# Matching science and economics for *Dunaliella* biomass production in India

Halotolerant microalga *Dunaliella*, which is exploited for the production of dried biomass or cell extract, is used as a medicinal food. With the advancement in this field in recent years, the production of bioorganic compounds such as $\beta$-carotene has been established in many countries[1]. *Dunaliella* is the emerald molecule of nutraceutical hope for the whole world with the dawn of this new century. *Dunaliella* algae production does not compete with the agrofood industry because the biomass can be grown on desert lands without freshwater and no or few fossil fuels. *Dunaliella* uses sunshine, carbon dioxide, waste or brine water with natural nutrients. It can use green energy for supporting biomass growth such as solar or wind. Production potential exists round the globe; however, cost-intensive production from intensive-type culture systems has resulted in escalating natural $\beta$-carotene prices. This has stalled the industry in a country like India, raising a host of research needs. Interestingly, there is a large, growing/manufacturing shortfall for *Dunaliella*, warranting requirement of more production capacities.

The challenges of commercializing algae production and their applications in energy production or other product applications are numerous. Fundamental technological questions are – Where to grow the algae? Which strains to choose? How to boost productivity? How to design the most cost-effective production system? Is earthen-pond *Dunaliella* culture technology the opportune way to beat high $\beta$-carotene prices? The high cost of production arises to a large extent from the lack of a clear understanding of the factors that govern the productivity of microalgae in large reactors. Capabilities and limitations of open system vs closed system need to be practically realized for coastal India. Research needs to examine and compare both the systems for the costs, land needed, tools required and productivity values involved. Irreversible system faults and maintenance costs need to be weighed and outweighed for both the systems. It must be noted that almost no information is available in India on the design, operation, yields, farm-gate production costing and other vital aspects of commercial open-pond algal production. At >25% NaCl levels, *Dunaliella* emerges as the unchallenged competitor, where hypersaline extremophilic media is the ecological defence mechanism here. *Dunaliella salina* production in Australia and Abu Dhabi presently uses large saline evaporation ponds (200 ha each), with the algae dominating naturally in >200 g/l of salt.

Relatively sparse growth occurred with this algal industry for three reasons: novelty product, intellectual property (IP) protections and avaricious claims. Minimal credible research has examined this new industry and most of the major firms are extremely discreet in holding technology obscure. IP protections for proprietary strains of algae are carefully protected and proprietary production methods undermine new scientific collaboration[2].

*Dunaliella* production strategies include open ponds, natural settings and closed alga culture systems. Eco-friendly harvesting technology, for example, dissolved air injection and froth floatation skimming processes, modified starch and alkali-induced or biopolymer flocculation must similarly be rendered adaptable to fit local needs. If private firms lock up the harvest preservation methods, then sustainable world food solutions even when they exist, are likely to be beyond the financial means of the people who need them the most. Widespread adoption and diffusion require open source, public access to technologies. Lack of government R&D investment has pushed the industry towards private investment.

Biofactories can be scaled from a few acres to large farms that recycle industrial $CO_2$ emissions into algal biomass. Open earthen pond technology allows deployment nearly anywhere there is sunshine. *Dunaliella* can engineer economic hope for a better life for billions of coastal people who live within 1000 m from the coastline. However, *Dunaliella* is still not a well-studied group from a biotechnological point of view in India. The country needs to improve upon the open earthen pond systems to become more competitive and more economically feasible for scientific commerce. The potential is immense for India, but the research screening for open cultivation remains limited. The biotechnology industry is at risk of losing billions of dollars through $\beta$-carotene imports owing to delayed Indian products in the next few decades. The future of Indian biotechnology in the mass production of *Dunaliella* biomass as an important industrial endeavour rests to a great extent on the development of research by the Ministry of Science and Technology in the days to come.

1. Raja, R., Hemaiswarya, S. and Rengasamy, R., *Appl. Microbiol. Biotechnol.*, 2007, **74**, 517–523.
2. Edwards, M., The Algal Industry Survey, Arizona State University & Centre for Management Technology, February 2009.

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