Chapter 4

MICROBIAL PRODUCTION OF CAROTENOIDS OTHER THAN β-CAROTENE

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I GENERAL ASPECTS

1 HISTORY

1.1 Discovery of Carotenoids in Nature

The early discovery of carotenoids in living organisms is obviously attributable to the conspicuous appearance of these yellow, orange or red pigments. In 1831 Wackenroder prepared 'carotene' in crystalline form (Isler, 1971), whereas xanthophylls were first isolated from autumn leaves by Berzelius in 1837 (Isler, 1971). Following the main-classical chromatographic experiments of Tswett at the beginning of this century (Isler, 1971), it was soon realized that there existed a complex group of carotenoids in nature. The next decades indeed saw the isolation and structural elucidation of a large variety of new derivatives. More recently, the advent of modern spectrometric techniques and the refinement of separation methods have resulted in the ongoing discovery of more new structures, the determination of their absolute configurations and the establishment of routes for their partial or total synthesis. Concurrently, the biochemistry of carotenoids in plants and animals has gradually been unravelled (Goodwin, 1980, 1984).

1.2 Early Observations on the Occurrence of Carotenoids in Micro-organisms

The occurrence of carotenoids in micro-organisms was first reported about 100 years ago, when a number of pigmented non-photosynthetic bacteria (quoted in Ingraham & Baumann, 1934) and fungi (quoted in Valadon, 1976) were isolated. A more systematic survey of carotenoid-producing non-photosynthetic bacteria was conducted in the 1930s (Ingraham & Baumann,
1934). Pioneering work on photosynthetic bacteria was carried out by Van Niel & Smith (1935).

2 CHEMICAL AND PHYSICAL PROPERTIES
(Davies, 1976; Moss & Weedon, 1976)

Chemically, carotenoids are polyenes consisting of a number of isoprenoid units (usually 8) arranged in such a way that the two central methyl groups (20 and 20', Fig. 1) are in the 1,6 position, while all remaining substituents are positioned 1,5 relative to each other. A series of conjugated double bonds constitutes a chromophore of variable length, resulting in the characteristic yellow to red colors (absorption maxima 400–500 nm). Figure 1 presents the five basic (no substituents) structures of which all compounds pertinent to this chapter are derived. Full structures of the latter are depicted in Fig. 2, together with their trivial (common), semi-systematic and systematic names (Table 1, legend to Fig. 2).

Unsubstituted carotenoid hydrocarbons, e.g. lycopene, β-carotene, and torulene, are commonly designated as ‘carotenes’. The collective term xanthophylls covers oxygenated derivatives, including alcohols (e.g. lutein and

Fig. 1. Basic structures of carotenoids of which the compounds of interest (Fig. 2, Table 1) are chemically derived. Systematic IUPAC names in parentheses. 1, lycopene (ψ,ψ-carotene); 2,γ-carotene (β,ψ-carotene); 3,β-carotene (β,β-carotene); 4,α-carotene (β,ε-carotene); 5, retrodehydro-β-carotene (4’S’-didehydro-4,5’-retro-β,β-carotene).