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Role of germinated fenugreek seed meal on growth performance, survival and proximate composition of *Cyprinus carpio* (Linnaeus, 1758) fingerlings

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Abstract
This experimental study was performed to evaluate the beneficial role of germinated fenugreek seed meal (GFSM) on growth performance, survival, and proximate composition of *Cyprinus carpio* fingerlings. Dietary supplementation of GFSM at an inclusion rate of 0% (T_0), 5% (T_1), 10% (T_2), 15% (T_3), 20% (T_4), and 25% (T_5) were fed to the fish @ 3% body weight. The experimental study duration was conducted for up to 60 days. Significantly (p< 0,05) higher growth performance such as weight gain (8.826±0.066 gm), % weight gain (92.586±0.356%), specific growth rate (1.092±0.003), gross conversion efficiency (0.351±0.001) and protein efficiency ratio (1.181±0.024) were observed at the 25% inclusion level of GFSM in the fish diet. While the lowest feed conversion ratio was recorded in T_5 group, i.e., (2.844±0.007) which indicated fish utilized a high amount of feed as compared to the control diet. A 100% survival rate occurred in treated fishes during the experimental period. The proximate composition of the experimental diet was not significantly different (p< 0.05). The crude protein level was increased with an increased dose of GFSM. However, the crude fat and ash amounts were found to be maximum in T_3 and T_5 group as compared to other treatments. No significant difference was observed in the moisture and carbohydrate levels of the *Cyprinus carpio* carcass. These results demonstrated that, GFSM at the rate of 25% in the diets of fish showed a beneficial effect on growth performance of fish and this level of GFSM can be used in the diet of carps.

Keywords: *Cyprinus carpio*, germinated fenugreek seed meal (GFSM), growth performance, proximate composition, survival

Introduction
Aquaculture becomes a more appealing and valuable component of national development and poverty reduction strategies in many parts of the world (Prabu and Santhiya 2016) [28]. Aquaculture benefits rural development in terms of health and nutrition, employment, income, vulnerability reduction, and farm sustainability. Aquaculture also contributes in market stabilization by meeting commercial fisheries' off-season demands and increasing production of desired-quality fish and shellfish. (Pillay, 1973) [27]. Fish is a high-quality source of animal protein and essential fatty acids, particularly long-chain polyunsaturated fatty acids (LCPUFA), as well as micronutrients, with a digestibility of over 90% (Kijora *et al.*, 2006) [23]. By 2030, aquaculture might provide an additional 16–47 million tonnes of fish (Hall *et al.*, 2013) [19]. The FAO–WHO expert consultation group found that fish consumption is advantageous for individual growth and development in the general population, and that consuming a certain amount of fish (fatty fishes in particular) is linked to a lower risk of coronary heart disease and stroke (FAO/WHO, 2011). Currently, fish provide nearly 20% of the average per capita animal protein intake for approximately 3.2 billion people, and these figures are still rising (Fisheries FAO, 2018; Godfray *et al.*, 2010).
The outbreaks of disease generally increased in semi-intensive and intensive aquaculture operations, which resulting in a partial or entire loss of fish productivity (Reantaso *et al.*, 2005) [8].
Furthermore, a variety of factors such as overcrowding, handling, temperature, poor water quality, and poor nutrition contribute to stress in fish, which leads to immunosuppression and increased susceptibility to infectious diseases (Cabello 2006; Reverter *et al.*, 2014) [10, 30]. Indeed, infectious diseases are major constraints of the aquaculture industry (Adams *et al.*, 2008) [2]. However antibiotics, hormones and several other chemicals have been tested as growth promoters, antibacterial and for other purposes in aquatic animals (Masahiro 1999), but their use in aquatic animal production have been criticized because their use have created

problems with drug resistance bacteria, toxicity and accumulation both in fish and in the environment (Citarasu, Babu, Sekar & Marian 2002; Sagdic & Ozcan 2003) [2, 34]. Vaccination is another effective method of treatment, but it is too expensive and unpractical for wide spread use in fish farms in addition to a single vaccine having a specific effect against only one type of pathogen (Harikrishnan *et al.*, 2011 and Sakai 1999) [31, 35].

