COLOUR QUALITY ENHANCED ON GOLDFISH JUVENILES THROUGH SHRIMP HEAD MEAL ENRICHED IN FEED

I Wayan Subamia*, Nina Meilisza, and Asep Permana

Research and Development Institute for Ornamental Fish Culture

(Received July 20th, 2012; Accepted May 10th, 2013)

ABSTRACT

Goldfish (*Carassius* sp.) is the ornamental fish which has been managed its culture by fish farmers. The objective of the research is to improve the colour quality of goldfish juveniles through enrichment of feed using shrimp head meal as source of carotenoid. The research was conducted at The Research and Development Institute for Ornamental Fish Culture, Depok, using completely randomized design with four treatments of shrimp head meal ratio, 0% (control), 5%, 10%, and 15% in feed, the feed formulation contained isoprotein (30%), and isolipid (15%) and three replications of each treatment. Ten juveniles of *Carassius* sp. with body weight of (1.08±0.02 g) stocked in aquarium with water volumes of 20 L. The growth and colour quality in qualitative standard using TCF (Toca Colour Finder) were examined, while total carotenoid content on feed were measured by spectrophotometry method. The colour quality of goldfish were also measured at three of fins those were dorsal, ventral, and caudal. The result showed that no significant different on growth and survival rates among the treatments. Based on the present research, the optimal colour improvement to goldfish was by addition of 10% shrimp head meal in feed.

KEYWORDS: colour quality, shrimp heal meal, feed, goldfish juveniles

INTRODUCTION

Goldfish is one of fish among thousands of ornamental fish species that has been cultured and commercialized. This ornamental fish have long history and popular in the fisheries sector due to their beautiful coloration and body shape variation, this beautiful character could be improve by treated feed.

The quality of ornamental fish is depending on their economical and esthetical values, beautiful colour performance was a part of indicator of the quality. The colour on fishes determined by the existence of pigment cell or chromatophores in fish dermis.

Red or yellow were dominant colours on ornamental fish. The main components which forming the red and yellow colour pigments is carotenoid. In fish, carotenoids cannot be synthesized (Goodwin, 1984; Rosa Cejas *et al.*, 2003; Kalinowski *et al.*, 2007). Colour enhancing sources in fish feed is expected would be able to increase of colour pigments concentration in body fish or at least the fish will be able to maintain the colour pigment in the body. Asthaxanthine dominantly come from crustaceans, krill, trout, and salmon. Shrimp head meal is source of carotenoids derived from the processing of shrimp body wastes and from this waste could produce chitin, chitosan, protein concentrates, flavour (tasting material), and carotenoid pigments (Desiana, 2000).

Along with technology development of fish feed, the sources of carotenoids can be formulated and incorporated into the feed. The main nutrient contents in artificial feed i.e. protein, fat, carbohydrates, vitamins and minerals, the

* Corresponding author. Research and Development Institute for Ornamental Fish Culture, Jl. Perikanan No. 13 Pancoran Mas, Depok 16364, Indonesia. Phone: +62 21 452 0482
E-mail: sirunina@yahoo.com

composition is to formulate as fish requirements. The utilize of shrimp head meal as a source of natural carotenoids is expected to give the value added in terms of quality and can be minimize the cost production cause by its ecological friendly, recycle waste, and still has the high contain of nutrients (± 49% protein, lipid ± 5% dry weight) (Sachindra & Mahendrakar, 2005; Sánchez-Camargo *et al.*, 2011).

The protein content in feed for growth is well known for cyprinid species ranged between 29%-43% (Lochmann & Phillips, 1994; Yanong, 1996; Min Xue & Cui Yibo, 2001; Sales & Janssens, 2003; Bandyopadhyang *et al.*, 2005). The use 30% of protein ratio in this research was considered more efficient. In addition, to get good results in this research, lipid ratio was also considered. Lipid ratio is one factor that may affects the body's absorption of carotenoids in fish, the optimal lipid ratio of 15% give high absorption of canthaxantine in rainbow trout (Tonissen *et al.*, 1990). The present study aimed to know the ratio of shrimp head meal in feed as carotenoid source for coloration of goldfish.

