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Carrot (*Daucus carota*) as a Colour Enhancer and Growth Promoter in Aquarium Fish: A Review

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Abstract: One of the most important qualities of aquarium fish for commercial acceptability is colour pigmentation. Carrot, *Daucus carota* acts as a plant-derived natural source of colour pigment for ornamental fish as it contains quite high β carotene, which helps bring out and intensify red, orange and yellow hues in the skin of ornamental fish. Furthermore, carrots have good nutritional values. Hence, carrot has been used in sufficient quantity in the formulated feed of different ornamental fishes, such as gold fish (*Carassius auratus*), red white koi carp (*Cyprinus carpio*), sword tail (*Xiphophorus hellerii*), blue Gourami (*Trichogaster trichopterus*), cichlid (*Cichlasoma severum*), molly (*Poecilia sphenops*), botia fish (*Chromobotia macracanthus*), Zebra fish (*Danio rerio*), clownfish (*Amphiprion ocellaris*) etc**.** With the increased amount of carrot meal in fish feed, fish growth and skin pigmentation were also enhanced simultaneously and suitable amount of species-specific carrot meal improves fish growth and colouration at a remarkable level, except for cichlids and blue gourami. This review aims to evaluate and compare the inclusion of carrot meal in ornamental fish diets, in terms of growth performance and skin pigmentation.

Keywords: Carotenoid, Carrot meal, Colour pigmentation, Ornamental fishes

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Introduction

Ornamental fish keeping is the second most popular hobby in the world, and this sector plays a crucial role in the international fish trade. Fish keepers prefer ornamental fish culture because of their attractive colours, characteristics, and good health (Jain *et al*., 2019). So, colour is one of the important factors for fish farmers who culture attractive ornamental fishes (García-Chavarría and Lara-Flores, 2013). Ornamental fish lack the ability to generate colour-producing carotenoid

pigments on their own. Consequently, they rely on dietary carotenoids in either natural or synthetic forms to attain their colour pigmentation (Kaur and Shah, 2017). In natural habitat, ornamental fish consume algae, plants, tubifex, some bacteria, etc. to maintain their health, growth, metabolism, reproduction as well as colour pigmentation but in indoor conditions for cultured fishes, if the available resources are not present in their diet, alternative natural or synthetic carotenoids should be given in a suitable amount according to the species of fish for their proper growth and pigmentation (Jain *et al*., 2019). Ornamental fishes contain different types of carotenoids, most dominant of them with their colours are tunaxanthin (yellow), lutein (greenish-yellow), beta-carotene (orange), alpha, beta-doradexanthins (yellow), zeaxanthin (yellow-orange), canthaxanthin (orange-red), asthaxanthin (red), eichinenone (red) and taraxanthin (yellow) (Kaur and Shah, 2017; Chapman and Miles, 2018). Astaxanthin, is a high-level carotenoid in red coloured fishes and yellow, orange, and their shade giving carotenoids are also common (Kaur and Shah, 2017).

According to Jain *et al*. (2019) various synthetic or natural resources (plants and animals) are used in ornamental fish diet for enhancing the colour pigmentation, however synthetic carotenoids are expensive and have limitations due to the specificity of fish. Animal based carotenoids are mostly extracted from crustaceans such as crabs, shrimps, etc., which are rich in Astaxanthin (Chapman and Miles, 2018). However, the limitation of animal-based carotenoid sources is due to the declining catch of such crustaceans. Whereas carotenoid-rich plant sources such as algae, yeast, flowers, vegetables, etc. which are not only economical but also have a good nutritional profile and some are natural diet of fish. Carrot (*Daucus carota*), marigold petal (*Tagetes erecta*), China rose petals (*Hibiscus rosa-sinensis*), spinach (*Spinacia oleracea*), potato (*Solanum tuberosum*), etc. are used profusely in aquarium fish farms (García-Chavarría and Lara-Flores, 2013).

