Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(4): 192-199

Received: 01-05-2019
Accepted: 03-06-2019

Neha Sharma
Department of Aquaculture, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab, India

Syed Shabih Hassan
Assistant Scientist (Fisheries), Department of Aquaculture, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab, India

MD Ansal
Department of Aquaculture, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab, India

Correspondence
Syed Shabih Hassan
Assistant Scientist (Fisheries), Department of Aquaculture, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab, India

Incorporation of press mud: A sugar factory byproduct in semi-intensive carp polyculture system and its effect on fish growth and survival

Neha Sharma, Syed Shabih Hassan and MD Ansal

Abstract
Experiment was conducted in (80m^2) outdoor cemented tanks for 180 days to assess the efficacy of press mud incorporated diets in semi-intensive carp polyculture system. Experimental diets were prepared by 15% (D_2), 20% (D_3), 25% (D_4) and 30% (D_5) replacement of rice bran (i.e. 50 %) of basal diet-D_1 (de-oiled rice bran and mustard meal in the ratio of 1:1) with dried press mud. These diets were fed to Indian major carp fry (*Catla catla* Ham., *Labeo rohita* Ham. *Cirrhinus mrigala* Ham) and exotic carp fry (*Cyprinus carpio* Linnaeus) stocked @ 10000/ha (80 per tank). The diets were fed @ 10% fish body weight (BW) for the first month, 3% BW for the second month and 1.5% BW for the next two months and @ 1% BW for the following months. All the species fed with press mud based diets reflected better condition factor which indicates better health and condition of fish. Press mud inclusion had no negative effect on the flesh quality of all the fish species. As compared to control, press mud incorporation supported higher or comparable growth in *L. rohita* with 20 % (D_3) and 25 % (D_4), in *C. mrigala* with 20-30% (D_3-D_5) and in *C. carpio* at 30% (D_5) rice bran replacement level; however, growth of *C. catla* declined significantly with press mud based diets. The maximum yield was recorded in control (Diet-D_1) comparable to this was D_2. Comparative net profit of experimental diets with respect to yield and feed cost reduction was also evaluated. Among the different treatments maximum fish harvest (6.089 kg) was recorded for diet D_1 (control) followed by D_2 (5.704 kg), D_3 (5.633 kg), D_4 (5.546 kg) and D_5 (5.450 kg). As compared to control 6.32 %, 7.49 %, 8.87 % and 10.49 % less fish biomass were recorded with diets D_2, D_3, D_4 and D_5, respectively. Lowest FCR was recorded for diet D_3 and D_2 (1.62 and 1.63) followed by D_1 (1.74), D_4 (1.77) and D_5 (1.84). Cost of feed decreased by 5.19, 6.96, 8.67 and 10.44 % in diet D_2, D_3, D_4, D_5, due to press mud incorporation. Maximum net profit with respect to fish harvest and feed cost was recorded for D_1, which was 3.16 % higher than D_2 followed by D_3, D_4, and D_5. The net profit and total fish harvest from press mud incorporated carp diet in different treatment (D_2 -D_5) were found to be comparable to control diet. The resulting lower FCR in 20 % and 15% level of press mud inclusion diet (1.62 and 1.63) showed that these feeds are efficiently used by the fishes. The results of present study reveal that press mud inclusion at all levels (15 - 30%) in carp supplementary diet did not affect water quality parameters, plankton productivity, survival, growth and flesh quality of fish. Hence, both these diets can be efficiently used to replace control diet. The results reveal that press mud can be included in carp diet up to 30% level for formulating low cost diets for production of good quality economical carp fish production.

Keywords: Pond aquaculture, press mud utilization, semi-intensive carp polyculture, low feed cost, sustainable production

Introduction
Indian aquaculture has become a dynamically developing sector with contribution of 4.21 million ton [1] to the world. Freshwater aquaculture sector in India is dominated by semi-intensive carp polyculture in ponds, where fertilizers are used to enhance natural productivity and fishes are provided with farm made supplementary feeds to meet various nutritional and energy requirements and to maximize growth performance. Sustainable and successful freshwater fish culture on scientific basis principally depends upon the use of adequate, economically viable and environment friendly artificial feeds [2]. Nutrition and feeding play a central and essential role in the sustained development of aquaculture and feed costs more than 60% of the total input cost. As conventional feed ingredients/formulated feeds, are costly so, it is becoming difficult for the small and marginal fish farmers to afford supplementary feeds for maximizing the rate of fish production. Hence there is need to identify locally available low cost non-conventional feed resources (NCFR), of high nutritive value, as substitute of

conventional feed resources viz. rice bran, wheat bran, mustard oil cake and groundnut oil cake, fish meal etc. Non-conventional feed resources (NCFRs) are feeds that are not usually common in the markets and are not the traditional ingredients used for commercial fish feed production [3]. Dhawan *et al* [4] stated that NCFR includes agro-industrial byproducts (sugar industry, distillery, brewery and starch industry), animal husbandry wastes (poultry waste, slaughter house waste, animal house waste etc.) and aquatic plants (*Azolla*, duckweeds etc.).

