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Evaluation of Dhaincha seed (*Sesbania aculeata*) as a Non-conventional feed ingredient for *Labeo rohita* (Ham.) fry

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Abstract
Dhaincha (*Sesbania aculeata*) is a leguminous shrub of Fabaceae family, distributed all over India. The dhaincha seed (DS) is rich in protein (30%) and energy (4.6 kcal/g). It contains 6.0% of ether extract. The fatty acid comprises ∑SFA, 11.92 %; ∑MUFA, 19.11%; ∑PUFA, 62.78%: ∑n-6, 57.33%, ∑n-3, 5.45% and ∑FA, 93.81%. Phenol, tannin, saponin, alkaloids and phytic acid are the secondary metabolites detected qualitatively. *Labeo rohita* fry (0.3±0.01 g) were fed with five iso-nitrogenous (27% CP) diets containing DS at 0% (D-1), 20% (D-2), 40% (D-3), 60% (D-4) and 80% (D-5) for 60 days in an indoor system. Fry survival (%) of D-1 to D-3 groups were statistically similar ($p>0.05$) among the group but significantly higher ($P<0.05$) than D-4 and D-5. Weight gain (%) and specific growth rate (SGR; %/day) were similar ($P>0.05$) among D-1 to D-3 but significantly higher ($P<0.05$) than D-4 and D-5 groups. Feed conversion ratio (FCR) was significantly lower ($P<0.05$) in D-2 and D-3 as compared to the other groups (D-1, D-4 and D-5). Protein efficiency ratio (PER) was significantly higher ($P<0.05$) in D-2 and D-3 as compared to rest groups. While the whole body protein was significantly higher ($P<0.05$) in D-1, D-2 and D-3 groups, the lipid content was significantly reduced ($P<0.05$) as the incorporation rate of DS was increased. The apparent dry matter and protein digestibility (%) at 40% level incorporation (D-3) found to be significantly higher ($P<0.05$) among all the groups. The study results indicated that there is scope to incorporate dhaincha seed in the in the diet of *L. rohita* up to 400 g kg^{-1} without any adverse effect on growth, survival and nutrient utilization.

Keywords: Fish feed, Dhaincha seed, *Sesbania aculeata*, Non-conventional ingredient, digestibility

1. Introduction
Aquaculture is the most promising animal protein producing sectors, intended to address the issues of hidden protein hunger and malnutrition in the developing countries. Feed is the most crucial input, which greatly influences the productivity and profitability in aquaculture. During 2015 the global feed dependent aquaculture production has reached over 50 million tones where feed is defined as fresh feed ingredients, farm made feed and or commercially manufactured feed [1]. It is also reported that over 47 million tons of industrial aqua feed has been exclusively used during this year apart from the supplementary feed used for the production of Indian major carp [1]. The envisioned annual inland fish production of India by 2020 is over 10.8 million ton. Irrespective of the type of feed, less competitive and cost effective ingredients are in focus for sustainable aqua-feeds production [2]. Fish needs more protein in their diet than the land animals. Protein supplement in aqua feeds is mostly met by incorporation of either fish meal or plant based ingredients [3]. Plant proteins are used as sole dietary protein for carps. Soybean meal is the common source of plant protein used in compound aqua-feeds followed by other oil cakes [4, 5]. Due to escalated price, edible oil cake incorporation becoming too competitive and costly for formulating fish feed, especially for carp culture [6, 7]. It is therefore need of the hour to choose some newer non-conventional protein reach ingredients for sustainable aqua-feed production [8-10, 7, 11].
Dhaincha (*Sesbania aculeata*) is a shrub of Fabaceae family, widely distributed across the Indian sub-continent. The shrub is popularly used as the green manure in crop field. A full grown shrub bears flowers and pods. Each pod carries about 10-15 seeds. The average yield of seed is 1.0-1.5 ton/ha [12, 13]. Dry ripe seeds can be stored for long period under normal condition. The *Sesbania* seed is a good source of protein and energy but so far the resource has not been fully explored for feed production [14, 15].

