Preliminary Evaluation of Jackbean (*Canavalia ensiformis* L. DC) Seed Meal as a Substitute for Fishmeal in diets for *Clarias gariepinus* (Burchell, 1822)

D. I Osuigwe[1], A. I. Obiekezie[2] , and Johnny O. Ogunji[3]

[1]Department of Fisheries
Michael Okpara University of Agriculture
Umudike, P.M.B. 7267 Umuahia , Nigeria.

[2]Institute of Oceanography
University of Calabar
Calabar, Nigeria.

[3]Department of Applied Biology
Ebonyi State University
P.M.B. 053 Abakaliki, Nigeria.

Email: Ogunjijo@yahoo.com

ABSTRACT

Jackbean (*Canavalia ensiformis*) is an under-utilised novel legume with crude protein content and amino acid profile that make it a potential candidate in the tropics as substitute for fish meal in fish diets. This study assesses the potentials of Jackbean seed meal (JBSM) for partial replacement of fish meal in diets of *Clarias gariepinus*. Fishmeal in control diet was replaced progressively (10%,20%,40% and 60%) by raw JBSM, 30- and 60-minute boiled JBSM. Test fish in each tank were fed 3% of their biomass twice daily for 56days. Fish fed control diet had the best SGR (1.61) and feed efficiencies (FCR 1.88, PER 1.74). SGR and PER of fish groups fed test diets were inversely related to the dietary levels of JBSM. The same trend applied to protein and fat contents of the fish carcass. FCR however had the reverse trend. Fish fed diets with up to 20% fishmeal substituted by 60 minute boiled JBSM had protein content similar to those fed the control diets (P<0.05). Fish fed diets with fishmeal substituted by 10% raw JBSM and up to 20% JBSM boiled for 30 and 60 minutes had similar fat levels in the fish flesh as those fed the controlled diets (P<0.05). The poor performance observed in fish fed diets containing increasing levels of boiled JBSM suggest the presence of probably thermostable antinutritional factors in processed JBSM as well as imbalance in the nutrient profile which may be corrected by supplementation. However, the study shows that 20% of fishmeal in the diet can be replaced with JBSM boiled for 60 minutes without any adverse effect on the growth performance.

INTRODUCTION

Catfish cultivation is a major farming industry in Nigeria with feed accounting for more than 50% of the production cost. The high cost of feed stems from the use of fish meal to meet high dietary protein requirement of farmed fish. Fish meal prices will likely continue to be high in future because of the increased requirement for feed (Rumsey, !983), without a corresponding increase in global fish meal production (Higgs et al., 1995) over the past several years. This situation calls for the need to develop alternatives to fish meal that are high in nutritive quality for cost effective fish feed production.

Fish nutritionists have been investigating the potentials for using plant proteins and other alternatives as partial or complete replacement of fish meal in fish diets (Ogunji and Wirth, 2001; Kissil et al., 1997) with variable results. The variability in response has been due to the ability to destroy or inactivate the numerous endogenous anti-nutritional factors within plant proteins (Kaushik, 1989). Fortunately, a proportion of the anti-nutritional factors present in plant proteins can be destroyed and inactivated by heat treatment process (Tacon and Jackson, 1985).

Many varieties of legumes because of their rich protein and mineral content and widespread distribution have been identified for use in animal feed in the tropics but only a few have been utilised (Adeparasi, 1994). Jack bean (*Canavalia ensiformis*) is one of the neglected novel legumes. The mature seed has a high crude protein content (20-32%) that recommends it for use as a substitute for fish meal in fish feed. It is cheap, readily available and hardly consumed by man. It however has some anti-nutritional factors some of which can be reduced by processing (Udedibie et al., 1996). The effectiveness of jackbean is yet to be evaluated in diets for catfish. This preliminary study examines, the potential of using jackbean seed meal as partial replacement for fish meal in the diet of catfish.

MATERIALS AND METHODS

Three different types of jackbean seed meal (JBSM) were obtained, by milling raw seed with hammer mill and subjecting some portions of the milled bean to boiling for 30 and 60 minutes respectively. Table 1, shows the proximate analysis of the three JBSM types (raw, 30 and 60 minute boiled) used in the study.

Thirteen isonitrogenous (30%) and isocaloric (ME, 2900kCal/kg) diets were formulated (Table 2). Diet 1 without JBSM served as control. Diets 2,3,4 and 5 had fish meal component replaced progressively by raw JBSM at 10%, 20%,40% and 60% respectively. In Diets 6,7,8 and 9 JBSM boiled for 30 minutes replaced fish meal progressively while the fish meal component in Diets 10,11,12 and 13 was replaced by JBSM boiled for 60 minutes as in diets 2,3,4 and 5 above.

