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Original article

Effects of *Beta vulgaris* powder on growth and survival of common carp *Cyprinus carpio*

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Abstract

The use of plant material in a diet to increase the growth of fish may be beneficial and can reduce the production cost. This research was carried out at Behbahan University, Iran, in 2016 with a view to determining effects of *Beta vulgaris* powder on feeding, growth and survival of common carp (*Cyprinus carpio*). A total of 360 individuals (mean weight, 20 g; mean standard length, 9 cm) were randomly divided into 12 tanks for treatments. Fish were fed diets with 0% (control), 0.5% (T1), 1% (T2) and 2% (T3) of *B. vulgaris* powder for six weeks. The results showed that the addition of *B. vulgaris* to fish diets had a positive effect on survival index and feed conversion index of fish. The presence of *B. vulgaris* in the diet had increased specific growth rate, and hepatosomatic and viscerosomatic indices.

Key words: Beetroot powder; *Beta vulgaris*; food and proximate composition; common carp

1 | INTRODUCTION

Beta vulgaris, commonly known as sugar beet, belonging to a family of spinach (Chenopodiaceae) and is a native plant to southern Europe (Jain *et al.* 2011). This species is widely cultivated in many parts of the world, including Iran (Mokhtari Dehkordi *et al.* 2014). It is cultivated as a foodstuff, especially for the production of sugar. This is a tall plant, about 2 feet height, and has many large shiny leaves and angled stems (Jain and Singhai 2012). It is a rich source of sucrose and many biochemical substances and compounds.

Beet leaves and roots have different chemical compositions. The presence of fatty acids (palmitic, stearic, oleic and linoleic), phospholipids, glycolipids, folic acid, ascorbic acid, pectin, as well as saponins and flavonoids in this plant have been reported earlier (Mokhtari Dehkordi *et al.* 2014).

One of the most important compounds in sugar beet plants is botanicals. Bethany alone accounts for 75–78% (Malekotian *et al.* 2016), which is used in fat metabolism in the synthesis of phosphatidylcholine and in the oxidation of fatty acids, which reduces carcass fat and increases the protein precipitate in pigs has been .

Nowadays, common carp is considered one of the most important species in Iran (Ghaderi Ramazi *et al.* 2012) and outside (e.g. Mohsin *et al.* 2012; Galib *et al.* 2013) due to its high resistance to environmental fluctuations and the use of a wide range of available foodstuffs. This species is cultivated in almost all provinces of Iran's aquaculture industry due to its unique breeding characteristics. One of the most important research objectives in relation to this species of fish is to reduce the conversion factor of food and increase the growth and also increase the resistance to diseases (Alishahi *et al.* 2011).

The high nutritional value of sugar beet leaves, as well as the abundance and low cost of this plant make *B. vulgaris* a potential food ingredient of fish feed. The aim of this study was to evaluate the effects of *B. vulgaris* powder on the growth and survival of common carp.

2 | METHODOLOGY

2.1 | Study sites

This research was carried out for a period of six weeks, between November and December 2016, at the Behbahan Khatam-al-Anbia University of Technology, Iran. In this regard, 12 cylindrical fiberglass tanks of 300 litres capacity and 2 tanks of 500 litres were used. The tanks were randomly distributed for four groups (one control [C] and three treatments [S0.5%, S1% and S2%] each with three replications. Aerated tubes were fitted and air stones were placed inside each tank and ran for 48 hours to remove toxic gasses like chlorine. Water required for the study was collected from the supply lines of Khatam-al-Anbia University of Technology in Behbahan.

2.2 | Fish collection and transportation

Five hundred common carp of 20–23 g weight and 8–9 cm standard length, collected from the Shahid Maleki Native Fish Reserve, were used in this study. During transportation, from source to the laboratory, large double-glazed plastic bags were used. Fish were carried out in five bags with adequate proportion of oxygen. In the laboratory, bags containing fish were placed in a pre-prepared storage tank to acclimatise. After two hours the bags were opened slowly and the fish were released into the storage tank for one week rearing until the main experiment. During this time, fish were fed with a special diet containing 61.6% protein (Brand name: Fera Deneh). Feeding was carried out twice a day with 3% of the body weight of the fish.