With this prohibition, the use of herbs and medicinal plants in fish diets promotes variety of function, such as an appetite stimulator, growth promoter, antiparasitic, antimicrobial, immunostimulating and antioxidant due to the presence of various active compounds, like flavonoids, alkaloids, phenolics, pigments, steroids, terpenoids and essential oils (Citarasu, 2010) [10]. The World Health Organization (WHO) promotes supplementing the fish diet with medicinal herbs or plants to reduce the use of chemicals (Dada, 2015) [13]. Herbal ingredients like garlic bulbs, fenugreek seeds, black seeds and ginger cloves etc have been proven to improve weight gain, survival, and feed conversion rates in fish by up to 50% (El-Dakar *et al.*, 2004; Shalaby *et al.*, 2004) [15, 36]. These additives could augment the growth of beneficial microbial colonies in the digestive tract which lead to enhance feed intake and weight gain of various aquatic species. Easy access and the cheap price for many plants are also encouraging factors for their use in large scale in aquaculture to provide better growth and protection at the same time.

Among the many potential herbal plants, *Trigonellafoenum – graecum* (Fenugreek) has received the most attention. It is a promising medicinal plant that has a variety of beneficial effects on fish, including growth promoters and immunostimulant (Bahi *et al.*, 2017) [18]. Fenugreek is a leguminous plant native to Northern Africa, the Mediterranean, Western Asia, and Northern India. The seeds of fenugreek are rich in carbohydrates 45-60%, protein 20-30%, fixed oils (lipids) 5-10%, and vitamins A, B1, C, (Blumenthal *et al.*, 1988). Germinated fenugreek seeds played beneficial role in the digestion of protein and absorption of fat (Rayyan *et al.*, 2010) [29]. In aquaculture sector, fenugreek seeds powder effectively enhanced the growth performance, immunity and wellbeing of gilthead seabream (*Sparusaurata* L.) (Awad *et al.*, 2015; Bahi *et al.*, 2017) [18], common carp (*Cyprinus carpio* L.) (Roohi *et al.*, 2017) [33], and striped catfish (*Pangasius hypophthalmus*) (Mehboob *et al.*, 2017) [24].

Common carp (*Cyprinus carpio*) is one of the most important fish species in aquaculture (Shirali, Erfani Majd, Mesbah & Seif 2012) [38]. It is the world's third-largest aquaculture producer, with over 100 countries cultivating it (Bostock *et al.*, 2010; FAO 2016) [9, 16]. Because of its excellent growth rate, omnivorous habits, breeding in confined water, hardy nature, and ease of adaptation to artificial feed; it is preferred by farmers for cultivation in ponds alongside or in combination with other fishes. According to research, this bottom feeder fish grows at a much faster rate than *Cirrhinus mrigala*, an Indian major carp with similar feeding habits (Parameswaran *et al.*, 1971) [26]. Cyprinus carpio also plays an important role in the economy of Pakistan, employing over 400,000 people and contributing to the country's gross domestic product (GDP). (Khan *et al.*, 2016) [22]. The fish has been classified as eurythermal, which means it can withstand a wide range of temperature fluctuations, making it ideal for culture in Rajasthan's climatic conditions. From the above presented baseline, the aim of the present study was to estimate the beneficial role of germinated fenugreek seed meal (GFSM) on growth rates, survival rates and proximate composition of *Cyprinus carpio* fingerlings.

Materials and Methods

Experimental Fish and Maintenance

The *Cyprinus carpio* fingerlings (9.520±0.047 gm) were selected for the experimental study. A total quantity of 90 fingerlings was procured from the Seed Production and Research Unit, MPUAT, Udaipur. In order to overcome the handling stress, the fishes were given a mild salt and KMnO4 treatment. The fish were acclimatized in a 500 Lcapacity FRP circular tank with a basal diet for a week. The feeding was stopped 24 hours before the commencement of experiment.

Basal Diet

The basal diet was prepared with several ingredients *viz.* fishmeal, groundnut oil cake, rice bran, wheat flour and, vegetable oil and a vitamin-mineral mixture. The proportions of basal ingredients were selected on the basis of previous report (Mostafa *et al.*, 2009) [25]. Cr_2O_3 was added as additional ingredients in the diets to check the digestibility.