Carrot is one of the most essential vegetables among the natural sources of carotenoids (Yanar and Tekelioglu., 1999). Major carotenoids determined in carrots are β-carotene (41.60-71.2 mg/kg) and α-carotene (13.44-30.11 mg/kg). It is the major source of β-carotene and provides 17% of total vitamin A (Koca *et al*., 2011). Due to these important factors, carrot (*Daucus carota*) has been chosen as a good source of dietary carotenoid, which is found to promote better growth, health, and colour pigmentation in a natural way in ornamental fishes.

This review paper aims to perform a comparative analysis of growth and colour pigmentation on various ornamental fishes by considering carrot as a carotenoid source in ornamental fish feed. This review will also find out the species specific-suitable amount of carrot in fish feed.

Effect of carrot meal on fish growth parameters

Earlier studies revealed inclusion of carrot meal in ornamental aquaculture. Different inclusion levels of carrot meal were noticed in the past investigations, claiming a species-specific amount of its inclusion in the fish diet. Such studies have focused on the effect of carrot meal-based diets on the growth performance of various ornamental fish species. Growth performance indices were used to obtain the impact of carrot meal on total gain in weight and length, specific growth rate (SGR), and feed conversion ratio (FCR). No negative effect of carrot meal-based diets on the growth of the previously studied fishes were observed.

(i) *Gold Fish* (*Carassius auratus*)

A sixty-day feeding experiment was carried on gold fish,*Carassius auratus*. Results revealed that carrot meal could be included up to 6% in their diets containing 30% crude protein to produce best results. The gold fishes fed with diet containing 6% carrot, showed the highest average weight gain (1.76 ± 0.02 g), weight gain percentage (26.91%) as well as the highest value for the specific growth rate (2.9 ± 0.04 %). The

control group, showed the lowest average body weight gain, weight gain percentage (5.63%) and also SGR (0.35 ± 0.06 %). Thus, maximum results were found in, carrot meal incorporated at 6% in the experimental diet fed to the gold fishes (Tiewsoh *et al*., 2019).

(ii) *Koi Carp* (*Cyprinus carpio*)

According to Jain *et al*. (2019), Koi carp (*Cyprinus carpio*) fries were tested for 120 days using 1%, 3%, 5%, 7% and control with 0% carrot meal incorporated diets. Significantly ($P<0.05$) maximum value for the total length gain was reported in 1% carrot meal included diet, followed by 7%, 5%, 0% and then in 3% carrot meal included diets. Whereas the highest body weight gain was noted in the set fed with 5% carrot meal included diets, followed by 1%, 0%, 3% and the lowest in 7% carrot meal diet. The reported value of SGR was higher in 5% and lower in 7%. Fishes fed with 5% carrot meal diet, had the highest PER and CF, while the fishes of the control group, had the lowest PER. It is also reported that the feed efficiency in terms of FCR was lowest in 5% carrot meal fed set. This study demonstrated that carotenoid had a significant role in fish growth up to level of carrot meal at 5% with beneficial impact on their growth in terms of enhanced weight gain and decreased FCR.

Similarly, Maiti *et al.* (2017) conducted an experiment for 45-days on the growth of *Cyprinus carpio,* fed with diet supplemented with 1% carrot meal and control with 0% carrot meal and reported that fishes fed with diet containing carrot meal showed significantly enhanced growth (37.75±0.58 g) compared to control (13.62±0.66 g). Similarly, best results were obtained for SGR (0.58±0.01) and FCR (2.25±0.20) in carrot meal fed fishes. Hence, it could be concluded that under indoor growth settings, carrot meal promotes koi carp growth as well as colour enhancement. Thus, carrot meal can be added to the diet of koi carp at a level of 5% to enhance the skin colour and also to boost their growth.

(iii) *Sword tail* (*Xiphophorus helleri*)

A feeding experiment was performed for 35 days with the juvenile of swordtail fish, *Xiphophorus helleri* by Wagde *et al*. (2018) which demonstrated carrot meal to have a significant effect on growth performance of these fishes. Here the fishes were fed with diets containing 1.82%, 2.27% and 2.73% of carrot meal replacing the rice bran to provide 20 mg, 25 mg and 30 mg of β-carotene per 100 g of diet, respectively. Towards the end of the experiment, maximum weight gain (0.54 g) was observed in the fishes fed with diet containing 2.73% carrot meal, followed by 2.27% and 1.82% carrot meal fed sets. Similar results were noted for SGR with significantly highest value (0.91) found in 2.73% carrot meal fed set. It was observed that FCR was higher in control set, which suggested that diet supplemented with 2.73% carrot meal to be most suitable for swordtail fish.