Very limited information is available at present on use of dhaincha seed as co-ingredient in the experimental diets of tilapia and common carp [16, 14, 15, 17]. The present study is intended to evaluate (DS) as a non-conventional ingredient in the diet of *Labeo rohita* fry.

2. Materials and Methods

2.1 Chemical analysis of Dhaincha seed and co-ingredients

Dhaincha (*Sesbania aculeata)* seed (DS) were collected from the local market Bhubaneswar, Odisha, India. The chemical analysis viz., crude protein, ether extract, total ash, crude fibre, etc of DS and other co-ingredients were determined following the standard procedure [18]. Dry matter was analyzed by drying the sample at 105 ^{0}C for 24 h. Crude protein (N×6.25) was estimated by microkjeldahl method (Vapodest, Gerhardt, Germany). Ether extract was determined by solvent extraction with petroleum ether (boiling point 60-80 ^{0}C) using Soxhelt method. Total ash content was estimated by igniting the sample at 550 ^{0}C in muffle furnace for 3 h. Crude fibre was determined by acid digestion (1.25%) followed by alkali digestion (1.25%) using Fibraplus system (FES 8 pelican, India) and then igniting the extracted sample in Muffle furnace at 600 ^{0}C for 1 h. Energy content was determined in adiabatic bomb calorimeter (IKA C5003 control, Germany) by igniting the sample in presence of oxygen and water. As DS contains good amount of oil, its fatty acid profile was also analyzed. Oil was extracted from 15 g powdered DS using (2:1 v/v) chloroform-methanol mixture containing 0.01% BHT [19]. Fatty acid methyl esters (FAME) were prepared by acid-catalyzed trans-esterification of total lipids according to the method of Christie [20]. Fatty acid methyl esters were separated by a gas chromatograph equipped with flame-ionization detector (Shimadzu GC-2010, Kyoto, Japan) on a DB-25 capillary column (20 m × 0.10 mm I.D., 0.10 μm, J&W Scientific, Santa Clara, CA, USA). The fatty acids were identified using fatty acid methyl ester (FAME) standards. Area percentage normalized values for the fatty acids were taken as weight percentage. The DS was also subjected to analysis of important anti nutritional factors by qualitative methods. Aqueous and n-hexane extracts of DS were prepared and screened for major secondary metabolites (tannin, saponin, alkaloids, phytic acid) as described by Evans and Harbone [21, 22].

2.2 Formulation of test diets

Five iso-nitrogenous diets with 27% crude proteins were prepared by incorporating 0, 20, 40, 60 and 80% DS meal with groundnut oil cake, rice bran as major co-ingredients (Table 1). Ingredients were finely powdered and pulverized. The diet pre-mix was soaked with 30% water and 1.0 mm feed pellets were drawn using a hand pelletizer. The dry pellets were crumbled.

Table 1: Ingredient composition (%) of test diets incorporating the dhaincha seed meal at different levels

Ingredients (%)	D-1	D-2	D-3	D-4	D-5
Dhaincha seed meal	0	20	40	60	80
Groundnut oil cake	50	38	28	15	4
Rice bran	49	41	31	24	15
Vitamin & mineral premix	1	1	1	1	1

Vitamin & mineral premix: Supplevite-M (Jeco Vet Chem. Pvt. Ltd, India) Each 1.0 kg of Supplevite-M contains: Vitamin A: 2 lakh IU, Vitamin D3: 400000 IU, Vitamin B2: 0.8 g Vitamin E: 300 IU, Vitamin K: 400 g, Calcium panthonate: 1 g, Nicotinamide: 4 g, Vitamin B12: 2.4 mg, Choline chloride: 60 g, Calcium: 300 g, Manganese: 11 g, Iodine: 0.4 g, Iron: 3. g, Zinc: 6 g, Copper: 0.8 g, Cobalt: 0.18 g.