Indian sugar industry is the second largest agricultural industry followed after the textile industry [5]. Indian sugar cane industries and fisheries industries are age old industrial practices. These industries produce a significant amount of byproducts as waste. Management, handling and processing of their byproducts are massive task, because sugarcane waste requires a large areas for storage and that of fish processing waste is perishable and its spoilage emits foul smell and gas to the surrounding environment. However, both the byproducts provide opportunity to utilize their byproducts in agriculture, plantation, animal husbandry, fisheries as organic nutrient sources and feed supplement. Application of press mud and bagasse improves physical condition of soil by reducing bulk density and enhanced macropore for a better root growth and productivity [6]. Sugar cane tops, molasses, bagasse and press mud are the major byproducts from sugar industry. Press mud is commonly called as sugarcane filter press mud, sugarcane press mud, sugarcane filter cake mud, sugarcane filtercake, sugarcane filter mud or scum [7]. Press mud is generated as the byproducts of sugar cane industries are characterized as a soft, spongy, amorphous and dark brown to brownish material [8]. Ghulamabbas *et al* [9] developed biofertilizer from soil rhizospheric microorganisms in sugarcane organic waste as carrier material for agriculture development. Press mud supplies good amount of organic matter which can be alternate source of plant nutrients and act as a soil ameliorator [10], [11]. Press mud contains 50-70 % moisture, which is most favorable for soil microorganism and earthworms. Press mud is used as one of the substrate for biocomposting [12]. The amount of sugar press mud production depends upon the carbonation and sulphitation process. It is around 3-9 % of the total weight of sugar cane from above process [13]. Press mud is insoluble, takes long time for natural decomposition and generates intense heat with foul odour [14]. Press mud is the compressed sugar industry waste, a good source of fertilizers, and very useful for energy production, agro-horticultural crops, periphyton based aquaculture and biocomposting due to its richness in various micronutrients [15, 16, 17]. Press mud is generated from alcohol distillation from the fermentation of sugarcane molasses which contains huge quantities of water soluble plant nutrients and there is scope in utility as an organic fertilizer [18].

Sugar mills in India produce about 12 million tonnes of press mud as a waste from double sulphitation processes [15, 19, 20]. Press mud is a soft, spongy, amorphous and dark brown to brownish material which contains sugar, fiber, coagulated colloids, including cane wax, albuminoids, inorganic salts, soil particles and is brown fibrous material [21, 22, 23] produced in large amount during sugar cane juice clarification after the extraction of raw juice from sugar cane [24]. About 36 - 40 kg of press mud is produced per 1 ton of cane crushing [25]. It contains inorganic constituents like N, P, K, Ca, Mg, Fe, and Mn. The content of protein, sugar and fiber makes press mud a potential feed ingredient, but actual feed trials are scarce [26]. However, Siddaiah *et al* [27] conducted a feeding trial for a period of 60 days to assess the potential of sugar factory by-products (press mud and molasses) as feed ingredients in *L. rohita* fingerlings. Press mud, show effectiveness as manure in the production of natural food and carp, and has chemical composition similar to that of cattle dung [28]. Low cost and easy availability of press mud makes it a potential substitute of carbohydrate based diet and its judicious use for suitable farming system can substantially reduce the cost of fish feed. The literature reviews suggest that such systematic knowledge has not been undertaken.

Hence, present study was carried out to investigate the possible replacement of rice bran with press mud in carp feed and evaluate the effect of press mud based diets on survival, growth, and productivity of carps in a semi-intensive polyculture system.

Thus the objective of the trial was to assess the effect of sugarcane byproduct press mud incorporated diets in different combinations in polyculture of Catla, Rohu, Mrigal and Common carp.

Materials and Methods

Experimental layout

An outdoor experiment was conducted (180 days) for each diet in 80 m^2 cemented tanks (in duplicate), at the Fish Farm of College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, Punjab (Figure 1). At the bottom of pond five cm thick soil layer was spread to enhance the primary productivity by decomposition process. The tube well water was used for filling and maintaining water level in the tanks during the culture period. Manuring was done with cow dung slurry @ 20,000 l/ha/yr (160 l/tank/year). One fourth (40 l/tank) of the slurry was applied 15 days prior to the stocking of fish and rest in equal fortnight installments (5 l/tank).

Fig 1: Panoramic view of outdoor experimental tanks (80m^2)

Preparation of supplementary diets

Dried press mud was procured from a nearby sugar plant (Nahar Sugar Mill, Khanna, Punjab) and to avoid microbial attack it was again sun dried for two days and further kept in a sealed container (Figure 2 & 3). Five supplementary diets (D_1 - D_5) were prepared with traditional used basal diet i.e. D_1 (solvent extracted mustard meal and solvent extracted rice bran in the ration of 1:1) and replacement of rice bran with press mud @ 15% (D_2), 20% (D_3), 25% (D_4) and 30% (D_5) (Table 1). The proximate composition of different feed ingredients and prepared diets was evaluated as per the methods of AOAC [29] (Table 2).

Fig 2: Sundrying of press mud

Fig 3: Press mud after grinding

Table 1: Per cent composition (%) and cost of different diets

Ingredients	D_1*	D_2	D_3	D_4	D_5
Mustard meal	50.00	50.00	50.00	50.00	50.00
Rice bran	50.00	42.50	40.00	37.50	35.00
Press mud	-	07.50	10.00	12.50	15.00

*Basal diet = Rice bran + Mustard meal (1:1)

Stocking of fish

Each tank was stocked with fry of Indian major carps viz; catla, *Catla catla* (Ham.); rohu *Labeo rohita* (Ham.) and mrigal, *Cirrhinus mrigala* (Ham.) and exotic carp *Cyprinus carpio* (Linnaeus) @ 10,000/ha (80/tank viz. *catla*-24, *rohu*-32, *mrigal*-12, *Common carp*-12). Fish were fed with different diets at fixed corners of the tank every day (Figure 4.). Feeding @ 10% body weight (BW) for the first month, @ 3% BW for the second month and @ 1.5% BW for the next two months and @ 1% for last two months.