In another 120-day feeding experiment carried for the enhancement of body colouration of sword-tail fish (*Xiphophorus helleri)* conducted with nutritional treatments created by combining carrot powder at a rate of 15 g/100 g with a commercial feed. It was observed that, total carotenoid content of the formulated diet of control treatment without natural source of carotenoid (commercial feed) and carrot meal diet was 1.69 (mg/100g) and 1.65 (mg/100g) respectively. After the completion of 4 months trial, the mean weight and mean length of fishes noted from the control set were 3.4555 ± 0.8218 g and 3.4144 ± 0.2508 cm, respectively whereas mean weight and length of the fishes fed with carrot meal diet were 3.3758 ± 0.5102 g and 3.3934 ± 0.3110 cm, respectively. The SGR value was 0.0419±0.0035. Thus, insignificant variations were recorded in fishes fed with carotenoid supplemented diet when compared with control set (Rana *et al*., 2023).

(iv) *Blue Gourami* (*Trichogaster trichopterus*)

Studies were conducted by Naeem *et al.* (2021) on growth performance of Blue gourami for 120 days. Where control and carrot mixed diet, each had an average ultimate weight of 5.455± 0.821 g and 3.776±0.418 g, respectively. Best results for mean

weights were obtained in control when compared with carotenoid incorporated diet fed to experimental fishes. Similarly, higher mean final lengths were observed in control (4.094±0.250 cm) than carrot mixed diet (4.083±0.311 cm). Thus, concerning length and weight gain, it is evident that control feed offers better growth performance than carrot mixed experimental feed. So, on the basis of these observations it can be stated that growth performance is not much affected by carrot powder incorporated diet fed to the experimental fish Blue gourami when compared with control set.

(v) *Cichlid* (*Cichlasoma severum*)

Cichlid, *Cichlasoma severum* was used by Kop et al. (2010) as a fifty-day feeding experiment. The experimental fish meal contained 41% crude protein, 6% crude fat, 2% crude cellulose and 9.5% ash. In the first group, carrot powder was added at 50 mg/g and the other group was used as control. At the end of the experiment, final fish weights obtained from first group was 3.51±0.412 g and control was 3.29±0.385 g. The FCR% (2.15) was low in carrot meal incorporated diet in comparison to control (2.27). The SGR% was also high in carrot meal supplemented diet. It was noted that the growth performance of Cichlids was affected by the incorporation of carrot powder in carotenoid-supplemented diet.

(vi) *Molly Fish* (*Poecilia sphenops*)

The comparative growth performance of Molly, *Poecilia sphenops* fry for 60 days, using the Latin square method, with two treatment diets, control diet and 3 g/100 g carrot powder diet, both contained 28% protein. Highest SGR values were recorded in carrot-mixed diet, followed by control. Similarly, higher values were found for average body weight gain (5.4567±0.89 g) in carrot-mixed diet than control. Surprisingly, final average length measured was 3.5333 cm in control. However 2.8227 cm in carrot mixed diet. Thus, it was found that some parameters of growth performance showed positive results while others exhibited altered values when compared with control set (Gamit *et al*., 2022).

(vii) *Zebra fish* (*Danio rerio*)

An experiment was conducted by Das (2023), for a period of six months to determine the effects of carrot meal as dietary carotenoid supplementation on growth of zebrafish, (*Danio rerio*). After the completion of the feeding trial, highest final weight was observed in fishes fed with diet containing 5% carrot meal (0.70±0.03 g) followed by diet containing 3% carrot meal (0.61±0.02 g) and finally in diet containing 7% carrot meal (0.55±0.01 g) and lowest values were found in set containing 10% carrot meal (0.29±0.02 g). Similarly, highest body weight gain (0.66 ±0.03 g) and specific growth rate (1.71 ±0.03) was recorded in fishes fed with diet containing 5% carrot meal, followed by 3% carrot meal diet with weight gain (0.58± 0.02 g) and SGR (1.63 ±0.02), then by 7% carrot meal diet with weight gain (0.52±0.01 g) and SGR (1.58 ±0.01), finally lowest values in 10% diet set with weight gain (0.26 ±0.02 g) and SGR (1.22±0.03). The final weight in 1% diet set and 7% diet set do not presents significant variation but were higher in relation to control. On increasing the level of carrot meal beyond 5% no further increase was recorded in growth performance of zebra fish.