Feed stuffs for the various diets were thoroughly mixed, moistened and moulded into pellets. They were oven dried at 40°C for 24 hours and stored in a freezer until used.

The thirteen test diets were assigned randomly to duplicate groups of ten fish with average weight of 1.87g. They were reared in 20 litre plastic aquaria filled with water. The aquaria were covered with netting fastened with rubber band to prevent fish loss. All fish were fed the prescribed diet by hand twice daily at 3% body weight for 56 days. Water was replaced from each aquarium every 3 days by siphoning. The water quality parameter were monitored daily and mean values were: temperature 28.5±1°C; pH 6.8±0.2; DO 6.4±0.5 mg/l. Four fish from each aquarium were sacrificed at the commencement of feeding trial and two fish at the end for proximate composition analysis. Fish in each aquarium were batch weighed bi-weekly after the initial weight records until the end of the trial. From the weight records the Specific growth rate (SGR), Food conversion ratio (FCR) and protein efficiency ratio (PER)were calculated. SGR = $\ln W_2 - \ln W_1 / t_2 - t_1$; W_1 & W_2 = initial and final weight of fish; t_1 & t_2 = time in days; FCR = food fed(g)/live weight gain (g); PER = Wet weight gain (g)/Amount of protein fed (g).

The data were subjected to analysis of variance ($P<0.005$) and the difference between means determined by Duncan multiple range test.

RESULTS

Crude protein , fats and total ash of the boiled JBSM decreased in comparison to the values obtained for raw JBSM. Ether extract and nitrogen free extract on the other hand increased (Table 1). The influence of the different diets on growth and nutrient utilisation of *Clarias gariepinus* is shown in Table 3.

Increasing the dietary level of JBSM significantly decreased SGR, PER as well as values of protein and fat in fish ($P<0.05$). The FCR however, increased (though not significantly) with increasing dietary level of JBSM (Table 3).

Processing (boiling) seemed to have improved the quality of the diets. Test diets containing JBSM boiled for 60 minutes resulted to a good performance at lower dietary inclusion. The SGR, PER and fat content of fish fed diets 10 and 11 and protein content in diet 10, did not show any difference from the values of the control ($P<0.05$; Table 3). Similarly, the fat content of fish fed diets 2, 6 and 7 equally had comparable values with the control diet, indicating that low level dietary inclusion of raw and 30 minute-boiled JBSM had minimal effect on the fat content of fish.

DISSCUSSION

All but one fish group fed diets containing JBSM, irrespective of the type of processing recorded inferior growth when compared with the control. Diet 10 containing 10% of JBSM boiled for 60 minutes had SGR value of 1.71 against 1.61 of the control. The inferior growth performance experienced by the fish fed diets containing JBSM may be attributed to the presence of anti-nutritional factors (ANF) in JBSM. Substantial quantities of ANF have been reported in jack bean seed (Merck, 1989; Rosenthal 1992; Udedibie et al., 1988, Belmaar and Morris 1994, Gomes-Sotillo et al., 1993). Protease inhibitors (trypsin and chymotrypsin inhibitors) are known to decrease the growth performance of animals (Liener 1994) and many fish are known to be sensitive to trypsin inhibitors (Shu, 1992). Significant growth reduction have been observed when fish were fed diets with low levels of tannic acid (Becker and Makkar 1999). Similarly, Muckhopadhyay and Roy (1996) reported that incorporating Sal (*Shorea robusta*) seed meal containing high amounts of phenolics into the diets of Indian major carp fingerlings reduced growth. Siddhuraju and Becker (2001) also reported that saponins in legumes are considered toxic or growth retardants to fish.

The values for PER showed the same pattern as SGR (Table 3). This indicates that increasing dietary level of JBSM markedly reduced the performance of *Clarias gariapinus*. Diets with the highest dietary raw JBSM had the poorest PER (0.89; Table 3). Olvera et al., (1988) observed the same trend for tilapia fed sesbania seed meal. De La Higuera et al., (1988) reported that saponins in lupin seed meal adversely affected dietary protein utilisation when fed rainbow trout. This negative effect was somehow moderated by processing. The fish fed diet containing 10% JBSM boiled for 60% (diet 10) had better PER (1.92) than the control diet (1.74). Fish fed up to 40% JBSM boiled for 60 minutes (diet 12) had comparable PER (1.51) to the control diet.

