difference (P<0.05) was recorded between fish fed control diets and fish fed other test diets using the above indices. Comparable performance in growth nutrient utilization and carcass crude protein deposition in *Clarias gariepinus* fed diets with SSM25 and SSM50 showed that these meals could be viable means of improving the cost of fish feeding.

Keywords: Sesame, African catfish, soybean meal, mechanically defatted.

Afrika Yayın Balığı (*Clarias gariepinus*) Diyetinde Pişmiş ve Mekanik olarak yağı uzaklaştırılmış Susam (*Sesamum indicum*) Tohumu Küspesinin Soya Küspesinin İkamesi Olarak Değerlendirilmesi

Özet

Clarias gariepinus diyetindeki soya küspesi yerine pişirilmiş ve mekanik olarak yağı uzaklaştırılmış susam tohumu küspesi ikame edilmesinin etkisini belirlemek için 56 günlük bir yemleme denemesi yürütülmüştür. Tüm diyetler, izonitrojenik, (%40 ham protein), isolipidik (%12 lipid) ve izoenerjik (18 Mj/g) olacak şekilde hazırlanmıştır. Soya küspesinin %0, 25, 50, 75, 100'i pişirilen ve mekanik olarak yağı ayrılan susam tohumu küspesi ile ikame edilmiştir. Susam tohumu küspesi içeren diyetlerin performansı, %40 ham protein içerikli soya küspesi içeren kontrol diyeti ile kıyaslanmıştır. Her muamele tank başına ortalama başlangıç ağırlığı 6,37±0,21g olan 15 adet yayın balığı ile 3 tekkerrürlü olarak yürütülmüştür. Protein verim değerinde, yem alımında, spesifik büyüme oranında, % ağırlık artışında ve ham protein birikiminde %25 susam içeren (SSM25) balık yemi ile beslenen balıklar ile kontrol diyeti ile beslenen balıklar arasında önemli bir fark (P>0,05) görülmemiştir. Benzer olarak, protein verim değerinde, yem alımında, spesifik büyüme oranında, % ağırlık artışında ve ham protein birikiminde %25 susam içeren balık yemi ile beslenen balıklar ile %50 susam içeren balık yemi (SSM50) ile beslenen balıklar arasında önemli bir fark (P>0,05) görülmemiştir. Buna rağmen, kontrol diyetiyle beslenen balıklar ile diğer deneme diyetleriyle beslenen balıklar arasında yukarıdaki indisler bakımından önemli farklılıklar (P<0,05) kaydedilmiştir. *Clarias gariepinus* un SSM25 ve SSM50 diyetlerinde büyüme amaçlı besin kullanımı ve karkas ham protein birikimi'nin kıyaslanabilir performansı, bu dietlerin yem maliyetinin iyileştirilmesi için uygulanabilir olduğunu göstermiştir.

Anahtar Kelimeler: Susam, Afrika Yayın Balığı, Soya dieti, Mekanik olarak yağın ayrılması.

Introduction

Catfish farming and indeed aquaculture offer strong potential for growth to meet the national fish demand thereby reducing importation, provides employment, alleviates poverty and helps to meet the millennium development goals. This potential is great as Nigeria is endowed with over 12 million ha of inland water and suitable soil for fish farming (Williams *et al*., 2007). The current very rapid increase in intensification of freshwater farming in Nigeria is evidenced in Williams *et al*. (2007). After the Fish For All Summit of 2005 in Nigeria, the awareness and interest in fish farming increased tremendously that as many as 40 % of over 5000 prospective farmers trained in its nation-wide fish farming workshop in five geo-political zones of the country adopted the practice almost immediately. However, cost of feed ingredients may limit the growth and expansion rate of aquaculture industry. Fishmeal production is rather localised in some regions of the world, as a result of which it is becoming more expensive and difficult to obtain in many countries practising aquaculture. Soybean meal (SBM) has high protein content and the best protein quality among plant protein feedstuffs used in fish feeds (Davies *et al*., 1999). It has been reported to partially or totally replace fish meal in diets of many aquaculture species (Lovell, 1988; Lim and Akiyama, 1992) hence it is widely used as a cost-effective feed ingredient for many aquaculture animals (Storebakken *et al*., 2000); it is currently the most commonly used plant protein source in fish feeds (El-Sayed, 1999). However, wider utilization and availability of this conventional source for fish feed is limited by increasing demand for human consumption and by other animal feed industries (Siddhuraju and Becker, 2001). This phenomenon according to Balogun (1988) has hindered the expansion and profitability of aquaculture enterprise in many developing countries and has to encourage the need to look for cheaper alternative protein source for the development of low-cost feed that can replace this conventional feedstuff without reducing the nutritional quality of the diets. It then becomes a priority to look for less expensive plant protein sources which would be beneficial in reducing feed costs (Barros *et al*., 2002).

