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REPLACEMENT OF FISH MEAL BY CORN GLUTEN MEAL IN FISH FEED: IMPACTS ON GROWTH AND BODY COMPOSITION OF *Labeo rohita* AND OVERALL PRODUCTION OF FISH POND

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In developing countries like Pakistan, the main constraint in aquaculture progress is the cost of production mainly; the feed. The present project will be helpful in formulation of cost effective fish feed by replacing costly fish meal with comparatively cheaper plant origin, corn gluten meal without any negative impacts on fish growth. The present study was conducted for the period of 270-days to replace costly fish meal ingredient of fish feed with Corn Gluten Meal (CGM) @ 25% (CGM1), 50% (CGM2) and 75% (CGM3) for development of low cost fish feed for *L. rohita* being raised in earthen pond aquaculture. The overall average gain in weight observed for *L. rohita* in Standard/Control (SC), CGM1, CGM2 and CGM3 were 832 g, 778 g, 752 g and 641 g at the termination of experimental period. Net fish production per hectare during the experimental period of on final harvest was 1933 kg, 1808 kg, 1747 kg and 1489 kg from the SC, CGM1, CGM2 and CGM3, respectively. The month wise data collected for growth parameters *viz.*, gain in weight, total length and fork length of fish were subjected to statistical analysis for comparison of means through ANOVA by using General Linear Model in SAS computer software showed no significant differences among the observations. During the cost benefit analysis it was concluded that replacement of fish meal from the *L. rohita* feed with corn gluten upto 50% will lower down the feed cost and there was no major differences in overall production from the fish ponds fed with control feed having fish meal and corn gluten replaced fed pond.
Keywords: Feed Formulation, cost, corn gluten, fish growth, *L. rohita*..

INTRODUCTION

Fish, mollusks, crustacean and aquatic plants culture are adopted both by the poor communities as well as the multi-national investors in the developing countries of the world. The use of aquaculture products including fish is essential for the poor communities of the developing countries as these are the good sources of macro and micro nutrients needed for the human body. Depending upon the progress from the previous thirty years in capture fishery products it is obvious to expect that future potential of the fishery sector will be strengthen by the aquaculture (Ye *et al.*, 2017). Aquaculture of developing countries is in its infancy and the use of commercial fish feeds are beyond the capacity of small scale fish farming communities, which is a limiting factor for promotion of this industry. The major costly fish meal ingredient of fish feed is fish meal and short falls in its supply have attracted the market towards its replacement with the cheaper protein sources ingredients of plant origin. The most of ingredients of fish feed are locally grown and if these are managed by the small scale farmers by their own man power and are replaced with costly feed ingredients like fish meal it will not only reduced the cost of production of fish but will also increase the per acre fish production and income of the farmers. There is concept generated among the nutritionist that the replacement of fish meal with low cost protein sources in fish feed will affect the quality of fish feed and will result in reduction of growth performance of the animal (Pai *et al.*, 2016). Corn gluten meal is a very good feed ingredient and can be replaced with costly fish meal upto ten percent without any negative impacts on digestibility and growth of fish. Fish meal substitution with corn gluten meal upto 20% in the isonitrogenous and isocaloric feed for Asian seabass have proved that no significant differences in growth of fish were observed (Nandakumar *et al.*, 2017). In fish feeds for aquaculture the main ingredient which is considered as the utmost important is fish meal, this is mainly due to its qualitative nature of compatibility and protein availability (Yigit *et al.*, 2006). The fish meal along with its importance as rich source of protein ingredient in fish feeds is also considered as the most expensive one by which the fish feed cost is increasing day by day. The increasing demand and uncertainty in its availability compelled the aquaculturists to decrease the levels of fish meal in fish feeds by replacing it partially or as a whole with plant sources. Globally fish meal demand for aquaculture was 32-Percent of the total world supply level of this product in 1999 (New and Wijkström, 2002) 37-Percent during the year 2000 (Chamberlain, 2000) and expected that the demand for fish meal for this purpose has crossed the limits of 70-Percent during the year 2015