2.3 Fry rearing and diet evaluation

The diet evaluation experiment was conducted in the wet laboratory facility of ICAR-CIFA, Bhubaneswar, India. Fifteen flow through cement tanks (140 L) with a flow rate of 0.5 L min^{-1} were used for rearing the fish. *L. rohita* fry (0.3 g) were stocked in 15 tanks at 65 fry tank^{-1}. Fish were fed *ad libitum* (5-7% of body weight; based on the daily consumption) twice daily at 09.00 and15.00 hours with respective experimental diet in triplicate tanks for 60 days. The unconsumed feed was siphoned out after 2 h of feeding, dried and weighed to calculate the daily feed intake. Faecal matters were collected daily before each feeding by siphoning and stored at -20 °C for chemical analysis to determine nutrient digestibility. The fish were batch weighed to determine the incremental weight at monthly intervals and final weight on termination of the experiment. Routine water quality parameters *viz.*, temperature, transparency, total alkalinity, hardness, un-ionized ammonia, dissolved oxygen and pH were monitored twice a week [23]. Proximate composition of the test feeds and initial and final carcass composition were determined. Acid insoluble ash of feacal matters and feeds were determined by dissolving the ash in (1:1) hydrochloric acid and repeatedly washing with dilute hydrochloric acid followed by ignition of insoluble part in muffle furnace at 600 ^{0}C [24]. Acid insoluble ash was used as the reference marker [25-27] for nutrient digestibility determination [28]. Survival rate, nutritional indices and apparent nutrient digestibility were calculated using the following equations.

$$\text{Survival (\%)} = \frac{\text{Total number of fish survived}}{\text{Total number of fish stocked}} \times 100$$

$$\text{Percent weight gain} = \frac{\text{Final body weight (g)} - \text{Initial body weight (g)}}{\text{Initial body weight (g)}} \times 100$$

$$\text{Specific growth rate} = \frac{\text{ln final body weight (g)} - \text{ln initial body weight (g)}}{\text{Experimental duration (days)}} \times 100$$

$$\text{Feed conversion ratio} = \frac{\text{Total feed intake (g)}}{\text{Total live weight gain (g)}}$$

$$\text{Protein efficiency ratio} = \frac{\text{Total live weight (g)}}{\text{Total protein intake (g)}}$$

$$\text{Apparent dry matter digestibility (\%)} = 100 - \left[100 \times \frac{\%\ \text{acid insoluble ash in feed}}{\%\ \text{acid insoluble ash in faeces}}\right]$$

$$\text{Apparent Nutrient digestibility (\%)} = 100 - \left[100\ \frac{\%\ \text{of acid insoluble ash in feed}}{\%\ \text{of acid insoluble ash in faeces}} \times \frac{\%\ \text{of nutrient in faeces}}{\%\ \text{of nutrient in feed}}\right]$$

2.4 Statistical analysis

Data were analyzed and compared using a one way ANOVA followed by Duncan Multiple Range Test (DMRT) to check the level of significance (P<0.05). The statistical analysis was done by using statistical package for the social sciences [29].

3. Results

The chemical composition of the ingredients and test diets are presented in Tables 2 and 3, respectively. The water quality parameters of all the cisterns were within the permissible range for carp culture (Temperature: 28-30^0 C, pH: 7.5-8.3, Dissolve oxygen: 6.0-6.5 mg/l, Total alkalinity: 110-130 mg/l Ammonia: 0.01-0.02 mg/l). The survival of fish among all the dietary treatments was in the range of 87-97% (Fig.1). The final weight gain, weight gain percentage, specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) are presented in Table 4. There was no significance difference (P>0.05) found in body weight gain (%) and SGR among the D-1 to D-3 dietary groups, whereas, these were significantly reduced in D-4 and D-5 dietary groups. The FCR in D-2 and D-3 groups was similar (P>0.5) and significantly lower (P<0.05) than other dietary groups. PER was found significantly (P<0.05) higher in D-1 to D-3. The whole body composition of initial and final fish carcass is presented in Table 5. The moisture contents of D-1 and D-2 dietary groups were lower (P<0.5) in comparison to other dietary treatments. Although there was no significant difference (P>0.05) found in final carcass protein among D-1, D-2 and D-3 groups, it was significantly higher than D-4 and D-5. The lipid content of the carcass among all the dietary groups showed a negative correlation with the moisture contents. The ash content was increased with the increased levels of DS incorporation (D-2 to D-5). The apparent nutrient digestibility of all the dietary groups is given in Fig 2. The apparent dry matter (ADM), protein (APD) and lipid (ALD) digestibility of the experimental diets were affected (P<0.05) by the inclusion level of DS meal. The ADM was increased up to 40% of DS meal incorporation and then reduced. Among all the treatments, the ADM of D-3 group was found to be significantly higher (P<0.05). The APD of D-2 and D-3 were found with significantly higher (P<0.5) than other groups. The ALD was found more or less similar (P>0.05) among all the groups.

