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EFFECTS OF RED YAM FLOUR (*Ipomoea batatas* L.) ON THE GROWTH, SURVIVAL RATE AND SKIN COLOR OF GOLDFISH (*Carrasius auratus*)**

DEDI FAZRIANSYAH PUTRA[1*], LIA ARMAYA[1], SAYYID AFDHAL EL RAHIMI[1] AND NORHAYATI OTHMAN[2]

[1]*Department of Aquaculture, Faculty of Marine and Fisheries, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia*
[2]*Cluster of Applied Sciences, Open University Malaysia, Penang 13700, Malaysia*

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ABSTRACT

The best quality goldfish requires a good environment and a highly nutritious feed. Thus, this study evaluated the effects of commercial diets supplemented with 0%, 3%, 6%, 9% and 12% red yam flour (*Ipomoea batatas L.*) on the growth rate, survival rate and skin color of the goldfish *Carrasius auratus*. A completely randomized experimental design with five treatments and three replicates was used. Seventy-five goldfishes with an average initial length of 4.4 cm were fed the supplemented commercial diets for twenty-eight days inside fifteen experimental tanks. The results showed that the 9% dietary treatment significantly affected the skin color of the goldfishes but not their growth and survival rates (P > 0.05). Hence, the administration of 9% concentrated red yam flour was a suitable dietary supplement to improve skin pigmentation, an important characteristic of aquarium fishes.

Keywords: *Carrasius auratus*, red yam flour, skin color

INTRODUCTION

Goldfish (*Carassius auratus*) is one of the most popular ornamental fishes in Indonesia. It is one type of ornamental fish that attracts many fish markets worldwide. The fish has a body-color ranging from red, yellow, green, black and silver. Since its first cultivation, there are approximately fifteen species of goldfish that have been recognized and favored by the public. In as much as the nutritional content of feeds supports the color, health, and quality of fishes, a good environment and highly nutritious feeds are needed to produce the best quality goldfish.

Many studies on most ornamental fishes are focused on improving the skin pigmentation, body shape, fin shape and the body size of the fish using synthetic pigments and natural sources (Kalinowski *et al*. 2005; Shahidi *et al*. 1998). These are the most important characteristics concerning their marketability (Paripatananont *et al*. 1999). Fishes, similar to other vertebrate animals, can not perform the de novo synthesis of carotenoids (Goodwin 1984). Thus, they depend on dietary supplies to obtain their natural pigmentation. The fish color is produced by the presence of chromatophore cells existing in the dermis layer of skin (Putra *et al*. 2012). Natural carotenoid substances are found in plants and fruits in the form of β-carotene. Thus, many studies on natural compounds such as *Chlorella zofin-giensis* (Bar *et al*. 1995), *Chlorococcum sp*. (Zhang *et al*. 1997), the green algae *Haematococcus pluvialis* (Harker *et al*. 1996; Yuan & Chen 2000) and *C. vulgaris* (Gouveia *et al*. 1996) have been conducted. Other latest works have been done using paprika (Minh *et al*. 2014), *Spirulina platensis* (Mahdi *et al*. 2013; Chen *et al*. 2016), *Medicago sativa* (Mahmut *et al*. 2008), and carrot starch (Pardosi *et al*. 2016) as sources of dietary carotenoids. One alternative source of a cheap

*Corresponding author: dfputra@unsyiah.ac.id
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and easily available carotenoid in Indonesia is the red yam which, among other vegetables and even among other sweet potatoes (Fatimah 2013), and is known to contain the highest amount of beta carotene. It contains 9900 mg (32 967 SI) of beta-carotene per 100 grams, and the thicker the color of the red yam is, the higher is its beta-carotene content. However, the effects of red yam flour enriched-fish feed on the growth and skin color of goldfish (*Carassius auratus)* is yet to be discovered.

MATERIALS AND METHODS

Experimental Design

The feeding trial was conducted for two months from July to August 2017 at the Marine Biology Laboratory of Faculty of Marine and Fisheries, Syiah Kuala University, Banda Aceh, Indonesia. Before the experiment, seventy-five goldfishes were purchased from a local market, acclimatized and fed with commercial fish feed for three days. Fishes with an average length of 4.4 cm were randomly selected and distributed into the fifteen containers, which has 25 L of water each.