Effect of carrot meal on fish skin pigmentation

To observe the effects of the inclusion of carrot meal in ornamental aquaculture various studies have been performed. Different inclusion levels of carrot meal have been reported in earlier studies, demonstrating species-specific amount of its inclusion in fish feed. These studies focus on the effect of carrot meal-based diets on enhancing colour pigmentation of different ornamental fish species. The enhancement of colour pigmentation of fish skin indicates that a certain amount of carotenoid is needed for maximum colour enhancement of red-yellow hues. The diets based on carrot meal had no negative effects on the colour of the fishes that had been previously tested.

(i) *Gold Fish* (*Carassicus auratus*)

Feeding experiment performed for sixty days on goldfish, *Carassius auratus,* revealed that carrot meal could be included up to 6% in experimental diets containing 30% crude protein (Tiewsoh *et al*., 2019). The carotenoid content of the fish was assessed using the Olson (1979) method. At the end of the experiment, it was recorded that goldfish produced maximum carotenoid concentration (23.45± 0.2 µg/g) with 6% carrot meal, followed by (22.32±0.8 µg/g) with 4% carrot meal and finally, (21.12±0.68 µg/g) with 2% carrot meal while lowest carotenoid concentration (20.48±0.32 µg/g) in the control. Significant variations were observed when compared with the control set thus showing a positive effect of carrot meal incorporation in the fish feed.

An experiment was conducted for the duration of forty days by Ahlam *et al.* (2019) on *Carassicus auratus* (Gold fish) by adding carrot flour to fish meal. In this study, two types of treatments were used: Control and 5% carrot flour treatment. Visual observations of colour intensity were made using the Toca Colour Finder's default setting. On day 40, the colour brightness score of fish using 5% carrot flour incorporated diet was greater than the control with 1.92 and 1.58, respectively.

(ii) *Koi Carp* (*Cyprinus carpio*)

Koi carp (*Cyprinus carpio)* fries were tested for 120 days using 1%, 3%, 5%, 7% and control with 0% carrot meal incorporated diets. Results showed highest colour intensity at 5% level of carrot powder incorporation in comparison to 1% , 3% and 7% carrot meal, digital images also presented enhanced RGB values as well as elevated values in 5% carrot meal incorporated diet. Thus, carrot meal can be added to the Koi carp diet at a rate of 5% as a colour enhancer to produce desired effects (Jain *et al*., 2019).Yanar and Tekelioglu (1999) also suggested that, the utilization of carrot as a potential carotenoid source for colour development in Gold fish (*C. auratus*).

An experiment was conducted by Azab *et al.* (2016) on pigmentation of *Cyprinus carpio* (Koi carp) by feeding control diet and 5% carrot for a duration of 4 months. Diets were prepared by adding 50 g (5%) of testing additive to 950 g (95%) of the basic diet. After 120 days the values of colour intensity observed in Koi fish in 5% carrot meal are-- red colour 298.8±396.41 pixels and yellow colour 7983.1±8458.7 pixels, while in control amount of red colour and yellow colour was 669.3±500.04 pixels and 169.0 ±215.57 pixels, respectively. Thus, amount of total colour pixels is 8281.9±8151.6 pixels in 5% carrot powder incorporated diet, however, total colour pixel of control is 1540.4±887.26 pixels. The results showed that at 60, 90, and 120 days, carrot meal had the most total colour pixels recorded.

Maiti *et al.* (2017) conducted an experiment for 45 days on the colour pigmentation of *Cyprinus carpio* revealing diets containing 1% carrot powder to have high amount of carotenoid in skin of Koi carp than control. Hence, it can be concluded that diet supplemented with 5% and 1% carrot meal acts as more effective colour enhancer.