(New and Wijkström, 2002). Aquaculturists have the view that if this demanded is increased at this rate then it is expected the total production may be exhausted by the aquaculture itself. As the fish meal demand will increase it will affect the cost of production of aquaculture products because in a typical farming system the feed cost is about 35-60-Percent of the total expenditures of production and most of the expenditures are of protein sources ingredients like of fish meal which costs 50-Percent of the total cost of the fish feed (Higgs, 1997). The aquaculture industry sustainability is depended upon the replacement of fish meal as protein source to other lower cost sources of mainly plant origin (Naylor *et al.,* 2000). The fish nutrionists are overcoming this issue by conducting research on alternatives of fish meal which will lower down the production cost without affecting the nutrional value of fish feeds in environment friendly formulation procedures for sustainable aquaculture practices. This replacement can be easily provided for herbi and omnivorous fishes as compared to carnivorous fishes which have many restrictions for use of these plant origin cheaper sources (Sargent and Tacon, 1999). Number of studies are surveyed for such experiments where fish meal has been replaced with; rice polish and maize gluten for carps (Hussain *et al.*, 2011), corn gluten for gilthead seabrem (Yigit *et al.*, 2012), corn gluten for rainbow trout (Gomes *et al.*, 1995), corn gluten meal for Yellowtail (Shimeno *et al*., 1993), corn gluten for flouder in Japan (Kikuchi, 1999), corn gluten for Tilapia (Wu *et al.*, 1995; Pereira and Teles, 2003)

Therefore, this project has been planned for replacement of costly fish meal at 25%, 50% and 75% levels with corn gluten without affecting the quality of fish feed for expected decrease in production cost of *L. rohita* aquaculture.

MATERIALS AND METHODS

***Ponds Preparation for Stocking*:** An experimental trial was conducted in 4-earthen fish ponds having water filled area of 375-sft (0.00860882-Acres) in three replicates designated as SC (Treated with Control/Standard formulated fish feed with normal levels of fish meal), CGM1 (Treated with feed formulated by replacing 25% of fish meal with Corn Gluten Meal), CGM2 (Treated with feed formulated by replacing 50% of fish meal with Corn Gluten Meal) and CGM3 (Treated with feed formulated by replacing 75% of fish meal with Corn Gluten Meal) each with dimensions of 15x25x5-CFT (Width x Length x Depth) at Fisheries Research Farms, of the Department of Zoology & Fisheries, University of Agriculture, Faisalabad, Pakistan for one production season of fish for 270-days from February to October. Necessary preparatory steps like; disinfection of ponds through lime application and manuring/fertilization was done by following Hora and Pillay (1962). After completion of this process fish ponds were filled with turbine water upto 5-feet and this water level was kept upto this filled condition throughout the production season by daily filling with turbine water. Optimum production conditions in terms of water quality for a warm water fish (Temperature 26-34^{0}C, pH from 7 to 7.5, hardness & alkalinity >20ppm) farming area were maintained throughout the study period.

***Experimental Fish Species*:** *Labeo rohita* was the experimental fish and at the 15th day of completion of above steps each pond was stocked with 20 individuals of *Labeo rohita*.

***Feed Preparation*:** For formulation of fish feed of 30% Crude Protein (CP) level on isonitrigenous basis for maintenance of protein levels, following feed ingredients were purchase from the commercial market and were analyzed for chemical composition before inclusion into feed as per below details;

***Fish meal*:** having 13.75% Moisture, 50.08% Protein, 11.22% Lipid and 2.17% Fiber and 22.8% Ash contents

***Sunflower Meal*:** having 7.5% Moisture, 35% Protein, 8.9% Lipid and 24% Fiber, 6.4% Ash and 18.2% Carbohydrate contents

***Rice polish*:** having 11.67% Moisture, 10.26% Protein, 10.45% Lipid, 20.45% Fiber, 16.44% Ash and 30.77% Carbohydrate contents

***Canola meal*:** having 10.78% Moisture, 36% Protein, 3.5% Lipid, 12% Fiber, 4.9% Ash and 32.82% Carbohydrate contents

***Corn gluten meal*:** having 7.1% Moisture, 30% Protein, 7.6% Lipid, 40.4% Fiber, 2.4% Ash and 12.5% Carbohydrate contents and

***Vitamin/mineral premix*:** Fish feeds; SC (Standard/Control), CGM1 (by replacing 25% fish meal from SC formula with Corn Gluten Meal), CGM2 (by replacing 50% fish meal from SC formula with Corn Gluten Meal) and CGM3 (by replacing 75% fish meal from SC formula with Corn Gluten Meal) were prepared as per below given formulation details in Table 1.

