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Original Article

Organoleptic qualities and proximate composition of fish grown in good aquaculture practice-based carp fattening pond

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Abstract
Organoleptic qualities and proximate composition of fish grown in carp fattening pond were studied under three treatments of feed and fertiliser management. Treatment T_1 was designed with the use of organic fertiliser and stocking of silver carp, T_2 with both organic and inorganic fertilisers and silver carp and T_3 with both organic and inorganic fertilisers but excluding silver carp. One day in a week feeding restriction was followed in all the treatments. Fishes were stocked with a stocking density of 2470 fishes ha^{-1}. Three fishes (*Gibelion catla*, *Labeo rohita* and *Cirrhinus cirrhosus*) were selected for organoleptic and proximate assessment. Cyanobacteria along with total phytoplankton cell density was significantly higher at treatment T_2 followed by T_3 and T_1. However, in terms of productivity (Chl-*a*) treatment T_2 was 27.1 and 13.3% higher compared to T_1 and T_3 respectively. Parameters assessed for proximate composition analysis did not vary across treatments and organoleptic test revealed comparatively higher acceptability of fishes collected from treatment T_1 followed by T_2 and T_3 for all the fishes. Overall acceptability was higher for *L. rohita* from treatment T_1. This study concluded that, inorganic fertilisation along with silver carp can improve the organoleptic properties of carps in pond.

Keywords: chlorophyll-*a*; cyanobacteria; organoleptic properties; surface feeder

1 | INTRODUCTION

Organoleptic valuation has proven to be a vital tool in the evaluation of freshness of farmed fishes (Cheng *et al.* 2015). Organic characteristics are also important determinants of food quality and drivers for consumer acceptance and food choice (Siret and Issanchou 2000); they can also provide valuable information in order to select the most appropriate market for each species and their respective products. Defining and measuring the organic attributes that characterise fish, seems to be necessary for product development in order to satisfy consumer expectations. The better the knowledge about accurate descriptors that best define fish, the less time needed for its product development (Carpenter *et al.* 2000). Moreover, in case of fish, taste has proven to be the strongest motive of consumption intention (Verbeke and Vackier 2005). Organoleptic properties strongly depends on the chemical composition of the fish, which in turn depends on many quality affecting factors that include intrinsic characteristics of the fish (such as species, age, sex etc.), environmental factors (temperature, salinity etc.) and feeding history (diet composition, feeding ratio etc.) (Huss 1988; Grigorakis 1999).

Unlike the most other production problems in aquaculture, off-flavour assessed by organoleptic valuation is less detrimental to the growth or health of the animals

(Tucker 2000), however, economic importance of organoleptic testing is high, making it one of the most severe challenges of the aquaculture industry worldwide (Moretto *et al.* 2022). Degradation of natural aquatic environment and increasing trend of semi-intensive aquaculture practices with supplementary feed has affected the taste and quality of fish muscle (Zhao *et al.* 2018). Typically, the nutrients in semi-intensive aquaculture system are supplied by a combination of diet and fertilisers (Carmo *et al.* 2008). All nutrients from artificial feeding cannot be assimilated by fish in culture system. For example fish assimilated only 26.80% nitrogen and 30.10% phosphorus from feed in catfish culture pond (Boyd 1985). Nitrogen and phosphorus released from feed can thus stimulate algal growth beyond the desirable levels and cause phytoplankton bloom (Xu *et al.* 2010). Furthermore, nutritional value, colour, texture, smell and appearance are also affected by the quality of nutrition and feed provided during culture in semi-intensive and intensive systems (Khan *et al.* 2011). Fish farmers have increased fish yields in ponds by using inorganic or chemical fertilisers and organic fertilisers (Kumar *et al.* 2005). When ponds are fertilised with organic and inorganic fertilisers, nutrients stimulate the growth of microscopic plants (phytoplankton) in the water (Terziyski *et al.* 2007). Abundant growth of these microscopic plants gives water a turbid, greenish colour (called a "bloom") that can prevent light from reaching the pond bottom and reduce the growth of rooted aquatic weeds (Jahan *et al.* 2010).