Fig 4: Supplying feed in experimental tank

Table 2: Per cent Proximate composition (DM basis) and gross energy of different feed ingredients and press mud incorporated diets

Ingredients/ diets	Crude protein %	Ether extract %	Crude Fiber %	Ash %	Nitrogen free Extract %	Gross Energy (Kcal/g)	Cost (Rs./kg)**
Rice bran*	17.95	0.73	10.55	11.35	59.42	3.519	9.50
Mustard meal*	36.60	2.17	10.89	9.27	41.07	3.957	17.50
Pressmud	15.22	6.02	15.23	21.29	42.24	3.161	0.10
$D_1(Control diet)	27.27	1.45	10.72	10.31	50.25	3.738	13.50
D_2	27.07	1.74	11.07	11.13	48.99	3.702	12.80
D_3	27.00	1.83	11.19	11.40	48.58	3.690	12.56
D_4	26.98	1.93	11.31	11.68	48.10	3.679	12.33
D_5	26.86	2.03	11.42	11.95	47.74	3.668	12.09

Observation

Water quality parameters (transparency, turbidity, conductivity, pH, temperature, dissolved oxygen, biochemical oxygen demand, total alkalinity, total hardness, chloride, ammonical nitrogen, nitrate-nitrogen, nitrite-nitrogen and soluble phosphates) and plankton productivity (phytoplankton and zooplankton), were analyzed through standard protocol as per APHA[45] on fortnightly basis throughout the experiment. Fish sampling was done at monthly intervals. A random sample of 10 fish of each species from each tank was collected to record total body length, standard body length and body weight (BW). Net weight gain (NWG), percent net weight gain (% NWG), specific growth rate (SGR), condition factor (K) and feed conversion ratio (FCR) for every treatment were calculated as per standard methods. Flesh quality was also analyzed at end of experiment.

Statistical analyses

The data was analyzed with SPSS version-16. One way ANOVA and Duncan's multiple range test [30] was applied to work out the effect of different diets on water quality, growth and flesh quality of different fish species [30] and to determine differences among the treatments, considered statistically significant when $P \leq 0.05$.

Results

The water quality parameters monitored were within favorable limits for the growth of fish. Transparency (16.5 to

36.5 cm), turbidity (18.56 to 49.34 NTU), specific conductance (0.13 to 0.46 mS), temperature (13.00 to 34.50 °C), pH (8.18 to 9.16), phenolphthalein alkalinity (8 to 40 $CaCO_3$ mg l^{-1}), methyl orange alkalinity (66 to 174 $CaCO_3$ mg l^{-1}), total alkalinity (110 to 200 $CaCO_3$ mgl^{-1}), total hardness (90 to 206 mg l^{-1}), chloride (11-24 mg l^{-1}), dissolved oxygen (6.2 to 18.5 mg l^{-1}), biochemical oxygen demand (1.2 to 4.8 mg l^{-1}), ammonical nitrogen (0.009 to 0.157 mg l^{-1}), nitrite-nitrogen (0.011 to 0.214 mg l^{-1}), nitrate - nitrogen (0.036 to 0.869 mg l^{-1}) and soluble phosphate (0.037 to 0.228 mg l^{-1}) concentrations in the different treatments (D_1 – D_5) were recorded to be within the optimum range for carp culture throughout the culture period.

The total phytoplankton (TP) population in the different treatments ranged from 144-276 x 10^6 l^{-1} during the culture period. The range of total zooplankton (TZ) population (No.l^{-1}) in the different treatments was between 638-1116 during the culture period showing that press mud incorporation in feed has no adverse effect on water quality of pond and the results are in agreement with the earlier study conducted by Singh *et al* [36].

Survival

At the termination of experiment 100% survival for *Cyprinus carpio* was reported in all the treatments having press mud incorporated diets (D_1 – D_5) which reveal that press mud inclusion had no effect on the survival of *Cyprinus carpio*. In *Catla catla*, maximum (100%) survival was recorded in D_1 and D_3 while minimum (83.33%) in D_5. In *Labeo rohita*, maximum (93.75%) survival was recorded in D_1, D_2 and D_3 while minimum (87.50%) in D_4 and D_5. In *Cirrhinus mrigala* maximum (100%) survival was recorded in D_1, D_2 and D_4 while minimum (83.33%) in D_3 (Table 3). As a whole the maximum percent survival was recorded in D_1 experimental tank followed by 96.3%, 95%, 92.5%, and 88.8% in D_2, D_3, D_4 and D_5 respectively (Table 3).

Table 3: Per cent Survival of culture species in different treatments at termination of experiment

Fish species	D1	D2	D3	D4	D5
Catla catla	100%	95.8%	100%	91.7%	83.3%
Labeo rohita	93.8%	93.8%	93.8%	87.5%	87.5%
Cirrhinus mrigala	100%	100%	83.3%	100%	91.7%
Cyprinus carpio	100%	100%	100%	100%	100%
Total	97.5%	96.25%	95%	92.5%	88.8%

Growth

Catla catla

In different treatments highest growth of *Catla catla* was recorded in D_1 followed by D_2, D_3, D_4 and D_5. At the end of culture period, the total length gain (TLG) and % TLG was maximum (11.89 cm and 277.8 %) in D_1 and minimum (10.02 cm and 194.2 %) in D_4. NWG was maximum (70.82 g) in fish fed with control diet (D_1) that was nearly equivalent to D_2 while minimum (52.79g) in D_4 and the difference among different treatments were significant. The percentage NWG was maximum (3476.8%) in D_1 and minimum (2663.9%) in D_4. SGR was maximum (2.00) in D_1 and D_2 and minimum (1.86) in D_4 fed fish (Table 4).

Labeo rohita

Press mud incorporated diets D_3 and D_4 supported higher growth of Rohu as compared to D_1, D_2 and D_5. At the end of culture period, TLG was maximum (10.84 cm) in D_4 and minimum (9.9 cm) in D_2. The NWG was maximum (47.1 g) in D_4 and minimum (40.9g) in D_2 and the difference among treatments were significant. The % NWG was maximum (2276.8%) in D_4 and minimum (1957.4%) in D_2. As compared to control (D_1) % NWG was 3.95 and 9.50 higher in D_3 and D_4 respectively, and SGR was maximum (1.76) in D_4 and minimum (1.68) in D_2 fed diets (Table 4).