***Fish Feeding Protocol*:** The above formulated fish feeds (SC, SGM1, SGM2 and SGM3) were offered to cultured fish in

Table 1. Formulation of Standard/Control, SGM1, SGM2 and SGM3 Fish Feeds.

Feeds	Required Quantity of Each Ingredient for 100g Feed					
	FM	SFM	RP	CM	CGM	V/M %
SC	24	24	30	22	-	1
CGM1	18	24	28	24	6	1
CGM2	12	24	22	22	20	1
CGM3	6	26	21	23	26	1

FM=Fish meal, SMF=Sun flower Meal, RP=Rice polish, CM=Canola meal, CGM=Corn gluten meal and V/M=Vitamin/Mineral Premix ponds @ 2% of their wet body weight twice a day at 9:00-AM and 3:00-PM daily with no feeding on Sunday to maintain the good health condition of fish by feeding on plankton produced by the manures/fertilizers applied in the fish ponds.

***Parameters of Studies*:**

***Fish Growth*:** After every one month the stocked fish were captured by using nylon drag net and data for minimum 10 samples from each pond of three replicates was recorded randomly to evaluate the impact of replacement of fish meal with corn gluten meals in the ponds designated as SC, SGM1, SGM2 and SGM3 and a comparison was made which was based on; average gain in body weight, total body length & fork length and Relative Condition Factor (K).

K value was calculated by using following formula of Pauly (1983);

$K = 100\ w/L^b$ (W = Weight of *L. rohita* in grams, L = Total Length of *L. rohita* in Centimeters, b = The value obtained from Length-Weight Formula)

The length- weight relationship of fish was calculated as per cube law by LeCren (1951) as; $W= aL^3$ Where, W= Weight of fish (g), a = Constant value, L = Length of fish (cm)

This formula was also expressed in logarithmic form as:

$$\text{Log } W= \log c + n \log L$$

***Overall Fish Production*:** Gross and net production of *L. rohita* in Kilograms was calculated and presented in the results section

***Fish Body Composition*:** At the time of termination of trial 5-*L. rohita* from each treatment having three replicates were harvested and were analyzed for their body composition in terms of Moisture, Crude Protein, Total Fat & Total Ash Contents and Bone-Meat ratio by following AOAC (2006). Following formulae/Methods were used for the calculations;

$$\text{Moisture (\%)} = \frac{W_1\text{-}W_2}{W_3}$$

W1 (Cumulative weight of china dish and sample prior to drying process), W2 (Cumulative weight of china dish and sample after the drying process), W3 (Weight of fish tissue/sample) and

Dried Matter % = 100 - Moisture Contents calculated from above formula

***Crude Protein*:** by Kjeldhal's Method developed by AOAC (2006) and final calculassions of protein will be done by following this formula

$$\text{Nitrogen (\%)} = A/W$$

Where A = Volume of H_2SO_4 used x Normality of H_2SO_4 x 0.014 x 250 x 100, B = Weight of samples x10; 0.014 (Standard for Volume of 0.1-N Sulfuric Acid Used for Neutralization of NH_3), 250 (Dilution Factor), 100(For %age), 10 (Volume of digestion and dilution)

While finally crude protein was estimated by;

$$CP\% = N2\% \times 6.25$$

where, 6.25 is Assumption Factor of equation of N2% to Crude Protein

***Total Fats*:** by Soxhlet Extractor/Apparatus Model HT2 1045 System and final calculation by using below given formula;

$$\text{Total Fats Percentage} = W2\text{-}W1 \times 100/W$$

W1 (Empty Cup Weight Used for Extraction), W2 (Cup Weight with Fat after Extraction), W (weight of sample)

***Total Ash*:** was calculated by 2-g fish tissue burned in Muffle Furnace at 550-600^{0}C for 4 to 5-Hrs time, and then following formula was used for final calculations;

Total Ash % = Weight of Ash x 100 / Weight of Sample

***Carbohydrates*:** by following formula;

100-Cummulative Weight of Moisture, Crude Protein, Total Fats & Total Ash

***Statistical Analysis*:** For comparison of means through ANOVA by General Linear Model regarding the data for fish collected from SC, CGM1, CGM2 and CGM3 for all the growth parameters *viz*; gain in body weight, total length, fork length, condition factor and body composition parameters *viz*, moisture, crude protein, total fats, total ash and carbohydrates were subjected to SAS computer software version 9.1.1 by following Steel (1997).