Phytoplankton is the major source of dissolved oxygen in fish ponds. Dissolved oxygen levels depend primarily on the relative magnitudes of photosynthetic oxygen generation and total plankton respiration (Smith and Piedrahita 1988). Given the complexity of this relationship and the importance of dissolved oxygen to aquaculture production, the interaction between dissolved oxygen and phytoplankton biomass should be examined in detail. Higher density of phytoplankton often causes eutrophication which ultimately results in harmful algal blooms dominated by cyanobacteria (Jewel *et al.* 2003). Furthermore, in the scenario of present global climate change the frequency and intensity of blooms are increased (Paerl and Huisman 2008). Many cyanobacteria that produce toxins can kill fish (Zimba 2001) or produce odorous metabolites responsible for off-flavours in fish tissue. The most common off-flavour compounds, geosmin and 2-methylisoborneol (MIB), are produced and released from cyanobacterial species, particularly filamentous forms such as *Anabaena circinalis*, *Lyngbya cryptovaginata*, *Oscillatoria* spp., *Phormidium* spp. and *Pseudanabaena* spp. into the water (Smith *et al.* 2008). The uptake by fish occurs mainly through the gills or skin and leads to an earthy and musty smell and taste. Therefore, in order to control phytoplankton blooms more effectively in a future warmer scenario, nutrient concentrations should be substantially reduced (Kosten *et al.* 2012). There are evidences that stocking silver carp, bighead carp or tilapia in eutrophic water bodies are effective for preventing cyanobacteria blooms (Guo *et al.* 2015; Wang *et al.* 2016). They are also able to remove huge amounts of organic particles from the water environment. Therefore, if the density of filter-feeding carps can be maintained properly, grazing intensity on algae will overcome the growth of algal biomass, and that is how algal blooms could be controlled in a pond (Wang *et al.* 2016).

In Bangladesh farmers offer large quantity of feed in semi-intensive carp fattening for getting higher profit within shorter period of time, which often results in excessive accumulation of metabolic and feed-wastes in the pond bottom (Hossain *et al.* 2022). The decomposition of these metabolic and feed-wastes makes the pond water nutrient rich that maximises the growth of phytoplankton which subsequently deteriorates the water quality through algal die-off and creates many unexpected problems, such as declined dissolved oxygen, reduced fish growth and off-flavour in fish muscle. Off-flavour lowers the consumer demand and market price of fishes (Schrader and Rimando 2003; Rahman *et al.* 2021). In this situation, if algal bloom of culture ponds can be managed and utilised in a positive way converting algae into fish-flesh then farmers might be benefited sustaining the fattening of carp practice.

Evaluating the overall proximate and organoleptic quality and their subsequent remedy can also largely affect the consumer acceptance and therefore market fate of aquaculture species (Nielsen *et al.* 2002). Therefore, the present study evaluated the effect of silver carp inclusion and fertiliser management on proximate composition and organoleptic characters of carps cultured in fattening ponds. The specific objectives of the study were to months the water quality parameters; to study the organoleptic characteristics of carps; and finally, to recommend suitable strategy for producing on-flavour carps from GAP based carp fattening ponds.

2 | METHODOLOGY

2.1 Study area and duration

Fattening of this study was carried out for a period and 6 months from March 2021 to August 2021 in feed and fertiliser based carp polyculture ponds located at Paba upazila (sub-district) of Rajshahi district, Bangladesh (Figure 1).

2.2 Experimental design

Three different management of fertiliser and feed applications and inclusion of silver carp in fattening ponds were tested under 3 treatments, each with 3 replications (Table 1). Fish rearing period (6 months), species combination of carps (surface: column: bottom = 40 : 30 : 30), stocking density (2470 fishes ha^{-1}), dietary protein content (25%) and feeding strategy (one day feeding restriction along with 30% substitution of commercial feed) were similar for all the treatments.

FIGURE 1 Location of the study area indicated with dot circle at Paba upazila of Rajshahi district, Bangladesh.

