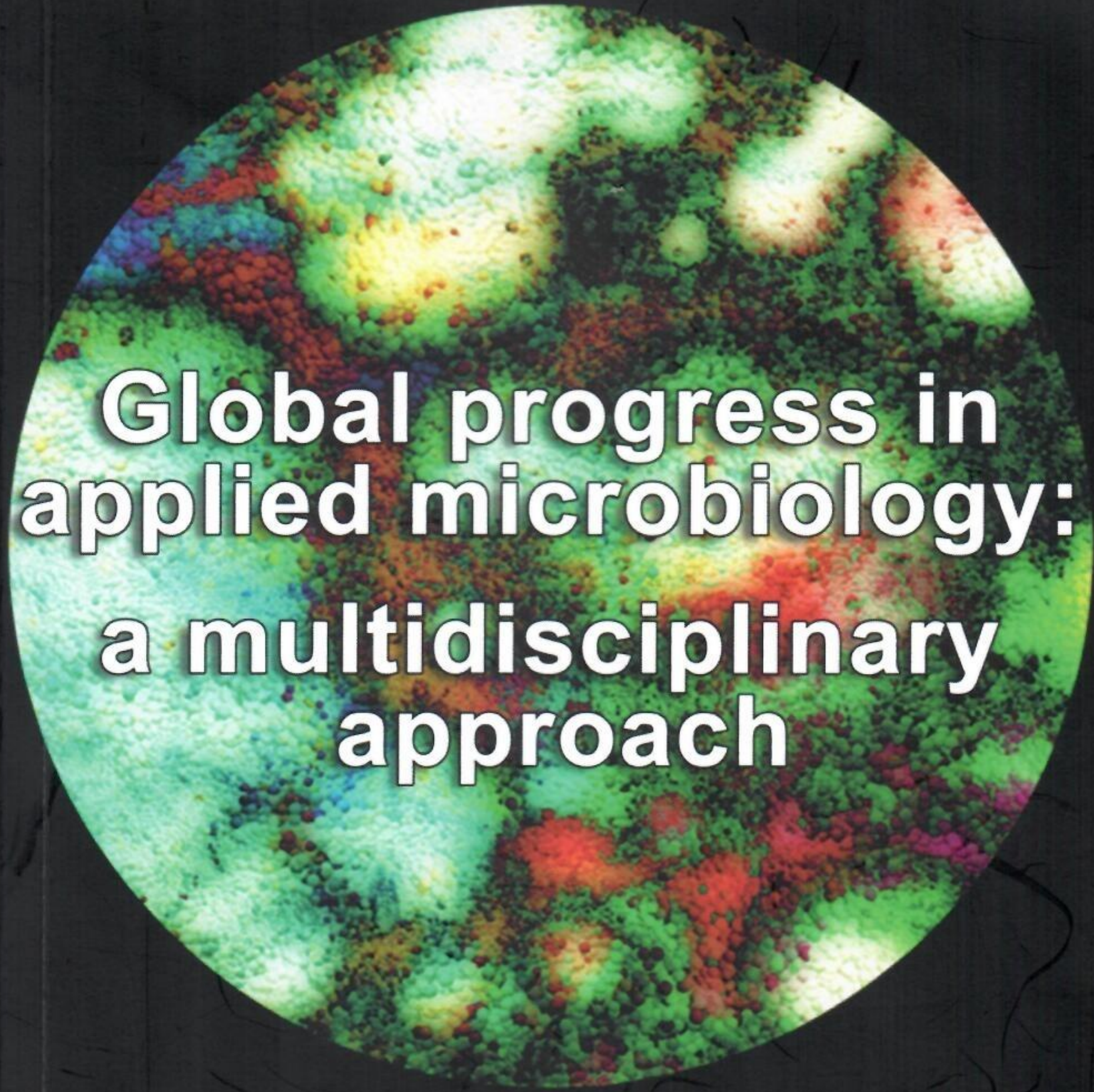

Global progress in applied microbiology: a multidisciplinary approach

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Introduction

Saccharomyces cerevisiae exposed to titanium dioxide nanoparticles of less than 100 nm in size under heat shock partially reverted glucose-mediated repression of the citrate cycle

