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Review

Next generation nutraceutical from shrimp waste: The convergence of applications with extraction methods

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ABSTRACT

In recent years considerable progress in health therapy makes a significant improvement in natural nutraceuticals. Shrimp is a valuable natural sea food and is processed by removing head, tail and carapace as waste. The large amounts of waste produced by sea food industries capitulate, recoverable nutraceutical compound astaxanthin. This review emphasizes the chemistry and role of astaxanthin in pigmentation. The study highlights progress in applications and describes the current extraction methods starting with chemical to the best eco-friendly microbial processes. Relevant literature on the methods giving summary of results obtained using each approach has been reviewed and critically discussed. Intense research in advancing extraction methods to enhance productivity and to meet the demands of the consumer was discussed in future challenges. Further, aimed at collating valuable information about applications and recent extraction methodologies will promote a concept of intake of "a nutraceutical a day may keep the doctor away".

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0. Introduction

Nutraceuticals are taken in as food by mankind from many years. Nutraceuticals are nutritive pharmaceuticals that provide health benefits ranging from prevention to treatment of diseases. Changes in the consumption and the production of food have given lead to a rapid rise in the dominance of diseases in the past few years. In response to this modern epidemic, many pharmaceutical companies are looking for nutraceuticals from natural sources instead of developing drugs.

Shrimp, a valuable product of the sea food industry is processed for its meat, by separating the carapace, head and the tail. Depending on the species, size and shelling procedure, these body parts comprise 40–50% of the raw material and are generally discarded as waste. Indian shrimp processing industries produces more than 150,000 tonnes of shrimp waste annually (Sachindra & Mahendrakar, 2005). It is a natural and cheap source of a nutraceutical called astaxanthin. At present aqua food industry is facing strategic issues including use of renewable sources, recovery of by products and control of pollution generated by dumping of waste, as this waste has a real threat to the environment. Thus, in food industries the production of astaxanthin is expanding, leading to an increasing interest in the development of extraction methods from natural sources (Keisuke et al., 2016; Mahfuzur et al., 2016).

Limited information on astaxanthin has been published; also efforts in the extraction of astaxanthin appear to have been unsatisfied. Two reviews are available in the literature, one on chemistry and applications of astaxanthin (Higuera-Ciapara, Felix-Valenzuela, & Goycoolea, 2006) and another focuses on sources, stability and commercial applications of the algae *Haematococcus pluvialis* (Ambati, Phang, Ravi, & Aswathanarayana, 2014). Development of nutraceutical based products is important and useful taking into consideration the evolving needs of the mankind. Simple extraction method of astaxanthin may be profitable, when obtained along with other value added compounds. However, design of nutraceutical is critical which depends on the sources, extraction methods, assurance of all nutrients and efficacy of dietary supplements for each medical condition (Trottier, Bostrom, Lawrentschuk, & Fleshner, 2010). Hence, here we reviewed chemistry and role of astaxanthin in pigmentation of shrimp. The review focuses not only on current progress in applications of astaxanthin but also presents knowledge on methods used for extraction of astaxanthin, finally elaborating the merits of extraction methods with future challenges.

1. Chemistry of astaxanthin

Carotenoids are divided into two major classes. The first class includes yellow and red-pigmented unsaturated hydrocarbons. The second class is oxygenated derivatives called as xanthophylls. Astaxanthin (3, 3′-dihydroxy-β-carotene-4, 4′-Dione) is the principal xanthophyll carotenoid in crustacean waste which is derived through oxidative transformations of ingested β-carotene or Zeaxanthin from feed microalgae (Ambati et al., 2014). Astaxanthin ($C_{40}H_{52}O_4$) is a fat soluble pigment which is most widely

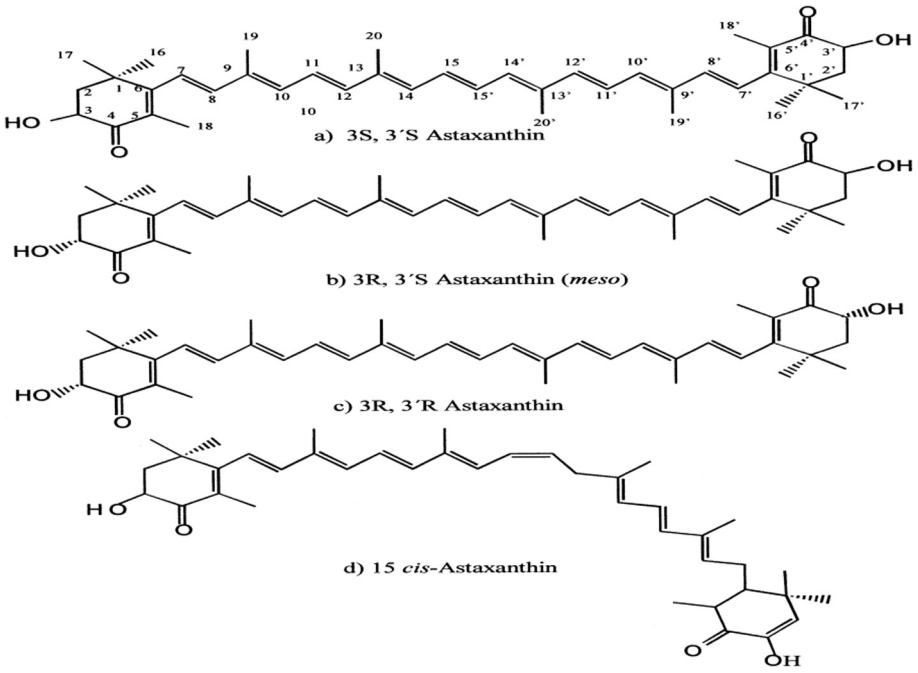

Fig. 1. Astaxanthin configurational isomers (a–c) and a geometric *cis* isomer (d). Adapted from Osterile, Bjerkeng, and Liaan-Jensen (1999).