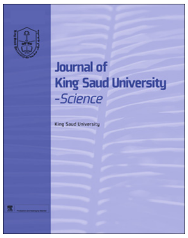
Journal of King Saud University – Science (2014) **26**, 83–87

King Saud University
Journal of King Saud University – Science
www.ksu.edu.sa
www.sciencedirect.com



ORIGINAL ARTICLE

Effect of soybean diet: Growth and conversion efficiencies of fingerling of stinging cat fish, *Heteropneustes fossilis* (Bloch)

Muzzammil Iqbal Siddiqui *, **Mukhtar Ahmed Khan, Mohammed Iqbal Siddiqui**

Zoology Department, College of Science, P.O. Box 2455, King Saud University, Riyadh 11451, Saudi Arabia

Received 30 December 2012; accepted 24 October 2013
Available online 6 November 2013

KEYWORDS
Stinging cat fish;
Heteropneustes fossilis;
Conversion efficiency;
Growth;
Soybean fish diet

Abstract Replacement of 15% protein from soybean meal in Diet II was feasible for the stinging cat fish, *Heteropneustes fossilis* and no significant differences in growth parameters were found in fish fed soybean meal-based diets compared to those fed control diet (Diet I). Live weight gain percent (165%) obtained in fish fed soybean meal based diet was not significantly different to that achieved (171%) in fish fed Diet I. Specific growth rate percent, SGR (2.79%), feed conversion ratio FCR (1.40) and protein efficiency ratio PER (1.79) recorded in fish fed Diet II were also more less comparable to those fed control diet. Mortality was not recorded in the period of the feeding trial. Body composition of the fish fed soybean meal based diet (Diet II) was also comparable to that fed control diet. Significantly higher fat content was noted in fish fed Diet II. However, the protein contents were not changed in fish fed Diet I and II. Similarly, no significant differences ($P > 0.05$) in protein productive value were noted between the two groups. However, ash content differed significantly ($P < 0.05$) in fish fed Diet I and II. Although soybean meal-based diet depressed growth and feed conversion efficiencies of the fish to some extent, inclusion of soybean meal was found to be cost-effective alternative to fish meal.

1. Introduction

Land resources are not adequate enough to satisfy the growing demand for food; therefore, universal requirement for aquatic food products is rising, the population from capture fisheries have exceeded the limits and most of the fishing areas have met its maximum potential. Fish and fisheries have contributed the food security and fought against poverty driven hunger in Asia. An additional 37 million tons of food fish will be required by 2020 to meet the needs of the growing population, with changing dietary habits due to increasing income levels. Production from capture fisheries has reached a plateau, with

---

* Corresponding author. Tel.: +966 501068699; fax: +966 14678514.
E-mail address: miqbals@ksu.edu.sa (M.I. Siddiqui).

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.jksus.2013.10.004

most fisheries having reached their maximum sustainable yields or being over exploited (worldfish.catalog.cgiar.org).

In addition to contributing to nutritional security, the fishery sector has been providing employment to over 35 million people in Asia directly and many more when the support sector is included. Today fish is the internationally most traded commodity with an estimated amount of US$63 billion. The exports of fish and fisheries products from developing countries exceeded those of meat, dairy, cereals, sugar, coffee, tobacco and oilseeds. About 40% of global fish production was traded across countries in 1998 as compared to 10% of meat production (Fagbenro and Davies, 2001). Feed is a vital component of aquaculture and protein remains its most expensive constituent. Fish meal forms the basis of good fish growth due of its protein quality and palatability. Fish meal is relatively scarce and very expensive, especially commercially available brands hence, it raises the cost of catfish production and its nutritional value is also very high (Weerd, 1995). As in most aquaculture programs, reducing feeds cost is a permanent concern due to its direct impact on the cost of production.

In order to reduce the feed cost, the use of fish meal has to be reduced. This can be achieved by replacing current fish meal with some suitable alternatives. Soybean meal has high protein content and the best protein quality among plant protein feedstuffs used as alternative protein sources in fish diets (Lovell, 1988; Rumsey, 1993). There is no published data in the scientific literature relating the use of soybean meal in the diet of *H*eteropneustes *Fossilis*. Therefore, the present study was aimed at evaluating the effect of soybean meal protein on growth, feed conversion efficiency and survival of the fingerling *H. Fossilis*.