Table 1: Ingredients used for the preparation of basal diets

S. No.	Ingredients	Amount (%)
1	Fish Meal	10
2	Groundnut Oil Cake	40
3	Rice Bran	30
4	Wheat Flour	15
5	Vegetable Oil	3
6	Vitamin and Mineral Mixture	2

Preparation of Experimental Diet

The germinated fenugreek seed meal was used with the basal diet to prepare an experimental diet for fish. The seeds were soaked in water for 48 hours. They were germinated within two days and dried in the shade before being crushed in the grinder (Prestige IRIS plus 750 watt, Udaipur). Finally, the seed meal was used in the fish diets with different inclusion of T_0 control (0% GFSM), T_1 (5% GFSM), T_2 (10% GFSM), T_3 (15% GFSM), T_4 (20% GFSM), T_5 (25% GFSM). All the basal ingredients (Fish meal, GNOC, RB, WF, Vegetable oil) and GFSM were thoroughly combined and formed into dough, which was then placed in an autoclave at 15 pounds of pressure for 30 minutes. After cooling, Cr_2O_3 and a vitamin and mineral mixture were mixed, and pellets were made with a hand pelletizer. This prepared spaghetti was kept for air-dried in an airtight vessel.

Table 2: Ingredients proportion and proximate composition of experimental diets supplemented with inclusion levels of germinated fenugreek seed meal (GFSM) during experimental period

S. No. A	Ingredients	Treatment wise Ingredient's Proportion					
		T_0 (Control)	T_1	T_2	T_3	T_4	T_5
1	Fish Meal	10	9.5	9	8.5	8	7.5
2	Groundnut Oil Cake	40	38	36	34	32	30
3	Rice Bran	30	28.5	27	25.5	24	22.5

4	Wheat Flour	15	14.25	13.5	12.75	12	11.25
5	Vegetable Oil	3	2.85	2.7	2.55	2.4	2.25
6	Vitamin and Mineral Mixture	2	1.9	1.8	1.7	1.6	1.5
7	GFSM	0	5	10	15	20	25
B	**Proximate Composition of Experimental Diets (%)**						
1	Moisture	8.546±0.288	8.523±0.295	8.543±0.291	8.570±0.241	8.596±0.263	8.543±0.229
2	Crude protein (CP)	29.520±0.332	29.570±0.406	29.656±0.496	29.630±0.451	29.713±0.279	29.786±0.673
3	Crude fat (CF)	8.686±0.240	8.616±0.329	8.636±0.367	8.690±0.320	8.586±0.365	8.620±0.340
4	Total ash (TA)	6.450±0.282	6.620±0.268	6.666±0.286	6.646±0.296	6.650±0.284	6.600±0.261
5	Nitrogen-free extract (NFE)	46.796±0.653	46.670±0.358	46.496±0.702	46.463±0.619	46.453±0.451	46.450±1.147
6	De (kcal 100 g^{-1})	383.44±2.291	382.51±3.628	382.34±3.332	382.58±2.200	381.94±2.746	382.52±2.664

Purchased from local market, Udaipur, India. Universal Medicare Pvt Ltd, Rajasthan, India. NFE = 100 – (% Moisture + % CP + % CF + % TA). Calculated digestible energy (DE) (kcal kg^{-1}) = 4.00 x CP (kcal $100g^{-1}$) + 9.00 x CF (kcal $100g^{-1}$) + 4.00 x NFE (kcal $100g^{-1}$) Halver (1976).

Experimental set up

The experimental study lasted for two months, from March 7 to May 7, 2021, at the wet lab of the Department of Aquaculture, College of Fisheries, MPUAT, Udaipur (Rajasthan).To conduct the experiment, eighteen tanks (225-liter capacity) were assigned in six triplicates (5 treated and 1 control) followed a completely randomized design (CRD). All of the tanks washed with clear water, and dried. The tanks were filled with 200 litters of water before the fingerlings were introduced. Following that, *Cyprinus carpio* fingerlings (9.520±0.047gm) were equally distributed into tanks with a stocking density of 5 fish per tank or 25fish/m^3.All of the experimental tanks were covered with nylon net to prevent dust particles entry and fish from jumping out. The fingerlings were fed twice a day @ 3% of their body weight in the form of pellets at 10.00 a.m. and 5.00 p.m. Control group was fed with a basal diet only while as the treated groups were fed GFSM at 5%, 10%, 15%, 20%, and 25% inclusion rates. To maintain the oxygen level in water, aeration was provided for 2 hours every day. At 15-day intervals, growth performance and water quality parameters for each group were recorded. Siphoning was done to collect all uneaten food and faces, and the faecal matter was placed in the oven at 60 degrees Celsius to test the digestibility of fish. By refilling, the water level in the tanks was kept constant.