This research was carried out using the Completely Randomized Design (CRD) with 5 treatments and 3 replications, namely; Treatment A: Control, without red yam flour; Treatment B, Red yam flour at 3% concentration; Treatment C: Red yam flour at 6%; Treatment D: Red yam flour at 9%; and Treatment E: Red yam flour at 12%. Fish feeding lasted for 28 days and was done three times a day at 09.00 am, 12.00 noon, and 5.00 pm for each treatment. The amount of feed given was 5% of the average weight of the fish's body.

The raw red yam, purchased from a traditional market in Banda Aceh city were first dried, then ground using a laboratory grinder until it became powdery (flour), and then mixed with progol as binder at a dosage of 2-3 g/kg of feed in one container, then stirred until the mixture was even and then added with water at a volume of 150 ml/kg. The red yam flour was then poured into the commercial fish feed and dried for 30-60 minutes. If the mixed-feed color and smell changed, the experimental feed must be re-mixed. During this period, the water temperature ranged from 25°C-32°C with pH from 6 to 9, and the dissolved oxygen was at approximately 5 mg/l.

Observation of Fish Color Change

The color measurements of the tested fishes followed that of Sitorus *et al.* (2015) using Toca Color Finder (TCF). This was conducted by 5 panelists who did not have visual impairments like color blindness nor farsightedness. The fish color was transformed into scores by scaling on a color measuring paper. The color observation was done every 7 days for 28 days.

Water Quality Monitoring

The measurement of water quality, including temperature, pH, and Dissolved Oxygen (DO). The water quality was monitored every seven days for 28 days.

Calculations and Statistical Analysis

Absolute weight growth (AWG)(g) = Fish weight at the end (g) – initial weight (g)

Absolute length (AL)(mm) = Fish length at the end (mm) – initial length (mm)

$$\text{Survival rate (SR)(\%)} = \frac{\text{The total fish number at the end}}{\text{Initial fish number}} \times 100\%$$

(Putra *et al.* 2018)

$$\text{Specific growth rate (SGR)(\%/day)} = \frac{\text{In Final mean weight} - \text{In Initial mean weight}}{\text{Time interval (days)}} \times 100\%$$

(Putra *et al.* 2018)

Data were analyzed by one-way ANOVA using SPSS 14.0 for windows (Kalinowski *et al.* 2005). Duncan test was used to compare the mean values at $P < 0.05$.

RESULTS AND DISCUSSION

The addition of Red yam flour significantly affected the coloration of the goldfish (*Carracius auratus*) (Table 1). Duncan's advanced test showed that the best color change occurred in treatment D (dose 9%) and the least occurred in treatment A (control) (Fig. 1). Color enhancement in fishes varies according to the fish absorption capacity of the pigment type and the dose administered in each treatment (Manas *et al.* 2017). Based on observed changes, the color of the goldfishes differed in each treatment of different dosages while the carotenoid material used was the same. The study results showed that the addition of 9% red yam flour was the best and the most effective treatment to improve the color of the goldfishes. In the study of Barus *et al.* (2014), fishes take a longer period to break the carotene material into color pigments if the carotene is present in large quantities. In another study (Panjaitan *et al.* 2016), carotene added to the fish feed in excessive doses did not improve the color of the fish. It could even reduce the color value of the fish.

On week 2, the color of the goldfish began to brighten until week 3 (Fig. 1). In previous research of Sitorus *et al.* (2015), the two-week administration of carotenoid in feed manifested a color improvement in the goldfish. The provision of carotenoid for three weeks resulted in maximum color enhancement. For more than 3 weeks application, the color was stable due to the increase of carotenoid in the pigment cells (chromatophore) of goldfish.