RESULTS

By following the all procedures discussed in the materials and method section data collected and analyzed by statistical tools and necessary calculations were made which are presented below under these headings:

1. Fish Growth
2. Overall Fish Production
3. Fish Body Composition

***Fish Growth*:** Monthly data by capturing stocked *L. rohita* randomly but samples not less than 10 individuals were recorded for calculations of gain in average body weight, gain in total body length, for fork length and estimation of relative condition factor (K) for fish health trend.

At the time of stocking in February 2010, the initial wet body weight in grams of *L. rohita* was 37, 35, 33 and 32, while, at the time of final harvest during October 2010, it was recorded as 869, 813, 785 and 673 for SC, CGM1, CGM2 and CGM3, respectively. During the whole production season from February to October, 2010 minimum fish growth in terms of gain in body weight in grams was observed on 1st netting on 2nd of March, 2010 which was gained during first month of growth, February 2010, while, maximum growth record which was gained by *L. rohita* during the month of August 2010, was observed on netting of 2nd September, 2010 and remained as 152, 144, 142 and 122 grams for SC, CGM1, CGM2 and CGM3, respectively. Overall weight gain by *L. rohita* throughout the production season was recorded as; 832, 778, 752 and 641 grams, respectively, for SC, CGM1, CGM2 and CGM3 (Table 2).

One way ANOVA conducted by GLM for comparison of means for gain in body weight of *L. rohita* showed non-

Table 2. Gain in Body Weight by *L. rohita* Stocked in SC, CGM1, CGM2 and CGM3.

Months	SC		CMG1		CMG2		CMG3	
	AW	GW	AW	GW	AW	GW	AW	GW
2nd February	37	-	35	-	33	-	32	-
2nd March	67	30	63	28	58	25	52	20
2nd April	158	91	97	34	89	31	81	29
3rd May	194	36	167	70	154	65	143	62
2nd June	312	118	280	113	262	108	242	99
2nd July	461	149	420	140	400	138	357	115
2nd August	613	152	564	144	542	142	479	122
2nd September	758	145	711	147	688	146	603	124
2nd October	869	111	813	102	785	97	673	70
Overall GW	-	832	-	778	-	752	-	641

AW = Average Weight in Grams, GW = Gain in Weight in Grams

Table 3. ANOVA for Gain in Body Weight by *L. rohita* Stocked in SC, CGM1, CGM2 and CGM3.

SOV	Df	SS	MS	F-Value	P-Value
Treatments	3	2395.336	798.445	0.37	0.7781^{NS}
Error	28	61093.932	2181.926		
Total	31	63489.269			

Table 4. Gain in Total Body Length by *L. rohita* Stocked in SC, CGM1, CGM2 and CGM3.

Months	SC		CMG1		CMG2		CMG3	
	ATL	GTL	ATL	GTL	ATL	GTL	ATL	GTL
2nd February	10	-	10	-	10	-	10	-
2nd March	13	3	12	2	12	2	12	2
2nd April	17	4	16	4	16	4	13	1
3rd May	21	4	20	4	20	4	19	6
2nd June	25	4	25	5	24	4	23	4
2nd July	30	5	29	4	28	4	27	4
2nd August	34	4	33	4	32	4	30	3
2nd September	36	2	35	2	34	2	33	3
2nd October	38	2	37	2	35	1	34	1
Overall GTL	-	28	-	27	-	25	-	24

ATL = Average Total Body Length in Centimeters, GTL = Gain in Total Body Length in Centimeters

Table 5. ANOVA for Increase in Total Body Length by *L. rohita* Stocked in SC, CGM1, CGM2 and CGM3.

SOV	Df	SS	MS	F-Value	P-Value
Treatments	3	0.9337	0.31125	0.22	0.8788^{NS}
Error	28	38.8850	1.38875		
Total	31	39.8187			

significant results for data recorded for SC, CGM1, CGM2 and CGM3 (Table 3, 10).