2.3 Pond management

Experimental ponds were subjected to the removal of aquatic weeds manually. Predatory and unwanted fishes were removed through repeated netting. Both wild (Indian major carps) and hatchery (exotic carps) produced seeds reared through overwintering were used for stocking into the ponds under different treatments. Regular liming was done (Basal dose of 250 kg ha^{-1} and periodic dose of 60 kg ha^{-1} $fortnight^{-1}$) for experimental ponds under the different treatments. Guideline for GAP aspects was followed after DoF (2012) and no organic manure was used except limited use of inorganic fertilisers (urea: basal dose of 40 kg ha^{-1} and periodic dose of 1 kg ha^{-1} day^{-1}; triple super phosphate, TSP: basal dose of 40 kg ha^{-1} and periodic dose of 1 kg ha^{-1} day^{-1}) to enhance the natural feed in ponds under the treatment T_1 and T_2. However, addition to the inorganic fertilisers, organic fertiliser like mustered oil cake (MOC) was used as only basal dose (247 kg ha^{-1}) in ponds under treatment T_2 (ICAR 2006). Basal dose of inorganic fertilisers was given after seven days of liming. Fishes were stocked early in the morning. Fishes were fed with supplementary feed (2 – 5% of body weight) at one day feeding restriction per week.

TABLE 1 Experimental layout. T_1, restricted feeding along with silver carp inclusion in carp fattening pond fed with only inorganic fertilisers; T_2, restricted feeding along with silver carp inclusion in carp fattening pond fed with both organic and inorganic fertilisers; T_3, restricted feeding without silver carp inclusion in carp fattening pond fed with both organic and inorganic fertilisers.

Parameters	Treatments								
	T_1			T_2			T_3		
	T_1R_1	T_1R_2	T_1R_3	T_2R_1	T_2R_2	T_2R_3	T_3R_1	T_3R_2	T_3R_3
Pond area (ha)	1.40	0.42	0.43	1.45	1.34	0.40	0.66	0.78	0.39
Pond depth (m)	1.70	1.66	1.69	1.65	1.74	1.70	1.66	1.65	1.60
Stocked carps (individual $pond^{-1}$)	3458	1037	1062	3581	3309	988	1630	1926	963

2.4 Water quality monitoring

Water quality parameters (water temperature, transparency, dissolved oxygen [DO], pH, NO_3-N, PO_4-P, NH_3-N, alkalinity and Chl-*a*) were measured in situ. Temperature was measured with a thermometer, transparency with a Secchi disk, DO, NO_3-N, PO_4-P, NH_3-N and alkalinity with a HACH kit (model FF2, USA). DO and pH were analysed by a Multimeter (model HQ 40 D, HACH, USA). Phytoplankton was sampled by filtering 20 L of pond water through plankton net with 25 µm mesh. Plankton was identified using the key after Ward and Whipple (1959), Prescott (1962) and Bellinger (1992) and their cell density in water was determined with the help of a microscope (Olympus, Japan) at X100 to 400 with bright field and phase contrast illumination on living materials after Stirling (1985) using Sedgwick-rafter counting cell count method. Chl-*a* of the experimental ponds was determined by spectrophotometer (model DR 6000, Germany) at 664 and 750 wavelengths.

2.5 Fish sampling and processing

Three fishes (*Gibelion catla*, *Labeo rohita* and *Cirrhinus cirrhosus*) were selected for proximate and organoleptic assessment. A total of nine individuals (average weight of 1.50 kg) were obtained selected from each experimental pond (three fish per species), sacrificed and weighed using a digital scale accurate to 1 g and packaged and placed on ice for 2 h prior to being filleted (skin and bone-free meat). The fish were filleted whole with viscera, and the skin was removed from the fillet with a knife. Fillets were washed, individually wrapped in plastic bags and preserved in refrigerator until the analysis.

2.6 Analysis of proximate composition

The proximate composition *viz.* moisture contents in the raw materials were determined by following oven method (Lovell 1975); crude protein was determined followed by Kjeldhal method (Crampton and Harris 1969; Jacobs 1973; Perason 1977); crude fat was quantified through Soxhlet extraction technique (Maynard 1970; Jacobs 1973) using hexane (65 – 70°C) as the solvent and ash content of each feed ingredients was estimated by following incineration method (AOAC 2005). On each chemical analysis, triplicate determinations were carried out.