(iii) *Sword tail* (*Xiphophorus helleri*)

Investigations by Wagde *et al.* (2018) on Swordtail, (*Xiphophorus helleri)* for 35 days was performed by replacing rice bran with carrot powder included diet at the rates of 1.82, 2.27 and 2.73 g/100 g. The experimental diets were prepared using Carrot powder mixed in the basal diet to supply 20 mg, 25 mg and 30 mg of b-carotene per 100 g of diet. As a result, the ranking of treatments for orange colour intensity combined with natural-carotene can be stated as maximum in 2.27 g carrot meal diet followed by 2.27 g , 1.82 g and then Control in order of their effectiveness to create orange colour prominence in the test fish.

Similarly, a 120-day feeding experiment was performed on enhancement of body colouration of sword-tail *(Xiphophorus helleri)* by feeding nutritional diet created by combining carrot

powder @ 15 gm/100 gm along with commercial feed (Rana *et al*., 2023). The total carotenoid content in body tissues of fishes in commercial feed without natural source of carotenoid (control) was 1.69 mg/100 g and carrot meal diet was 1.65 mg/100 g. After 4 months trial, the mean carotenoid content of experimental fish in control set and carrot mixed diet was 0.1742 ± 0.0851 mg/10 kg and 0.2341 ± 0.1128 mg/10 kg, respectively, where the carrot mixed diet produced effective results.

(iv) *Blue Gourami* (*Trichogaster trichopterus*)

Naeem *et al.* (2021) experimented with Blue Gourami for 120 days, to test the colour pigmentation using control and carrot mixed diet. The commercial feed (Tiger Brand AEON Nursery Powder Feed-1) was then included with the sources at a rate of 15 g/100 g. The Torrissen and Naevdal method (1984) was used for determination of carotenoid content in skin of experimental fish. Towards the end of the experiment, mean carotenoid content of the experimental fish was 0.1226±0.0115 mg/100 kg in control and 0.1487±0.0228 mg/100 kg in carrot mixed diet. Carrot mixed meal showed higher amount of carotenoid gain than control. Thus, positive effects were observed with carrot meal fed diet to experimental fish and lowest values were recorded in control set.

(v) *Cichlid* (*Cichlasoma severum*)

Kop et al. (2010) conducted fifty-day feeding experiment on Cichlid, *Cichlasoma severum*. The fish meal that was used contained 41% Crude protein, 6% Crude fat, 2% Crude cellulose and 9.5% ash. In the first group, carrot powder was added at 50 mg/g and other group was used as control. Two weeks after the onset of the study, the first group fishes fed with carrot, started to produce pigmentation with bright orange colour. The total carotenoid content (mg/g) in the skin and flesh of cichlid fish noted in first group was 0.416±0.20 mg/g and 0.272±0.87 mg/g in control. After the completion of experiment, it was observed that carrot-fed fish had significantly greater colour pigmentation compared to the control group.

(vi) *Molly Fish* (*Poecilia sphenops*)

An experiment was conducted by Gamit *et al.* (2022), using the Latin square method on the comparative growth performance of molly, *Poecilia sphenops* fry for 60 days, here two treatment diets were used, control diet and 3 g/100 g carrot powder, both contained 28% protein. After the trial, analysis of carotenoid in fish muscle and skin was performed using Olson's method (1979). For instance, fish fed with diet of 3 g/100 g carrot powder had the highest total carotenoid content at 41.4 µg/g wet weight, while the control group, had a lower value of 26.4 µg/g wet weight. Hence, positive results were derived with incorporation of carotenoid in the diet.