Sesame seed (*Sesamum indicum*) is one of the important annual crops of the world grown for oil. Sesame cake/meal (SSM) is obtained as byproducts of oil extraction process deploying converting waste to wealth principle. Work on the use of oilseeds residue such as sesame meal in warm water fish nutrition is limited (Davies *et al*., 1999). Sesame seed cake is not commonly used as animal feed ingredients but has nutritive potentials as a feedstuff in diets for warm water fish species (Hossain and Jauncey, 1989). Its incorporation in fish diets has been little investigated (Olukunle and Falaye, 1998).

This study thus evaluates the sesame meal left over after oil production process as a replacer of highly demanded soybean meal in *Clarias gariepinus* diets using growth, digestibility and nutrient utilization as indices.

Materials and Methods

The feed ingredients; fish meal, soybean meal (SBM), corn, vit-min premix were bought from the University of Agriculture Abeokuta (UNAAB) feed mill, Kotopo, Abeokuta, Ogun State. Vegetable oil and starch were bought from Kuto market, Abeokuta Ogun state. Fish oil (cod liver oil) was bought from a pharmacy store. These ingredients were separately milled, screened to fine particle size (<250 µm) and triplicate samples were analysed for proximate composition. Sesame seedmeal were obtained from a farm in Kebbi State and ground in a hammer mill and the oil was removed from the seed meal using the pressure generated from locally made screw press. After 72 hours, the defatted cake was analysed for its proximate composition (AOAC, 1990) as presented in Table 1.

Based on the nutrient composition of the protein feedstuff (Table 1), five isonitrogenous and isoenergetic (containing 40% crude protein, 12% crude lipid and 18.45 Mj/g gross energy) experimental diets were formulated. The experimental diets were formulated to produce diets in which 0% (SSM0), 25% (SSM25), 50% (SSM50), 75% (SSM75), and 100% (SSM100) of proteins from SBM were replaced with that from SSM. The fish oil and soybean oil (V/V=1:1) were added to keep lipid and energy constant in all treatments. The feedstuffs were blended, moistened, steam pelleted producing 2.0 mm diameter pellets and oven dried for 24 h as presented in Table 2.

Clarias gariepinus fingerlings were acclimated to experimental condition for 7 days prior to the feeding trial. Groups of 15 catfish fingerlings (6.37±0.21 g) were stocked into aquaria comprising 60 litre-capacity rectangular plastic tanks. Each diet was fed to the catfish in triplicate tanks twice daily (09.00h, 16.00h) at 5% body weight for 56 days. Fish mortality was monitored daily, total fish weight in each tank was determined at two weeks intervals and the amount of diet was adjusted according to the new weight. Growth response and feed

Table 1. Proximate Composition (%) of the Feed Ingredients

	Feed Ingredients			
Parameter	Fish meal	Soybean	Sesame meal	Corn meal
Moisture	9.75	10.70	10.68	10.48
Crude Protein	71.4	45.74	38.73	9.87
Crude Lipid	10.48	9.68	12.75	4.28
Crude Fibre	-	5.10	5.78	6.29
Ash	8.36	4.48	9.48	6.73
Nitrogen Free Extract	-	30.00	22.56	62.35

Table 2. Gross Composition (g/100 g Dry Matter) of Experimental Diets Fed to *Clarias gariepinus* at Varying Replacement Levels of Sesame Seedmeal Based Diets