The fluctuation of color intensity is caused by the changes occurring in the chromatophore cells, physiologically, and morphologically. Physiological changes are the changes caused by chromatophore cell activities that are spread and concentrated in the epidermal cells. The spread of chromatophore pigment stimulated the pigment to absorb the sun perfectly, which then increases the intensity of the fish body color. Whereas, the chromatophore pigment that concentrated or gathered near the nucleus could cause a decreased light intensity resulting in a paler fish body. The movement of pigments in the epidermal layer is caused by external stimulation such as temperature, pH, and light intensity. The morphological changes are due to the amount and composition of the feed containing the carotenoid sources (Sari *et al.* 2012). Wang *et al.* (2018) mentioned that fish skin coloration is a complicated biological process. Fish possess six types of pigment cells, such as melanocytes (black, dark brown), cyanophores (blue), erythrophores (red/orange), xanthophores (yellow), iridophores (reflecting) and leucophores (white) (Braasch *et al.* 2007; Kelsh *et al.* 2004). The complicated process of fish skin color determination involves the six types of pigment cells, associated with a series of genetic, physiological, cellular, nutritional, and environmental factors (Colihueque 2010).

The ANOVA showed that the feeding of red yam flour did not significantly affect (P > 0.05) the absolute weight growth, absolute length, specific growth rate and survival rate of the fishes (Table 1). However, it significantly affected the intensity of the pigmentation (Fig. 2).

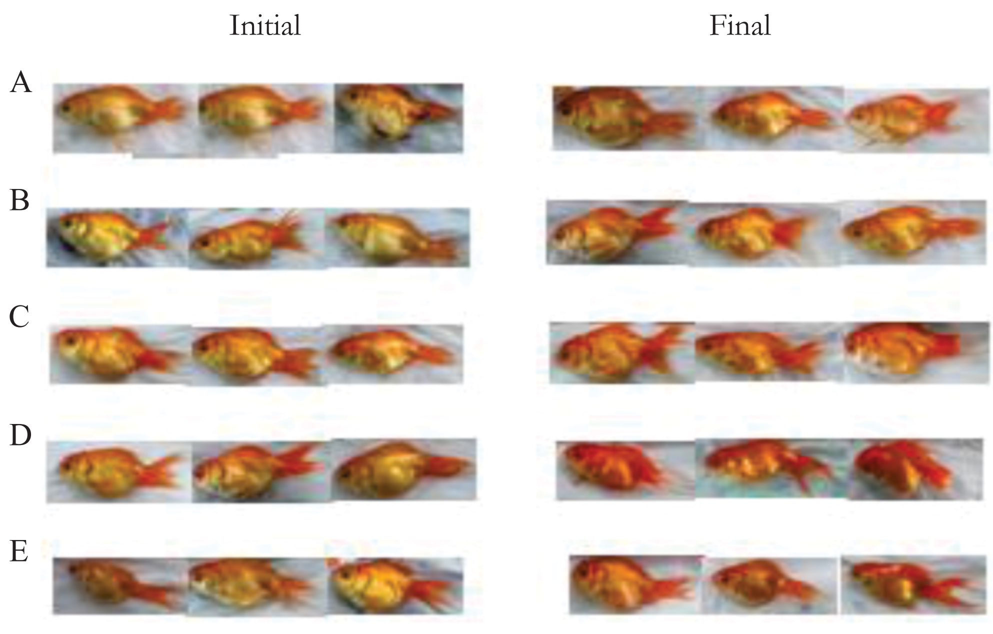

Figure 1 Color changes in the goldfish *(Carassius auratus*) (A, Control, at 0% Red yam flour; B, at 3% Red yam flour; C, at 6% Red yam flour; D, at 9% Red yam flour; and E, at 12% Red yam flour)

Table 1 Changes in color, growth, survival and specific growth rate of goldfish after 28 days rearing period