(vii) *Botia fish* (*Chromobotia macracanthus*)

Andriani *et al.* (2020) experimented for 40 days on Botia fish (*Chromobotia macracanthus* Bleeker). Various blends of Tubifex natural feed, carrot meal, commercial feed was used for preparing the test feed. The values obtained at the end of the experiment for average colour enhancement in Tocacolour finder tool were 2.66 for the caudal fin colour and 3.4 for body colour in control, 4.37 for body colour and 3.55 caudal fin colour in 3% carrot meal incorporated diet, 4.06 for the body and 3.37 for caudal fin in 4% carrot meal incorporated diet, 5.04 for body colour and 3.93 for caudal fin in 5% carrot meal incorporated diet, 4.62 for body colour and 3.73 for caudal fin in 6% carrot meal incorporated diet and finally 4.44 for body colour and 3.26 for caudal fin colour in 7% carrot meal incorporated diet. The colour produced in fishes fed with 5% carrot meal was a bright orange colour with the code of TCF 0605 on the body and a clear orange colour on the caudal fin with the code of TCF 0805. A one way ANOVA test results of botia fish body and caudal fin colour shows that combination of Tubifex and carrot meals leads to increased colour value of the body in 5% carrot meal included diets, followed by 6%, 3%, 7%, 4% and control. Hence, determination of

appropriate dose is required to generate best results.

(viii) *Zebra fish* (*Danio rerio*)

A six months trial was carried out on zebra fish by Das (2023) to evaluate the effects of carrot meal supplemented diet on total carotenoid content in fish skin and muscle. For the conduction of the experiment, the fishes were fed, diet supplemented with carrot meal at a rate of 0%, 1%, 3%, 5%, 7% and 10%. At the end of the experiment, the values obtained are -- 6.67±0.09 µg/g in 5% carrot meal set, followed by 5.72±0.07 µg/g in 3% carrot meal set, while lowest 2.59± 0.07 µg/g in control set. Thus, highest carotenoid content was recorded in 5% carrot meal incorporated diet. The results depicts that carrot meal can be supplemented in the diet up to 5% level to ensure enhanced pigmentation in zebrafish.

(ix) *Amphiprion ocellaris*

A study was performed by Ramamoorthy *et al.* (2010) for 60 days on marine ornamental fish *Amphiprion ocellaris* to access the effect of feeding carrot on colour enhancement of these fishes. In this experiment, two treatment sets were prepared with one control set and the other carrot meal incorporated diet at a rate of 15 g/100 g. The experimental feed was formed by using ingredients like wheat flour, rice bran, tapioca flour, soyabean, fish meal and groundnut oil cake. Natural carotenoid like carrot was collected and dried then powdered and finally mixed with the feed before pelletization and were fed to these test fishes twice a day. Towards the end of the experiment, the average carotenoid content in fish body tissue recorded in control was 2.687±0.287 mg/kg and 7.681±0.462 mg/kg in carrot meal incorporated diet. Pigmentation was highest in carrot meal fed diet. Hence, carrot is an effective colour enhancer at a low price.

Conclusion

It can be concluded that carrot meal has a positive effect on growth as well as colour enhancement of *Carassius auratus* (Gold fish), *Cyprinus carpio* (Koi Carp), *Xiphophorus helleri* (Sword tail), *Poecilia sphenops* (Molly) in indoor rearing conditions, but in *Cichlasoma severum*(Cichlid) and *Trichogaster trichopterus* (Blue Gourami), there is no effect produced on the growth, however pigmentation is slightly enhanced. Owing to the adverse effects of synthetic carotenoids on aquatic environments, natural plant sources like carrot can be harnessed and incorporated into formulated feeds for colour retention or enhancement as well as growth in captive environments. It will open the opportunities for advancement of the ornamental fish industry, along with the colour enhancer feed sector, contributing to the generation of employment (Das and Biswas, 2016).

Ethical Statement

This is a review article hence no Ethical Approval needed.

Author Contributions

All the authors have contributed equally to the completion of this review and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

References

Ahlam NR, Hamdani LW and Bangkit H. (2019) Effect of adding pumpkin flour and carrot flour on changes in color intensity of Goldfish (*Carassius auratus* L.) Strain Oranda. World News Natural Sci. 26: 52-60.

Andriani Y Rosidah I, Priyadi A and Firdaus SN. (2020) Effect of Tubifex and carrot meal combination on color quality of Botia *Chromobotia macracanthus*. E3S Web Conf. 147: 01007. doi:10.1051/ e3sconf/202014701007

Azab A, Khalaf-Allah H and Maher H. (2016) Effect of some food additives on color enhancement of koi fish, *Cyprinus carpio* (Linnaeus, 1758). Int J Develop. 5(1): 109-128.