Cirrhinus mrigala

Diets D_3-D_4 supported higher growth of Mrigal as compared control D_1 and D_2 diets. At the end of culture period, TLG and % TLG was maximum (14.15 cm and 268.5 %) in D_4 and minimum (13.31 cm and 248.3 %) in D_1. The NWG was maximum (75.1 g) in D_5 and minimum (66.10 g) in D_2 and the difference among treatments were significant. The % NWG was maximum (4144.4%) in D_4 and minimum (3634.5%) in D_2 and SGR was maximum (2.08) in D_3, D4, D5 and minimum (2.01) in D_2. As compared to control (D_1), % NWG was 8.33, 9.95 and 10.69 % higher in D_3, D_4 and D_5, respectively (Table 4).

Table 4: Growth in different treatments

Parameter	Treatments				
	D_1	D_2	D_3	D_4	D_5
	Catla catla				
Initial total length	5.22^a±0.29	5.21^a ±0.28	5.14^a ±0.27	5.16^a ±0.35	5.26^a ±0.28
Final total length(cm)	17.11^a±0.14	16.86^a±0.15	16.11^b ±0.24	15.18^c±0.29	15.56^{bc}±0.29
Initial body weight (gm)	1.98^a±0.11	1.90^a±0.10	1.92^a±0.10	1.91^a±0.12	1.96^a±0.09
Final body weight (gm)	72.80^a±2.20	69.60^a±1.68	61.50^b±1.67	54.70^c±1.46	58.70^{bc}±1.65
NWG	70.82	67.70	59.58	52.79	56.74
% NWG	3476.8	3463.2	3003.1	2663.9	2794.9
% NWG over control		-4.41	-15.87	-25.46	-19.88
SGR	2.00	2.00	1.93	1.86	1.89
	Labeo rohita				
Initial total length	5.23^a±0.29	5.21^a±0.30	5.10^a±0.25	5.17^a±0.24	5.14^a±0.25
Final total length(cm)	15.41^a±0.49	15.11^a±0.43	15.52^a±0.39	16.01^a±0.22	15.08^a±0.15
Initial body weight (gm)	2.05^a±0.07	2.09^a±0.09	2.06^a±0.07	2.07^a±0.09	2.02^a±0.09
Final body weight(gm)	45.00^{ab}±2.20	43.00^b±2.55	46.80^{ab}±1.61	49.20^a±1.74	44.00^{ab}±1.12
NWG	43.00	40.90	44.70	47.10	42.00
%NWG	2095.1	1957.4	2171.8	2276.8	2078.2
% NWG over control		-4.88	+3.95	+9.50	-2.33
SGR	1.72	1.68	1.74	1.76	1.71

Cirrhinus mrigala					
Initial total length	$5.36^{a}\pm0.23$	$5.16^{a}\pm0.27$	$5.32^{a}\pm0.28$	$5.27^{a}\pm0.23$	$5.23^{a}\pm0.22$
Final total length(cm)	$18.67^{b}\pm0.21$	$18.68^{b}\pm0.21$	$19.24^{ab}\pm0.25$	$19.42^{a}\pm0.21$	$19.37^{a}\pm0.21$
Initial body weight(gm)	$1.85^{a}\pm0.07$	$1.77^{a}\pm0.07$	$1.79^{a}\pm0.07$	$1.80^{a}\pm0.06$	$1.82^{a}\pm0.06$
Final body weight(gm)	$69.70^{b}\pm2.01$	$66.10^{b}\pm1.75$	$75.30^{a}\pm1.71$	$76.40^{a}\pm1.46$	$76.90^{a}\pm1.78$
NWG	67.85	64.30	73.50	74.60	75.10
%NWG	3667.57	3634.46	4106.7	4144.4	4125.3
% NWG over control		-5.23	+8.33	+9.95	+10.69
SGR	2.02	2.01	2.08	2.08	2.08
Cyprinus carpio					
Initial total length	$7.14^{a}\pm0.14$	$7.08^{a}\pm0.14$	$7.18^{a}\pm0.22$	$7.03^{a}\pm0.15$	$7.22^{a}\pm0.15$
Final total length(cm)	$21.36^{ab}\pm0.38$	$21.04^{ab}\pm0.36$	$20.74^{b}\pm0.35$	$21.08^{ab}\pm0.24$	$21.88^{a}\pm0.34$
Initial body weight (gm)	$7.08^{a}\pm0.10$	$7.03^{a}\pm0.11$	$7.05^{a}\pm0.18$	$7.01^{a}\pm0.11$	$7.20^{a}\pm0.09$
Final body weight (gm)	$179.60^{a}\pm7.20$	$168.30^{a}\pm2.86$	$166.70^{a}\pm6.42$	$170.70^{a}\pm7.86$	$183.20^{a}\pm7.87$
NWG	172.50	161.30	159.70	163.70	176.00
%NWG	2436.4	2294.5	2264.5	2335.1	2444.4
% NWG over control		-6.49	-7.42	-5.11	+2.02
SGR	1.79	1.76	1.75	1..77	1.80

Cyprinus carpio

All press mud based diets supported increase in growth from D_2 to D_5 with maximum growth recorded in D_5 followed by D_1 (control), D_4, D_2 and D_3. At the end of culture period, TLG was maximum 14.66 cm in D_5 and minimum 13.56 in D_3. NWG was maximum (176 g) in D_5 and minimum (159.7 g) in D_3 and the differences among treatments were not significant. The % NWG was maximum (2444.4%) in D_5 and minimum (2264.5 %) in D_3 and SGR was maximum (1.80) in D_5 and minimum (1.75) in D_3. As compared to control (D_1), % NWG was 2.02 higher in D_5 (Table 4).