2.7 Organoleptic evaluation

The preserved fillet samples were salted with one teaspoon common salt and steamed in oven at medium high temperature for ten minutes. The cooked samples were cooled at room temperature (23 – 25°C) and then presented to judges for evaluation. The fishes were evaluated according to their smell (freshness), texture, taste and the acceptability. The fresher, whiter, firmer, juicier and the more acceptable the fish was, the higher the score assigned. The score was given from 1 to 10 as the following 9 – 8 very good; 7 – 6 good and 5 – 4 fair; 3 – 1 poor (Gabr and Gab-Alla 2007). A panel of twelve trained judges was selected to evaluate the organoleptic properties of experimental fish fillet. Among the twelve panel members eight were male and four were female. The age of the panellists were ranged from 35 to 50 years. All the panellist participated in the test were professors of Department of Fisheries, University of Rajshahi. Each judge had to taste all of the samples. The panellists were given briefing and training prior to performing the tests. The resulting values were then processed using hedonic tests.

$$\text{Average quality value: } x = \frac{\sum xi}{n}$$

Where x = average quality scores, xi = value of organoleptic quality testing; panels i, and n = number of panellists.

2.8 Data analysis

Descriptive analysis was done for organoleptic study whereas water quality parameters and proximate composition of carps under different treatments were analysed by one-way analysis of variance (ANOVA). When a mean effect was significant, the ANOVA was followed by Duncan New Multiple Range Test (Duncan 1995) at 5% level of significance (Gomez and Gomez 1984). The percentages and ratio data were analysed after the arcsine transformation and all the analyses were performed using SPSS (Statistical Package for Social Science) version 20.0 (IBM Corporation, Armonk, NY, USA).

3 | RESULTS

3.1 Water quality parameters

Mean values of physio-chemical parameters recorded during the study period are shown in Table 2. Water temperature did not show significant variation among the treatments, while it ranged between 29.38 ± 0.13°C (T_1) and 29.78 ± 0.19°C (T_3). Water transparency was significantly ($p < 0.05$) higher at T_1 (26.75 ± 0.54 cm) and lower at T_2 (20.84 ± 0.40 cm). During the study period, DO was significantly higher at T_2 (6.39 ± 0.11 mg L^{-1}) and lower at T_1 (5.39 ± 0.04 mg L^{-1}). However, pH value did not differ significantly among the treatments. Nutrient content in the form of NO_3-N and PO_4-P of the experimental ponds were significantly ($p < 0.05$) higher at T_2 (0.36 ± 0.01 and 0.14 ± 0.01 mg L^{-1} respectively). NH_3-N content was also significantly ($p < 0.05$) higher at treatment T_2 (0.05 ± 0.00 mg L^{-1}) followed by T_3 (0.03 ± 0.01 mg L^{-1}) and T_1 (0.02 ± 0.01 mg L^{-1}). Significant difference was also observed in alkalinity among the treatments ranging from 119.42 ± 0.66 mg L^{-1} at T_2 and 132.24 ± 0.71 mg L^{-1} at T_1.

TABLE 2 Water quality parameters under different treatments during study period. T_1, restricted feeding along with silver carp inclusion in carp fattening pond fed with only inorganic fertilisers; T_2, restricted feeding along with silver carp inclusion in carp fattening pond fed with both organic and inorganic fertilisers; T_3, restricted feeding without silver carp inclusion in carp fattening pond fed with both organic and inorganic fertilisers.

Parameters	T_1	T_2	T_3	*F*-value	*p*-value
Temperature (°C)	29.38 ± 0.13^a	29.72 ± 0.05^a	29.78 ± 0.19^a	7.4	>0.05
Transparency (cm)	26.75 ± 0.54^a	20.84 ± 0.40^c	23.42 ± 0.56^b	103.4	<0.001
DO (mg L^{-1})	5.39 ± 0.04^c	6.39 ± 0.11^a	6.12 ± 0.03^b	163.4	<0.001
pH	7.42 ± 0.02^a	7.39 ± 0.05^a	7.38 ± 0.06^a	0.6	>0.05
NO_3-N (mg L^{-1})	0.31 ± 0.01^b	0.36 ± 0.01^a	0.27 ± 0.01^c	210.3	<0.001
PO_4-P (mg L^{-1})	0.12 ± 0.00^c	0.14 ± 0.01^a	0.13 ± 0.01^b	38.4	<0.001
NH_3-N (mg L^{-1})	0.02 ± 0.01^c	0.05 ± 0.00^a	0.03 ± 0.01^b	843.2	<0.001
Alkalinity (mg L^{-1})	132.24 ± 0.71^a	119.42 ± 0.66^c	126.42 ± 0.74^b	250.9	<0.001

Figures bearing common letter(s) in a row as superscript do not differ significantly ($p > 0.05$)

