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Book Reviews

Biotechnology: A Comprehensive Treatise in 8 Volumes. Volume 3. *Biomass, Micro-organisms for Special Applications, Microbial Products I, Energy from Renewable Resources.* Edited by H.-J. Rehm and G. Reed, Weinheim; Deerfield Beach, Florida; Basel: Verlag Chemie. 1983, 642 pages, DM 495.

Volumes 3 and 5 are the second and third of this major eight-volume series to be published, though the original titles of these volumes are retained. However, the order of publication is not important, since each volume has its own editor and contributors and forms a separate entity, with occasional linkage between volumes by cross-referencing. The 32 authors who contribute to the present volume discuss a variety of loosely related topics in applied microbiology, generally in an authoritative manner. The articles cover the conversion into microbial biomass of a number of raw materials – carbohydrates, higher *n*-alkanes, methane and methanol; biomass from phototrophic microalgae and from edible mushrooms (including truffles); use of microbes for special applications – starter cultures, soil amelioration, microbial insecticides; microbial products – ethanol, some organic acids, amino acids, extracellular polysaccharides, emulsifiers and de-emulsifiers; and finally the use of microbes to obtain energy from renewable resources – particularly to produce ethanol and methane for fuel.

Varied technical problems remain in all these areas, whether the applications are simple or highly sophisticated. An example of the former is the use of domestic 'biogas' plants to produce methane by anaerobic digestion of animal and human excreta and other waste products. Developed in India, these have been taken up enthusiastically in China, where some seven million household-sized units have been built since 1970. These produce 1–2 cubic meters of gas a day – enough to generate about 2 kWh of electricity. Technical problems remain in making them cheaply out of local materials (the Indian design costs as much as a year's earnings of the average rural household to build) and in making them sufficiently leak-proof to be efficient, while the complex bacterial interactions involved in the digestion process (numerous microbial species and three successive stages have been recognized) are still not fully understood. The same processes are used in many large-scale sewage plants, but here the methane gas evolved is generally wasted.

Ethanol fermentation is examined in great detail by Kosaric *et al.*, in the longest chapter in the book, which deals thoroughly with the microbiology, chemistry and technology of different fermentation systems, and discusses energetic and economic aspects. Raw materials include not only sugar and starch crops, but also waste sulphite liquor, whey from cheese factories (1 litre of 100 % ethanol can be obtained from 42 litres of whey containing 4·4 % lactose, but the yield can be increased by treatment of the whey with β-galactosidase). Lignocellulosic materials from agricultural, domestic and industrial wastes can also be used. Each raw material requires a particular pretreatment, e.g. treatment of cellulosics with cellulase from *Trichoderma reesii* – a soil fungus first isolated from a rotted cartridge belt in New Guinea 40 years ago. The traditional alcohol fermenters are yeasts, but recent work indicates that some anaerobic bacteria, e.g. *Zymomonas mobilis*, are much more efficient fermenters under certain conditions. This is partly due to the fact that the bacteria can use the Entner–Doudoroff pathway, while yeasts need oxygen for cell-wall synthesis and maintenance of cellular processes and must use the Embden–Meyerhof pathway. It has been calculated that use of *Z. mobilis* in place of *S. cerevisiae* in a 150 m^3/day continuous fermentation unit should give a 20 % reduction in operating costs and a 30 % drop in fixed investment costs. Another new development of great interest is the use of immobilized cell systems, which can give a much increased productivity, whether based on yeast or bacteria. The problems of extracting and purifying the ethanol and other useful by-products were also examined.

Additional information of interest is to be found in the short article by Barnard and Hall, which overlaps that of Kosaric *et al.* Ethanol from sugar for fuel if of major importance in Brazil in saving foreign currency (their ethanol target for 1985 is about 10 billion litres). However, if the price ratio of sugar to oil, measured as $ per ton of sugar to $ per barrel of oil, is greater than 5·8, more foreign exchange is earned by exporting sugar than by producing ethanol. This was the case in April 1982 (sugar price $250 ton) but the position was reversed in June 1982 when the sugar price fell to $150 per ton. Ethanol has some advantages as automobile fuel over gasoline, with which it can be mixed to improve engine efficiency and give cleaner exhaust gases. This article also discusses socio-economic aspects, including the deleterious effect which the great increase in sugar-cane production has had on the rural areas of Brazil.

Surfactants, traditionally made from petrochemicals and lipids of plant and animal origin, play an important role in numerous industrial processes. A new source of these surface-active agents, discussed in another article by Kosaric and others, is being found in the lipids and lipid derivatives produced by microbes during growth, including microbial cell surfaces which can act as solid-phase de-emulsifiers. Both the nature of the hydrocarbon substrates and the age of the culture can have marked effects on the characteristics of the biosurfactant obtained from a particular microbial strain, and the possibilities of genetic modification are also obvious. A variety of surfactant properties can be obtained from different microbes, and this new technology could be of considerable benefit to industry. Sutherland discusses a related field, the production of extracellular polysaccharides with particular properties. Zanthan from *Zanthomonas campestris* is the only microbial polysaccharide in large-scale industrial production at present, with patents covering its use in a variety of applications in food, pharmaceutical and other industries. Dextrans, which can actually be made in a cell-free system, form the basis of the Sephadex products which play an important part in modern biochemical analysis; they also have pharmaceutical and possible clinical uses. The potential here should be considerable.

To the geneticist the most interesting chapter will be that of Soda, Tanaka and Esaki on amino acids. The world production is now about 500000 tons, valued at nearly 2 billion US$. In price terms, 48% is used for food, 22% for feed and 30% (only 4% by total weight) for medicines, cosmetics and chemicals. The output leader in both tonnage and price is L-glutamic acid, used as monosodium L-glutamate (350000 tons in 1980) for food seasoning – the L-enantiomer stimulates the taste receptor of the taste bud, and its flavour-enhancing action is increased sixfold by adding 12% sodium inosinate. The authors describe in considerable detail the genetic tailoring of bacterial strains to over-produce particular amino acids: these include single or multiple auxotrophic mutants which are unable to effect negative feedback (e.g. Phe^-, His^-, Ile^- *Corynebacterium glutamicum* for L-leucine production), and regulatory or auxotrophic-regulatory mutants for amino acids which themselves cause end-product inhibition or repression (e.g. L-histidine from a strain of *Serratia marcescens* which is $histidase^-$ and resistant to 1, 2, 4-triazole alanine and methyl histidine). Other production methods – enzymic and chemical synthesis – are also described.

This volume contains much that should be of interest to ecologists and those concerned with the environment, as well as to applied microbiologists and biologists in general. What emerges clearly is that the steps from laboratory to pilot-plant to success on an industrial scale are usually large ones, taking up to ten years in the ascent. Genetic engineering has yet to make a significant impact in the fields discussed here.

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