2.3 | Main experiment

Before the end of the rearing in pre-treatment storage tank, a total of 360 individuals of fish with an average weight of 20 g and a standard length of 9 cm were selected and randomly divided into 12 fibreglass tanks, on 23 November 2017, for a period of 42 days. During this time fish were fed twice a day at the rate of 3% of the body weight. One control and three treatments depending on proportion of *B. vulgaris* powder in fish feed were used in this study where control (C) fish were fed with feed without *B. vulgaris* powder and other treatment groups were fed by feed with 0.5% (T1), 1% (T2) and 2% (T3) *B. vulgaris* powder.

Half of the tank water was replaced every day with uneaten food, if any. The environmental conditions including water temperature and dissolved oxygen (DO) were measured daily. In addition, pH was recorded weekly. The average water temperature, DO and pH were 24°C, 7.5 mgL^{-1} and 7.5 respectively. The photoperiod was 12:12 hrs.

Fortnightly biometrics were carried out to check the growth rate of fish. For this purpose, six individuals were randomly caught from each tank and their length and body weight were recorded using standard devices. Precautions were ensured to avoid any handling damage to fish.

Daily losses (= mortality) in each treatment tank were recorded separately for the survival. Each of the dead fish was described, and abnormalities were noted. During the whole period, pathogenicity was not observed. Before the final day of experiment, fish feed was cut 48 hours in advance to empty the digestive system and final weight and length were recorded. After dissection, skin was removed and the fish tissue was separated to for chemical analysis.

The following formulas were used to study growth factors and nutritional indices. Growth and Survival Parameters (Zokaeifar *et al.*, 2012)

Body weight increase, WG = final weight (g) – initial weight (g); daily weight gain, DWG = average final weight (g) – average initial weight (g) / 100 × length of breeding season (day) (Benetti *et al.* 2010); percentage weight gain (% body weight gain), %BWG = final weight (g) – initial weight (g) / initial body weight (g) × 100; specific growth rate, SGR = logarithm of body final weight (g) – logarithm of initial body weight (g) / breeding period (day) ×100 (Benetti *et al.* 2010); survival rate, SR = SR = final fish number / initial fish number × 100 (Geurden *et al*. 1997); viscerosomatic index, VI = viscose weight (g) / final body weight (g) × 100; hepatosomatic index, HIS = liver weight (g) / final body weight (g) × 100 (Geurden *et al*. 1997).

Data were analysed using SPSS software (version 16) and the Kolmogorov-Smirnov test was employed to test the normality of data. One way ANOVA was used to determine differences among treatments. If significant variation was recorded, *post-hoc* Duncan test at 95% confidence level was considered.

3 | RESULTS

Results showed that body weight increase on the final day (i.e. 56th day) was significantly different between C and T1 groups ($P < 0.05$) but not in other groups (Figure 1). The lowest average weight increase was recorded in T1 group and the highest was for the C group.

Percentage of body weight increase on the final day was significantly different ($P < 0.05$) between the control (C) and first treatment (T1) groups (Figure 2). The highest percentage of body weight found for the control group and the lowest percentage of body weight was recorded in T1.