MATERIAL AND METHODS

This research was conducted at the Research and Development Institute for Ornamental Fish Culture, Depok. Ten juveniles of Carassius sp. 1.08±0.02 g were stocked in 12 aquariums with each capacity 20 L. The rearing system was natural photoperiod (12 hours light; 12 hours dark).

The research designed completely randomized with four treatments and three replications. The feed containing various ratio of shrimp head meal (SHM) as carotenoid source in feed i.e. 0% (control), 5%, 10%, and 15%. The formulate fish set containing isoprotein (30%), isolipid (15%), and isoenergy (20 MJ/kg), and added the shrimp head meal accordance with a specified composition (Table 1). The fish were fed 5% of body weight and the nutritional value of feed was analyzed.

Table 1. Ingredients composition and nutrition values on each treatment

Ingredients (g/kg feed)	Ratio of shrimp head meal in feed (%)			
	0	5	10	15
Fish meal	287	275	298	303
Soybean meal	200	187	131	100
Shrimp head meal	0	50	100	150
Corn meal	167	141	127	200
Wheat flour	200	200	200	105
Palm oil	20	20	20	20
Fish oil	75	76	73	72
Vitamins	10	10	10	10
Minerals	30	30	30	30
Binder	10	10	10	10
Nutritional value (g/kg feed)				
Protein	300	300	300	300
Lipid	150	150	150	150
Ash	93	103	119	134
Crude fiber	11	10	8	8
Nitrogen Free Extract	455	444	428	398
Gross energy (MJ/kg feed)	20.8	20.6	20.4	20.0
Protein energy ratio (g prot./kg feed)	14.4	14.5	14.7	15.1
Total carotenoid contain in feed (mg/L)	155.85	162.98	168.96	177.42

The sampling was held every 10 days, for growth and the research was end after 60 days. The colour quality was performed by Toca Colour Finder (TCF) and the total content of carotenoid was also checked by spectrophotometer.

The colour quality parameters were specified by TCF and then visual quantified with a ranking system. Initially first standard was taken at three observation points of the body that were a part of the dorsal, ventral, and caudal fins. In addition to these parameters, supporting parameters of water quality such as pH, DO, ammonia, nitrite, and alkalinity were also measured. Data were analyzed statistically using the JMP7 software through analysis of variance (ANOVA) and if there is same difference among treatments the analyzed followed by Tukey test.

RESULT AND DISCUSSION

The growth and survival performance of goldfish in this study are shown in Table 2. There was no significant different on growth and survival rates among the treatments $P>0.05$ (Table 2). The average weight and length in each sampling date are presented in figure 1 and 2.

The visual quantification using TCF (Toca Colour Finder) colour on goldfish were taken from three areas of fins such as dorsal, ventral and caudal fins have revealed five ranking of colouration on dorsal and ventral parts started

Table 2. The parameters of weight, length, and survival rate on the juveniles of gold fish during experiment

Parameters	Treatments (shrimp head meal/SHM)			
	A (0%)	B (5%)	C (10%)	D (15%)
Weight gain (g)	13.20±3.07[a]	6.92±0.61[a]	7.53±1.77[a]	8.51±4.49[a]
Length gain (cm)	13.03±2.89[a]	11.40±5.94[a]	11.21±2.81[a]	11.55±4.58[a]
Specific growth rate of weight (%)	1.31±0.22[a]	1.21±0.04[a]	1.18±0.13[a]	1.19±0.35[a]
Specific growth rate of length (%)	0.37±0.09[a]	0.20±0.17[a]	0.21±0.08[a]	0.23±0.13[a]
Survival rate (%)	76.67±15.28[a]	77.5±20.64[a]	66.67±15.38[a]	63.33±5.77[a]

Note: The values under the same superscript in the same row indicate no significant difference ($P>0.05$)

