SHORT COMMUNICATIONS

A Correlation between Oxygen Requirements and the Products of Sterol Synthesis in Strains of *Saccharomyces cerevisiae*

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Although *Saccharomyces cerevisiae* is regarded as a facultative anaerobe, oxygen may be required for the growth of the organisms. The requirement is removed if the growth medium is supplemented with ergosterol dispersed in Tween 80, and is absent if aerobically grown cells are used as the inoculum (David & Kirsop, 1973), presumably because of the high sterol content of such cells; the oxygen requirement develops after several generations of new organisms have been produced in anaerobic conditions. The magnitude of the oxygen requirement of organisms which have been produced anaerobically varies with yeast strain. A comparison of seven strains of *Saccharomyces cerevisiae* used in brewing showed that the quantity of dissolved oxygen which allowed normal growth to occur in a complex malt extract medium varied from 2 to > 12 p.p.m. (David & Kirsop, 1973). In view of the influence of oxygen on sterol synthesis, it seemed possible that this variation reflected differences between strains in the detailed sterol synthetic pathways. Anaerobically produced organisms contain little sterol (Table 1), but instead accumulate squalene (Thompson, Starr & Parks, 1971). Differences in sterol synthesis were accordingly sought by examining the sterols present in the aerobically grown, sterol-rich cultures.

METHODS

The strains of yeast used were obtained from the National Collection of Yeast Cultures (Brewing Industry Research Foundation, Nutfield, Redhill, Surrey). They differed with regard to the quantity of oxygen required in the medium in order to ensure normal growth after anaerobic propagation. In the experimental conditions used earlier (David & Kirsop, 1973) this ranged from 2 to 30 p.p.m. of dissolved oxygen, but as the precise requirement varies with the medium to which the organisms are added, values are quoted on an arbitrary scale. The yeasts were grown in a complex malt-extract medium, with or without access to oxygen, as described elsewhere (David & Kirsop, 1973). The sterol extracts were prepared by the method of Shaw & Jefferies (1953) and the extracts were analysed spectrophotometrically, by the method of Breivik & Owades (1957).

RESULTS AND DISCUSSION

The principal sterol constituents in the aerobically grown cells were ergosterol, 24(28)-dehydroergosterol and an unidentified sterol which gave maximum absorption at 208 nm – that is, at a wavelength close to but distinct from the peak given by zymosterol. This sterol is most readily detected in extracts containing relatively low quantities of dehydroergosterol.

Table 1. Sterol components of five strains of *Saccharomyces cerevisiae* with differing oxygen requirements

Yeast strain and growth condition	Magnitude of oxygen requirement (arbitrary units)	Ergosterol (%)	Dehydroergosterol (%)	Unknown sterol (<i>E</i> at 209 nm)*	Squalene (<i>E</i> at 205 nm)*
1236					
Aerobic	—	1.63	0.76	1.18	0
Anaerobic	1	0.17	0	0	0.27
240					
Aerobic	—	0.49	0.72	1.22	0
Anaerobic	4	0.17	0	0	0.22
1307					
Aerobic	—	0.81	0.54	1.0	0
Anaerobic	5	0.22	0	0	0.28
1134					
Aerobic	—	0.99	0.53	1.28	0
Anaerobic	7	0.25	0	0	0.28
1062					
Aerobic	—	1.23	0.43	1.0	0
Anaerobic	10	0.11	0	0	0.18

* Using the extraction and analytical methods described in Methods.

The total content of sterols varied relatively little with yeast strain. An exact value for the quantity of sterols extracted cannot be stated because the identity of one sterol was unknown, but its concentration did not vary greatly and such differences as were observed were not related to the magnitude of the oxygen requirement (Table 1). However, the relative quantities of ergosterol and of dehydroergosterol differed substantially from strain to strain (Table 1). Moreover, when the strains were ranked in order of increasing oxygen requirement, they were also in order of decreasing content of dehydroergosterol. It seems that dehydroergosterol is synthesized in preference to ergosterol in those strains which show least requirement for oxygen after anaerobic growth.

The presence of dehydroergosterol has been reported earlier. Breivik & Owades (1957) commented that a wide variety of strains could form as much dehydroergosterol as ergosterol. The presence of dehydroergosterol in the sterol fraction isolated from yeasts was noted by Lampen, Arnow, Borowska & Laskin (1962) and by Woods (1971). Longley, Rose & Knights (1968) showed that dehydroergosterol was the major component of the sterol fraction obtained from whole cells and from the protoplast membrane of a strain of *Saccharomyces cerevisiae*. They commented that the accumulation of dehydroergosterol did not seem to affect the ability to produce a functional membrane; the present results suggest that its preferential synthesis is possibly characteristic of yeast strains which possess a biological advantage in conditions of low oxygen availability.

When organisms containing dehydroergosterol are added to a medium in which growth is oxygen-limited, it seems that both dehydroergosterol and the unidentified sterol are converted to ergosterol, this being the only sterol detected in organisms which have ceased to grow as a result of oxygen deficiency (Table 1). The ergosterol content is then of the order of that expected if the sterols in the aerobically grown organisms had been converted to ergosterol, which had then been diluted by growth.

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