Carotenoid Metabolism in Fancy Red Carp, *Cyprinus carpio*—I Administration of Carotenoids

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Fancy red carp accumulated ingested astaxanthin in the integument. Zeaxanthin was converted to astaxanthin de novo. Lutein was converted not to astaxanthin, but to doradexanthin.

It is well known that the reddish colour of fancy carp is caused by the accumulation of ketocarotenoids such as astaxanthin and doradexanthin in the integument.¹⁻³⁾ The carotenoid metabolism in fancy carp, however, is not studied sufficiently.⁴⁻⁶⁾

This paper deals with the carotenoid metabolism, especially the biosynthesis of astaxanthin in fancy red carp.

Experiments

Fancy red carp The fishes, body length 11-15 cm, body weight 37-103 g, were obtained from the fishculturist in the Niigata prefecture and cultured in an aquarium in a room for eight months until they showed pale colour.

Administration of carotenoids Astaxanthin, zeaxanthin and lutein were prepared from the carapace of shrimp, physalis and xanthophyll concentrate (Tokyo Kasei Co.) respectively. These carotenoids were administered with assorted feed prepared by the previous method for 35 days.⁷⁾ ¹⁴C-labeled lutein (1.2×10^6 dpm/mg) and zeaxanthin (1.8×10^6 dpm/mg) were prepared from physalis.⁷⁾ These labeled carotenoids were dispersed in water with tween 80 and introduced directly to digestive organ with polyethylene catheter. The water temperature was kept at 20-25°C.

Analysis of carotenoids Carotenoids were extracted with acetone and separated by silicic acid column chromatography and silica gel thin layer chromatography.⁸⁾ Carotenoids were identified by the absorption spectrum. The radioactivity was counted with liquid scintillation spectrometer.

Results and Discussion

Pigmentation of the integument was observed distinctly after a week. Fine reddish colour was observed on the fishes administered astaxanthin and zeaxanthin. The compositions of carotenoids in these integuments are summarized in Table 1. The accumula-

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Table 1. The compositions of carotenoids in the integuments of fancy red carp administered various carotenoids for 35 days

Dosed carotenoids	(μg/4 fishes)			
	Control	Astaxanthin	Zeaxanthin	Lutein
Xanthophyll ester	50	97	261	497
4-Ketodihydroxy-carotene ester	162	213	287	1383
Astaxanthin ester	117	664	571	72
Others	50	96	134	153
The amounts of administered carotenoid (mg)	—	75.5	82.0	83.6
Accumulation ratio of carotenoid in the integument (%)	—	0.9	1.0	2.1
Colour of the integument	pale orange	red	red	yellowish orange
Body length 11–14 cm. Body weight 37–67 g.				

Table 2. The distribution of radioactivities in the integument of fancy red carp administered ¹⁴C-labeled zeaxanthin and lutein after a week

	(dpm/6 fishes)	
	¹⁴ C-Zeaxanthin	¹⁴ C-Lutein
Xanthophyll ester fraction	395 (+)* 11.4%	1595 (+)* 25.9%
4-Ketodihydroxycarotene ester fraction	1085 (+) 31.2	4445 (+) 72.1
Astaxanthin ester fraction	2000 (+) 51.5	130 (–) 2.1
Accumulation ratio of radioactivity in the integument (%)	1.4	4.4

* The radioactivity of purified carotenoid after saponification; + positive, – negative Body length 13–15 cm, Body weight 60–103 g

tion of astaxanthin was observed in the astaxanthin and zeaxanthin groups. The lutein group accumulated not astaxanthin, but 4-ketolutein (doradexanthin). These results suggest that fancy red carp is able to accumulate the ingested astaxanthin and convert zeaxanthin to astaxanthin as like as goldfish.⁷⁾ These results were confirmed distinctly by the administration of radioactive carotenoids (Table 2). The astaxanthin fraction of lutein group was saponified, and the astance fraction was purified by silicic acid column chromatography and silica gel thin layer chromatography. This purified astacene fraction had not radioactivity. On the other hand, the purified astacene fraction of the zeaxanthin group had radioactivity. KATAYAMA *et al.*^{2,3)} claimed that astaxanthin was mainly biosynthesized from lutein in fancy carp as like as goldfish. Their claim, however, was denied by the above-mentioned results.

The following order of accumulation ratios of carotenoids was observed, lutein—zeaxanthin—astaxanthin, same as the case of goldfish.⁷⁾ It seems that hydroxyl group of carotenoid increases its absorbability of carotenoid and keto group decreases.

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