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Influence of *Acalypha indica* supplemented diet on the feeding energetics and growth of fish *Labeo rohita*

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Abstract
Aquaculture production relies on the quality of feed and a balanced diet helps to maximize fish yield and profitability. Plant based feed supplements in aquaculture are ideal as growth promoters and immunostimulants. The present study assessed the effect of a medicinal plant, *Acalypha indica* leaf on the feeding energetics and growth of the freshwater fish, *Labeo rohita.* Incorporation of different concentrations of *Acalypha indica* leaf supplemented diet enhanced the assimilation, conversion and metabolic rate when the fish were fed with 20% concentration of *A. indica* leaf in the feed. The assimilation efficiency as well as the gross conversion efficiencies showed an increase and maximum growth was observed at 20% concentration suggesting the leaf inclusion as a growth promotor.

Keywords: *Acalypha indica*, bioenergetics, feed supplement, growth promoter, *Labeo rohita*

1. Introduction
Aquaculture is an imperative source of fish which serves as a vital source of protein and essential micronutrients and is an important food-producing sectors that has enhanced the development rate of the growing population (Ashkan Ajdari, *et al.* 2022) [3]. The current annual growth rate of fisheries in India is 8% higher in comparison to other sectors namely, agriculture and livestock production (Tejpal, *et al.*, 2014) [34]. With increase in population, there is a great demand for protein food which has made it indispensable to explicit more efficiently the inland waters available. In the context of increasing global demand for fish, nutrition is a key factor that influences the growth and reproduction of fish. Products obtained from nature can stimulate the growth of gut microbes thus aiding in protein assimilation and conversion thus promoting the growth of fishes without significant toxicity. Feed ingredients comprising of single cell protein, algal meal, aquatic weeds, legumes, roots and tubers, cereals, forages (grams and legumes), horticulture wastes, oil seed cake, ingredients of animal origin such as fishery and poultry processing waste are highly attractive for exploitation on account of their protein.
Nutrition and feeding are the significant factors which influence the fish growth and feed additives could lead to better utilization of nutrients thereby increasing the feed efficiency (Thanalakshmi, *et al.*, 2005) [35]. Feed additives are added to the conventional diet in minimum quantity to enhance the quality of the feed which inturn enhances the growth and reduces the mortality of fishes (Dada, 2015) [7]. Since feed acceptance, palatability and digestion differ with the type of ingredients and quality of feed the feeding activity should be carefully monitored to determine feed acceptance, feed conversion, and feed efficiencies and feed demand throughout the year (Steven Craig and Helfirich, 2002) [32].
The dietary supplement with medicinal plants along with its derivatives in fish feed has created a global spotlight; hence, it is now an active scientific investigation. Medicinal plants which were reported as feed for fishes have many bioactive constituents and nutrients which are used as pharmacological and therapeutic agents and are incorporated in the fish feed to promote growth, treat diseases and boost the immunity (Citarasu, *et al.*, 2002 [6]; Pandey, *et al.*, 2012) [21].

Harsimranjit *et al.*, (2020) [10] analysed the effect of *Aloe vera* powder on the growth rates of rainbow trout and notable differences was observed with 0.1 and 0.2% in terms of weight gain in only 30 days. Leaves have been incorporated as feed additives in the diet of fishes as reported with leaves of *Sesbania grandiflora*, *Ocimum basilium* and *Moringa oleifora* which induced the growth of fish *Oreochromis mossambicus* (Karpagam and Krishnaveni, 2014) [13]. Similarily, onion, garlic, caraway, fennel, black seed and fenugreek have enhanced the growth and feed conversion in fishes (Sivaram *et al.*, 2004; Shalaby, 2004) [31, 29]. Garlic supplemented diet increased the growth rate and specific growth rate in Tilapia (Abou-zeid, 2002) [1], *Oreochromis niloticus* (Shalaby, 2006) [30] and *Labeo rohita* because of increased protein synthesis (Johnson and Banerji, 2007) [12]. Sunitha *et al.* (2017) [33] observed that inclusion of *Phyllanthus niruri* as feed additive improved the feeding energetics, body composition and growth of *Cyprinus carpio*. Salomiya *et al.* (2023) [18] studied the effect of papaya leaf extract as feed additive on fish *Labeo rohita* and noted an enhanced feed consumption, assimilation and conversion which resulted in increased growth of fish. Positive effect of medicinal plants and herbs have been reported as feed additives which has influenced the growth and feed utilization of fishes and reduced the pathogen attack in the gastrointestinal tract (Manaf *et al.*, 2016; Mzengereza, *et al.*, 2016) [14, 19]. Since medicinal plants are biodegradable, cost-efficient, and environmentally friendly, they are a promising substitute for synthetic hormones and antibiotics that were used conventionally in the fisheries sector (Maria Latif *et al.*, 2021) [15].