2. Materials and methods

Fingerling *H. Fossilis* were procured from a local fish market and stocked in 55 l polyvinyl troughs. Two isonitrogenous (40% CP) and isocaloric (4.28 kcal/100 g) diets were formulated using fish meal, soybean meal, mustard oil cake and wheat bran. Crude protein content in the diet was fixed at 40% on the basis of earlier available information (Niamat and Jafri, 1984). In Diet I, 30% of the protein was contributed by fish meal alone whereas in Diet II the same amount was contributed by the inclusion of fish meal and soybean meal protein in equal proportions (Table 1). Remaining 10% of the protein in both the diets was contributed by inclusion of equal amounts of protein from wheat middlings and mustard oil cake. Defatted soybean meal was used to replace the fish meal in Diet II. All ingredients were finely ground, mixed and cooked at 80 °C. The dough thus obtained was cut into small cubes and stored in sealed plastic boxes in freezer at 4 °C until used. Fingerling *H. Fossilis* (6.22 ± 0.01 cm, 9.1 ± 0.02 g) were sorted out from the acclimatised lot stocked in triplicate groups at the rate 10 fish each in 55 l high density polyvinyl flow through (1–1.5 l/min) circular trough. Fishes were fed with the experimental diets six days a week in the form of moist cake, twice daily at 800 and 1600 h, to apparent satiation. Left over diet, if any, was siphoned over a filter screen, dried in a thermostat for 24 h and reweighed to measure the total amount of food consumed. Faecal matter was siphoned off from the experimental trough daily. Scrubbing and cleaning of troughs were done at the time of weekly measurements. Initial and weekly mass weights of fish from each trough were recorded on an electronic balance.

Table 1 Composition of experimental diet.

Ingredients (g/100 g dry diet)	Diets I	Diets II
Fish meal	39.42	19.71
Soybean meal	–	33.60
Mustard oil cake	24.29	24.29
Wheat middlings	14.29	14.29
Proximate composition of the diet		
Protein (%)	40.02	40.98
Fat (%)	2.96	3.87
Ash (%)	3.14	4.11
Moisture (%)	51.23	55.61

Approximate composition of ingredients, experimental diets, and initial and final carcass was estimated using standard methods of AOAC (1995) for dry matter (oven drying at 105 ± 1 °C for 22 h.), crude protein (N-Kjeldhal X 6.25), crude fat (solvent extraction with petroleum ether B.P 40–60 °C for 12–14 h.) and ash (oven incineration at 650 °C for 4–6 h) following Singh and Khan (2006).

Protein was estimated by a slight modification of the Wong's micro-kjeldahl method as adopted by Jafri et al. (1964). 100 mg of dry powdered sample was treated with 5 ml diluted (1:1) sulphuric acid in Kjeldahl flask and boiled for a few minutes till fumes disappeared. After cooling, 0.5 ml saturated potassium per sulphate solution was added to oxidise the digesting mixture. The digestion was continued till the solution in the Kjeldahl flask became water clean, indicating that all the nitrogenous materials present in the sample have been converted into ammonium sulphate. The clean solution was diluted to 50 ml with distilled water. 0.5 ml aliquot of the digested sample was mixed with 0.1 ml each of dilute (1:1) sulphuric acid and saturated potassium per sulphate the content was raised to 3 ml with distilled water. This was then nesslerised with 7 ml Nessler's reagent. The solution was kept at room temperature for 10 min for complete colour development. A blank was prepared, side-by-side, substituting the aliquot with distilled water. The colour was read on a spectrophotometer at 480 nm. The intensity of colour developed was proportional to the amount of ammonium sulphate contained in the solution. The values of optical density obtained for various samples were read off against a standard calibration curve prepared by taking readings of a series of different dilutions containing different grades of known amount of nitrogen in stock solution.

Crude protein was calculated by multiplying the nitrogen value with protein factor (6.25). The values were recorded as percentage on dry weight basis.