L. rohita stocked in February 2010 was with average initial total body length of 10-Centimeters in all the treatments, while, at the time of final harvest during October 2010, it was recorded as 38, 37, 35 and 34 centimeters from SC, CGM1, CGM2 and CGM3, respectively. During the whole production season from February to October, 2010 average Minimum-Maximum gain in total body length varied as; 2-5 centimeters for SC & CGM1, 2-4 centimeters for CGM2 while it remained 1-6 for CGM3. Overall average increase total body length of *L. rohita* throughout the production season was recorded as; 28, 27, 25 and 24 centimeters, respectively, for SC, CGM1, CGM2 and CGM3 (Table 4).

One way ANOVA conducted by GLM following DMR for comparison of means for average values of increase in total body length of *L. rohita* found non-significantly ($P>0.05$) different among the SC, CGM1, CGM2 and CGM3 (Table 5 10).

In February 2010 *L. rohita* was with an average initial fork length of 9-Centimeters for SC and CGM1, while, having 8-centimeters of fork length which was cultured in CGM2 &

Table 6. Gain in Fork Length by *L. rohita* Stocked in SC, CGM1, CGM2 and CGM3.

Months	SC		CMG1		CMG2		CMG3	
	AFL	GFL	AFL	GFL	AFL	GFL	AFL	GFL
2nd February	9	-	9	-	8	-	8	-
2nd March	10	1	10	1	9	1	10	2
2nd April	12	2	12	2	11	2	11	1
3rd May	16	4	15	3	14	3	14	3
2nd June	20	4	19	4	18	4	18	4
2nd July	24	4	23	4	23	5	23	5
2nd August	28	4	27	4	26	3	26	3
2nd September	33	5	32	5	30	4	30	4
2nd October	35	2	34	2	32	2	32	2
Overall GFL	-	26	-	25	-	24	-	24

AFL = Average Fork Length in Centimeters, GFL = Gain in Fork Length in Centimeters

Table 7. ANOVA for Increase in Fork Length by *L. rohita* Stocked in SC, CGM1, CGM2 and CGM3.

SOV	Df	SS	MS	F-Value	P-Value
Treatments	3	0.703437	0.23447917	0.15	0.9260^{NS}
Error	28	42.553750	1.51977679		
Total	31	43.257187			

CGM3. At the time of final harvest during October 2010, average fork length was recorded as 35 and 34 centimeters from SC and CGM1, while, samples captured from CGM2 & CGM3 were with an average fork length of 32-centimeters. During the whole production season from February to October, 2010 an average Minimum-Maximum gain in fork length varied as; 1-5 centimeters for all the treatment. Overall an average increase fork length of *L. rohita* throughout the production season was recorded as; 26 and 25 for the fish captured from SC & CGM2, while, it was observed as 24 centimeters for fish harvested from both remaining treatments (Table 6).

One way ANOVA conducted by GLM following by DMR test for comparison of means for average values of increase in fork length of *L. rohita* were found non-significantly (P>0.05) different among the SC, CGM1, CGM2 and CGM3 (Table 7 & 10).

Considering the importance of health conditions of stocked fish in optimum maintained water quality of the fish ponds, length-weight based Relative Condition Factor (K) was computed for *L. rohita*. The average K values remained as 2.3, 2.2, 2.2 and 2.3 for SC, CGM1, CGM2 and CGM3 (Table-8) by which it was concluded that fish remained healthy and this iso-meteric trend of growth as depicted from almost similar k-values showed that growth conditions were at their optimum desirable levels for fish farming. From the ANOVA conducted by GLM by following DMR test for comparison of mean values for K-values also showed that there were no significant difference (P>0.05) among the treatments (Table 9 & 10).

Table 8. Values of Condition Factor for *L. rohita* in SC, CGM1, CGM2 and CGM3.