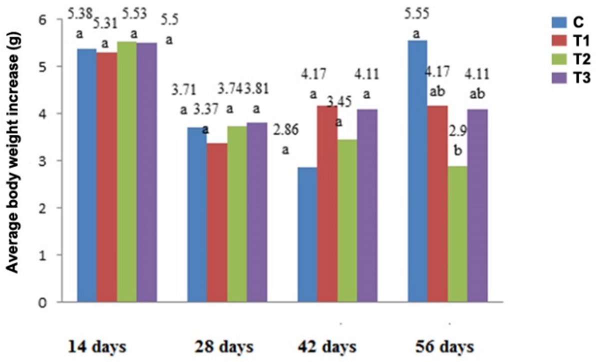

FIGURE 1 Comparison of average body weight increase of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

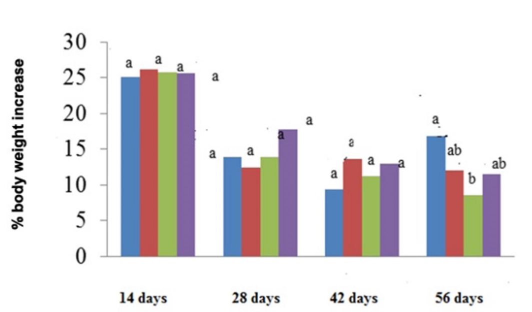

FIGURE 2 Comparison of percentage body weight increase of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

No significant difference was recorded in specific growth rates between groups ($P > 0.05$; Figure 3). However, the highest specific growth rate (1.48%), at the end of the study, was found in T3.

Daily weight gain on the final day significantly varied between control and T1 ($P < 0.05$). The highest and lowest daily weight gain was recorded in T1 (1.86 g) and T2 (0.6 g) respectively (Figure 4).

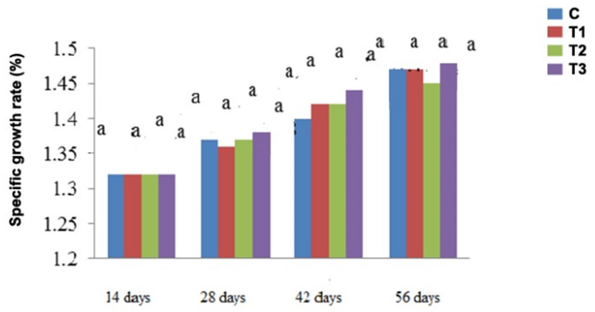

FIGURE 3 Specific growth rate of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

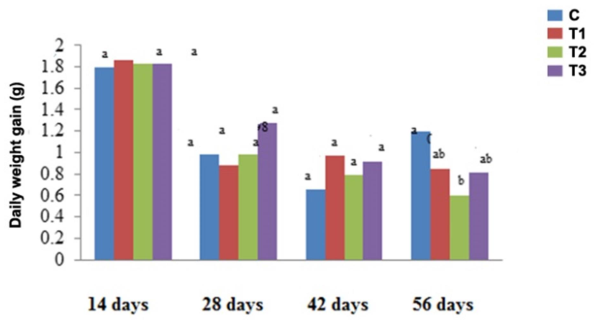

FIGURE 4 Daily weight gain of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

On the final day survival rate of fish in control group differed significantly from treatment groups (Figure 5). However, survival rate also decreased in T3. Viscerosomatic index value was the highest in third treatment group (T3) and this group differed significantly from other treatment (T1 and T2) and control groups ($P < 0.05$; Figure 6).

Hepatosomatic index value differed significantly among groups except for T1 and T3 (Figure 7). The highest index value (3.13) was recorded in fishes from T2.

4 | DISCUSSION

One of the most important goals in aquaculture is to increase the production efficiency. Food additives are one of the strategies that, in addition to provide the necessary nutrients, can promote growth and development of fish, and can also play an important role in improving fish health by increasing resistance to pathogens and stress. In recent years, extensive research has been carried out on the use of food additives including plants that can improve fish health (Muir 2005).

