Catalytic degradation of lactose by β-galactosidase entrapped in a silica gel matrix

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Lactose intolerance is one of the most common food intolerances; it represents the inability to digest lactose[1]. Lactose is a disaccharide that consists of one glucose molecule linked to a galactose molecule; to be digested, lactose needs to be cleaved into its subunits, which are then adsorbed in the bloodstream. If lactose passes indigested from the small intestine into the colon it can cause physiological effects that result in clinical manifestations such as abdominal pain, bloating, flatulence and diarrhea, typical symptoms of *lactose intolerance*[2]. Lactose intolerance is due to a deficiency of lactase, an enzyme present on the brush border of small intestine responsible for the hydrolysis of lactose[1,2]. Actually dietary supplements containing bacterial or yeast β-galactosidase (EC 3.2.1.23) are commercially available, in tablets or capsules to be taken just before or with meal[3]. The major lack of these formulations is the rapid denaturation of the enzyme in the intestinal environment, thus forcing to several assumptions during the day.
The aim of our work was to improve the performance of lactase as dietary supplement for the treatment of lactose intolerance. We tried to prolong the activity of β-galactosidase by its entrapment in a porous matrix, to avoid a direct contact of the enzyme with the surrounding medium, thus increasing its stability.
We made ready an effective procedure for the immobilization of β-galactosidase in a three-dimensional network of silica, which is an inert, biocompatible and resistant material. A one-step approach was optimized by using the sol-gel method; this technique is particularly suitable for entrapping host molecules because it is non-invasive and preserves the integrity of the guest. Homogeneous and stable systems were obtained, regardless of the enzyme concentration introduced in the silica gel; we found that a complete reticulation of the matrix (which requires 21 days) is necessary to obtain a reproducible behaviour.
We studied, in particular, the stability of the β-galactosidase/silica gel composites towards pH and temperature, in order to evaluate the effectiveness of the immobilization technique. The activity of the free and of the immobilized β-galactosidase was evaluated in the hydrolysis of o-nitrophenyl-β-D-galactopyranoside (an artificial substrate used instead of lactose) at pH 7.4 and 37°C, in order to reproduce the human intestine conditions. A remarkable increase of the enzyme stability was obtained: after 3 hours at pH 7.4 and 37°C the encapsulated enzyme activity was 20% higher than that of the free enzyme, and after 24 hours the system still preserves 60% of its initial activity.
Our work can represent the starting point for the realization of a new pharmaceutical formulation for the treatment of lactose intolerance, capable of explaining its therapeutic action for a long period of time.

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