The diets containing higher levels of JBSM produced significantly lower levels of protein and fat in the fish. This agrees with the findings of Dabrowski et al., (1981) for carp with rapeseed meal. Hossain and Jauncey (1989) noted same pattern for common carp fed diets containing mustard oil cake, linseed and sesame meals. In this study, the lipid content of test fish decreased when the dietary raw JBSM is above 10% and dietary boiled JBSM is more than 20%. It is possible that the ANF present in JBSM only causes pronounced effect on *Clarias gariepinus* at higher levels of inclusion.

The relatively better performance of the control diet over diets containing JBSM indicates that the level of boiling employed did not eliminate totally the presence of ANF which exert negative effects on growth and nutrient utilisation. However, the result from this work showed that boiling and particularly for 60 minutes significantly improved the performance of *Clarias gariepinus* fed such diets at low inclusion level. This may be due to the enhancement of the protein digestibility. Bressani et al., (1987) reported the a digestibility of 47.9% for raw JBSM but the values appreciated to 76.4% and 78.7% respectively when cooked or roasted.

The poor growth and food utilization in the fish fed higher levels of JBSM may be due to the adverse effect of heat treatment (boiling) on some essential amino acids contained in the legumes. Bressani et al., (1987) observed that pressure cooking and roasting reduced lysine and methionine level in *Canavalia ensiformis*. Ogunji and Wirth, (2001) reported a decrease of some amino acids in cracked soybean seed after heat treatment. Lysine, leucine and arginine among other amino acids were said to be lost in the range of 11.45%, 12.98%, and 9.96% (dry matter) respectively. Voila et al., (1983) also observed that soybean meals heated at 105°C and 17% moisture for 60 and 120 minutes respectively lost about 10% lysine. On the other hand, the fact that the analysed protein content of legumes are lower than the real values due to the presence of non protein amino acids might have contributed to the observed poor performance of the experimental fish. It has been reported that *Canavalia ensiformis* is deficient in sulphur-containing amino acids (Bressani et al., 1987). This may also have contributed to the relatively poor performance by the test fish.

REFERENCES

Adeparasi, F. D., 1994. Evaluation of nutritive potentialof cooked pigeon pea (*Cajanus cajan*) meal as aplant protein source for *Clarias gariepinus* fingerlings. Journal of Agric. Technology, 2(1):48 - 57.

Becker, K. and Makka H. P. S., 1999. Effects of dietary tannic acid and quebracho tannin on growth performance and metabolic rates of common carp (*Cyprinus carpio* L.). Aquaculture, 175: 327 - 335.

Belmar, R. and Morris T. R., 1994. Effects of raw and treated jackbeans (*Canavalia ensiformis*) and canavanine on the short-term feed intake of chick and pigs. Journal of Agric Science, Cambridge, 123: 407 - 414.

Bressani, R., Brenes, R. G., Garcia, A, and Elias, L. G. 1987. Chemical composition, Amino acid content and Protein Quality of *Canavalia* spp. Seeds. J. Sci. Food Agric. 40: 17 - 23.

Dabrowski, K., Dabrowski, H. and Kolzlowska, H., 1981. Rapeseed meal in the diet of common carp reared in heated waters. II. Biochemical parameters as indices of dietary protein value. Z. Tierphsiol. Tierernaehr. Futtermittelkd., 45: 66 - 76.

De La Higuera M., Garcia-Gallege M., Sanz A., Cardenette G., Saurez M. D. and Mayono F. J., 1988. Evaluation of lupin seed meal in feeding of rainbow trout (*Salmon giardneri*) Aquaculture, 71: 37 - 50.

Gomez-Sotilo, A., Carmona A. and Seidi S. (1993). Fractionalisation of *Canavalia ensiformis* proteins. Distribution of the proteic anti-nutritional factors. In Recent Advances of Research in Anti-nutritional Factors in legume seeds: Proceedings of the Second International Workshop on Anti-nutritional Factors ANFs in Legume Seeds (Van der Poel, AFB and Saini H. S. Eds.) EAAP publication No 70 Wageningen, The Netherlands, pp. 235 - 239.

