

## **Betalains — The Colors of Succulents: A historical review of chemical structure work in Zürich**

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The 75th anniversary of the Zürich Succulent Plant Collection brings to mind our interdisciplinary cooperation 50 years ago. At the Organic Chemistry Institute of the University of Zürich, we had just begun to work on pigments like the ones in cactus flowers, then thought to be anthocyanins (1). Among these pigments there were the red betacyanins (2) and the yellow betaxanthins (3), together called betalains (4). We obtained plant material and expert advice from DÄNIKER of the Botanical Garden and from KRAINZ of the Succulent Collection. In appreciation of this contribution, it seems appropriate to review here briefly our work on the chemical structure of these coloring constituents:

In the first section, we mention general efforts in this field prior to 1956 in order to outline the state of knowledge at the time and to draw attention to the varied history and the apparent intractability of the problem.

In the second section, we report, in a condensed way, our own work on a typical betacyanin (2), called betanin, as follows: We extracted the pigment from the red beetroot and *inter alia* from red cactus figs. In most sources, the red betacyanins (2) were accompanied by the chemically similar yellow betaxanthins (3). The isolation of the red pigment betanin (2) via electrophoresis led to crystals and degradation afforded two nitrogen-containing fragments. This, together with spectroscopic data, allowed the elucidation of the pigment structure containing a dinitrogenous conjugated system (as in 2 and 3, marked red and yellow), which was responsible for the colours. That chromophoric skeleton differed from that in anthocyanins (1) and turned out to be the essential feature common to all betalains (4), the actual colour (red or yellow) being due to the substituents (p-hydroxyphenyl or alkyl) on the chromophore (top nitrogen), The different colour tones (from red-violet over orange and red to yellow) in the plant are determined by the ratio of betacyanin (2) to betaxanthin (3).

In further sections we summarize our investigation of the betalain biosynthesis and our elaboration of a total chemical synthesis of betalains.

In the final section, some applications of betalains (4) are mentioned.