A known quantity of sample was taken in petri-dish (with known weights) and placed in hot air oven at 100 °C for 24 h. The petri-dish containing the dried sample was cooled to room temperature in a desiccator and reweighed to ensure that the sample had become completely dried, the entire process was repeated till a constant weight was obtained.

The loss in weight gave an index of water from which its percentage was calculated. A known quantity of sample was taken in a pre-weighed vitreosil crucible, dried in hot air oven (100 °C) and ignited in muffle furnace (650 °C) for 2–3 h till the sample became carbon-free. The crucible was cooled in desiccators and reweighed to estimate the quantity of ash. The result was expressed as percentage on dry weight basis. For the estimation of crude fat, continuous soxhlet extraction techniques, using petroleum ether (40–60 °C B.P) was employed (Harwood and Moody, 1989). A weighed quantity of finely powdered and dried sample was taken in Whatman filter paper and introduced into the soxhlet.

The extraction was carried out for about 10–12 h. At the end of extraction, the solvent was recollected and the flask gave the quantity of crude fat extracted from the known weight of the sample. The results were expressed as percent on dry basis.

Moisture% = [(Initial weight – Final weight)/Weight of the sample} × 100

Growth performance of the experimental diets was measured following Khan and Abidi (2007) as a function of the weight gain by calculating following parameters:

% Live weight gain = (Final body weight – Initial body weight/Initial body weight) × 100

PER = Weight gain/Protein fed

FCR = Feed fed/Weight gain

Survival Rate (SR%) = (Final number of fish/Initial number of fish) × 100

Protein productive value (PPV) = Protein gain/Protein fed.

3. Results

Results of 6 weeks feeding trial are depicted in Table 2. It was noted that inclusion of 15% of fish protein with soybean meal (Diet II) was feasible for *H. fossilis* without significant differences in growth parameters compared to those fed with control diet (Diet I). Live weight gain percent (165%) obtained in fish fed soybean meal based diet was not significantly different to that achieved (171%) in fish fed with Diet I. Specific growth rate percent, (SGR) (2.79%), feed conversion ratio (FCR) (1.40) and protein efficiency ratio PER (1.79) recorded in fish fed with Diet II were also comparable to those fed with control diet. No mortality was recorded during the period of the feeding trial.

Body composition of the fish fed with soybean meal based diet (Diet II) was also comparable to that fed with control diet (Table 3). Significantly higher fat content was noted in fish fed with Diet II. However, the protein content remained almost unchanged in fish fed with Diet I and II. Similarly, no significant differences ($P > 0.05$) in protein productive value were noted between the two groups. However, ash content differed significantly ($P < 0.05$) in fish fed with Diet I and II.

Table 2 Growth, conversion efficiencies and survival of fingerling *H. fossilis* fed soybean meal based diet.

	Diet I	Diet II
Average initial weight (g)[a]	4.01 ± 0.02	4.50 ± 0.01
Average final weight (g)[a]	10.89 ± 0.04	11.99 ± 0.04
Live weight gain (%)[a],[b]	171.45 ± 4.2^{a}	165.33 ± 12.8^{b}
Food conversion ratio$^{1ry\ ss}$	1.37 ± 0.01^{a}	1.40 ± 0.01^{b}
Specific growth rate%	2.85 ± 0.08^{a}	2.79 ± 0.02^{a}
Protein efficiency ratio$^{1'2'5}$	1.82 ± 0.01	1.79 ± 0.02
Percentage survival	100	100

[a] Mean values of 3 replicates ± SEM.

[b] Mean values sharing the same superscripts are insignificantly different ($P > 0.05$).

Table 3 Body composition of fingerling *H. fossilis* fed soybean meal based diet.

	Diet I	Diet II
Moisture	76.82 ± 0.03^{a}	77.71 ± 0.02^{b}
Protein	15.69 ± 0.03^{a}	15.36 ± 0.02^{a}
Fat	2.79 ± 0.02^{a}	3.21 ± 0.05^{b}
Ash	3.09 ± 0.06^{a}	3.94 ± 0.07^{b}
Protein productive value	0.34 ± 0.01^{b}	0.32 ± 0.03^{b}

Mean values of 3 replicates ± SEM. Mean values with the same superscripts are insignificantly different ($P > 0.05$).