Table 2: Chemical composition (% DM basis) of the ingredients used for formulating the test diets

Parameters	Dhaincha seed	Groundnut cake	Rice bran
Proximate compositions			
Dry matter	93.80±0.02	92.34±0.01	90.46±0.04
Crude protein	30.41±0.01	42.12±0.02	11.23±0.01
Ether extract	5.86±0.01	7.91±0.02	8.45±0.02
Total ash	3.78±0.02	8.96±0.01	9.51±0.03
Crude fibre	11.31±0.01	6.95±0.02	13.73±0.01
Nitrogen free extract	48.64±0.01	34.06±0.01	57.08±0.02
Energy (k.cal/g)	4.63±0.01	4.36±0.01	3.38±0.02
Fatty acid compositions (%)			
∑SFA	11.92±0.88	17.49±1.10	22.35±0.97
∑MUFA	19.11±0.94	45.85±1.38	35.53±1.22
∑PUFA	62.78±0.78	31.43±1.02	32.27±0.84
∑n-6	57.33±0.47	30.74±1.12	30.49±1.01
∑n-3	5.45±0.03	0.69±0.31	1.78±0.18
Total fatty acids	93.81±0.91	92.77±1.26	90.15±1.05
Anti-nutritional factors (qualitative assessment on extract basis)			
Total phenol	+++	+	+
Tannin	++	+	+
Saponin	++	-	+
Alkaloid	++	-	-
Phytic acid	++	+	+
Trypsin inhibitor	++	-	-

(SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids)
(Qualitative estimation (+ less presence, ++ moderate presence, +++ high presence, - not detected)

Table 3: Chemical composition (% DM basis) of different test diets

Diets	Dry Matter	Crude Protein	Ether Extract	Total Ash	Crude Fibre	Nitrogen Free Extract
Diet-1	92.47±0.06^{ab}	27.09±0.14^{a}	8.16±0.02^{e}	9.61±0.01^{e}	7.42±0.03^{a}	47.72±0.20^{a}
Diet-2	92.57±0.03^{bc}	26.98±0.08^{a}	7.65±0.07^{d}	8.75±0.02^{d}	9.06±0.03^{b}	47.56±0.06^{a}
Diet-3	92.31±0.08^{c}	27.43±0.19^{a}	6.86±0.03^{c}	7.71±0.03^{c}	9.34±0.06^{c}	48.66±0.19^{b}
Diet-4	92.41±0.08^{ab}	26.99±0.18^{a}	6.59±0.04^{b}	7.24±0.01^{b}	9.74±0.03^{d}	49.44±0.20^{c}
Diet-5	92.67±0.03^{c}	26.86±0.04^{a}	6.36±0.04^{a}	6.58±0.03^{a}	10.33±0.03^{e}	49.87±0.11^{c}

Values are represented as Mean ±SE. The values with different superscripts are significantly different (P<0.05)

Table 4: Growth and nutrient utilization of *L. rohita* fry fed diets with different levels of Dhaincha seed meal