Fish growth performance

The growth performance (weight gain, % weight gain, specific growth rate, feed conversion ratio, gross conversion efficiency, and survival) were determined by using standard methods (Halver and Hardy, 2002) [20].

Weight gain (g)

Weight gain (g) = Final weight (g) – Initial weight (g)

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

Specific growth rate (SGR)

$$\text{SGR \%} = \frac{(\text{In Wt} - \text{In Wo})}{\text{D}} \times 100$$

Where, W_0 = Initial weight of live fish (gm)
Wt = Final weight of live fish (gm)
D = Duration of feeding (days)

Feed conversion ratio (FCR)

$$\text{FCR} = \frac{\text{Weight of feed given (g)}}{\text{Net weight gain of fish (g)}}$$

Protein efficiency ratio (PER)

$$\text{PER} = \frac{\text{Gain in body mass (g)}}{\text{Protein intake (g)}}$$

Gross conversion efficiency (GCE)

$$\text{GCE} = \frac{\text{Weight gained (g)}}{\text{Feed givn (g)}}$$

Survival of fish

$$\text{Survival \%} = \frac{\text{Total harvested number}}{\text{Total stocked number}} \times 100$$

Water quality analysis

The water quality parameters *viz.* water temperature, pH, electrical conductivity, dissolved oxygen, alkalinity, and total hardness were determined by using standard procedures of APHA (2005) [4].

Proximate composition of experimental diets and fish

The proximate composition of the feed was estimated by slandered protocols (AOAC, 1995) [3].

Moisture estimation

Two grams of the fresh powdered feed sample and fish were weighed and placed in a moisture cup. In a hot air oven, the sample was dried to a constant weight at 60±2˚ C for 24 hours. All of the dried samples were transferred to a desiccator for cooling before being accurately weighed to determine the moisture percentage using the formula below:

$$\text{Moisture content (\%)} = \frac{Weight\ of\ fresh\ sample - Weight\ of\ dry\ sample}{Weight\ of\ fresh\ sample} \times 100$$

Crude protein estimation

The crude protein content of the diet was estimated by Micro kjeldahl Method.

Reagents used

Con. sulphuric acid, 30% solution of Hydrogen peroxide, 10% solution of Sodium silicate, 10% solution of Sodium hydroxide, Standard solution of nitrogen, and Nessler reagent.

Methods

Digestion process

A well-grounded sample of fish feed and fish '0.1' g was taken and put into a 100 ml dry Kjeldahl flask to avoid sticking to the neck. Following that, 2 ml of concentrated $H_2 SO_4$ was poured into the Kjeldahl flask and mixed with the contents. These flasks were placed on top of the digestion assembly and heated until the sample was properly digested. The flasks were then cooled, and 0.5 ml (30 percent $H_2 O_2$) was added, followed by heating the contents of the flasks again. This process was repeated until the $H_2 O_2$ vapours began to emerge. The digested contents of the Kjeldahl flask were transferred to a 100 ml volumetric flask after cleaning it 3-4 times with distilled water and adjusting the volume to the desired level.

Color development

A 50 ml volumetric flask was used, and a 5 ml aliquot was placed into it, along with a few ml of distilled water. Besides this, I sequentially added 2 ml of 10% sodium hydroxide solution and 1 ml of 10% sodium silicate solution, along with some water. After properly blending the contents, I added into the flask 1.6 ml of Nessler's reagent. The liquid solution was then brought up to the level. Using a blue filter or setting the Spectrophotometer to a wavelength of 420 nm, the first measurements of the standard working solution were taken. A standard curve was created by plotting nitrogen concentration on the X-axis and reading on the Y-axis. The standard curve was used to evaluate the nitrogen content of the sample. The crude protein content was then estimated by multiplying the nitrogen content's 6.25 conversion factor (for fish).