Condition factor (k)

At the end of the experiment condition factor (K) values of two species *Catla catla* and *Labeo rohita* fed with press mud incorporated diets were found to be higher in majority of the treatments than that of control fish (Table 5). In *Catla catla* higher K values were recorded with diets D_3 - D_5, whereas *L. rohita* recorded higher K values in diets D_2, D_3 & D_5.Whereas, *Cyprinus carpio* recorded higher K value in 20 % press mud inclusion level (D_3) as compared to control. *C. mrigala* recorded lower K values up to 30 % press mud inclusion level $D_2 – D_5$ as compared to control (Table 5).

Table 5: Condition Factor (K) of different fish species in different treatment at termination of experiment

Fish species	Diets				
	D_1	D_2	D_3	D_4	D_5
Catla catla	1.45	1.45	1.47	1.56	1.51
Labeo rohita	1.23	1.25	1.25	1.20	1.28
Cirrhinus mrigala	1.07	1.01	1.06	1.04	1.06
Cyprinus carpio	1.84	1.81	1.87	1.82	1.75

Average total weight of fish at the end of culture period revealed maximum growth response in *Cyprinus carpio* (183.2 g) followed by *Cirrhinus mrigala* (76.90 g), *Catla catla* (72.80 g) and *Labeo rohita* (49.20 g) (Table 6).

Table 6: Economic evaluation of different diets

Parameters		D_1	D_2	D_3	D_4	D_5
Average weight of different fish species	*Catla catla*	72.80	69.60	61.50	54.70	58.70
	Labeo rohita	45.00	43.00	46.80	49.20	44.00
	Cirrhinus mrigala	69.70	66.10	75.30	76.40	76.90
	Cyprinus carpio	179.60	168.30	166.70	170.70	183.2
Total fish yield (kg)		6.089	5.704	5.633	5.546	5.450
% yield over control (D_1)			-6.32	-7.49	-8.87	-10.49
Return (@ Rs. 100/kg) = A		608.9	570.4	563.3	554.6	545.0
Total feed given (kg)		10.94	9.66	9.50	10.14	10.44
Feed cost/ kg (Rs.) (% cost reduction over control)		13.5	12.80 (-5.19)	12.56 (-6.96)	12.33 (-8.67)	12.09 (-10.44)
Total feed cost (Rs.) = B		147.69	123.65	119.32	125.03	126.22
Net profit in Rs. (A-B)		461.21	446.75	443.98	429.57	418.78
% profit over control (D_1)			-3.16	-3.74	-6.86	-9.20
FCR		1.74	1.63	1.62	1.77	1.84

Comparative economic evaluation

Among the different treatments maximum fish harvest (6.089 kg) was recorded for diet D_1 (control) followed by D_2 (5.704 kg), D_3 (5.633 kg), D_4 (5.546 kg) and D_5 (5.450 kg) (Figure 5, and Table 6). As compared to control 6.32 %, 7.49 %, 8.87 % and 10.49 % less fish biomass were recorded with diets D_2, D_3, D_4 and D_5, respectively. Lowest FCR was recorded for diet D_3 and D_2 (1.62 and 1.63) followed by D_1 (1.74), D_4 (1.77) and D_5 (1.84) (Figure 6 and Table 6). Cost of feed decreased by 5.19, 6.96, 8.67 and 10.44 % in diet D_2, D_3, D_4, D_5, due to press mud incorporation. Maximum net profit with respect to fish harvest and feed cost was recorded for D_1 which was 3.16 % higher than D_2 followed by D_3, D_4, and D_5. The net profit and total fish harvest from press mud incorporated carp diet in different treatment (D_2 -D_5) were found to be comparable to control diet.

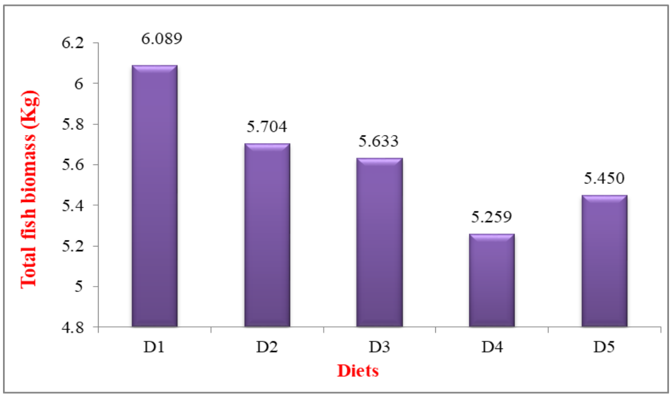

Fig 5: Total fish biomass (Kg) in different treatments

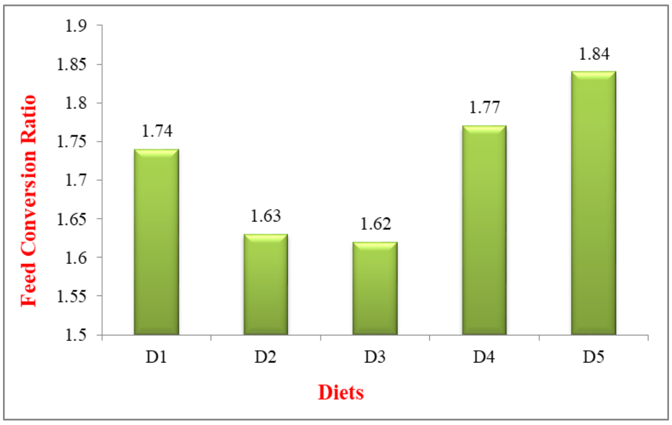

Fig 6: Feed conversion ratio in different treatments

Discussion

The survival of major carps was recorded between 87.5% and 100% at the end of the experiments in control fish as well as in all the treatments ($D_2 – D_5$) it corroborates that inclusion of press mud in diet of major carps did not affect the survival of experimental fish species. All press mud based diets supported increase in major carp growth in different treatments. Growth is the result of a balance between the process of anabolism and catabolism, which occurs in each individual [46]. Growth is generally measured by weight gain and it can be expressed as the increase in length and weight against time.