Parameters	Diet-1	Diet-2	Diet-3	Diet-4	Diet-5
Initial average weight (g)	0.30±0.001[a]	0.30±0.00[a]	0.31±0.01[a]	0.30±0.002[a]	0.31±0.00[a]
Final average weight (g)	0.87±0.01[c]	0.87±0.00[c]	0.88±0.00[c]	0.83±0.002[b]	0.79±0.00[a]
Average weight gain (g)	0.58±0.01[c]	0.57±0.00[c]	0.57±0.01[c]	0.53±0.01[b]	0.49±0.00[a]
Average weight gain %	193.99±1.84[c]	191.53±2.41[c]	187.14±4.42[c]	171.02±3.39[b]	159.74±2.59[a]
Specific growth rate (SGR)	1.73±0.02[c]	1.72±0.02[c]	1.71±0.04[c]	1.52±0.03[b]	1.37±0.01[a]
Feed conversion ratio (FCR)	1.87±0.01[ab]	1.78±0.04[a]	1.76±0.03[a]	1.96±0.04[b]	2.14±0.04[c]
Protein efficiency ratio (PER)	1.99±0.01[c]	2.09±0.04[c]	2.08±0.03[c]	1.89±0.03[b]	1.74±0.03[a]

Values are represented as Mean ± SE. The values with different superscripts are significantly different ($P<0.05$)

Table 5: Carcass whole body composition (DM % basis) fed with different level of raw dhaincha seed meal based diets

Diets	Moisture	Crude protein	Ether extract	Total ash
Initial	78.67±0.01	62.89±0.04	7.84±0.03	26.47±0.00
Diet-1	77.23±0.02[b]	65.95±0.01[e]	17.77±0.05[d]	13.51±0.04[b]
Diet-2	77.14±0.01[a]	65.55±0.04[c]	18.87±0.01[e]	13.22±0.04[a]
Diet-3	77.32±0.02[c]	65.66±0.05[d]	15.32±0.04[c]	16.50±0.08[c]
Diet-4	77.77±0.02[d]	64.57±0.04[b]	13.62±0.06[b]	18.92±0.02[d]
Diet-5	77.95±0.01[e]	63.42±0.02[a]	12.87±0.02[a]	20.80±0.04[e]

Values are represented as Mean ± SE. The values with different superscripts are significantly different ($P<0.05$)

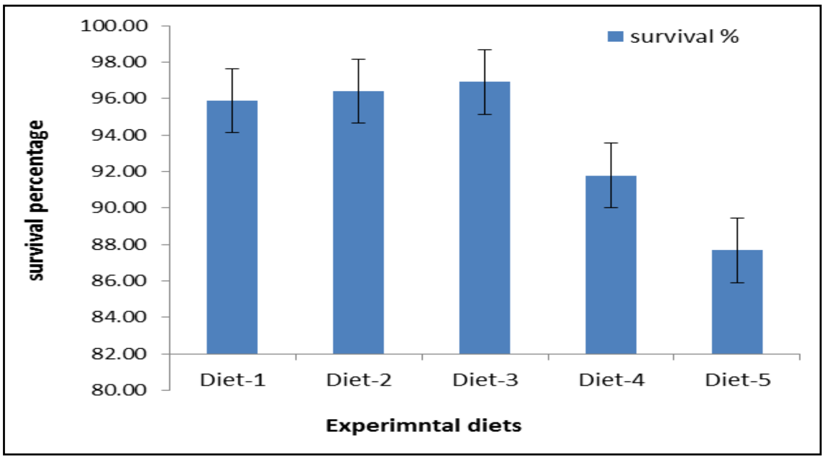

Fig 1: Survival rate (%) of fish fed with different levels of dietary DS meal incorporation. Values are represented as Mean ± SE