Crude fat estimation

In a what man filter paper (N0. 40), a weight of 3 gm of a dried and powdered sample of fish feed and fish was placed. The sample of fat was extracted with petroleum ether at 60°C using Soxhlets apparatus. The pre-dried solvent flasks were connected beneath the apparatus and the required quantity of solvent was poured into it and then connected to condenser. The heating rate was adjusted to give a condensation rate of 2 to 3 drops/second and the sample was extracted for 16 hours. On completion, the samples were dried for 30 minutes at 100 °C. Then it was cooled in a desiccator and the final weight was recorded soluble lipids. The total organic solvent soluble lipids were determined by comparing the weight of the sample before and after extraction. The sample's fat content was measured in grams per 100 grams of dried sample.
The sample's fat content was calculated as follows:

$$\text{Crude fat \%} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Ash estimation

A 2g of dried and powdered sample of fish feed and fish was weighed in a silicon crucible and then was placed in a muffle furnace at 550˚C for 4 hours. With the use of a pair of pliers, crucibles were then transferred to desiccators. After cooling, the samples were weighed again.

$$\text{Ash (\%)} = \frac{\text{Weight of Ash}}{\text{Weight of sample}} \times 100$$

Nitrogen free extract estimation

The NFE content of the fish and fish feed was estimated by a different method. Crude protein, fat, moisture, and ash were added and the derived sum was subtracted from 100.

% NFE = 100 – (%moisture + % crude protein + % crude fat + % ash)

Statistical Analysis

SPSS software (Version 16.0, SPSS, USA) was used to analyse the data. The significant dissimilarities between the groups were determined using one-way ANOVA and Duncan's multiple range tests. All data is presented as mean± SD, with a statistical significance level of $P< 0.05$.

Results and Discussion

The concept of the current study revealed that, the growth performance of *Cyprinus carpio* fingerlings in terms of weight gain, % weight gain, specific growth rate (SGR), feed conversion ratio (FCR), gross conversion efficiency (GCE) and survival rate of fish throughout 60 days were significantly affected ($p< 0.05$) by different concentration levels of germinated fenugreek seed meal.
Highest performance of weight gain (8.826±0.066), % weight gain (92.586±0.356), SGR (1.092±0.003) and GCE (0.351±0.001) were observed in T_5 group as compared to control and other treatments group. The T_5 group showed better adaptation and higher feed utilization with low feed conversion ratio (2.844±0.007) followed by T_4 , T_3 , T_2 , and T_1 dietary group of GFSM while lowest feed utilization was found in control group T_0 . During the experimental period, the test fishes had a 100 percent survival rate. The survival rate of each treatment was found to be unaffected by varying inclusion rates of GFSM. The outcomes of this study concluded that the highest dose of germinated fenugreek seed meal could be considered a good food supplements to improve the immune status, enhance growth rates and increase production of *Cyprinus carpio* fingerlings. The other researcher studies also showed a beneficial role of fenugreek seed as supplementary diets for fish. Roohi *et al.*, (2015) [32] studied fenugreek effect on common carp (*Cyprinus carpio*) and reported significant higher weight gain, specific growth rate, and condition factor in treated group than control one, he add that no mortality was recorded during the feeding trial. Sheikhlar *et al.*, 2011 [37] who reported that adding FSM to diet up to 30% as substituted amounts with fishmeal showed significant optimum growth performance by African catfish. Furthermore, the addition of FKSM at 50 g/kg improved gilthead seabream *Sparus aurata* growth as well as some immunological responses (Bahi *et al.*, 2017; Guardiola *et al.*, 2017) [18]. The fenugreek seeds have a bitter taste (Billaud and Adrian, 2001) [7], which might increase feed palatability and thus feed intake in fish**.** This study is supported by Syeed *et al.*, 2018 [39] and Roohi *et al.*, 2015 [32] they suggested that PER and FCR were significantly ($p< 0.05$) improved in Common carp groups fed with fenugreek based diet compared to the control. Abdelhamid and Soliman, 2012 [1] confirmed that Fenugreek Seeds had significantly improved the feed utilization in form of protein productive value and energy retention.