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Energy metabolism in yeast cells can be manipulated by providing different carbon sources: *Saccharomyces cerevisiae* grown on glucose rapidly proliferates by means of fermentation, whereas in non-fermentable carbon sources, such as glycerol, metabolism shifts towards respiration. In general, fermentation is preferred by the yeast in rapidly proliferating cells even in the presence of oxygen, a process also called the Crabtree effect. In the present study, it was observed that the addition of glucose to *S. cerevisiae* UE-ME$_3$ grown in a glycerol-rich medium caused an increase in the growth-marker enzyme alkaline phosphatase and a blockage of respiratory enzymes. In addition, the simultaneous exposure of yeast cells to TiO_2-NP <100 nm (5 μg/mL) under heat shock (28/40), after 100 min of culture in respiratory-fermentative mode, caused a partial reversion of glucose-mediated repression of citrate synthase and succinate dehydrogenase activities, key-enzymes of the citrate cycle, and a decrease in the level of alkaline phosphatase activity similar to those detected in cells grown in respiratory mode.

Keywords: alkaline phosphatase; pyruvate kinase; citrate synthase; succinate dehydrogenase; nanomaterials

1. Introduction

The survival of living organisms depends on their ability to mobilise the energy accumulated in the chemical bonds of the nutrients to ensure their functioning [1] [2] [3]. The accumulation of O_2 in the terrestrial atmosphere, as a byproduct of photosynthesis, allowed some prokaryotic organisms to use the oxidising power of this molecule in more profitable processes of the mobilisation of the chemical potential of the nutrients that later gave rise to cell respiration [4]. Most yeast species are able to convert carbohydrates as glucose into ethanol and carbon dioxide. However, this property does not lead to a good specific growth rate in the total absence of O_2 [5] [6] [7]. Although the level of environmental O_2 is a key-regulator of glucose metabolism in yeast, since it is also capable of converting carbohydrates into CO_2 and H_2O via respiratory metabolism, fermentation often predominates over respiration when levels of glucose in the medium are high, even under aerobic conditions, thus allowing the reoxidation of NADH, generated by glycolysis, a process described as the Crabtree effect [8] [9] [10]. This phenomenon occurs due to the inactivation of the respiratory metabolism by glucose and does not depend on O_2 availability [11].

Wine strains such as UE-ME$_3$ preferentially consume glucose by means of alcoholic fermentation [12] [13] [14]. The conversion of pyruvate, a product of the glycolytic pathway, into ethanol involves two enzyme steps: pyruvate decarboxylase and alcohol dehydrogenase.

Ethanol, after diauxic transition, is metabolised by the respiratory pathway, leading to the coupled formation of ATP. *S. cerevisiae* can thus metabolise a wide variety of carbon sources, including non-fermentable compounds such as ethanol or glycerol [15]. The oxidative metabolism of these compounds through the citrate cycle and the mitochondrial electron transport chain is more efficient in the production of ATP, although the use of O_2 as a final electron acceptor may contribute to generating reactive oxygen species (ROS), such as the superoxide anion radical, which is potentially damaging to the cell [16].

Pyruvate, the end-product of glycolysis, is released into the cytoplasm and transported to the mitochondrial matrix where, after conversion to acetyl-CoA, it is metabolised by the citrate cycle to generate reducing equivalents used by the respiratory chain during oxidative phosphorylation. Under fermentative conditions, the availability of pyruvate to the citrate cycle is greatly constrained while its cytoplasmic metabolism is activated.

The Crabtree effect or catabolic repression of respiratory metabolism by glucose, detected in several yeast species, is similar to the aerobic glycolysis of tumour cells which have a high rate of glycolysis. Glucose breakdown yields ATP and it also provides intermediaries for several anabolic and antioxidant pathways that lead to the rapid growth and proliferation of cancer cells.

Thus, the selection of *S. cerevisiae* for evaluating the biological effects of new materials with a wide environmental dissemination, such as TiO_2-NP with regard to its energy metabolism, may be a suitable option.