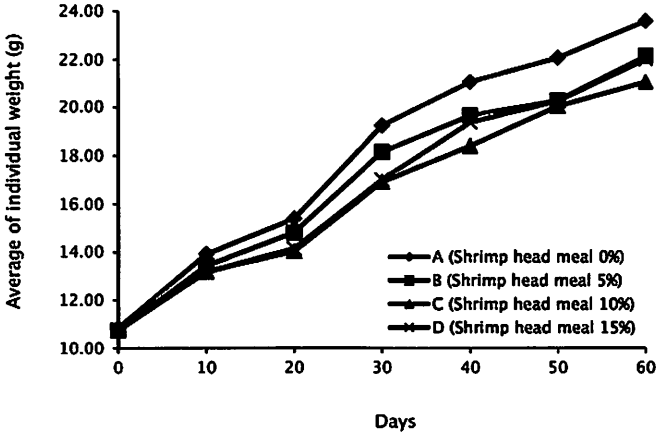

Figure 1. The average of individual weight (g) of gold fish during research period

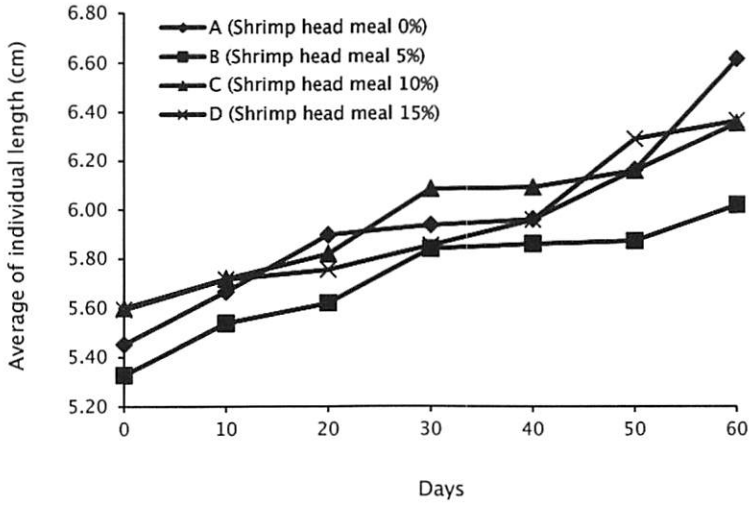

Figure 2. The average of individual total length (mm) during research period

from the lowest to the highest colour. The colour were as rank 1 (gray), 2 (greenish gray), 3 (yellowish green), 4 (yellow), and 5 (bright yellow).

Figure 3 shows the colours on dorsal area of goldfish increase compared to initial colour in all treatments. The increasing from initial to the end of research was significant. The five degree of colour were changes, from gray to bright yellow and shown by two treatments. Those treatments were by shrimp head meal (10% and 15%) in the feed. Feed with a ratio of 0% and 5% of shrimp head meal in feed resulted in the lowest colour performance.

Figure 4 shown the colour on the ventral fin area of goldfish increased compared to initial research in all treatment. Increment of colour from initial to the end of research as realized 40 days after rearing. The highest rank at the end of research was achieved by 10% shrimp head meal in feed. While feed with ratio of 0% and 15% of shrimp head meal in feed produces the similar colour performance while treatment of 5% is the lowest.

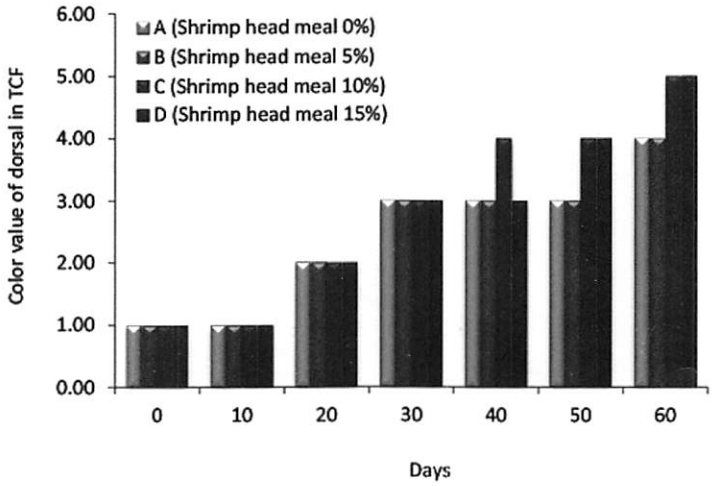

Figure 3. Colour value on dorsal area in visual quantification during research period

