Catabolism of Glucose and Lactose in Bifidobacterium animalis subsp. lactis, Studied by 13C Nuclear Magnetic Resonance.

Bifidobacteria are widely used as probiotics in several commercial products; however, to date there is little knowledge about their carbohydrate metabolic pathways. In this work, we studied the metabolism of glucose and lactose in the widely used probiotic strain Bifidobacterium animalis subsp. lactis BB-12 by in vivo 13C nuclear magnetic resonance (NMR) spectroscopy. The metabolism of [1-13C]glucose was characterized in cells grown in glucose as the sole carbon source. Moreover, the metabolism of lactose specifically labeled with 13C on carbon 1 of the glucose or the galactose moiety was determined in suspensions of cells grown in lactose. These experiments allowed the quantification of some intermediate and end products of the metabolic pathways, as well as determination of the consumption rate of carbon sources. Additionally, the labeling patterns in metabolites derived from the metabolism of glucose specifically labeled with 13C on carbon 1, 2, or 3 in cells grown in glucose or lactose specifically labeled in carbon 1 of the glucose moiety ([1-13C]lactose), lactose specifically labeled in carbon 1 of the galactose moiety ([1-13Cgalactose]lactose), and [1-13C]glucose in lactose-grown cells were determined in cell extracts by 13C NMR. The NMR analysis showed that the recovery of carbon was fully compatible with the fructose 6-phosphate, or bifid, shunt. The activity of lactate dehydrogenase, acetate kinase, fructose 6-phosphate phosphoketolase, and pyruvate formate lyase differed significantly between glucose and lactose cultures. The transcriptional analysis of several putative glucose and lactose transporters showed a significant induction of Balat_0475 in the presence of lactose, suggesting a role for this protein as a lactose permease. This report provides the first in vivo experimental evidence of the metabolic flux distribution in the catabolic pathway of glucose and lactose in bifidobacteria and shows that the bifid shunt is the only pathway involved in energy recruitment from these two sugars. On the basis of our experimental results, a model of sugar metabolism in B. animalis subsp. lactis is proposed.