4. Discussion

Feed cost is maximum in aquaculture, ranging from 30% to 60% of variable operating costs, depending on the intensity of the operation (Riaz, 1997). The manipulation of feed formulation with respect to ingredient costs, nutrient profile and digestibility can result in significant reduction in feed costs. This can also assist in lowering the dependence on expensive fish meal. The use of plant protein materials in fish diets is recommended because of low prices and regular availability (Lovell, 1988).

The nutritional prospects and the potential of soybean meal as protein source for the fish feeds have been studied in myriad studies (Pongmaneerat and Watanabe, 1992; Watanabe and Pongmaneerat, 1993; Oliva-Teles et al., 1998; Olli and Krogdahl, 1994; Refstie et al., 1997; Bhosale et al., 2010; Ahmed et al., 2012). The maximum level of soybean meal inclusion in diet has been limited up to 20% for rainbow trout (Oliva-Teles et al., 1998). Incorporation of more than 20% soybean meal in the diet is found to suppress growth, mainly through a reduction of feed intake (Fowler, 1980; Pongmaneerat and Watanabe, 1992). A number of findings have suggested the palatability problems for the feeds when SBM was included in the diets (Fowler, 1980; Hajen et al., 1993) this effect is more important for the first period of fish feeding (Ahmed et al., 2012; Refstie et al., 1997,). However, increasing soybean meal up to 20% was found to be acceptable as observed in the present study which is in conformity to the findings of others (Watanabe and Pongmaneerat, 1993; Sanz et al., 1994). There are differences in the maximum dietary levels of soybean meal tolerance in different species (Bhosale et al., 2010; Kaushik et al., 1995; Nengas et al., 1996; McGoogan and Gatlin, 1997; Refstie et al., 2000; Khan et al., 2003). During the present study, it was observed that the soybean meal-based diet was readily accepted by *H. Fossilis*. The peculiar taste in soybean meal, like the other vegetable foodstuffs, affects diet acceptance, probably due to the presence of some organic substances (Price and Fenwick, 1984) such as in seabass (*Lates calcarifer*), solvent-extracted soybean meal is more palatable than the full-fat soybean meal (Adelizi et al., 1998; Boonyaratpalin et al., 1998).

Findings on replacement of fish meal by plant protein sources usually are based on growth, feed utilisation and survival of fish in response to the substitution level (Lech and Reigh, 2012; Nguyen and Davis, 2009). Plant protein sources are not easily digested, due to anti-nutritional factors and an imbalanced amino acid profile, possibly leading to loss of nutrients either in egesta or metabolic excretion. However, no such reduction in growth and conversion efficiencies was apparent during the present trial indicating the suitability of incorporating soybean meal protein at 15% of the diet for fingerling *H. Fossilis*. Studies have shown that diet with soybean meal substituting 37.5% of fish meal protein gave an acceptable growth, though with a slight growth difference in comparison to that of fish fed with a fish meal based diet (Boonyaratpalin et al., 1998; Ogunkoya et al., 2007). In the present study, fish fed with diet replacing 15% fish meal by soybean meal (Diet II) resulted in almost similar growth performance. Soybean meal, though considered as the best plant protein source with regard to amino acid profile, may have insufficient methionine for meeting the essential amino acid need of the fish (Tantikitti et al., 2005). Inclusion of soybean meal at 15% of the protein in the present experiment possibly did not had any negative impact on the growth and conversion efficiencies of the fish whereas at higher levels it causes methionine insufficiency causing slower growth, reduced feed conversion efficiency and less protein utilisation. This is in conformity with the previous findings where 20% dehulled soybean meal was used in diet of young tin barb replacing 50% of fish meal (Choi et al., 2004; Elangovan and Shim, 2000; Tantikitti et al., 2005).