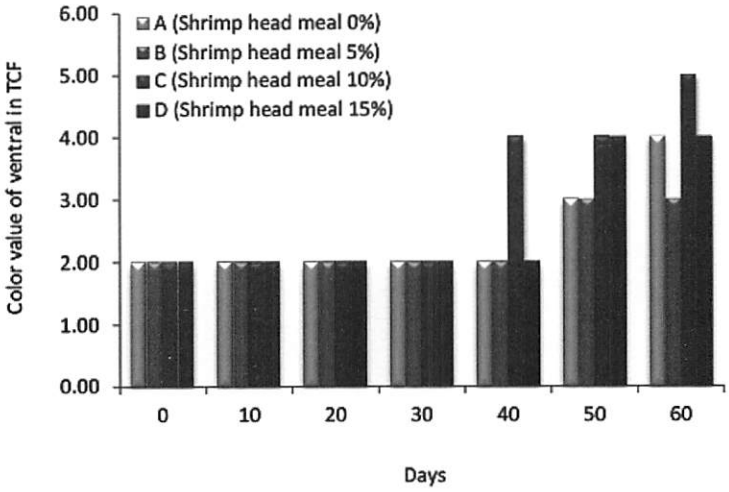

Figure 4. Colour value on ventral area in visual quantification during research period

On the caudal fin, the colour at the beginning of research started was more pronounced was in the yellowish green colour and change occurs only in the treatment of 15% shrimp head meal after days 20th, but tends to stagnant until the end of the research. Discolouration of the tail fin is not significant, only two levels of colour have changed that was from yellowish green to yellow and bright yellow. Treatments 10% and 15% of shrimp head meal results the similar colour performances (Figure 5).

The value of carotenoid content on the body of goldfish are presented in Figure 6. The carotenoid value of fish showed differences each other where carotenoid values will be even greater as much as percentage of shrimp head meal in feed until 10%. The 15% shrimp head meal in feed decreased if compared with 10%, but 15% was higher than the two other treatments (Figure 6). The other data to support this research such as water quality shows the parameters of chemical physics which has been still within the normal range for maintaining of fish in the aquarium (Table 3).

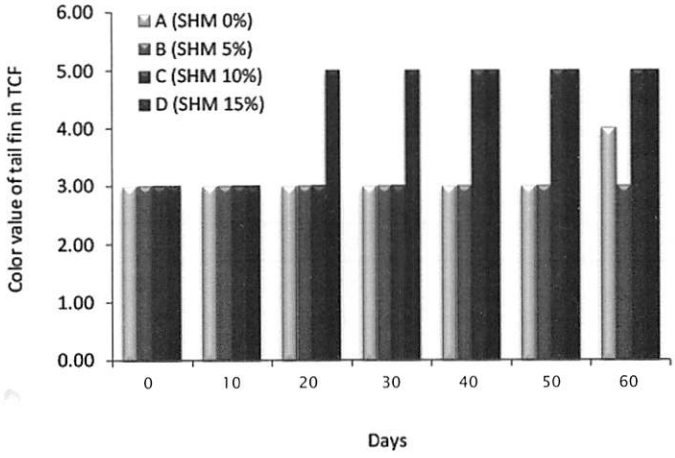

Figure 5. Colour value on caudal fin in visual quantification during research period