Gross Composition	Experimental Diets				
Ingredients	CTR	SSM 25	SSM 50	SSM 75	SSM 100
Fish meal	26.61	26.61	21.61	21.61	21.61
Soybean meal	43.73	32.79	21.86	10.93	-
Sesame meal	-	12.90	25.80	38.70	51.61
Corn meal	10.20	10.20	10.20	10.20	10.20
Fish oil	3.21	3.21	3.21	3.21	3.21
Veg. oil	-	0.13	0.15	-	-
*Vit-Premix	5.00	5.00	5.00	5.00	5.00
Starch	11.25	9.16	7.17	5.00	3.37
Proximate Composition					
Moisture	9.82 ± 0.40^{a}	10.47 ± 0.21^{a}	10.00 ± 0.20^{a}	9.99 ± 0.61^{a}	10.14 ± 0.57^{a}
Protein	39.69 ± 0.02^{a}	38.82 ± 0.40^{a}	39.55 ± 0.49^{a}	39.35 ± 0.49^{a}	40.18 ± 0.11^{a}
Lipid	9.89 ± 0.30^{a}	10.71 ± 0.70^{a}	11.06 ± 0.35^{a}	11.03 ± 0.38^{a}	11.25 ± 0.07^{a}
Fibre	4.79 ± 0.03^{b}	5.81 ± 0.18^{a}	5.55 ± 0.18^{a}	5.66 ± 0.35^{a}	5.94 ± 0.30^{a}
Ash	6.65 ± 0.31^{b}	8.05 ± 0.07^{a}	7.47 ± 0.07^{ab}	6.69 ± 0.67^{b}	8.29 ± 0.14^{a}
Nitrogen Free Extract	29.13 ± 0.33^{a}	28.65 ± 2.90^{a}	26.38 ± 0.78^{ab}	27.29 ± 0.40^{ab}	23.34 ± 3.05^{b}

Values with the same superscript are not significantly different (p>0.05). Values with different superscripts are significantly different (P<0.05)

* Specification: each kg contains: Vitamin A , 4,000,000 IU; Vitamin B, 800,000 IU; Vitamin E, 16,000 mg, Vitamin K_3, 800 mg; Vitamin B_1, 600 mg; Vitamin B_2, 2,000 mg; Vitamin B_6, 1,600 mg, Vitamin B_{12},8 mg; Niacin,16,000 mg; Caplan, 4,000 mg; Folic Acid, 400 mg; Biotin, 40 mg; Antioxidant 40,000 mg; Chlorine chloride, 120,000 mg; Manganese, 32,000 mg; Iron 16,000 mg; Zinc, 24,000 mg; Copper 32,000 mg; Iodine 320 mg; Cobalt,120 mg; Selenium, 800 mg manufactured by DSM Nutritional products Europe Limited, Basle, Switzerland.

utilization indices were estimated. Water temperature and dissolved oxygen were measured using a combined digital YSI dissolved oxygen meter (YSI Model 57, Yellow Spring Ohio); pH was monitored weekly using pH meter (Mettler Toledo – 320, Jenway UK). Eight catfish and 6 catfish per treatment were respectively sacrificed at the beginning and end of the feeding trial respectively and analysed for their carcass composition (AOAC, 1990).

All data were subjected to one-way analysis of variance (ANOVA) test using SPSS version 16.0. Where ANOVA revealed significant difference (P<0.05), Duncan multiple – range test (Zar, 1996) was applied to characterize and quantity the differences between treatments.

Results

Feed Quality

Table 2 shows the proximate composition of the experimental diets fed to *Clarias gariepinus* for 56 days, it revealed the diets to be isonitrogenous as there was no significant difference (P>0.05) in the protein content of the diets.

Feed Intake and General Behaviours of Clariid Catfish

Fish in different dietary groups fed actively on the experimental diets throughout the experiments. Highest mortality was recorded in Tank of fish fed with diet SSM100 followed by SSM75.

Growth Performance and Nutrient Utilization

Table 3 presents growth performance and nutrient utilization of *Clarias gariepinus* fed the experimental diets. Percent weight gain, specific growth rate, net protein utilization and percentage survival were not statistically different (P<0.05) among the fish fed diets CTR and SSM25.

However, there was significant difference (P<0.05) in the feed conversion ratio (FCR) of control diets and other test diets. Fish fed diet SSM100 had the lowest value in each of these parameters except for its FCR value which was the highest. The % WG, SGR, FCR, PER and NPU reduced with increasing level of replacement of sesame seed meal. Higher inclusion of sesame resulted in reduction of final body weight, SGR, FCR when compared to control diet. Fish fed diet SSM25 and SSM50 were not significantly different (P>0.05) from each other with respect to their body weight gain, % WG, FCR, PER, NPU. So also fish fed SSM75 and SSM100 were not significantly different (P>0.05) from each other with respect to their body weight gain, % WG, FCR, PER, NPU.

Whole Body Composition

Table 4 revealed the whole body composition of fish at the beginning and at the end of the experiment. There was significant difference (P<0.05) between the initial and final body composition of fish used during the experiments with respect to moisture crude protein, crude lipid and ash content.

