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Seasonal changes in total carotenoid contents of wild marine shrimps (*Penaeus semisulcatus* and *Metapenaeus monoceros*) inhabiting the eastern Mediterranean

Yasemen Yanar *, Mehmet Çelik, Mahmut Yanar

Fisheries Faculty, Department of Fishing and Fish Processing Technology, Cukurova University, Adana, Turkey

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Abstract

Penaeus semisulcatus and *Metapenaeus monoceros*, harvested in January, April, July and October, were analysed for total carotenoid contents. During spring and summer, for both species, the carotenoid contents were considerably higher than in winter and autumn seasons $p < 0.05$. Mean carotenoid contents of *P. semisulcatus* and *M. monoceros* were 14.1 ± 0.45 and 16.9 ± 0.26 mg/kg, respectively. These values are quite high compared to other seafoods.

Keywords: Shrimp; Carotenoid content; Seasonal changes

1. Introduction

The market value of shrimp is predominately based on the visual appeal of their body colour. Product appearance and resulting quality implications play a significant role in maintaining the highest consumer acceptance. The main pigment material of shrimps is astaxanthin, one of the main carotenoid pigments. It provides the tissue with red–orange pigmentation (Katayama, Hirata, & Chichester, 1971, 1972; Tanaka, Matsuguchi, Katayama, Simpson, & Chichester, 1976; Okada, Nur-E-Borhan, & Yamaguchi, 1994). In addition to pigmentation, carotenoids are known to play an important potential role in human health by acting as biological antioxidants, protecting cells and tissues from the damaging effects of free radicals and singlet oxygen (Di Mascio, Murphy, & Sies, 1991). Other health benefits of carotenoids that may be related to their antioxidative potential include enhancement of immune system function (Bendich, 1989), protection from sunburn (Mathews-Roth, 1990), and inhibition of the development of certain types of cancers (Nishino, 1998).

Knowledge of the total carotenoid contents of wild marine shrimps is very limited. Gopakumar and Nair (1975) found a general average of 13.3 mg/kg total carotenoid content in four penaeid species (*Metapenaeus affinis*, *M. dopsoni*, *Penaeus indicus, Parapenaeopsis stylifera*) and 4.2 mg/kg in *Metapenaeus monoceros* from brackish water. Clarke (1979) stated that the total carotenoid content of *Pandalus montagui* varies from 21 to 72 mg/kg. The carotenoid contents of shrimps vary, depending on their native habitat or manufactured diets. However, knowledge on this subject is restricted to that gained from aquaculture. Dependent on the carotenoid content in the diet of the cultured *Penaeus japonicus*, the total carotenoid content of muscle tissue showed a significant variation, between 10 and 40 mg/kg (Iwamato, Myers, & Hersberger, 1990; Yamada, Tanaka, Sameshima, & Ito, 1990; Negre-Sadargues et al., 1993).

Algae, the main carotenoid producers in the aquatic environment, depend on the season, so the carotenoid contents of shrimps change, also depending on the seasons.

In this study, seasonal changes in the carotenoid contents of *Penaeus semisulcatus* and *M. monoceros*, two

* Corresponding author. Tel.: +90-322-338-7213; fax: +90-322-3386439.
E-mail address: yyanar@mail.cu.edu.tr (Y. Yanar).

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of the most commercially important shrimp species in the northeastern Mediterranean, were examined.

2. Materials and methods

2.1. Materials

Shrimps, *P. semisulcatus* and *M. monoceros,* were caught off Karataş on the coast of the eastern Mediterranean of Turkey, in January, April, July and October, 2001. The samples were maintained in ice until they arrived at the laboratory. The mean length and weight of *P. semisulcatus* and *M. monoceros* were 18.93 ± 0.07 and 12.67 ± 0.04 cm, 63.93 ± 0.71 and 16.49 ± 0.15 g, respectively. Only the edible portion was used for carotenoid analysis. Four lots of each species were analysed in triplicate during four seasons.