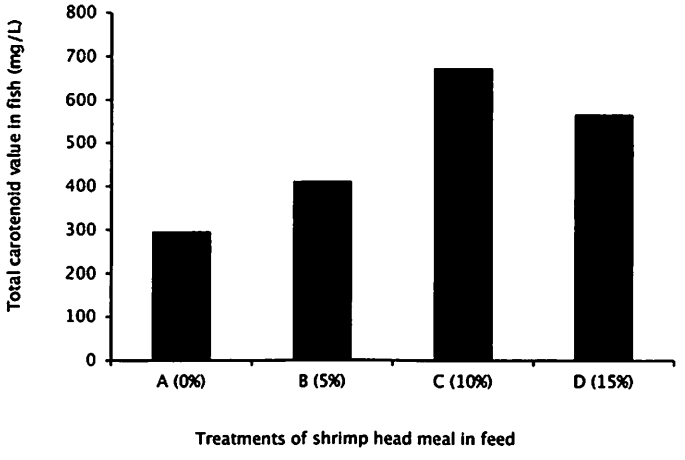

Figure 6. The total value of carotenoid content on goldfish detected by spectrophotometer at the end of the research

DISCUSSION

The enrichment of shrimp head meal in feed for all treatments has resulted in the good response on feed intake as shown on increment of weight and length. It was proved that fish is able to utilize of feed for body maintenance and growth. Feed in this research was considered to comply all of nutritional fish requirements, it is seen from the nutrient contains in the feed and its results performance. Fish feed requirements linked to feed functions in living organisms, nutrition and energy for growth and reproduction which provided by its feed (Lovell, 1989).

Ornamental fish quality also assess by colour performances. Basically, colour was produced by pigment cells (chromatophore) located in dermis layer. Cells which has pigment are shaped resemble of stars. Colour changes occur on fish influenced by the distribution of granules pigment within the cell. Nyquist & Toner (1996) opinion says that the movement of granules pigment on the chromatophore could be divided into two types, namely chromatophore with granules pigment was gathered near the nucleus and chromatophore dispersed throughout the cell. Granules pigment are scattered in the cell causing this cell to absorb of light perfectly till to increase the colour scales, while the granules pigment are assembled in cells causes a decrease in the colour scales.

According to Evans (1993), the movement of granules pigment caused the colour changes due to of temperature, light, and others and its controlled by the nervous and hormonal

Table 3. Data of water quality

Parameters	Units	Range of values
Oxygen	(mg/L)	3.18-7.41
Temperature	(°C)	24.0-27.0
pH	-	6.00-7.00
Hardness	(mg/L)	41.59-61.00
NH^{3}-N	(mg/L)	0.000-0.005
NO^{2}-	(mg/L)	0.000-0.004
Alkalinity	(mg/L)	11.33-45.31

system. Some studies use a few of carotenoid sources to colour enhance. Carotenoids are the pigments group of yellow, orange, or red-orange, which have characteristics of fat-soluble or organic solvents, but insoluble in water. Latscha (1991) said that carotenoids are carotene group in xanthophyll form and consist of clusters of carbon, hydrogen and oxygen, for example taraxanthin, lutein, and astaxanthin. Furthermore, the sexual development of male adult fish will keep carotenoids on skin (Bjerkeng *et al.*, 1992).

In this case, carotenoids storage in the goldfish body has been performed on the skin where the colour increases. Guillaume *et al.* (2001) said that the carotenoids are fat-soluble pigments that have a range of colours from yellow to dark red. Carotenoids only able to deposited in the specific tissues (skin, muscle, exoskeleton and digestive gland). Astaxanthin is a kind of carotenoid which could be absorbed by fish and able converted to be canthaxanthin, its source widely available in many crustaceans.

Astaxanthin was most widely used and applied (Johnson, 1991). Astaxanthin (3,3'-dihydroxy-β, β-carotene-4,4-Dione) is a red-orange pigment in algae, microorganisms and crustaceans. These pigments was used as food additives for pigmentation of animals such as salmon, shrimp, and animals and it cannot be synthesized of β-carotene alone (Storebakken, 1992). Red was basic colour of astaxanthin, which will be absorbed and stored as a red pigment, therefore if there was a change of pigment in the fish body, the colour pigmentation in fish can be showed (Latscha, 1990).