Chapman FA, Miles RD (2016) How ornamental fishes get their color. FA 192, IFAS Extension School of Forest Resources and Conservation Program in Fisheries and Aquatic Sciences University of Florida. pp 1–9. https://doi.org/10.32473/edis-fa192-2018

Das AP and Biswas SP. (2016) Carotenoids and pigmentation in ornamental fish. J Aquac Mar Biol 4(4): 93.

Das M. (2023) Effect of dietary supplementation of carrot meal on growth, survival, whole body composition and total content of zebra fish, *Danio rerio*. Intern J Zool Invest. 9(2): 575-585.

Gamit SA, Kapila M, Bengani R, Gamit DN, Lende SR, Vasava RJ, Solanki VK, Vadher DR and Mevada JN. (2022) Comparision of growth and colour enhancement in *Poecilia sphenops* using different carotenoid supplements. Pharma Innovation J. 11(11): 1943-1946.

García-Chavarría M and Lara-Flores M. (2013) The use of carotenoid in aquaculture. Res J Fish Hydrobiol. 8(2): 38-49.

Jain A, Kaur VI and Hollyappa SA. (2019) Effect of dietary supplementation of carrot meal on survival, growth and pigmentation of freshwater ornamental fish, Koi carp, *Cyprinus carpio* (L). Indian J Anim Nutrit. 36(4): 405-413.

Kaur R and Shah TK. (2017) Role of feed additives in pigmentation of ornamental fishes. Int J Fish Aquat Stud. 5(2): 684-686.

KocaBozalan N and Karadeniz F. (2011) Carotenoid profile, total phenolic content, and antioxidant activity of carrots. Int J Food Properties 14(5): 1060–1068.

Kop A, Durmaz Y and Hekimoglu M. (2010) Effect of natural pigment sources on colouration of cichlid (*Cichlasoma severum* sp. Heckel, 1840). J Anim Vet Adv. 9(3): 566-569.

Maiti MK, Bora D, Nandeesha TL, Sahoo S, Adarsh BK and Kumar S. (2017) Effect of dietary natural carotenoid sources on colour enhancement of Koi carp, *Cyprinus carpio* L. Int J Fish Aquat Stud. 5(4): 340-345.

Naeem MA, Rana S, Shimul SA and Al Nahid SKA. (2022) Effects of natural carotenoids on the body coloration and growth performance of Blue Gourami fish (*Trichogaster trichopterus*). Bangladesh J Fish. 33(2): 235-241.

Olson JA. (1986) Vitamin A deficiency. Nutr Rev. 44(3): 121-124.

Ramamoorthy K, Bhuvaneswari S, Sankar G and Sakkaravarthi K. (2010) Proximate composition and carotenoid content of natural carotenoid sources and its colour enhancement on marine ornamental fish Ampiprionocellaris (Cuveir, 1880). World J Fish Mar Sci. 2(6): 545-550.

Rana S, Bari AA, Shimul SA, Mazed MA and Nahid SA. (2023) Enhancement of body coloration of sword-tail fish (*Xiphophorus helleri*): Plant-derived bio-resources could be converted into a potential dietary carotenoid supplement. Heliyon 9(4): e15208.

Tiewsoh W, Singh E, Nath R, Surnar SR and Priyadarshini A. (2019) Effect of carotenoid in growth and colour enhancement in gold fish, *Carassius auratus* (L.). J Exp Zool India 22(2): 765-771.

Torrissen OJ and Naevdal G. (1984) Pigmentation of salmonids -- Genetical variation in carotenoid deposition in rainbow trout. Aquaculture (Amsterdam, Netherlands) 38(1): 59-66.

Yanar M and Tekelioglu N. (1999) The effect of zeaxanthin and tank colour on pigmentation and growth of gold fish (*Carassius auratus*). Turkish J Biol. 23(3): 303-307.

Wagde MS, Sharma SK and Sharma BK. (2018) Effect of natural β-carotene sources- Carrot (*Daucus carota*) and Spinach (*Spinacia oleracea*) on the growth of an ornamental fish-sword tail (*Xiphophorus hellerii*). J Entomol Zool Stud. 6(5): 2112-2115.