Press mud contains large quantity of organic matter which can act as a substrate for microorganisms. Manure is converted into fish flesh either by direct consumption of feed remains in the manure or stimulation of pond ecosystem to increase autotrophic and heterotrophic production [31]. Significant higher growth of *C. mrigala* was recorded in all the treatment ($D_2 – D_5$) with respect to total length gain of the fish fed with 15% to 30% press mud incorporated diets, whereas higher growth of *L. rohita* was recorded in D_3 and D_4 treatments having 20% to 25% press mud in comparison to control. The higher growth was also observed in *C. carpio* in 30% press mud included diet compared to the control. The significant NWG was recorded in *C. mrigala* with increase in press mud inclusion level from 20%-30%, whereas higher NWG in *L. rohita* was recorded in 20% and 25 % press mud incorporated diets in comparison to control. Although growth and weight of *L. rohita* declined in treatment D_5 (30% press mud inclusion level), but in other treatments overall average growth of *L. rohita* was still higher than the control. *C. carpio* exhibit highest growth in D_5 treatment (30% press mud incorporated diets) in comparison to control. The higher growth in aforesaid fish during this experiment in comparison to control shows that supplementary diet incorporated with sugarcane press mud does not affect the growth and survival of the fish in culture pond. Higher growth of above mentioned fish fed with press mud incorporated diet is attributed to the comparable nutritive quality of diets when compared with control with respect to crude protein (CP) and gross energy (GE) and higher ether extract, crude fiber and ash content that lead to nutrient availability required for optimum growth, development and good health of fish which are in agreement with the work of Singh and Dhawan [32]. The same author (Singh and Dhawan) [33] pointed out that the 30% protein diet is sufficient for maturing fishes and increase of protein to some extent can enhance fish growth.

The lower growth (comparable to control) in *C. catla* was noticed in all the treatments which might be related to the feeding behavior of the fish. As *C. catla* is zooplankton feeder and most of the time lives on surface of water for grazing zooplankton. However, the growth of *C. catla* at 15 % press mud incorporated diet (D_2) was comparable to traditional rice bran carp diets. However the less growth depends on the water quality parameters, plankton productivity and other environmental factors also. The press mud was found in no way inferior to rice bran, provided the same protein level was maintained [34]. The lower growth in *C. catla* species fed on press mud supplementary diet was attributed to the sufficient level of crude fiber and ash (11%) and lipid level (2%) in the diet. As per the previous work record on increasing lipid levels from 5 to 15% in diets, the fish growth and FCR did not alter significantly [35]. However, the rest three species is either column feeder or bottom feeder which have shown the considerable higher growth in most of the treatments compare to the control.

Singh *et al* [36] also used press mud at different levels in common carp and found that incorporation of press mud up to 50% level in the carp diet resulted in the growth comparable with that of fish fed on supplementary traditional diet, but its inclusion at 25% level proved most effective for carp growth. The study and findings furnished considerably good condition of fish health that was fed with press mud based diets over the control diet fed fish.

Virk [37] carried out comparison of growth in *Cyprinus carpio* and *Labeo rohita*, fed on diets containing untreated and treated (treated with 56% NaoH) press mud (at 20, 35 & 50% levels). The study revealed that the incorporation of either untreated or treated press mud at 20% level gave best growth in *Cyprinus carpio*. Specific interactions among fish species are important in the sustenance of any polyculture system and much research work has been done on the culture of Rohu, Catla and Mrigal [38]. Ritvo *et al* [39] observed that Common carp has the potential to improve conditions in pond bottom soil. The large quantity of organic matter (771.7 g/kg) present in press mud can act as a substrate for microorganisms.

The physico-chemical characteristics (transparency, turbidity, conductivity, pH, temperature, dissolved oxygen, biochemical oxygen demand, total alkalinity, total hardness, chloride, ammonical nitrogen, nitrate-nitrogen, nitrite-nitrogen and soluble phosphates) of experimental water tank in different treated and control groups remained in the favourable ranges and did not vary significantly ($p<0.05$) among different treatments during the study period. The growth of Catla, Rohu, Mrigal, and Common carp fish species was meagerly influenced by these parameters in various treated and control group.

Plankton (phytoplankton and zooplankton) constitutes natural food of fish and plays vital role in the productivity of semi-intensive aquaculture systems. Maximum (215 x 10^6 l^{-1}) mean total phytoplankton populations and maximum ($932l^{-1}$) mean total zooplankton population was recorded in D_2 and the differences among treatments were analyzed to be significant ($p<0.05$). Phytoplankton are the microscopic primary producers (photosynthetic organisms) in an aquatic ecosystem responsible for fixing inorganic carbon (CO_2) into organic carbon, whereas zooplankton (microscopic animals) are primary consumers in the herbivorous fish food chain which graze on phytoplankton. The findings are in agreement with the earlier study conducted by Singh *et al* [36]. The higher levels of phytoplankton and zooplankton in the treated group receiving pressmud may be attributed to the manurial effect of press mud because of its nutrient content [40]. Keshavanath *et al* [28] recorded higher plankton biomass in press mud applied ponds compared to cow dung treated ponds. Presence of high carbon content in press mud increased ecosystem functionality by increasing phytoplankton and zooplankton and fish with more food source [28].