3.2 Biological analysis

Total cell density of phytoplankton and its relations with cyanobacteria is shown in Figure 2. Total cell density was significantly higher ($p < 0.05$) at treatment T_2 followed by T_3 and T_1. Furthermore, cyanobacteria cell density was significantly higher ($p < 0.05$) at treatment T_2 and the lowest at treatment T_1. Monthly variation in the relative abundance of major group of phytoplankton is shown in

Figure 3. Chlorophyceae were the most dominant group followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. However, in terms of productivity status expressed by Chl-*a*, treatment T_2 was 27.10 and 13.31% higher compared to T_1 and T_3 (Figure 3). Productivity status of the studied ponds also varied with the sampling months, whereas the ponds were mostly productive during the last few months of culture period. Cyanophyceae was found to be dominated at treatment T_2, followed by T_3 and T_1.

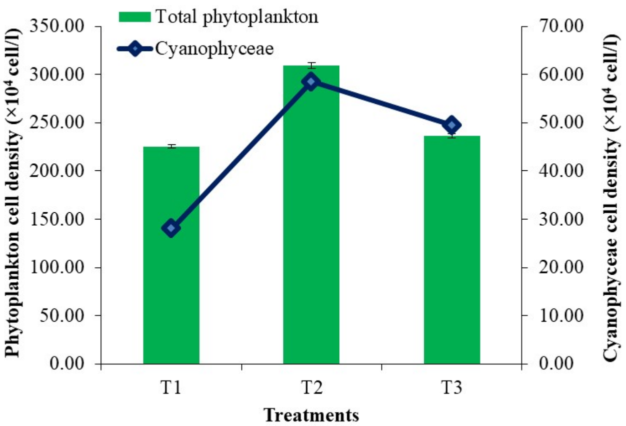

FIGURE 2 Total cell density of phytoplankton and Cyanophyceae group.

3.3 Proximate composition of fish muscle

Proximate composition of fish muscle analysed during the study period are shown in Table 3. Parameters assessed for proximate composition analysis did not vary significantly among the treatments. However, moisture was ranged from 78.73 ± 1.27 (T_1) to 79.60 ± 1.10% (T_2) in *G. catla*; 78.55 ± 2.62 (T_1) to 80.47 ± 1.63% (T_2) in *L. rohita* and 79.24 ± 1.14 (T_1) to 80.12 ± 1.83% (T_3) in *C. cirrhosus*. Protein was ranged from 11.98 ± 0.40 (T_3) to 12.51 ± 0.75% (T_1) in *G. catla*; 11.87 ± 0.34 (T_2) to 11.98 ± 0.41% (T_1) in *L. rohita* and 11.39 ± 0.17 (T_2) to 12.19 ± 0.89% (T_3) in *C. cirrhosus*. Lipid was ranged from 2.72 ± 0.48 (T_1) to 2.93 ± 0.43% (T_2) in *G. catla*; 2.51 ± 0.27 (T_1) to 2.86 ± 0.37 (T_3) in *L. rohita* and 2.35 ± 0.22 (T_1) to 2.82 ± 0.35 (T_2) in *C. cirrhosus*. Ash content was ranged from 2.16 ± 0.04 (T_1) to 2.22 ± 0.04 (T_3) in *G. catla*; 2.20 ± 0.09 (T_1) to 2.27 ± 0.03 (T_3) in *L. rohita* and 2.21 ± 0.07 (T_1) to 2.29 ± 0.20 (T_2) in *C. cirrhosus*.