Shrimp head meal as the natural source of carotenoids (astaxanthin and canthaxanthin) used to facilitate of absorption metabolism process in the body. Astaxanthin have biological functions related to growth, reproduction, and antioxidants on salmon and shrimp (Bell, 2000). Natural or synthetic astaxanthin could be added in fish feed to colour enhances of ornamental fish (Torrissen, 1989). Beside it, there is another carotenoid form likely canthaxanthin (β, β-carotene-4,4-Dione) that has a longer chromatophores and absorb a light at higher wavelengths (Guillaume *et al.*, 2001).

Based on its components, shrimp waste also containing 4.3% of total non-protein N, 0.5% of fat, 26.8% crude of protein, 2.4% nitrogen of chitin, 34.9% of chitin, 29.3% of ash, 0.8% of phosphorus, 8.2% of potassium, 1.7% of calcium (Benjakul & Sopharodora, 1993). According to Shahidi & Synowiecki (1992) shrimp waste containing 41.9% of protein, 17.0% of chitin, 29.2% of ash, and 4.5% of fat in dry matter. It gives information that shrimp head meal also providing the nutritional value as alternative ingredients.

In this research, results show that shrimp head meal in feed could be enhance the colour quality of goldfish. Colour quality measured by visual quantification using Toca Colour Finder (TCF) for colour assessment. Besides it, the measurement of colour quality was also carried out by spectrophotometry method and results significantly colour changes among the treatments.

On goldfish, yellow red performance has increased compared to initial conditions. These results indicate that fish colour enhances influenced by shrimp head meal in feed as a carotenoids source. The absorption of carotenoids in the tissue cells will affect to the pigment cells (chromatophores) in fish skin. The content of astaxanthin in carotenoid would increase red pigment in cells (erythrophore), where colour results will appear more sharply. Vevers (1982) opinion, carotenoids in animals play a role in the provision of yellow, orange, and red colour, but when it binds to protein there will be a carotenoprotein, which produces blue and purple colour. Its carotenoids were identified as asthaxantin and canthaxanthin.

Enrichment of carotenoid in fish feed, would be able to increase the absorption of pigment cells. The colour quality in fish will also increase compared with no carotene feeding. It was proven in this research, goldfish which given feed without a carotenoids source, colour enhancement show slightly slow than use of shrimp head meal.

CONCLUSION

Results showed that no significant differences in growth rate among treatments. There was an effect of shrimp head meal level to colour performances on dorsal, ventral, and tail fin of goldfish. The optimum level of shrimp head meal to enhance of fish colour quality was 10% in the feed.

REFERENCES

Bandyopadhyang, P., Swain, S.K., & Mishra, S. 2005. Growth and dietary utilization in goldfish (*Carassius auratus* Linn.) fed diets formulated with various local agroproduces. *Bioresource Technology*, 96: 731-740.

Bell, J.G. 2000. Depletion of tocapherol and asthaxanthine in Atlantic Salmon affect autoxidative defence and fatty acid metabolism. *Journal of Nutrition*, 130(7): 1,800-1,808.

Benjakul, S. & Sopharodora, P. 1993. Chitosan production from carapace and shell of black tiger shrimp. *Asean Food Journal*, 8: 4.

Bjerkeng, B., Storebakken, T., & Jensen, S.L. 1992. Pigmentation of rainbow trout from start feeding to sexual maturation. *Aquaculture*, 108: 333-346.

Desiana. 2000. *Ekstraksi pigmen karotenoid dari limbah kulit udang windu (Penaeus monodon Fabricus) dengan bantuan enzim papain.* Skripsi. Fakultas Perikanan dan Ilmu Kelautan IPB. Bogor, 36 pp.

Evans, D.H. 1993. The physiology of fishes. First Edition (Ed.), CRC Press, Boca Raton, 592 pp.

Guillaume, J., Kaushik, S., Bergot, P., & Metailler, R. 2001. Nutrition and Feeding of fish and crustaceans. UK: Praxis Publishing, 408 pp.

Johnson, E.A. 1991. Asthaxanthinee from microbial source. *Crit. Rev. in Biotechnology*, 11(4): 297-326.