Ponds/Months	SC	CGM1	CMG2	CGM3
February	3.3	3.3	3.1	3.2
March	3.4	3.5	3.4	3.4
April	3.5	2.3	2.3	2.6
May	2.2	1.9	2.0	2.1
June	1.9	1.9	1.9	2.0
July	1.7	1.7	1.8	1.8
August	1.6	1.6	1.7	1.8
September	1.6	1.6	1.8	1.8
October	1.6	1.7	1.8	1.8
Average K-values	2.3	2.2	2.2	2.3

***Overall Fish Production*:** Experimental ponds designated as SC, CGM1, CGM2 and CGM3 were of an area of 375-sft having dimensions 15x25x5-cft (Width x Length x Depth), the stocked fish was *L. rohita* which is a warm water fish which performs well from February to October when water temperature normally remains between 20-36^{0}C which suitable for it growth and this season is marked as fish production season in Pakistan. During present experiment at its final netting overall gross fish production was calculated as; 17.38, 16.26, 15.7 and 641 kg/pond/year, 2019, 1889, 1824 and 1564 kg/acre/year, 4987, 4666, 4505 and 3863 kg/hectare/year, while, net overall production remained as; 16.64, 15.56, 15.04 and 12.82 kg/pond/year, 1933, 1808, 1747 and 1489 kg/acre/year and this production was 4775, 4466, 4315 and 3678 kg/hectare/year, respectively for SC, CGM1, CGM2 and CGM3. From these values for production, it is clear that there were not too much decreasing trend in overall performance of *L. rohita* upto 50% replacement of too much

Table 9. ANOVA for Values of Condition Factor for *L. rohita* in SC, CGM1, CGM2 and CGM3

SOV	Df	SS	MS	F-Value	P-Value
Treatments	3	0.1112	0.03707	0.07	0.9748^{NS}
Error	32	16.5776	0.51805		
Total	35	16.6888			

costly fish meal with comparatively too much cheaper corn gluten meal in earthen ponds (Table 11). From the Table 10 for comparing means of gain in weight it was also clear that production trend was almost similar in all the treatments.

Table 10. Duncan's Multiple Range Values for Comparisons of means for increase in weight, total length and fork length AND Relative Condition Factor (K) of *L. rohita.*

Parameters	No.	Treatment	Mean	Std. Dev.
Increase in average Weight of *L. rohita*	8	SC	103.925A	48.045
		CGM1	97.200A	48.369
		CGM2	94.013A	48.882
		CGM3	80.188A	41.115
Increase in average Total Length of *L. rohita*	8	SC	3.425A	1.214
		CGM1	3.300A	1.186
		CGM2	3.125A	1.160
		CGM3	2.975A	1.154
Increase in average Fork Length of *L. rohita*	8	SC	3.250A	1.290
		CGM1	3.150A	1.252
		CGM2	2.963A	1.196
		CGM3	2.875A	1.190
Relative Condition Factor for *L. rohita*	9	SC	2.313A	0.848
		CGM1	2.178A	0.733
		CGM2	2.190A	0.621
		CGM3	2.266A	0.656

***Fish Body Composition*:** At the time of termination of trial 5-*L. rohita* for each treatment having three replicates were harvested and were analyzed for their body composition in terms of Moisture, Crude Protein, Total Fat, Total Ash Contents and Carbohydrates. The results presented in Table 14 showed that body of fish was composed of; moistures contents percentage 74, 76, 74 & 76, CP %age 20, 16, 16 & 18, Ash Percentage 2, 3, 3.3 & 3.3, Fat content percentage 1.9, 1.9, 2 and 2 while carbohydrate ratio in percent was 2, 2.4, 2.1 and 2.4 for SC, CGM1, CGM2 and CGM3, respectively. Statistical comparison of means through ANOVA showed no significant differences among the fishes raised with replacement of fishmeal with corn gluten meal at different levels of 25, 50 and 75%. Comparison of mean values for these parameters showed that moisture, ash and carbohydrates contents were not significantly different ($P>0.05$) for the *L. rohita* while, CGM3 was significantly different ($P<0.05$) from the other treatments in terms of fat contents and this trend between the all treatments was highly significantly different (($P<0.01$) for the protein contents (Table 12).