Present study also revealed that press mud can be considered as an economical and effective fertilizer for aquaculture pond. Press mud is available as a by-product from the sugar industry in Punjab, it can be used as an alternative organic manure for semi-intensive fish farming. It is pertinent from Middendorp works [41] who obtained poor growth of *Oreochromis niloticus* in ponds fertilized with cattle dung. Press mud also showed effectiveness as manure in the production of natural food and growth of carp and has chemical composition similar to that of cattle dung [42, 28].

Milstein *et al* [43] pointed out that Common carp feeds on the bottom and is more dependent on feed supplied than the other fish present in the pond. According to Milstein *et al* [47] Common carp as a bottom feeding fish produces a fertilizing effect through a food web that benefits the filter feeding fishes and stimulate efficiency nutrient availability in the bottom of the ponds, so the inclusion of Common carp in polyculture is economical to farmer as it lowers the input costs and it also benefits the pond water ecosystem [44].

The net profit and total fish yield from press mud incorporated carp diet in different treatment (D_2 –D_5) were found to be comparable to control diet.

Conclusions

The present findings of press mud incorporated diets from 15 - 30% level in above four species exhibits no adverse influence on quality of experimental pond water, productivity, survival and growth of fish. Carps fed with press mud based diets reflected better fish health condition of experimental fish species. The net profit as well as total yield in D_2 and D_3 is comparable to control and hence both these diets can be efficiently used to replace control diet. The resulting lower FCR in 20 % and 15% level of press mud inclusion diet (1.62 and 1.63) revealed that these feeds are efficiently used by fish. Press mud is cheaper than rice bran, available in most of the states and considered effective as well as economical alternative carbohydrate source in feed for pond aquaculture. Therefore, press mud can be incorporated in carp diet up to 30% inclusion level to formulate low cost quality diets for higher aquaculture productivity, sustainability and in large interest of fish farmers in the country. Further, research work on potential dose of high percentage wise application of press mud in aquaculture industry need to be evaluated for the large interest of fish farmer in our country.

Acknowledgements

The authors are highly thankful to Dean, College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India for providing financial support and laboratory facilities for carrying out this work. The support of Head, Department of Aquaculture for conducting the present study is duly acknowledged.

References

1. FAO. The State of World Fisheries and Aquaculture. Rome, 2014.
2. Prabaharan C, Murugan AS. A study on effects of fertilization and supplementary feed on growth performance of three Indian Major Carps. International Journal of Pharmaceutical & Biological Archives. 2012; 3(1):186-191.
3. Madu CT, Sogbesan OA, Ibiyo LMO. Some non-conventional fish feed resources in Nigeria. In: A.A. Eyo (Ed.), Proceeding Joint FISON/NIFFR/SPFS National workshop on Fish feed and Feeding Practices in Aquaculture held. National Institute for Freshwater Fisheries Research. 15th -19th September, 2003. New-Bussa, 2003, pp. 73-82.
4. Dhawan A, Kaur VI, Virk P. Non-conventional fish feed resources: an overview. Fishing Chimes. 2004; 23(10&11):66-72.
5. Yadav RL, Solomon S. Potential of developing sugarcane by-product based industries in India. Sugar Technology. 2006; 8(2&3):104-111.
6. Dey PL, Singh SN, Buragohain SK, Borthakur MP. Integrated effect of organic and inorganic fertilizer for chil yield and sugar production in spring planted sugar cane. Indian sugar cane. 1997; 46:279-282.
7. Tran G. Sugarcane press mud. Feedipedia.org. A programme by INRA, CIRAD, AFZ and FAO, 2012.
8. Ghulam S, Khan MJ, Usman K, Shakeebullah. Effect of different rates of press mud on plant growth and yield of lentil in calcareous soil. Sarhad J. Agric. 2012; 28(2):249-252.
9. Ghulamabbas, Hussain A, Rasool S, Yasir AM, Ali M, Bokhari TH *et al*. Development of biofertilizer from sugar industry organic waste I. J Chem. Soc. Pak. 2013; 35(2):415-419.
10. Bokhtriar SM, Paul GC, Rashid MA, Rahman ABM. Elrat of press mud and organic nitrogen on soil fertility and yield of sugar cane growth in high gangs river flood plains soils, 2001.
11. Rocha GJM, Martin C, Soares IB, Soutomajor AM, Baudel HM. Moraes CA. Diluted mixed acid pre-treatment or sugar cane bagasses for the ethanol production. Biomass Bioenergy. 2011; 35:663-670.
12. Chand K, Shahi NC, Loharri UC, Garg SK. Effect or storage condition on keeping qualities or jaggery. Sugar Technology. 2011; 13(1):81-85.
13. Sardar S, Illyas SU, Malik SR, Javed K. Compost fertilizer production from sugar press mud (SPM). Intl. J. Microb. Res. 2013; 1(2):20-27.
14. Sen B, Chandra TS. Chemolytic and solid-state spectroscopic evaluation of organic matter transformation during vermicomposting of sugar industry wastes. Bioresource Technology. 2007; 98:1680-1683.