Indian major carps and exotic carps contribute a lot to aquaculture production. *Labeo rohita* commonly referred as 'rohu' is an Indian major carp that prefers to feed on plant matter and is cultured due to its fast growth, taste and colour of the meat. *Acalypha indica* is a medicinal herb with antimicrobial, anti-inflammatory and antioxidant properties (Jagatheeswari *et al.*, 2013) [11]. *A. indica* supplemented diets were found to increase the immunity, survival rate and growth of Penaeus sps. (Yogeeswaran *et al.* 2012; Reverter *et al.* 2017) [37, 26] and fish *Osphronemus gourami* (Pinandoyo *et al.* 2021) [25]. Hence the present investigation was undertaken to analyze the influence of *Acalypha indica* supplemented feed on the feeding energetics and growth of *Labeo rohita*.

2. Material and methods

2.1 Fish Feed Preparation

The composition of fish feed includes wheat bran, groundnut cake, beetroot, carrot, egg, spleen Amaranthus, tapioca powder, fish oil, vitamin C tablet, mineral mix and *Acalypha indica* at different concentrations (Table 1). The feed ingredients were dried, steam boiled and ground finely and the feed excluding *Acalypha indica*, were mixed thoroughly and kneaded to form a dough, and the required amount of vitamins and minerals was added. The feed was portioned into four parts and *Acalypha indica* leaf (AIL) powder was added. The first part of the food without *Acalypha indica* served as control feed (0%). To the 2nd, 3rd and 4th parts *Acalypha indica* was added to get 10%, 20% and 30% concentration and it constituted the experimental feed 1, 2 and 3 respectively. The feed was mixed well and prepared as noodles using a mechanical extruder. This was then dried and served as the feed for the fish during the experimental period

Table 1: Ingredients of fish feed

Ingredients	Weight in grams
Wheat Bran	250
Groundnut cake	200
Beetroot	100
Carrot	100
Egg	4.5
Spleen amaranthus (Arai keerai)	100
Tapioca powder	200
Fish oil	2
Vitamin C	2.6603
Mineral mix	
Calcium chloride	0.3
NaCl	0.0315
Zinc sulphate	0.003
Potassium iodide	0.0015
Copper sulphate	0.0037
Total	1000g

2.2 Collection and Maintenance of experimental fish

The fingerlings of Rohu were procured from Chittar Dam Fisheries Department and acclimatized to laboratory condition and were fed with control feed.

2.3 Experimental design

This study comprised of four treatments and three replicates with seven fishes in each tub. The control consisted of feed formulation without *A. indica* leaf and Experimental 1, Experimental 2, and Experimental 3 with 10%, 20% and 30% of the experimental feed with *Acalypha indica* leaf powder. The initial body length and weight of the fishes were recorded, and were introduced in similar quantity plastic tubs filled with tap water. The fishes were fed regularly in the morning and after four hours the unfed and the fecal pellets were collected separately from each trough before changing the water. Both the unfed and fecal matter were dried and then stored separately. The experiment was conducted for 45 days and initial and final body length and weight were measured. All the feeding energetics measurements were taken to assess the growth and bioenergetics of the fishes.

2.4 Feeding energetics

IBP formula of Petrusewicz and Macfadyen (1970) [24] was applied for the scheme of energy balance which is usually represented as C = P + R + F + U where, C = Food consumed i.e., food given- unfed. P = Production i.e. difference between the initial wet weight of the fish at the beginning of the experiment and the final wet weight of the fish at the end of the experiment, R = Respiratory loss, F = Faeces, U = Nitrogenous excretory products.

