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Physiological and Biochemical Studies on the ι -Carrageenan Producing Red Alga *Euclima uncinatum* Setchell and Gardner from the Gulf of California

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Abstract

Cystocarpic and tetrasporic plants were identified from three geographically separate populations of the endemic red alga, *Euclima uncinatum* Setchell and Gardner, at two sites on the east and one site on the west coasts of the Gulf of California, Mexico. Photosynthetic and respiratory rates of each population were determined under varying light, temperature and salinities. The physiological studies indicate that *E. uncinatum* is a stenohaline alga requiring high light levels with peak rates of photosynthesis occurring under cooler temperatures (20-28 C). Our findings suggest that cool temperatures, high salinities, and shallow tanks should be used in mariculture efforts. Also, higher temperatures may be a major cause of the annual life history reported for natural populations (Dawson 1971, Norris 1975). No distinctions could be found between sexual stages or populations in the levels of ash, protein or carbohydrate for entire plants or for carrageenan yield, viscosity, gel strength, and chemistry including molar ratios of galactose/3, 6-anhydrogalactose/ester sulfate. *Euclima uncinatum* carrageenan has a high level of sulfation, approaching, after alkali modification, the theoretical molar ratio of 0.5/0.5/1 for galactose/3, 6-anhydrogalactose/ester sulfate. The "typical" carrageenan of *E. uncinatum* is contrasted with the "deviant" ι -carrageenan found in *E. isiforme* from Florida where a lower sulfation level is apparent.

Introduction

Euclima is a pantropical genus of the red algal family Solieriaceae (order Gigartinales) that yields the economically important phycocolloid, carrageenan. Species of this genus are found in the Caribbean (Dawes 1974, Taylor 1960), the Gulf of California (Norris 1975) and the central Pacific (Doty 1973). Carrageenans are sulfated galactans extracted with hot water and used extensively as thickeners, stabilizers, and gelling agents for food processes (Silverthorne and Sorenson 1971). At present, species of *Euclima* are reported to yield κ , μ , ν or ι forms of carrageenan (Dawes *et al.* 1977). A single specimen of *E. uncinatum* Setchell and Gardner (1924), endemic to the Gulf of California, has been reported to yield a form of ι -carrageenan (Stancioff and Stanley 1969). However, Lawson *et al.* (1973) investigated the same material and reported it to be a "deviant" ι , possibly lacking ester sulfate on the sixth carbon of some of the 1, 4-linked galactose residues.

Differences in carrageenan chemistry between cystocarpic (N) and (2N) tetrasporic plants of *E. uncinatum* are not known. However, the presence of different carrageenans in other members of the Gigartinales such as *Chondrus* and *Gigartina* (McCandless *et al.* 1973, McCandless and

Cragie 1974, Pickmere *et al.* 1973) and *Iridaea* and *Gigartina* (McCandless *et al.* 1975; Waaland 1975) has been established. Tetrasporic and cystocarpic plants of four species and six populations of *Euclima* from the Caribbean were found to contain only a "deviant" lower sulfated form of ι -carrageenan (Dawes *et al.* 1977). Pacific species of *Euclima* are reported to contain only κ or only ι (Stancioff and Stanley 1969, Lawson *et al.* 1973) or a mixture of both (Doty, unpublished data).

Euclima uncinatum, in the Gulf of California, is of special interest since it has been the subject of mariculture efforts in the past with growth rates reported over 8%/day (Marine Colloids Inc., unpublished data). However, populations died off by the middle of the summer requiring collections of new plants the following early winter months for reestablishment of the farm. Occasional harvesting of natural populations (Gel Mex Ltd, unpublished data) and seasonal collections by Dawson (1961) and Norris (1975) of *E. uncinatum* led them to describe the plant as an annual.

This paper presents photosynthetic and respiratory responses of *E. uncinatum* to light, temperature and salinity in three populations from the east and west coasts of the Gulf of California. Analysis of the entire plant (percent ash, dry weight, protein, carbohydrate, pigment levels) and carrageenan (ash, sulfate, 3,6-anhydrogalactose levels; molecular weights and infrared analysis) were

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