For crude protein, the highest value was

Table 3. Growth response and feed utilization of *Clarias gariepinus* fed varying levels of sesame seed meal based diets

Parameters	Initial	SSM 25	SSM 50	SSM 75	SSM 100
Initial wt (g)	6.37±0.21[a]	6.365±0.007[a]	6.38±0.004[a]	6.37±0.007[a]	6.37±0.014[a]
Final wt (g)	34.27±1.05[a]	31.20±0.82[ab]	28.88±0.94[c]	23.89±0.31[d]	21.35±0.35[e]
Mean WG[1](g)	30.4±2.50[a]	24.84±0.81[ab]	22.50±0.95[b]	17.52±0.32[c]	14.64±0.83[c]
% WG[2]	477.68±40.91[a]	390.17±12.35[ab]	351.23±17.29[b]	275.08±5.41[c]	235.21±4.66[c]
SGR[3](%) /day	3.01±0.05[a]	2.84±0.05[ab]	2.69±0.06[c]	2.36±0.02[d]	2.16±0.03[e]
FCR[4]	1.30±0.09[c]	1.46±0.01[b]	1.50±0.07[b]	1.71±0.04[a]	1.79±0.04[a]
PER[5]	1.93±0.13[a]	1.71±0.03[ab]	1.60±0.19[bc]	1.47±0.02[bc]	1.40±0.03[c]
NPU[6]	15.53±13.54[a]	13.47±5.70[a]	10.69±4.89[b]	10.45±6.85[c]	9.91±3.62[c]
% survival[7]	93.30[a]	83.30±4.67[ab]	76.67±4.72[bc]	69.98±4.70[cd]	63.33±9.43[d]

Row means with common or same superscript are not significantly different (p>0.05)
Row means with different superscript are significantly different (p<0.05)
[1] Mean weight gain= final mean weight –initial mean weight
[2] Percentage weight gain= [final weight-initial weight /initial weight] X 100
[3] Specific growth rate= [In final weight-In initial weight] X 100
[4] Feed conversion ratio=dry weight of feed fed /Weight gain (g)
[5] Protein efficiency ratio=fish body weight (g)/ Protein fed
[6] Net protein utilization= [protein gain/protein fed] X 100
[7] Percentage survival = {(total number of fish- mortality)/total number of fish] X 100

Table 4. Carcass composition (%) of *Clarias gariepinus* fed varying levels of sesame seed meal based diets

Parameters	Initial	Control	SSM 25	SSM 50	SSM 75	SSM 100
Moisture	72.19±1.05[a]	71.90±0.97[a]	71.07±0.54[a]	72.09±1.01[a]	70.40±0.85[a]	71.40±0.71[a]
Protein	14.02±0.16[d]	16.86±0.80[a]	16.76±1.62[a]	16.39±0.58[b]	16.02±0.74[c]	16.00±0.59[c]
Lipid	5.96±0.09[c]	5.23±0.33[d]	5.20±0.57[d]	6.00±1.13[bc]	6.04±0.33[b]	6.79±1.11[a]
Ash	6.84±0.98[a]	6.88±0.71[a]	6.88±0.77[a]	5.53±0.46[a]	6.81±0.44[a]	5.80±1.08[a]

[a] Values with same superscript are not significantly different (P>0.05)

recorded for fish fed CTR followed by SSM25 and the lowest value was recorded for fish fed SSM100. There was reduction in crude protein, crude lipid and ash value with increasing level of replacement of sesame seed meal. However, there was no significant difference (P>0.05) in the protein content of the fish fed diet CTR and SSM100. So also there was no significant difference (P>0.05) in the protein contents of the fish fed SSM75 and SSM100. The highest crude lipid was recorded in the fish fed diet SSM100 followed by SSM75. The lipid content reduced between the initial compositions up to 50% replacement level beyond which it increased. There was no significant difference (P>0.05) in lipid content of the fish fed diets CTR and SSM25. However, there was significant difference ((P<0.05) in the lipid content of the fish fed these diets and other diets. The highest ash content was recorded in fish fed diet CTR and SSM25 however, the ash contents of the fish were not significantly different (P>0.05) from fish fed control diet. So also there was no significant difference (P>0.05) in the ash contents between the fish fed the diets and the initial ash content of the fish used.