Kalinowski, C.T., Izquierdo, M.S., Schuchardt, D., & Robaina, L.E. 2007. Dietary supplementation time with shrimp shell meal on red porgy (*Pagrus pagrus*) skin colour and carotenoid concentration. *Aquaculture*, 272: 451-457.

Latscha, T. 1990. Carotenoids in aquatic animal nutrition, their nature and significance in animal feeds. Roche Publication. No. 2175, F Hoffman-La Roche. *Animal Nutrition and Health*, Basle, Switzerland, 110 pp.

Latscha, T. 1991. Carotenoids in aquatic animal nutrition. Akiyama, D.M. & Tan, R.K.H. (Eds.). *Proceed of The Aquaculture Feed Processing and Nutrition Workshop*. American Soybean Association, Singapore, p. 68-79.

Lochmann, R.T. & Phillips, H. 1994. Dietary protein requirement of juvenile golden shiners (*Notemigonus crysoleucas*) and goldfish (*Carassius auratus*) in aquaria. *Aquaculture*, 128: 277-285.

Lovell, T. 1989. Nutrition and feeding in fish. Van Nostrand reinhold, New York, xi+267 pp.

Xue, M. & Cui, Y. 2001. Effect of several feeding stimulants on diet preference by juvenile gibel carp *Carassius auratus* gibelio, fed diets with or without partial replacement of fish meal by meat and bone meal. *Aquaculture*, 198: 281-292.

Nyquist, S.E. & Toner, K.B. 1996. Pigment granule transport in *chromatophores.* 322 pp. *In* Tested studies for laboratory teaching. Glase, J.C. (Ed.), *Proceedings of the 18th Workshop/Conference of the Association for Biology Laboratory Education (ABLE)*, 18: 143-157.

Rosa Cejas, J., Almansa, E., Tejera, N., Jerez, S., Bolan, A., & Lorenzo, A. 2003. Effect of dietary supplementation with shrimp on skin pigmentation and lipid composition of red porgy (*Pagrus pagrus*) alevins. *Aquaculture*, 218: 457-469.

Sachindra, N.M. & Mahendrakar, N.S. 2005. Process optimization for extraction of carotenoids from shrimp waste with vegetable oils. *Bioresource Technology*, 96: 1,195-1,200.

Sales, J. & Janssens, G.P.J. 2003. Nutrient requirements of ornamental fish. *Aquat. Living Resour*, 16: 533-540.

Sánchez-Camargo, A.P., Almeida-Meireles, M.Â., Fontoura-Lopes, B.L., Antonio-Cabral, F. 2011. Proximate composition and extraction of carotenoids and lipids from Brazilian red spotted shrimp waste (*Farfantepenaeus paulensis*). *Journal of Food Engineering*, 102: 87-93.

Shahidi, F. & Synowicki. 1992. Quality and composional characteristic of new faunland shellfish processing discard in "Advance In Chitin and Chitosan". Brine, J., SadFord, P.A., & Zakakis, I.P. (Eds.). *Elsevier Applied Science.* London.

Storebakken, T. 1992. Pigmentation of rainbow trout. *Aquaculture*, 100: 209-229.

Tonissen, O.J., Hardy, R.W., Shearer, K.D., Scott, T.M., & Stone, F.E. 1990. Effects of dietary canthaxanthin level and lipid

level on apparent digestibility coefficients for canthaxanthin in rainbow trout (*Oncorhynchus mykiss*). *Aquaculture*, 88: 351-362.

Torrissen, J. 1989. Pigmentation of salmonids: Interactions of astaxanthin and canthaxanthin on pigment deposition in rainbow trout. International *Symposium on Feeding and Nutrition in Fish. Aquaculture*. 79: 363-374.

Vevers, G. 1982. The colours of animals. Edward Arnold (publisher) London. *Studies in Biology*, 146: 55.

Yanong, R.P.E. 1996. Reproductive management of freshwater ornamental fish. *Seminars in Avian and Exotic Pet Medicine*, 5(4): 222-235.