2.5 Growth

Growth in terms of wet body weight (weight gain) = Final weight - Initial weight

Growth in terms of body length (length gain) = Final length - Initial length.

$$Specific\ growth\ rate\ (SGR) = \frac{\text{final weight} - \text{initial weight}}{\text{Initial live weight} \times \text{Experimental duration}} \times 1000$$

2.6 Consumption rate (Cr) or feeding rate

Feeding rate is a term used to describe the amount of food that a fish consumes per unit of its live body weight over a specific period of time (mg/g. wt/day). Consumption (C) = Food given – unfed.

$$Consumption\ rate = \frac{\text{Food consumed}}{\text{Initial weight} \times \text{Experimental duration}} \times 1000$$

2.7 Assimilation rate (Ar)

Assimilation rate refers to the proportion of food consumed by fish that is absorbed and utilized per unit weight of fish per unit time (mg/g. wt/day).

Assimilation (A) = Consumption – feces

$$Assimilated\ rate = \frac{\text{Food assimilated}}{\text{Initial live weight} \times \text{Experimental duration}} \times 1000$$

2.8 Conversion or Production rate (Pr)

Production rate is also known as growth rate or conversion rate. It represents the amount of food converted into body mass per unit weight of the fish per unit time (mg/g. wt/day) Conversion or Production (P) = Final wet weight - Initial wet weight.

$$Consumption\ rate = \frac{\text{Food consumed}}{\text{Initial weight} \times \text{Experimental duration}} \times 1000$$

$$Food\ conversion\ ratio\ (FCR) = \frac{Food\ Consumed}{\text{Weight gain (wet weight)}}$$

2.9 Metabolic rate (Mr)

It represents the amount of food metabolized per unit weight of the fish per unit time (mg/ g. wt. / day).

Food metabolized (M) = Food assimilated - Food converted

$$Metabolic\ rate = \frac{\text{Food metabolised}}{\text{Initial live weight} \times \text{Experimental duration}} \times 1000$$

2.10 Assimilation Efficiency (%)

The term assimilation efficiency is preferred over the term "approximate digestibility" used by Waldbauer (1968) [36] because not all digested food is necessarily absorbed and assimilated (Pandian, 1967) [22]. Assimilation is defined as the percentage of food energy, absorbed in relation to the food energy consumed.

$$Assimilation\ efficiency = \frac{\text{Food assimilated}}{\text{Food consumed}} \times 1000$$

2.11 Conversion efficiency (%)

Production efficiency or growth efficiency is another term used to describe the percentage of food energy converted in relation to food consumed. Gross conversion efficiency refers to the percentage of food energy converted in relation to the total food consumed, while net conversion efficiency refers to the percentage of food energy converted in relation to the assimilated food.

$$Gross\ conversion\ efficiency, K1\ (\%) = \frac{\text{Food converted}}{\text{food consumed}} \times 100$$

$$Net\ conversion\ efficiency, K2\ (\%) = \frac{\text{Food converted}}{\text{food assimilated}} \times 100$$

3. Result

The effect of *Acalypha indica* leaf supplemented diet on the growth and feeding energetics of the fish, *Labeo rohita* was analysed.

3.1 Growth of the Fish

Influence of *Acalypha indica* leaf supplemented diet on the growth of fish in terms of body length and wet weight showed maximum growth in experimental 2 (20% AIL diet) group fishes when compared to the experimental 1 (10% AIL diet) and 3 (30% AIL diet) and control groups (Table 2). The specific growth rate was also higher in the second group fed with 20% *Acalypha indica* leaf supplemented diet.

Table 2: Growth of the fish *L. rohita* fed on *Acalypha indica* leaf supplemented diet for a period of 45 days.