5. Conclusion

Since the inclusion of soybean meal by replacing fish protein meal at 15% of the protein in the present experiment did not have any negative impact on the growth and feed conversion efficiencies of the fish, it is concluded that soybean meal can be used as an excellent alternative to fish meal for developing cost effective diets for fingerling *H. Fossilis*.

References

Adelizi, P.D., Rashti, R.R., Warner, K., Wu, Y.U., Munch, T.R., White, M.R., Brown, P.B., 1998. Evaluation of fish meal free diet for rainbow trout. Aquaculture Nutrition 4, 255–262.

Ahmed, M., Qureshi, T.A., Singh, A.B., Manohar, S., Borana, Kamlesh., Chalko, S.R., 2012. Effect of dietary protein, lipid and carbohydrate contents on the growth, feed efficiency and carcass composition of Cyprinus carpio communis fingerlings. International Journal of Fisheries and Aquaculture 4 (3), 30–40.

AOAC, 1995. Official Methods of Analysis of the Association of Official Analytical Chemist, 16th ed. Association of Official Analytical Chemist, Washington, DC, USA (pp. 1234–1565).

Bhosale, S.V., Bhilave, M.P., Nadaf, S.B., 2010. Formulation of fish feed using ingredients from plant sources res. Journal of Agricultural Science 1 (3), 284–287.

Boonyaratpalin, M., Suraneiranat, P., Tunpibal, T., 1998. Replacement of fish meal with various types of soybean meal products in diets for the Asian sea bass, *Lates calcarifer*. Aquaculture 161, 67–78.

Choi, Se-Min, Wang, X., Park, G.J., Lim, S.R., Kim, K.W., Bai, S.C., Shin, I.S., 2004. Dietary dehulled soybean meal as a replacement for fishmeal in fingerling and growing olive flounder Paralichthys olivaceus (Temminck at Schlegel). Aquaculture Research 35, 410–418.

Elangovan, A., Shim, K.F., 2000. The influence of replacing fish meal partially in the diet with soybean meal on growth and body composition of juvenile tin foil barb (Barbodes altus). Aquaculture 189, 133–144.

Fagbenro, O.A., Davies, S.J., 2001. Use of soybean flour (dehulled, solvent-extracted soybean) as a fish meal substitute in practical diets for African catfish, Clarias gariepinus (Burchell 1822): growth, feed utilizati. Journal of Applied Ichthyology 17 (2), 64–69.

Fowler, L., 1980. Substitution of soybean and cottonseed products for fish meal in diets fed to chinook and coho salmon. The Progressive Fish-Culturist 42 (2), 87–90.

Hajen, W.E., Higgs, D.A., Beames, R.M., Dosanjh, B.S., 1993. Digestibility of various feedstuffs by post-juvenile chinook salmon (Oncorhynchus tshawytscha) in sea water. 2. Measurement of digestibility. Aquaculture 112, 333–348.

Harwood, L.M., Moody, C.J., 1989. Experimental Organic Chemistry: Principles and Practice (Illustrated edition ed.). WileyBlackwell (pp. 122–125).

Jafri, A.K., Khawaja, D.K., Qasim, S.Z., 1964. Studies on the biochemical composition of some freshwater fishes. Technology 1, 148–157.

Kaushik, S.J., Cravedi, J.P., Lall, J.P., Sumpter, J., Fauconneau, B., Laroche, M., 1995. Partial or total replacement of fishmeal by soybean protein on growth, protein utilization, potential estrogenic or antigenic effects, cholesterolemia and flesh quality in rainbow trout, O. Mykiss. Aquaculture 123, 257–274.

Khan, M.A., Abidi, S.F., 2007. Dietary isoleucine requirement of fingerling Indian major carp, Labeo rohita (Hamilton). Aquaculture Nutrition 13 (6), 424–430.

Khan, M.A., Jafri, A.K., Chadha, N.K., Usmani, N., 2003. Growth and body composition of rohu (Labeo rohita) fed diets containing oilseed meals: partial or total replacement of fishmeal with soybean meal. Aquaculture Nutrition 9, 391–396.

Lech, G.P., Reigh, R.C., 2012. Plant products affect growth and digestive efficiency of cultured florida pompano (trachinotus carolinus) fed compounded diets. PLoS ONE 7 (4), e34981. http://dx.doi.org/10.1371/journal.pone.0034981.