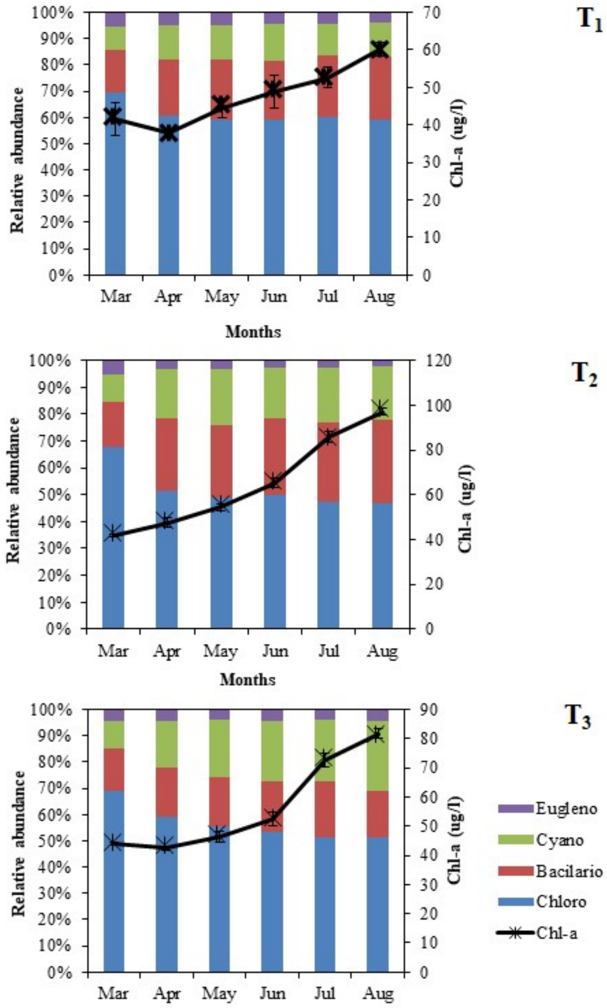

FIGURE 3 Monthly variation of phytoplankton classes and Chl-*a* under different treatments.

TABLE 3 Proximate compositions of fishes under different treatments.

Species and treatment		Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Gibelion catla	T_1	78.73 ± 1.27	12.26 ± 0.65	2.72 ±0.48	2.16 ± 0.04
	T_2	79.60 ± 1.10	12.51 ± 0.75	2.93 ± 0.43	2.19 ± 0.04
	T_3	79.55 ± 2.02	11.98 ± 0.40	2.78 ± 0.31	2.22 ± 0.04
Labeo rohita	T_1	78.55 ± 2.62	11.96 ± 0.64	2.51 ± 0.27	2.20 ± 0.09
	T_2	80.47 ± 1.63	11.87 ± 0.34	2.63 ± 0.23	2.20 ± 0.09
	T_3	80.45 ± 1.33	11.98 ± 0.41	2.86 ± 0.37	2.27 ± 0.03
Cirrhinus cirrhosus	T_1	79.24 ± 1.14	11.82 ± 0.66	2.35 ± 0.22	2.21 ± 0.07
	T_2	79.07 ± 1.93	11.98 ± 0.40	2.82 ± 0.35	2.29 ± 0.20
	T_3	80.12 ± 1.83	12.19 ± 0.89	2.70 ± 0.22	2.27 ± 0.05

3.4 Organoleptic properties

Fishes reared under different treatments were assessed based on the criterion like aroma, colour, texture, taste and overall acceptability. Organoleptic test revealed comparatively higher acceptability of fishes collected from treatment T_1 followed by T_2 and T_3 for all the fish species (Table 4). Overall acceptability was comparatively higher for *L. rohita* from treatment T_1.

TABLE 4 Organoleptic evaluations of fishes from different treatments.

Species and treatment		Mean ± SD score (out of 10)				
		Texture	Taste	Smell	Acceptability	Total acceptability
Gibelion catla	T_1	9.2 ± 0.42	8.1 ± 0.74	9.0 ± 0.63	8.1 ± 0.74	34.4 ± 0.74
	T_2	7.2 ± 0.63	7.2 ± 1.03	8.1 ± 0.88	7.0 ± 0.82	29.5 ± 3.36
	T_3	6.5 ± 0.71	6.3 ± 0.95	6.2 ± 0.92	6.0 ± 0.94	25.0 ± 3.52
Labeo rohita	T_1	7.2 ± 1.03	8.2 ± 0.70	9.1 ± 0.99	8.3± 0.67	34.4 ± 0.74
	T_2	9.1 ± 0.74	7.1 ± 0.74	8.1 ± 0.88	7.1± 0.74	29.5 ± 3.36
	T_3	6.2 ± 0.92	9.3 ± 0.92	6.1 ± 0.99	6.3 ± 0.95	25.0 ± 3.52
Cirrhinus cirrhosus	T_1	9.1 ± 0.99	8.2 ± 1.03	9.1 ± 0.99	6.5 ± 1.43	29.3 ± 4.24
	T_2	7.1 ± 0.74	7.0 ± 1.33	8.2 ± 1.03	7.0 ± 1.15	34.4 ± 4.18
	T_3	6.4 ± 1.07	6.0 ± 1.05	6.1 ± 0.99	8.0 ± 1.15	25.0 ± 4.56