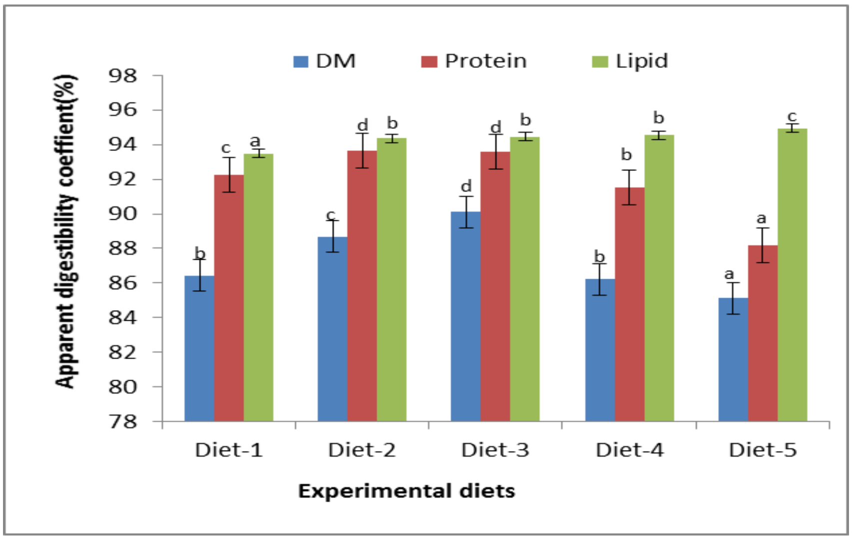

Fig 2: ADC (Apparent digestibility coefficient) fed diets containing different levels of DS meal incorporation. The data are represented as mean ± SE and values with different superscripts are significantly different ($P<0.05$)

4. Discussion

The physico-chemical parameters of water were found within the permissible range for carp seed rearing [30]. The crude protein and crude lipid content of DS as reported by earlier workers was 27-33% and 4-6% respectively [12, 31-33]. Considering fairly good nutritive value of DS, the earlier workers recommended to incorporate the same in cattle and aqua-feeds [34, 35].The CP and EE values of DS in the present study were estimated as 30 % and 6% respectively. DS is also rich in many essential amino acids except sulpho-amino acids, minerals and unsaturated fatty acids especially linoleic acid [32, 33]. The fatty acid profile in the present study reveals ∑SFA, 11.92%; ∑MUFA, 19.11%; ∑PUFA, 62.78%: ∑n-6, 57.33%, ∑n-3, 5.45% and total fatty acids, 93.81% which were more or less similar to previous study [33]. The presence of phyto-chemicals *viz.*, phenol, tannin, saponin, trypsin inhibitor, alkaloids, lectins which were detected in our study by qualitative analysis is in agreement with the finding of other workers [14, 33]. The DS meal is palatable to the carp. In the present study, there was no significant difference (P<0.05) in survival, growth, nutrient utilization and whole body composition of *L. rohita* fry in the dietary groups D-1, D-2 and D-3 where DS is incorporated at 0, 20 and 40% level. It was observed that the survival of tilapia did not get affected up to 10% DS level of incorporation in the diet [16]. Again, according to Hosaain *et al*, the DS could be incorporated up to 12% in the diets of common carp and tilapia without compromising the survival rate of fish [14, 15, 17,]. They attributed the role of anti-nutrients like tannin, saponin, phytic acid trypsin inhibitors and lectin etc. as the limiting factors for better survival rate at higher incorporation levels of DS. Tannin at higher concentration binds to lysine and makes it unavailable which affects the protein utilization in mono-gastric animals and fish [36]. Though tannin in higher concentrations reduce feed intake and affect protein and carbohydrate digestibility, it is reported to be useful in lower concentrations [37]. In the present study, as the whole body protein and PER were unaffected in D-2 and D-3 dietary groups, probably tannin is not a limiting factor for protein utilization even at 40% dietary inclusion level of DS for *Labeo rohita* fry. Tannin above 5.0% level reduces feed intake, affect protein and carbohydrate digestion [36]. Common carp have been shown to tolerate 2.0% condensed (quebracho) tannin powder in the diet without any adverse effects on feed intake and growth [38]. The condensed tannin at 2.4% level in copra is the reason for growth depression in tilapia and rohu fingerlings when fed diets containing copra cake and samanea pod meal [39, 37, 10, 40]. While incorporated about 2.16% of tannin through rain tree pod as non-conventional ingredient in *Labeo rohita* diet did not result any adverse effect in growth and survival of fish. In the present study, with the incorporation DS up to 40% level may not contain the tannin level which could affect the survival and growth of *L. rohita* fry. The principle of hemolytic effect of saponin absorbed through gill helps to eradicate unwanted fish prior to aquaculture. The morbidity of Indian major carps with saponin was reported by application of mahua oil cake at 250 ppm in water [41]. Saponin is toxic to tilapia when fish is exposed to water containing 1 mg/L for 14 h. The toxicity occurred through gill [42]. Saponin ingested though feed is lost in the normal process of intestinal epithelial replacement. Saponin is also lost by binding with cholesterol which forms an insoluble compound that is not digestible. Saponin forms a complex between other anti-nutritional factors found in feed and neutralizes the toxic effect of both the substances [43]. Further, they added that consumption of saponin and tannin together forms a tannin-saponin complex, which inactivates the biological activity of both the anti-nutrients. According to Francis *et al* [44], the dietary saponin increases permeability of intestine membrane to the digested dietary components and increases the feed utilization efficiency. Saponin acts as a growth promoter and found better growth in *Labeo rohita* fry when fed mahua oil cake up to 30% in the diet [6].