15. Partha N, Krishnan MRV. Pressmud for chemicals/fine chemicals. Kisan World, 2000, 27.
16. Rasappan K, Kumar A, Santhosh P. Studies on sugarcane press mud and distillery waste as a biofertilizer through composting. International Journal of Chemical Sciences. 2015; 13(3):1333-1344.
17. Gangadhar B, Umalatha H, Hegde G, Vasundhara R, Sridhar N. Influence of commonly used manures on the growth and nutrient composition of periphyton. Insights Aqua. Cult. Biotechnol. 2017; 1:1.
18. Patil NH, Jadhav S, Ghorpade SS, Lharme AB. Isolation and environment of sugar press mud (SPM) adopted microorganism for production of biofertilizer by using sugar press mud. Intl. J Adr. Biotech. Res. 2013; 14(1):96-104.
19. Sarvane R, Sivasankaran MA, Sundararaman S. Anaerobic pre-treatment and increased sold destruction of organic municipal solid wastes and secondary sewage sludge for reuse and recovery. Deptt. of Civil Engineering, Pondicherry Engineering College, Pondicherry and Deptt. of Environmental Engineering, PES College of Engineering, Karnataka, 2005.
20. Partha N, Sirasubramanian V. Recovery of chemicals from press mud – A sugar industry waste. Indian Chem. Engr. Section A, 2006, 48(3).
21. Wee TH, Suryavanshi AK, Tin SS. Evaluation of rapid chloride permeability test (RCPT) results for concrete containing mineral admixtures. Material Journal. 2000; 97(2):221-32.
22. Paya J, Monzo J, Borrachero MV, Pinzon DL, Ordonez LM. Sugarcane bagasse ash (SCBA): studies on its properties for reusing in concrete production. Journal of Chemical Technology and Biotechnology. 2002; 77(3):321-5.
23. Rizvi SJAR. Sugar industry in Pakistan: problems, potentials. FCMA, 2011.
24. Gupta N, Tripathi S, Balomajumder C. Characterization of press mud: A sugar industry waste. Fuel. 2011; 90(1):389-394.
25. Bhosale PR, Chonde SG, Nakade DB, Raut PD. Studies on physico-chemical characteristics of waxed and dewaxed press mud and its effect on water holding capacity of soil. ISCA Journal of Biological Sciences. 2012; 1:35-41.
26. Budeppa HB, Reddy BSC, Suresh BN. Screening sugarcane press mud as a source of minerals. Indian Veterinary Journal. 2009; 86(3):323.
27. Siddaiah GM, Kumar SM, Sahu NP, Pal AK, Jain KK, Biju J, Aklakur R. Utilization of sugar factory by-products in the diet of *Labeo rohita* (ham) fingerlings, Central Institute of Fisheries Education, Department of fish nutrition and Biochemistry, 2010.
28. Keshavanath P, Shivanna, Gangadhara B. Evaluation of sugarcane by-product press mud as a manure in carp culture. Bioresource Technology. 2006; 97:628-634.
29. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists. 16th ed., Arlington, Virginia, USA, 2000.
30. Duncan DB. Multiple range and multiple F-tests, Biometry. IInd. 1955; 11:1-42.
31. Wohlfarth GW, Hulata G. Use of manures in aquaculture. In: Moriarty, D.J.W., Pullin, R.S.V. (Eds.), Detritus and Microbial Ecology in Aquaculture. ICLARM, Manila, 1987, 353-367.
32. Singh R, Dhawan A. Utilization of sugar industry by-products in aquaculture. In: National Symposium on Aquaculture. Jammu University, Jammu, 1995.
33. Singh R, Dhawan A. Effect of formulated diets on the growth and ovarian maturation in common carp, *Cyprinus carpio* communis, Indian J. of Fish. 1996; 43(4):349-353.
34. Ogino C, Saito K. Protein nutrition in fish. The utilization of dietary protein by young carp. Bulletin of the Japanese Society of the Science of Fishing. 1970; 36:250-254.
35. Takeuchi T, Watanbe T, Ogino C. Digestibility of hydrogenated fish oils in carp and rainbow trout. Bulletin of the Japanese Society of the Science of Fishing. 1979; 45:15-21.
36. Singh R, Dhawan A, Saxena PK. Potential of press mud-a sugar factory by product in supplementary diets and its impact on fish growth. Bioresource Technology. 1999; 67:61-64.
37. Virk P. Studies on the utilization of non-conventional resources in fish feed. Ph.D. dissertation. Punjab Agricultural University, Ludhiana, 2000.
38. Chakrabarti NM. Biology, culture and production of Indian Major Carps. Fisheries Scientist in Indian Council of Agricultural Research, 1998, pp. 175.
39. Ritvo G, Kochba M, Avnimelech Y. The effects of common carp bioturbation on fishpond bottom soil. Aquaculture. 2004; 242:345-356.
40. Ranjhan SK. Agro-industrial by-products and non-conventional feeds for livestock feeding. I.C.A.R., India Publication, 1990, pp. 127.
41. Middendorp AJ. Pond farming of Nile tilapa, *Oreochromis niloticus* (L.), in northern Cameroon. Mixed culture of large tilapia (>200 g) with cattle manure and cotton seed cake as pond inputs, and African catfish, *Clarias gariepinus* (Burchell), as police-fish. Aqua. Res. 1995; 26:723-730.
42. Seth S, Chandra R, Kumar N, Tyagi AK. Utilization of composted sugar industry waste (press mud) to improve properties of sodic soil for rice cultivation. Journal of Environmental Science and Engineering. 2005; 47(3):212-7.
43. Milstein A, Alkon A, Avnimelech Y, Kochba M, Hulala G, Schenedier G. Effect of manuring rate on ecology and fish performance in polyculture ponds. Aquaculture. 1991; (96):119-138.
44. Wahab MA, Rahman MM, Milstein A. The effect of common carp, *Cyprinus carpio* (L.) and mrigal, *Cirrhinus mrigala* (Hamilton) as bottom feeders in major Indian carp polycultures. Aquacult. Res. 2002; 33:547-556.
45. APHA. Standard Methods for the Examination of Water and Wastewater. 21st ed. APHA, AWWA, and WEF. DC. Washington, 2005.
46. Bertalanffy L von. A quantitative theory of organic growth (Inquiries on growth laws. II). Human Biol. 1938; 10:181-213.
47. Milstein A, Azim ME, Wahab MA, Verdegem MCJ. The effects of periphyton, fish and fertilizer dose on biological processes affecting water quality in earthen fish ponds. Environmental Biology of Fishes. 2003; 68:247-260.