4 | DISCUSSION

In carp fattening system, acceptability of organoleptic taste score of *G. catla*, *L. rohita* and *C. cirrhosus* was comparatively higher with the inclusion of silver carp and inorganic fertiliser treated ponds over other treatments. The results of the present study are in harmony with the findings of Khan *et al.* (2011) who reported significant differences among the taste scores of three fish species of the present study reared under different fertilisation and feeding regimes. Organoleptic qualities of a fish muscle are generally determined by its proximate composition. Textural quality of fish is believed to depend on protein content of fish muscle. As Hatae *et al.* (1990) have stated that the species with less water, plus higher protein content became firmer when cooked. While, concerning the taste, it seems that fat content strongly affects the mouth impression, since cultured fish is characterised as more fatty and also fishy descriptors are often correlated with fat content (Grigorakis 1999). Therefore, proximate composition of fish largely affects the organoleptic properties of fish. However, in the present study, no significant effect of treatments was observed, indicating the contribution of pond water quality and plankton density to the variation of organoleptic characters of the cultured fish. It is evident that fertilisation regime and species biomanipulation affects the phytoplankton abundance and pond productivity (Chl-*a*).

The results of the present study indicated that phytoplankton density was significantly higher at treatment T_2, where both organic and inorganic fertilisers were used. Furthermore, density of cyanobacteria, which are responsible for altering the organoleptic properties of fish muscle, was also higher at treatment T_2. However, significantly lower total phytoplankton and cyanobacteria cell density were recorded at treatment T_1 where only inorganic fertiliser was used. Although inorganic fertilisers are known to increase phytoplankton density due to its easy availability in water (Padmavathi and Veeraiah 2009; Kumar *et al.* 2014) presence of filter feeding planktivore silver carp in the present study reduced cell density of cyanobacteria at treatment T_1. However, despite having silver carp at treatment T_3, total density of phytoplankton was significantly higher at treatment T_3 compared to treatment T_1, might be due to the presence of organic fertiliser, which might cause excessive growth of phytoplankton that was not effectively checked by filter feeding silver carp. Although organic fertiliser has beneficial effect on phytoplankton productivity, it sometimes causes nutrient enrichment and heavy bloom, which can deteriorate the quality of water and causes off-flavour in cultured fish. Using higher rates of organic fertiliser also eventually produce responses in phytoplankton or zooplankton, but ponds are recommended not fertilising with organic fertilisers because of the potential dissolved oxygen reduction.

Higher cell density of cyanobacteria at treatment T_2 and T_3 compared to T_1 in the present study reduced the organoleptic scores of carps. Cyanobacteria are assumed dominant producers of off-flavour in open, outdoor aquaculture systems due to the presence of sunlight and inorganic nutrients (Tucker 2000; Schrader and Dennis 2005). Species and biomass of cyanobacteria are known as important factors influencing geosmin (trans-1, 10-dimethyl-trans-9-decalol) and 2-methylisoborneol (MIB) concentrations in water (van der Ploeg and Boyd 1991).

Filter-feeding silver carp stocked for algae control benefited treatment T_1. Other improvements in water quality also occurred due to the inclusion of silver carp at treatment T_1. Silver carp being a voracious algal feeder and blue-green algae being the preferred food (Mu *et al.* 2012), the earthy-musty flavour recorded in the present study may be due to blue-green algae. Therefore, silver carp is more effective for restraining algal blooms in the presence of only inorganic fertilisation in ponds.

4 | CONCLUSIONS

Organoleptic studies confirmed a positive effect of both the inclusion of silver carp as filter feeding fish and use of only inorganic fertiliser. This improvement of the culture system and organoleptic properties by inclusion of silver carp and using only inorganic fertiliser in pond showed promising result in terms of organoleptic attributes of fish.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTION

This work was carried out in collaboration among all the authors. Md. Anwar Hossain conducted the research work, collected the data and organised the data; Md. Akhtar Hossain supervised the research work and critically reviewed the manuscript; Md. Ayenuddin Haque carried out the analysis and prepared the manuscript and Mst. Nurjahan Begum helped in the preparation of the manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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