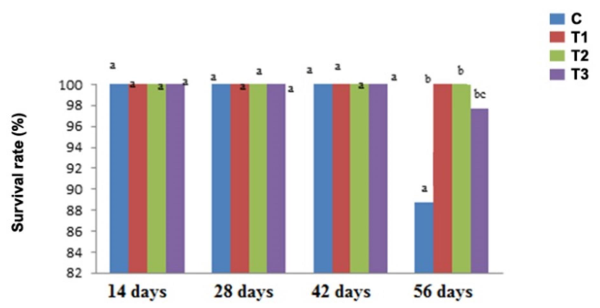

FIGURE 5 Survival rate of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

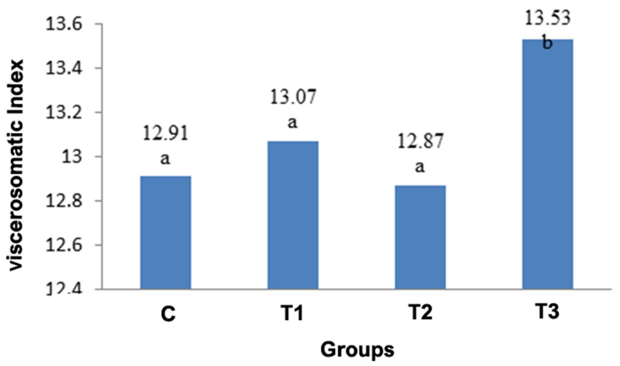

FIGURE 6 Viscerosomatic index of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

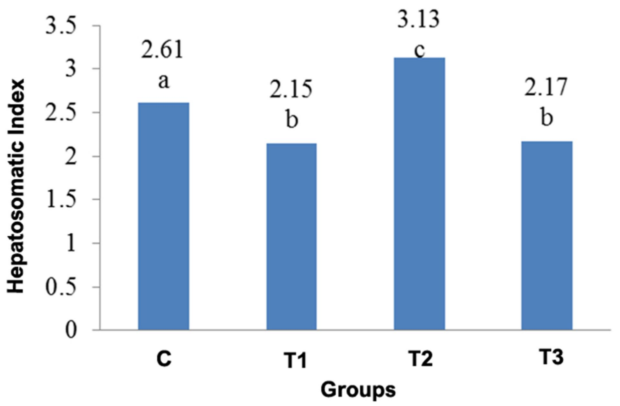

FIGURE 7 Hepatosomatic index of fish in different groups (C, control; T1, feed with 0.5% *B. vulgaris*; T2, feed with 1% *B. vulgaris*; T3, feed with 2% *B. vulgaris*). Similar letters for each column indicate no significant difference ($P > 0.05$).

Due to high nutritional value and low prices of *B. vulgaris* leaves they have been used to feed animals. The different compounds present in this plant can have a positive effect on growth (Goyal *et al.* 2015). The results of this study showed a decrease in various growth indices including mean body weight increase, daily weight gain and percentage of body weight increase of fish fed with feed containing different proportions of *B. vulgaris* powder. Moreover, specific growth rates in fishes fed with feed with different levels of *B. vulgaris* powder were not significantly different from control treatment. Similar results were also reported by Zokaeifar *et al.* (2012). Changes in food flavour and the presence of abundant oxalates in *B. vulgaris* leaves may be responsible for this decrease. However, feeds with *B. vulgaris* powder had a positive effect on common carp survival which is in accordance with Reissanzadeh *et al.* (1992). *Beta vulgaris* contains a large amount of carotenoids (alpha, beta-carotene and lutein) and vitamin E which act as a protective and antioxidant and might have played a key role in improving survival of common carp.

5 | CONCLUSION

This study presents a new perspective on the use of *B. vulgaris* pulp in the diet of common carp to improve fillet compositions. The results showed that the addition of *B. vulgaris* leaves to fish diets had a positive effect on survival index and feed conversion index of fish. The presence of *B. vulgaris* in the diet increased specific growth rate, hepatosomatic index and viscerosomatic index. We recommend using 2% *B. vulgaris* with fish diet for proper growth and survival of common carps.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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CONTRIBUTION OF THE AUTHORS

NA data collection and laboratory works; **AA & SZN** research design, data analysis and manuscript writing

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