2.2. Total carotenoid analysis

The carotenoids were extracted by the method of Torissen and Naevdal (1984), modified after Amano et al. (1968) and Renstrøm, Borch, and Liaaen-Jensen (1981). Acetone and anhydrous sodium sulphate were used for the extraction. About 1 g homogenised sample was mixed with equal amounts of anhydrous sodium sulfate and the carotenoids were then extracted in 2×5 ml acetone during three days in the dark in a refrigerator at 4 °C. The samples were homogenized and centrifuged at 5000 rpm for four min. The absorption of the extract was measured at 480 nm in a spectrophotometer (Ultraspec II 5050). The extinction coefficient, $E_{(1\%,\ 1\ cm)} = 1.900$, was used to calculate the carotenoid content (Foss et al., 1984).

2.3. Statistical analysis

Total carotenoid contents, obtained separately for each sampling season, were analysed by analysis of variance (one-way ANOVA), and any significant difference was found by Duncan (1955) multiple range test.

3. Results and discussion

The total carotenoid contents, of both *P. semisulcatus* and *M. monoceros* showed seasonal changes (Table 1). To our knowledge, no equivalent data have been reported for other penaeid species. During spring and summer, for both species, the carotenoid contents were considerably higher than those of winter and autumn seasons $p < 0.05$. The total carotenoid contents in spring, summer, autumn and winter for *P. semisulcatus* and *M. monoceros* were 16.2 ± 0.18, 15.8 ± 0.22, 13.3 ± 0.45 and 11.1 ± 0.27 mg/kg and 18.1 ± 0.24, 18.0 ± 0.24, 16.0 ± 0.22 and 15.6 ± 017 mg/kg, respectively (Table 1).

The seasonal variation in the total carotenoid contents determined in our study is thought to be due to seasonal changes in the quality and quantity of algae which are direct or indirect natural diets of shrimps. In a study carried out in the same region, it is reported that the algae intensity was highest in spring (Polat, Sarihan, & Koray, 2000).

Knowledge of total carotenoid contents of wild marine shrimps is very limited. For *M. monoceros* caught from the brackish water of the Indian Ocean, Gopakumar and Nair (1975) determined the total carotenoid content as 4.2 mg/kg. This value is rather lower than that determined in the present study. In the same study Gopakumar and Nair (1975) found that the total carotenoid content was 10 mg/kg in *P. indicus*, 10 mg/kg in *Parapenaeopsis stylifera*, 14 mg/kg in *M. affinis* and 14.4 mg/kg in *M. dobsoni*. These results demonstrate that carotenoid content of shrimps is species-specific and that it shows a considerable variation by geographical region even within the same species.

Mean total carotenoid contents found in *P. semisulcatus* and *M. monoceros* (14.1 ± 0.45 and 16.9 ± 0.26 mg/kg, respectively) are quite high compared to other seafood or even to terrestrial animal meats. For example, the highest level of carotenoid deposition in rainbow trout is reported to be 10.2–13.7 mg/kg (Torissen, Hardy, & Shearer, 1989). It is known that, besides pigmentation, carotenoids also have some biological functions, since they act as the precursor of vitamin A by means of β-carotene. They are also known to correlate with a lesser risk of many health problems, including some forms of cancer, cardiovascular diseases and visual degeneration for human beings. In this context, shrimps may be a good alternative food for humans when carotenoids are necessary for health.

Table 1
Seasonal changes in the total carotenoid contents of *P. semisulcatus* and *M. monoceros* (mg kg^{-1} muscle tissue)[A]

Seasons	*P. semisulcatus*	Body weight (g)	*M. monoceros*	Body weight (g)
Winter	11.1 ± 0.27^{c}	60.8 ± 0.83	15.6 ± 0.17^{b}	18.0 ± 0.28
Spring	16.2 ± 0.18^{a}	65.4 ± 1.53	18.1 ± 0.24^{a}	14.4 ± 0.26
Summer	15.8 ± 0.22^{a}	64.7 ± 1.45	18.0 ± 0.24^{a}	16.3 ± 0.18
Autumn	13.3 ± 0.45^{b}	68.0 ± 1.23	16.0 ± 0.22^{b}	17.3 ± 0.13
Mean	14.1 ± 0.45	63.9 ± 0.71	16.9 ± 0.26	16.5 ± 0.15

Values marked with different letters in each column are significantly different from each other $p < 0.05$.
[A] Data are expressed as means $\pm$ SD ($n = 4$).

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