Higgs, D. A., Dosnjh B. S., Pendergast A. F., Bams R. M., Hardy R. W., Reiley, W. and Deacon, G., 1995. Use of rapeseed/canola protein products in finfish diets, pp 130 - 156. In C. E. Lim and D. J. Sessa (eds). Nutrition and utilisation technology in Agriculture. AOCS Press Champaign Illinois

Hossian, M. A. and Jauncey K., 1989. Studies on the protein, energy and amino acid digestibility of fish meal mustard oil cake, linseed and sesame meal for common carp (*Cyprinus carpio*) Aquaculture, 133: 257 - 274.

Kaushik, S. K., 1989. Alternative protein sources in the diets for carnivorous fishes. In R. Flos, L. Tort and P. Torres (Eds). Mediterranean Aqaculture. Ellis Horwood, London pp. 125-138.

Kissil, G. W., Lupatsch, I., Higgs D. A. and Hardy R. W., 1997. Preliminary evaluation of rapeseed protein concentrate as an alternative to fish meal in diets for giltherd seabream (*Sparus aurata*) Bamidgeh, 49: (3): 135 - 143.

Liener, I. E. 1994a. Implecations of antinutritional components in soybean foods. Crit. Rev. Food Sci. Nutri. 34: 31 - 67.

Liener, I. E. 1994b. Anti-nutritional factors related to proteins and amino acids. In: Hui Y. H., Gorham, J. R., Murell, K. D., and Cliver, D. O. S. (eds). Food borne Diseases Handbook Vol. 3 Mercel Dekker, New York pp. 261 - 309.

MERCK 1989. An encyclopaedia of chemicals, drugs and biologicals (Budevari, S., O'Neal M. J., Smith A. and Heckelman, P. E. (Eds.). Merck and Co., Rahway, N. J. USA p 26.

Mukhopadhyay, N. and Roy A. K. 1996. The potential of de-oiled sal (*Shorea robusta*) seed meal as a feed stuff in pelleted feed for Indian major carp, rohu *Labeo rohita* (Hamilton) fingerlings. Aquaculture Nutr., 2: 221 - 227.

Ogunji, J. O. and Wirth, M. 2001. Alternative protein sources as substitutes for fish meal in the diet of young Tilapia *Oreochromis niloticus (Linn.)* Isreali Journal of Aquaculture - Bamidgeh 53(1), 34 - 43.

Olvera, N. M. A., Martinez, P. C. Galvan, C. R. and Chavez, S. C. 1988. The use of the leguminous seed Sesbania grandiflora as a partial replacement for fish meal in diets for tilapia (*Oreochromis mossambiicus*).Aquaculture, 71: 51 - 50**.**

Rosenthal, G. A. Non-Protein amino acids in the life processes of higher plants. In B. K. Singh (Ed.) Biosynthesis and molecular regulation of amino acids in plants. Rockville, M. D. American Soc. of plant Physiologists., pp. 249 - 261

Rumsey, G. L., 1993. Fish meal and alternative sources of protein in fish feeds. Update 1993. Fisheries, 18(7): 14 - 19.

Siddhuraju, P. and Becker, K., 2001. Preliminary nutritional evaluation of Mucuna seed meal (*Mucuna pruriens var. utilis*) in common carp (*Cyprinus carpio* L.): an assessment by growth performance and feed utilisation. Aquaculture, 196: 105 - 123.

Shu, S. W. 1992. Effect of trypsin inhibitor on the growth of Nile tilapia. Acta Hydro. Sinica 16: 18 - 23.

Tacon, A.G. and A.J. Jackson, 1985. Utilisation of conventional and unconventional protein sources in practical fish feeds. In Cowey C.B, Mackie A.M., Bell J.G. (ed.) Academic Press, London, pp. 119 –145.

Udedibie, A. B. I., Nwaiwu J., Madubuike, F. N., Nkwocha, C. O. and Imo, I. O. 1988. Jack bean (*Canivalia enciformis*) poison turned to good protein feed. Publication of Federal University of Technology Owerri, Nigeria.

Udedibie, A. B. I., Esonu, B. O., Iwuoha, M. C. and Unachukwu, C. N., 1996. Two-staged cooking as a method for improving the nutritive value of jackbean (*Canivalia enciformis*) for broiler chicks. Nig. Journ. Anim. Prod. 24:

Viola, S., Mokady, S. and Y. Arieli, 1983. Effects of soybean processing methods on the growth of carp (*Cyprinus carpio*). Aquaculture, 32: 27 – 38.