Lovell, R.T., 1988. Use of soybean products in diets for aquaculture species. Journal of Aquatic Production 2, 27–52.

McGoogan, B.B., Gatlin III, D.M., 1997. Effects of replacing fishmeal with soybean meal in diets for red drum Sciaenops Ocellatus and potential for palatability enhancement. Journal of the World Aquaculture Society 28, 374–385.

Nengas, I., Alexis, M., Davies, S.J., 1996. Partial substitution of fish meal with soybean meal products and derivatives in diets for the gilthead bream, Sparus aurata (L.). Aquaculture Research 27, 147–156.

Nguyen, T.N., Davis, A., 2009. Evaluation of alternative protein sources to replace fish meal in practical diets for juvenile tilapia, Oreochromis spp 2009. Journal of World Aquaculture Society 40 (1), 113–121.

Niamat, R., Jafri, A.K., 1984. Growth response of Siluroid *Heteropneustus fossilis* Bloch fed pelleted feed. Aquaculture 37, 223–229.

Ogunkoya, A.E., Page, G.I., Adewolu, M.A., Bureau, D.P., 2007. Dietary incorporation of soybean meal and exogenous enzyme cocktail can affect physical characteristics of faecal material egested by rainbow trout (Oncorhynchus mykiss). Aquaculture 254, 466–475.

Oliva-Teles, A., Pereira, J.P., Gouveria, A., Gomes, E., 1998. Utilization of diets supplemented with microbial phytase by sea bass (Dicentrachus labrax) juveniles. Aquatic Living Resources 11, 255–259.

Olli, J.J., Krogdahl, A., 1994. Nutritive value of four soybean products in diets for rainbow trout Onchorynchus mykiss Walbaum. reared in freshwater. Acta Agriculture Scandinavica, Section A: Animal Science 44, 185–192.

Pongmaneerat, J., Watanabe, T., 1992. Utilization of soybean meal as protein sources in diets for rainbow trout. Nippou Suisan Gakokishi 59, 157–163.

Price, K.R., Fenwick, G.R., 1984. Soyasaponins I, a compound possessing undesirable taste characteristics isolated from the dried pea (Pisum sativum L.). Journal of Science of Food and Agriculture 35, 887–892.

Refstie, S., Helland, S.J., Storebakken, T., 1997. Adaptation to soybean meal in diets for rainbow trout, O. Mykiss. Aquaculture 153, 263–272.

Refstie, S., Korsoen, O.J., Storebakken, T., Baeverfjord, G., Lein, I., Roem, A.J., 2000. Differing nutritional responses to dietary soybean meal in rainbow trout Oncorhynchus mykiss and Atlantic salmon Salmo salar. Aquaculture 190, 49–63.

Riaz, M.N., 1997. Aquafeeds to optimise water quality. Feed International 18 (3), 22–28.

Rumsey, G.L., 1993. Fishmeal and alternative sources of protein. Fisheries 18, 14–19.

Sanz, A., Morales, A.E., de la Higuera, M., Cardenete, G., 1994. Sunflower meal compared with soybean meal as partial substitutes for fish meal in rainbow trout (Oncorhynchus mykiss) diets: protein and energy utilization. Aquaculture 128, 287–300.

Singh, S., Khan, M.A., 2006. Dietary arginine requirement of fingerling hybrid Clarias (Clarias gariepinus×Clarias macrocephalus). Aquaculture Research 38 (1), 17–25.

Tantikitti, C., Sangpong, W., Chiavareesajja, S., 2005. Effects of defatted soybean protein levels on growth performance and nitrogen and phosphorus excretion in Asian seabass (*Lates calcarifer*). Aquaculture 248 (1–4), 41–50.

Watanabe, T., Pongmaneerat, J., 1993. Potential of soybean meal as a protein source in extruded pellets for rainbow trout. Nippon Suisan Gakkaishi 59, 1415–1423.

Weerd, J.H., 1995. Nutrition and growth in Clarias species – a review. Aquatic Living Resources 8, 395–401.