Group	Weight (gm) (Mean ± SD)	Length (cm) (Mean ± SD)	SGR (%)
Control	0.41 ± 0.23	0.91 ± 0.18	0.92
10% AIL diet	0.50 ± 0.36	0.75 ± 0.11	1.118
20% AIL diet	0.58 ± 0.37	1.17 ± 0.32	1.307
30% AIL diet	0.42 ± 0.26	0.88 ± 0.24	0.951

Values are Mean±SD of 15 observations; AIL- *Acalypha indica* leaf

3.2 Food Consumption, Assimilation and Metabolization

Food consumption of the fishes was similar in all the three experimental diets when compared to the control at 1 to 45 days duration (Table 3). However, a reduction in the assimilation of food consumed in the experimental group when compared to the control (8989.03mg) was observed. Among the experimental groups, an increase in assimilation was observed at 10% concentration (8934.77) for a period of 45 days (Table 3). The food conversion was higher at 10 and 20% concentration (0.5033 and 0.5885mg respectively) when compared to the control (0.414). The metabolism was highest in the control group (8989.02) followed by 10% concentration (8934.76) and 20% concentration (8928.09) at the end of the 45th day.

Table 3: Food consumption (C), Assimilation (A), Convertion (P) and Metabolization (M) by *L. rohita* fed on *A. indica* supplemented diet for a period of 45 days

Group	Consumption	Assimilation	Conversion	Food metabolized
Control	8963.97	8989.03	0.414	8989.02
10% AIL diet	8965.75	8934.77	0.5033	8934.76
20% AIL diet	8963.83	8928.1	0.5885	8928.09
30% AIL diet	8963.67	8920.23	0.428	8920.22

Values are expressed in mg

3.3 Rate of Consumption, Assimilation, Conversion, Metabolism and Food conversion ratio

The food conversion and assimilation rates were high in the control group and 20% concentration (56.1124 and 43.7793 and 56.2693 and 43.6048 respectively). The conversion rate was high at 20% concentration when compared to other groups (Table 4). The food conversion ratio was high in control, at 30% and 10% but low at 20%.

Table 4: Influence of different concentrations of *A. indica* leaf supplemented diet on consumption rate (Cr), assimilation rate (Ar), metabolic rate (Mr), conversion rate (Pr) and food conversion ratio (FCR) of the fish, *L. rohita* fed for a period of 45 days

Group	Cr	Ar	Pr	Mr	FCR
Control	56.1124	56.2693	0.0025	56.269	21712.63
10% AIL diet	35.326	35.2039	0.0019	35.203	17752.37
20% AIL diet	43.7793	43.6048	0.0028	43.604	15170.94
30% AIL diet	42.1126	41.9085	0.0020	41.908	20841.65

Rates are expressed in mg/g body weight/day

3.4 Assimilation Efficiency, Gross Conversion Efficiency, Net Conversion Efficiency

The assimilation efficiency was almost similar in the experimental group (99.65, 99.60 and 99.51) when compared to the control (100.27) at the end of 45 days. Similarly, the Gross conversion efficiency and net conversion efficiency were comparatively higher at 20% (0.00639 and 0.00642) when compared to the control and the other experimental concentrations (Table 5).

Table 5: Efficiencies of assimilation, gross conversion (K1) and net conversion (K2) shown by *L. rohita* fed on *A. indica* supplemented diet for a period of 45 days

Group	Assimilation Efficiency	K1	K2
Control	100.27	0.00445	0.00444
10% AIL diet	99.65	0.00537	0.00539
20% AIL diet	99.601	0.00639	0.00642
30% AIL diet	99.51	0.00474	0.00477

Values are expressed in %

4. Discussion

Bioenergetics and growth are inseparable. The relation between the food consumed by the fish and the resulting growth is a matter of great practical importance (Ricker, 1979) [27]. A well-balanced diet not only yields good production but also delivers nutrients necessary for the recovery from disease and environmental stresses (Chol, *et al.*, 1983) [5].

In the present study, the diet prepared with different concentrations of *Acalypha indica* showed an increase in growth at 20% concentration when fed for 45 days. Both body weight and length increased at this concentration suggesting the influence of food in the growth of fish. Arunachalam, *et al.*, (1985) [2] working on the feeding energetic of *Heteropneustes fossilis* have also reported that food quality significantly affects the growth of the fish. A similar report has also been given by Pandian (1967) [22] after working on the feeding energetics of *Megalops cyprinoid*.