Treatment	Tested parameters				
	Color change	**Absolute weight growth (gram)**	**Absolute length (mm)**	**Specific growth rate (% / day)**	**Survival rate (%)**
A (control)	0.93 ± 0.31[a*]	2.44 ± 0.57[a]	11.99 ± 1.60[a]	2.28 ± 0.26[a]	100 ± 0.00[a]
B (3%)	1.20 ± 0.00[ab]	2.90 ± 0.33[a]	13.75 ± 0.75[a]	2.71 ± 0.46[a]	100 ± 0.00[a]
C (6%)	1.80 ± 0.53[b]	2.35 ± 0.42[a]	13.08 ± 2.76[a]	1.93 ± 0.50[a]	93.33 ± 11.55[a]
D (9%)	3.87 ± 0.31[d]	2.17 ± 0.65[a]	12.46 ± 3.22[a]	2.21 ± 0.53[a]	100 ± 0.00[a]
E (12%)	2.47 ± 0.31[c]	2.18 ± 0.43[a]	10.48 ± 2.93[a]	2.24 ± 0.22[a]	100 ± 0.00[a]

Note: *a - d = different superscripts in a column show significant differences among treatments at P <0.05 based on Duncan Test

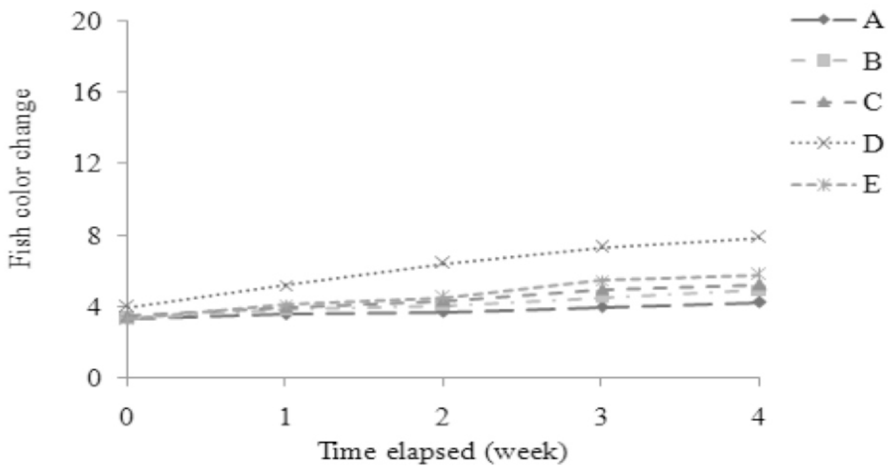

Figure 2 Color changes of the goldfishes (A = Control (Red yam flour at 0%), B = Red yam flour at 3%, C = Red yam flour at 6%, D = Red yam flour at 9%, E = Red yam flour at 12%)

Although the absolute weight growth, absolute length growth and specific growth rate of the goldfish increased in both control feed and artificial feed with the addition of red yam flour (Fig. 3, 4), no significant difference was observed (P > 0.05). Similarly, no significant difference in the growth of juvenile olive flounder *Paralichthys olivaceus* fed with different level of carotenoid (Minh *et al.* 2014). Moreover, neither was there a significant effect observed on the growth and feed conversion ratio of rainbow trout, *Oncorhynchus my kiss* (Walbaum) fed with semi-purified diets with and without carotenoid supplementation (Amar *et al.* 2001). The similarity in growth and feed utilization of Atlantic salmon when fed with diets containing different ratios of astaxanthin and canthaxanthin was also reported (Baker *et al.* 2002). However, the dietary astaxanthin appeared to have significant effects on the growth and survival of first-feeding fry Atlantic salmon, *Salmo salar* L. (Christiansen *et al.* 1995). In addition, the excessive inclusion level of about 6.6% red pepper lowered the feed intake and consequently impaired the growth of rainbow trout (Büyüçapar *et al.* 2007). Dietary addition of paprika produced negative effects on the feed consumption of for koi carp (Hancz *et al.* 2003). During the 28-day study period, the monitored water quality parameters were relatively constant and still within tolerable range (Table 2). The water temperature fluctuated within considerably narrow limits (27-32°C) and was in the optimum values for fish (25-32°C). The pH for the whole period was relatively constant (6-7), and the amount of dissolved oxygen (DO) in the water were 5.0-6.0 mg/L. Accordingly, the water quality during the experiment was still tolerable for goldfish culture (Boyd 1998).