Digestibility is not only determining the nutrient availability to fish for growth but also helps in accurate feed formulations. There are many post-absorptive factors that influence nutrient utilization and growth. In addition, the nutrient digestibility of a particular feed ingredient depends on the nature [45], dietary components [46-48], type of ingredients [49]), presence of anti-nutritional factors [50, 51] and the level of inclusion of the ingredients [52-54] In the present study, the ADM digestibility was increased up to 40% DS incorporation level and then reduced at higher levels (60 and 80%) with an overall range between 85-90%.This study is more or less similar to other studies [52, 55, 48]. The ADM digestibility in Indian major carp was reported in the range of 87-88% when fed with soybean hull [56], 79-84% in common carps [57], 82% in grass carp [58] when fed with soybean meal and 56-60% in rainbow trout fed with canola meal [59]. Similar to the ADM digestibility, the apparent protein digestibility (APD) in the present study was increased up to 40% of DS incorporation level beyond which it was decreased significantly (P<0.5). This is in agreement with the previous reports [52, 60]. The APD of the present study was in the range of 88-93% which was more or less similar as reported by earlier workers for different fish species fed with diets containing different plant ingredients. The Crude protein digestibility of Indian major carps when fed soybean hull and SBM were found with a range 86- 97% [56, 61]. In common carp, hovens carp (Jelawat) and silver perch, the APD was in the range of 69-100% when fed with soybean meal, mustard meal and peanut meal [57, 62, 63]. The APD of 64-87% was reported in Atlantic salmon and rainbow trout fed canola meal based diet [59]. Protein digestion might have reduced due to the increase in concentration of protease inhibitors with the increasing levels (60% and 80%) of DS incorporation. The reduced growth and nutrient utilization in diet containing soybean with higher amount of trypsin inhibitors in carp and tilapia feed were observed by Dabrowski & Kozak, Viola *et al*, and Siddhuraju *et al* [64-66]. Again Krogdahl and Webster *et al* [50, 67] opined that the presence of grain legumes and vegetable ingredients in feed ingredient containing anti nutritional factors such as protease inhibitors, saponins, oligosaccharides, phytates and tannins which have been implicated in reduced digestive enzymes, poor protein utilization, reduced palatability and growth in fish. The ALD in the present study was found to be more or less similar among all the treatments with a range of 94-95%, which is in agreement with the other reported values in other fishes, viz., silver barb (94-95 %), rohu (90-94%), Atlantic salmon (91-92%) [68-70] when fed with different plant protein based practical diets. The ALD values of common carp was lower (82-90 %) as compared to the other fishes fed with different plant based practical diets [63]. In the present study, the ADCs of nutrients in the dhaincha based diets were fairly good as compared to earlier reported values by different workers irrespective of species and practical diets used for their studies as mentioned above.

5. Conclusion

Dhaincha foliage is used as the green manure in India and abroad. Many farmers in India cultivate it for organic fertilization. Dhaincha seed meal contains about 30% crude protein with reasonably good acceptability, palatability, digestibility, survivability, growth and nutrient utilization up to 40% incorporation level in the diet of rohu fry. However, suitable processing of the seed may further increase its incorporation level. Hence, Dhaincha seed meal could be used as a non-conventional alternate protein source for formulating the cost-effective diets for the carp.

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