Discussion

The experiment results showed that it is possible to replace soybean meal in *Clarias gariepinus* diet with cooked and mechanically defatted sesame seed meal with optimum growth response at a 25% replacement level though at 50% replacement with sesame seedmeal the growth response was different from that of control however it was similar to that of fish fed diets SSM25. The result observed for fish fed diets CTR, SSM25 and SSM50 are similar to that of Olukunle and Falaye (1998) who found out that 25% sesame seed cake incorporation supported weight gains in *Clarias gariepinus* similar to diets with 100% fish meal. Sesame seed meal was suggested by Tacon (1997) for a maximum level of inclusion in both omnivorous and herbivory fish species to be 35%. Hossain and Jauncey (1989) found that Bangladeshi variety of sesame oilseed meal can be included up to 25% in raw condition in the diet of *Cyprinus carpio* L. Hossain *et al*. (1992) substituted fish meal with sesame oilseed meal in the diets of catfish, *Heteropneustes fossilis* and reported promising result. Similarly, Stickney *et al*. (1996) found that sunflower protein concentrate can replace 25% fish meal protein in rainbow trout diets. Sanz *et al.* (1994) observed better results when replacing 40% of the animal protein in rainbow trout with sunflower protein supplemented with Essential Amino Acids. Jackson *et al*. (1982) reported good growth in tilapia (*Sarotherodon mossambicus*) fed rations containing 35.2% sunflower meal replacing 50% of the fish meal protein. Martinez (1984) reported that there was no loss in growth performance and diet utilization efficiency when rainbow trout (*Salmo gairdneri*) was fed diets containing 22 and 37.3% sunflower meal though he added L-methionine to that of 37.5% sunflower meal. These results also show a reduction in growth and feed conversion ratio as the raw plant protein increased beyond 25%. Lower growth performance recorded for fish fed diets SSM75 and SSM100; higher inclusion levels of SSM could be related not only to dietary amino acid profile but also the presence of anti-nutritional factors. Sesame seed is reported to contain high amount of oxalate and phytic acid (Narasinga Rao, 1985; Johnson *et al*., 1979). Oxalic acid reduces the physiological availability of calcium from the seed. However dehulling reduces the oxalic acid contact of the seed (Salunkhe *et al.,* 1991). Cooking also reduces antinutrients contents of the seed; Hossain and Jauncey (1990) reported reduction of phytic acids in linseed and sesame meals by up to 72 and 74% respectively. The bio availability of phosphorus for animal seems to depend on the level of phytate – splitting enzyme, phytase, in the intestinal tract. Monogastric animals have little or no phytate activity. Sesame usually contains anti-nutritional factor, phytic acid which either forms complex with protein or binds metal ions such as calcium and magnesium inhibiting the absorption of these important minerals (Gohl, 1981). However, it seems that at a lower level of inclusion, there is a physiological mechanism in fish that could compensate for the presence of these antinutrients hence their negative effect may not be felt; but at higher level of inclusion, when the limit might have been exceeded, then the negative effect of these anti-nutrients will be well pronounced. Hence this plausibly explains why at lower level of inclusion of these meals, the growth and nutrient utilization of fish fed these cooked and mechanically defatted sesame seedmeals were comparable to that of control. Another plausible explanation that can be attributed to why at lower level of inclusion of these meals, the growth and nutrient utilization of fish fed these cooked and mechanically defatted sesame seedmeals were comparable to that of control is the possible interactions between the various anti-nutrients which has been reported could also remove their inhibitory action. Fish and Thompson (1991) reported that interaction between Tannins and Lectins removed the inhibitory action on amylase and interaction between Tannin and cyanogenic glycosides reduced the deleterious effects of the latter (Goldstein and Spencer, 1985). So also, Makkar *et al*. (1995) reported complex formation between saponins and other antinutrients could lead to inactivation of the toxic effects of both substances. Simultaneous consumption of saponin and tannin resulted in the loss of their individual toxicity in rat (Freeland *et al*., 1985). This is considered to be due to chemical reactions between them leading to formation of tannin-saponin complexes, inactivating the biological activity of both tannins and saponins. The lowered growth performance of fish fed high phytate containing sesame diets can be attributed to various factors, namely reduced bioavailability of minerals, impaired protein digestibility caused by formation of phytic acid-protein complexes and depressed absorption of nutrients due to damage to pyloric cecal region of the intestine (Francis *et al*., 2001). It then implies that at higher replacement level of soybean meal with sesame seedmeal, poor growth and nutrient utilization of *Clarias gariepinus* will be recorded. This is similar to the report of Davies *et al.,* (2000) who found out that higher inclusion of certain oilseed meal recorded poor growth and nutrient utilization by *Oreochromis niloticus.* Comparable performance in growth nutrient utilization and carcass crude protein deposition in *Clarias gariepinus* fed diets with SSM25 and SSM50 showed that these meals could be viable means of improving the cost of fish feeding.

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