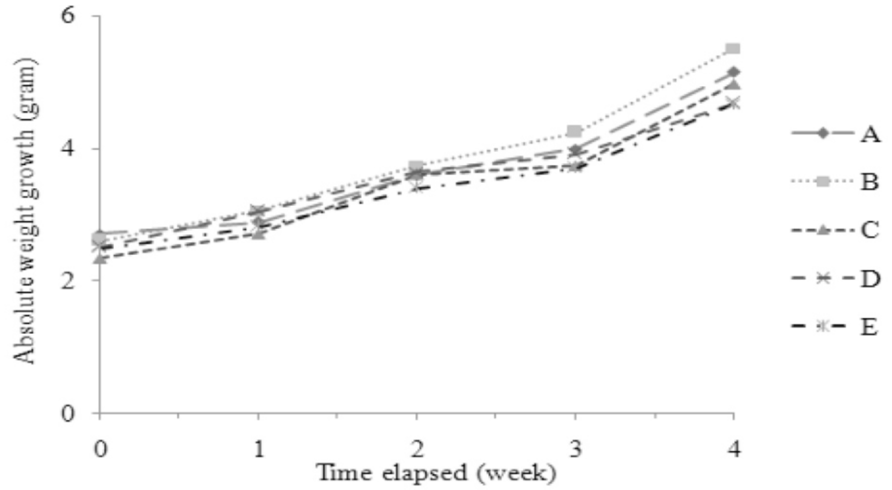

Figure 3 Absolute weight growth of the goldfishes (A = Control (Red yam flour at 0%), B = Red yam flour at 3%, C = Red yam flour at 6%, D = Red yam flour at 9%, E = Red yam flour at 12%)

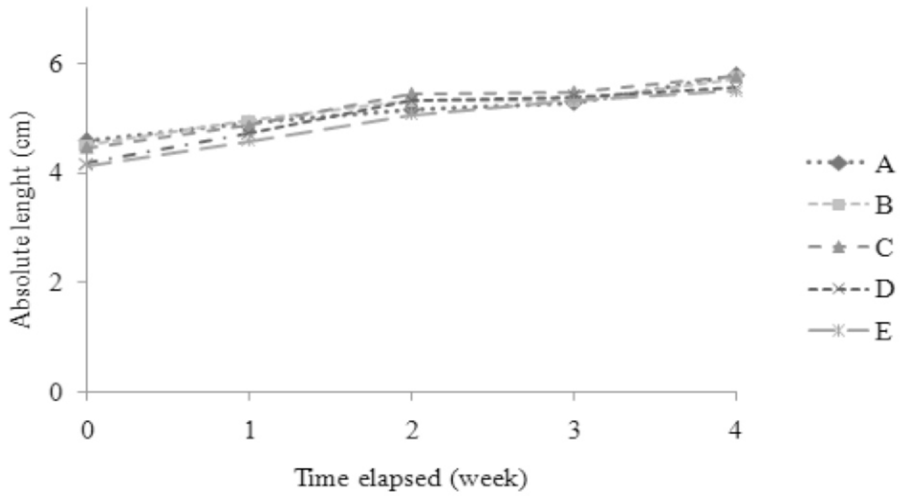

Figure 4 Absolute length growth of the goldfishes (A = Control (Red yam flour at 0%), B = Red yam flour at 3%, C = Red yam flour at 6%, D = Red yam flour at 9%, E = Red yam flour at 12%)

Tabel 2 Water quality monitoring

Treatment	Parameter		
	Temperature (°C)	**pH**	**DO (mg/L)**
A	27-28	7	4.82-5.97
B	27-28	7	4.76-5.97
C	27-28	7	4.97-5.13
D	27-29	7	4.94-5.97
E	27-28	7	4.91-5.97

CONCLUSION

The addition of red yam flour (*Ipomoea batatas L.*), at an optimal dose of 9% concentration on the fish feed, resulted in significant improvement on the color of the goldfish *Carassius auratus*, yet, its application at different concentration levels did not significantly affect the absolute weight, absolute length, daily growth rate and the survival of the goldfish. However, red yam flour can still be considered as a potential feed supplement to enhance the economic value of the ornamental goldfishes in the markets, since the color is readily noticeable and is an attractive characteristic among ornamental fishes.

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