Table 1: Chemical composition of Jack bean (g/kg DM)

	Raw	Boiled (30 minutes)	Boiled (60 minutes)
Protein (N X 6.25)	282.5	254.3	254.0
Ether Extract	29.0	28.2	28.0
Crude Fibre	67.3	62.0	62.1
Ash	34.4	29.4	29.2
NFE[1]	586.8	626.1	626.7
P(total) [2]	6.2	-	-
Ca[3]	0.9	-	-
Mg[4]	0.8	-	-
Gross energy (Kcal/100g)	459.32	-	-

[1]NFE =Nitrogen Free Extract; [2]P=Phosphorous; [3]Mg=Magnesium; [4]Ca=Calcium

Table 2: Composition of the experimental diets

	Diet No/ fish meal substitution by Jack bean[2]												
	1	2	3	4	5	6	7	8	9	10	11	12	13
	Control	10%	20%	40%	60%	10%	20%	40%	60%	10%	20%	40%	60%
Fish meal	22.0	19.80	17.6	13.20	8.80	19.80	17.60	13.20	8.80	19.80	17.60	13.20	8.80
JBSM[1]	0.00	4.36	8.72	17.44	26.17	4.93	9.86	19.71	29.57	4.93	9.86	19.71	29.57
G.Nut Meal	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
SoyBean M.	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Maize	35.0	32.84	30.68	26.36	22.03	32.27	29.54	24.09	17.63	32.27	29.54	24.09	17.63
Wheat bran	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Palm oil	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Bone	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[3]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
% CP	30.27	30.15	29.50	29.50	29.07	30.10	29.83	29.28	28.63	30.10	29.83	29.28	28.63
ME(Kcal/kg)[4]	2986.0	2975.1	2964.23	2942.62	2920.05	29.73.66	2961.30	2936.5	2967.47	2973.66	2961..30	2936..5	2967.47

[1]Jackbean seed meal; [2]diet 2-5 =raw jackbean meal; diet 6-9 =30 min. boiled; diet 10-13 =60 min boiled jackbean meal

[3]Vitamin and Mineral mix Vitamin A 800 IU; Vitamin D3 2000 IU; Vitamin E 51 u; Vitamin K 2 mg; Riboflavin 4.20 mg; Vitamin B12 0.01 mg; Nicotinic acid 20 mg; Biotin 544.65 µg; Folic acid 0.05 mg; Pantothenic acid 5 mg; Choline 300mg; Iodine 1 mg; Iron 20 mg; Copper 10 mg, Zinc 50 mg Cobalt 1.25 mg.

[4]ME calculated.

Table 3: The influence of the different diets on growth and nutrient utilisation of *Clarias gariepinus*

	Diet No/ fish meal substitution by Jack bean												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Parameter	Control	10%	20%	40%	60%	10%	20%	40%	60%	10%	20%	40%	60%
Initial wt.(g)	1.83	1.92	1.84	2.00	1.83	1.87	1.83	1.89	1.86	1.86	1.86	1.98	1.80
Final wt. (g)	4.50	4.00	3.73	3.35	2.86	4.00	3.70	3.64	3.15	4.83	4.50	3.90	3.42
SGR[1]	1.16^{a}	1.31^{b}	1.26^{b}	0.92^{d}	0.79^{de}	1.36^{b}	1.28^{b}	1.17^{bc}	0.94^{d}	1.71^{a}	1.58^{a}	1.22^{b}	1.15^{bc}
FCR[2]	1.88^{a}	2.28^{a}	2.39^{a}	3.27^{ab}	3.85^{ab}	2.23^{a}	2.41^{a}	2.55^{a}	3.21^{ab}	1.71^{a}	1.92^{a}	2.49^{a}	2.63^{cd}
PER[3]	1.74^{ab}	1.48^{ab}	1.38^{bc}	1.04^{ef}	0.89^{fg}	1.49^{bc}	1.40^{bcd}	1.35^{cde}	1.09^{def}	1.92^{a}	1.73^{ab}	1.51^{bc}	1.37^{cd}
Protein %	64.45^{a}	62.21^{bc}	61.74^{cd}	60.03^{e}	59.68^{e}	62.66^{bc}	61.87^{c}	60.29^{de}	59.72^{e}	63.60^{ab}	62.80^{bc}	52.50^{bc}	61.93^{c}
Fat %	8.30^{a}	8.13^{abc}	7.93^{c}	7.57^{def}	7.38^{fgh}	8.19^{ab}	8.06^{abc}	7.69^{d}	7.45^{efg}	8.26^{a}	8.21^{a}	7.98^{bc}	7.62^{de}

[1]SGR = Standard growth rate; [2]FCR= Food conversion ratio; [3]PER= Protein efficiency ratio