Table 3: Growth performance data of *Cyprinus carpio* fingerling fed with different inclusion level of Germinated fenugreek seed meal diets in different treatments

S. No.	Treatments	Parameters					
		Net weight gain (g)	Per cent weight gain	SGR	FCR	GCE	PER
1.	T_0 (Control)	6.660^{a}±0.080	69.955^{a}±0.667	0.883^{a}±0.006	3.473^{f}±0.024	0.287^{a}±0.002	0.975^{a}±0.012
2.	T_1	7.293^{b}±0.012	76.560^{b}±0.368	0.947^{b}±0.003	3.251^{e}±0.011	0.307^{b}±0.001	1.040^{b}±0.010
3.	T_2	7.656^{c}±0.038	80.400^{c}±0.202	0.983^{c}±0.001	3.138^{d}±0.005	0.318^{c}±0.000	1.074^{bc}±0.016
4.	T_3	7.910^{d}±0.040	82.857^{d}±0.088	1.005^{d}±0.000	3.072^{c}±0.002	0.325^{d}±0.000	1.099^{c}±0.016
5.	T_4	8.210^{e}±0.032	86.180^{e}±0.279	1.035^{e}±0.002	2.988^{b}±0.006	0.334^{e}±0.001	1.126^{e}±0.011
6.	T_5	8.826^{f}±0.066	92.586^{f}±0.356	1.092^{f}±0.003	2.844^{a}±0.007	0.351^{f}±0.001	1.181^{d}±0.024

Data expressed as Mean ± SE (n=3).Mean values in the same column sharing different superscripts are significantly different (p< 0.05)

Table 4: Proximate composition of fish carcass of *Cyprinus carpio* fingerlings in different treatments

Treatments	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Carbohydrate (%)
Initial (In)	72.806^{a}±0.288	17.633^{a}±0.254	3.076^{a}±0.017	3.883^{a}±0.020	2.6^{a}±0.533
T_0 (Control)	73.956^{a}±0.236	18.170^{a}±0.017	3.106^{a}±0.088	3.136^{a}±0.024	1.630^{a}±0.225
T_1	73.703^{a}±0.269	18.233^{a}±0.014	3.230^{c}±0.011	3.173^{ab}±0.017	1.660^{a}±0.240
T_2	73.643^{a}±0.103	18.366^{b}±0.026	3.140^{ab}±0.011	3.123^{a}±0.046	1.726^{a}±0.078
T_3	73.120^{a}±0.341	18.483^{c}±0.026	3.336^{d}±0.012	3.243^{b}±0.014	1.863^{a}±0.338
T_4	73.186^{a}±0.358	18.606^{d}±0.024	3.170^{b}±0.036	3.200^{ab}±0.017	1.836^{a}±0.346
T_5	73.196^{a}±0.321	18.690^{e}±0.011	3.290^{d}±0.011	3.246^{b}±0.014	1.530^{a}±0.310

Data expressed as Mean ± SE (n=3).Mean values in the same column sharing different superscripts are significantly different (p< 0.05)

The proximate composition of *Cyprinus carpio* fingerlings were found significantly different among all treatments. The result of the experimental study indicated that, the T_5 group had higher protein content (18.690±0.011%) followed by T_4 (18.606±0.024%), T_3 (18.483±0.026%), T_2 (18.366±0.026%) and T_1 (18.233±0.014%) group. While the lowest level of protein was found in control (18.170±0.017%) and initial group (17.633±0.254%). Crude fat content was observed highest in T_3 group or T_5 group and found lowest in initial and control group. Similarly the ash amount recorded high in T_5 group as compared to control or initial one. The moisture and carbohydrate level of fish carcass was does not found significantly different (p> 0.05) among all treatments group. This result shows the improvement in body composition due to the enhancement of fish health by GFSM fed. Similar finding revealed by Abdelhamid and Soliman, 2012 [1] declared that fenugreek seed (at 2% addition level) had significantly increased Nile tilapia carcass protein percent. Tonsy *et al.*, 2011 [40] indicated that supplementation level of 1% different six medical plants for mono six Nile tilapia revealed significantly the highest CP %, EE % and energy content (Kcal /100g). Mostafa *et al.*, 2009 [25] showed that dry matter, crude protein, fat and ash in Nile tilapia body did not be affected by different FSM levels.

Conclusion

According to the outcomes of the current study, a higher dose of germinated fenugreek seed meal at an inclusion level of 25% is considered best for the optimal production and survival rate of Cyprinus carpio fingerlings. Fish showed better growth performance and complete utilization of feed at an increased dose of GFSM. From this point of view, it can be suggested that this herbal ingredient has a beneficial role in aquaculture expansion.

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