***Discussion*:** Till the recent past fish was the chief protein source in formulation of fish feeds due to its important profile, however, the fish meal provision is at risk due to high demands and prices, therefore, there is a need to evaluate the alternate sources which are cheaper and easily available

Table 11. Overall Production of *L. rohita* from SC, CGM1, CGM2 and CGM3 having an Area of 375-sft (0.00860882-Acres)

Ponds	SC	CGM1	CGM2	CGM3
Total Individual Stocked	20	20	20	20
Survival Rate	100%	100%	100%	100%
Overall Initial Average Weight in grams/Fish	37	35	33	32
Overall Average Final Weight in grams/Fish	869	813	785	673
Overall Average Weight Gain in grams/Fish	832	778	752	641
Gross Production in Kg /Pond/Season	17.38	16.26	15.7	13.46
Gross Production in Kg /Acre/Season	2019	1889	1824	1564
Gross Production in Kg /Hectare/Season	4987	4666	4505	3863
Net Production in Kg /Pond/Season	16.64	15.56	15.04	12.82
Net Production in Kg /Acre/Season	1933	1808	1747	1489
Net Production in Kg /Hectare/Season	4775	4466	4315	3678

Table 12. Body Composition of *L. rohita* in SC, CGM1, CGM2 and CGM3.

Ponds	Moisture (%)	CP (%)	Ash (%)	Fat (%)	Carbohydrates (%)
SC	74 A	20 A	2.0 A	1.9 A	2.0 A
CGM1	76 A	16 BC	3.0 A	1.9 A	2.4 A
CGM2	74 A	16 BC	3.3 A	2.0 A	2.1 A
CGM3	76 A	18 BC	3.3 A	2.0 B	2.4 A

(Daniel, 2018), taking in account this fact the present study was planned to test the alternate source of maize gluten meal which is more cheaper than the fish meal. The results of this study showed that the trend in growth parameters like increase in average body weight, total body length and fork length was not significantly different (*P*>0.05) among all the treatments *viz.*, SC, CGM1, CGM2 and CGM3. Overall comparison made in terms of overall production also confirmed that the replacement of fish meal from standard/control diet at 25% & 50% levels with corn gluten meal also confirmed that not too much differences were found among the per acre production of fish. These results are supported by the work of Jerile and Pirhonen (2017) on similar feed regime for rainbow trout and in which positive results were found in terms of growth and overall production when fish meal was replaced with corn gluten meal. The fish feeds containing corn gluten in replacement to fish meal are much cheaper that the fish meal based diets. In the present study the economics of ponds was much better in case of CGM1 & CGM2 when fish meal was replaced with corn gluten meal upto 50%. These findings are supported by the work done by Noreen *et al.* (2007) on plant origin; soybean and maize gluten meal upto 30% which had a positive effect on growth and body composition of hbrid of *L. rohita x C. catla* fingerlings and this study is also in accordance with work of Nandakumar *et al.* (2017) on development of cost effective feeds for Asian seaboss by replacing fish meal with the corn gluten meal upto 20%. The present study also matches with findings of Bulut *et al.* (2014) the work on growth potential and utilization of feed by 2-species of banded seabream, the inclusion of corn gluten meal as replacement to fish meal upto 30% showed no negative impacts on growth and feed utilization. Health conditions of stocked *L. rohita* compared by relative condition factor values (K) also showed that there were no differences found among the harvest fish from all the treatments in terms of health, it was concluded that fish remained healthy and this iso-meteric trend of growth as depicted from almost similar k-values showed that growth conditions were at their optimum desirable levels for fish farming. These results are similar with the earlier findings (Ighwela *et al.,* 2011) on tilapia culture where the isometric trends were observed in k-value which is very good indicator of fish health and ultimately the good production conditions in the fish ponds. Results for body composition of *L. rohita* showed no significant differences among the fishes raised with replacement of fishmeal with corn gluten meal at different levels of 25, 50 and 75%, in case of moisture, ash and carbohydrates contents, while, CGM3 was significantly different (P<0.05) from the other treatments in terms of fat contents and this trend between the all treatments was highly significantly different ((P<0.01) for the protein contents. These results are in line with the earlier work (Nandakumar *et al*., 2017) on Asian seaboss by replacing fish meal with the corn gluten meal upto 20% and there were found no significant results among the both sources for fish body composition upto 10%.

***Conclusion*:** From this study it has been concluded that fish meal replacement with corn gluten meal upto 50% has no negative impacts on growth of fish and overall production of earthen ponds. By following the results of study cost effective feeds can be developed for pond aquaculture.

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