The results of the present investigation reveal that all feeding parameters of the fish varied with different concentrations of *Acalypha indica* supplemented diet. The variation was seen in all the observed parameters like consumption, assimilation, conversion and metabolism. Among the four concentrations, feed supplemented with 10% *A. indica* showed higher consumption when compared to the other groups. The incorporation of *Acalypha indica* has been found to enhance the feeding behaviour of *Labeo rohita*. The slight decrease in food consumption and assimilation may be due to the slow rate of feeding and digestion. The difference in food consumption and assimilation has also been observed by Mathavan and Christopher (1983) [16] and Fischer (1973) [9] by feeding animals with different food combinations.

Production of an animal population depends on the growing range and biomass (Brocksen, *et al.*, 1968) [4]. The incorporation of *Acalypha indica* has been found to increase the growth of *Labeo rohita* as revealed by the experimental results. The conversion rate was higher at 20% concentration which is exemplified in the growth of fish. The increased consumption and assimilation also show a higher amount of food metabolized and a higher metabolic rate. The result also shows that the fish *Labeo rohita* allocates more energy for metabolism, conversion or growth. This is in accordance with the report of Pandian and Vivekanandan, (1990) [23] who compared the energy budgets of fish and insect and reported that insect allocates more energy for growth than metabolism whereas fish allocates more energy for metabolism than growth. The feed conversion ratio was low with 20% supplemented feed and was higher in other concentrations which suggests the efficient feed utilization by the fish as reported in fish *Osphronemeus goramy* when supplemented with *Acalypha indica* and *Vigna radiata* (Pinandoyo, *et al.* 2021) [25].

The gross and net conversion efficiency reflects the digestibility of nutrient content, food searching or feeding activity, etc. The conversion efficiency, the gross conversion efficiency is found to be higher at 20% concentration. A similar pattern is seen in the case of net conversion efficiency values. Various aspects of food production from plants have been advanced in many countries. Many plants have been reported to have a stimulatory effect. Addition of 50mg kg-1 of synthesized allicin to the tilapia diet increased more than 2-3% of its weight gain after 45 days of culture (Zeng, et al, 1996) [38]. Incorporation of different concentrations of garlic in the diet improved the growth, feed efficiency and specific growth rate in *Oreochromis niloticus* (Metwally, 2009, Shalaby, *et al.*, 2006, Diab, *et al.*, 2002) [17, 30, 8], in tilapia (Abou-Zeid, 2002) [1] and Rainbow trout (Nya and Austin, 2009) [20].

Leaves of *Sesbania grandiflora, Moringa oleifera, Coleus aromaticus, Ocimum basilium* and *Solanum verbascifolium* have been found to promote growth in *Oreochromis mossambicus*. An increase in weight and specific growth rate was observed in *O. mossambicus* fed with a diet containing *Moringa oliefera* and an increase in length was observed in the fishes fed with an *Ocimum basilium*-supplemented diet (Karpagam and Krishnaveni, 2014) [13]. Thus, plant ingredients are included in the fish diet for their better growth. From our present study, it is very obvious that *Acalypha indica* can be used as a good supplement for fish feed. By incorporating the optimum concentration one can achieve the maximum growth of the experimental animal.

This suggests that *Acalypha indica* contain some constituents that stimulate consumption and growth in *Labeo rohita*. The results from our study would be a great help to those who engage themselves in farming practices. The growth stimulatory effect of *Acalypha indica* can be considered during the feed formulation and can be incorporated into the feed as feed additive.

5. Conclusion

Acalypha indica supplemented diet has enhanced the growth of fish at 20% concentration which suggests that at a particular concentration the feed utilization efficiency and feed conversion ratio influences the growth of fishes. Thus from the above experiment, we can understand that *Acalypha indica* can be utilized for the formulation of fish feed. Since

Acalypha indica is also known to boost the immunity as reported in various research, this medicinal herb can be incorporated in the feed to improve the culture of fresh water carps.

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