Salmonella savors flavors

Salmonella is a common bacterial pathogen that causes a type of food-poisoning in humans (salmonellosis) which is characterized by diarrhea, fever, vomiting, and abdominal cramps. In general, the illness is self-limiting and most people recover without treatment. Salmonellosis usually results from the consumption of contaminated meat, poultry and eggs. *Salmonella* colonizes the intestinal tract a variety of food animals and typically enters the human food supply through the contamination of animal carcasses during slaughter or the contamination of eggs during egg production. *Salmonella* is unable to break down complex carbohydrates in its host's diet, and must scavenge simpler compounds released by the action of the primary degraders in the intestinal tract which constitute the bulk of the normal microflora.

Salmonella was recently reported to use fructoselysine and glucoselysine for growth via a phosphotransferase system (PTS) and associated deglycase enzymes. Phosphotransferase systems transport certain sugars into bacterial cells. The sugar is modified by the addition of a phosphate group as it is transported across the cell membrane. Figure 1 illustrates the transport of fructoselysine and glucoselysine by the PTS and the subsequent breakdown of the resulting phosphorylated compounds by the action of the associated deglycases.

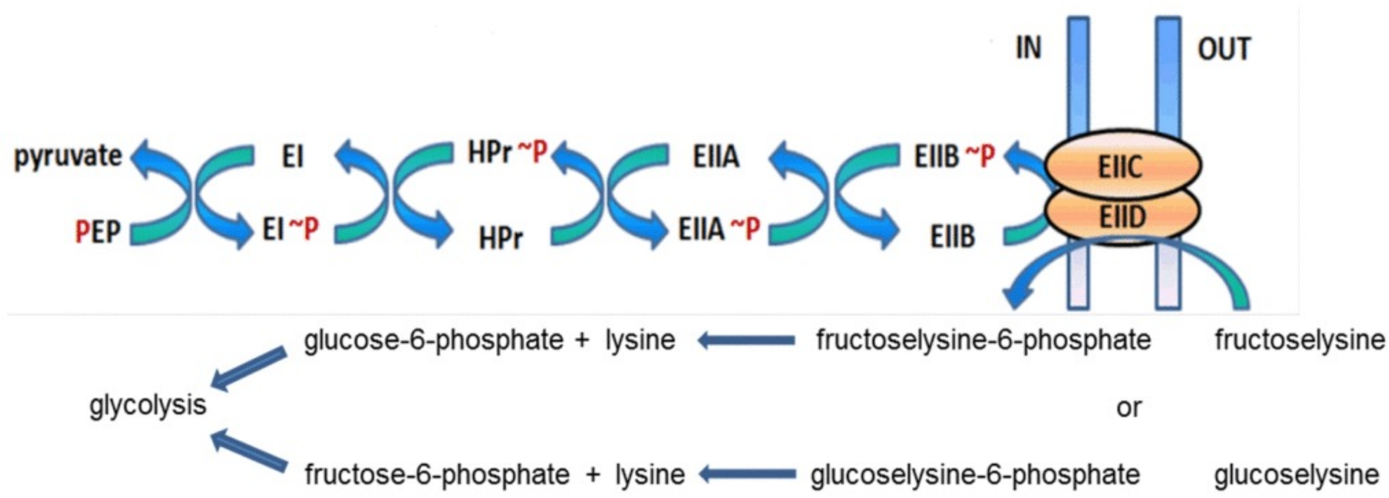

Fig. 1. Transport and metabolism of fructoselysine and glucoselysine in Salmonella. Fructoselysine and glucoselysine are transported by a phosphotransferase system in Salmonella. A phosphorylation cascade occurs in which a phosphate originating from phosphoenolpyruvate (PEP) is transferred through a series of proteins to the sugars of fructoselysine and glucoselysine as they are transported across the cell membrane. Inside the cell, fructoselysine-6-phosphate and glucoselysine-6-phosphate are hydrolyzed by the action of deglycase enzymes to release lysine along with glucose-6-phosphate and fructose-6-phosphate, respectively. The released phosphorylated sugars are further metabolized through glycolysis.

Fructoselysine and glucoselysine are examples of Maillard reaction products, which are compounds formed by the reaction of sugars with compounds that contain primary amines, such as amino acids. Maillard reaction products are important in food chemistry as they are responsible for the aromas and flavors associated with many foods. For example, Maillard reaction products are formed when sugars combine with amino acids as meats are cooked, and these compounds are responsible for the "meaty" flavor associated with cooked meat. The Maillard reaction occurs optimally around 150^{o}C to 260^{o}C, but does occur at ambient temperatures. Fructoselysine is formed when glucose reacts with the amino acid lysine, followed by a molecular rearrangement of the sugar. Similarly, glucoselysine is formed from the reaction of fructose with lysine, followed by a rearrangement of the sugar.

In addition to fructoselysine and glucoselysine, *Salmonella* can use other Maillard reaction products for growth. Ali and co-workers recently reported that *Salmonella* possesses an uptake and utilization pathway for fructose-asparagine. Fructose-asparagine is thought to be converted to fructose-aspartate by an enzyme known as an asparaginase before the compound is transported into the cell. The gene encoding the asparaginase is associated with the other genes required for transport and utilization of fructose-asparagine. The fructose-aspartate formed outside the cell is transported across the cell membrane by a permease rather than a PTS as occurs with fructoselysine and glucoselysine. In addition to the genes required for utilization of fructoselysine and glucoselysine, *Salmonella* possess set of genes which encode another PTS and two predicted deglycases which may have roles in the transport and utilization of other Maillard reaction products. Thus, *Salmonella* appears to be somewhat unique in its ability to use Maillard reaction products for growth. Primary degraders in the intestinal tract likely release Maillard reaction products from modified proteins in the host diet, but do not appear to use these compounds. Given the novelty of these nutrients, the systems for utilizing Maillard reaction products may prove to be new therapeutic targets for reducing the incidence of *Salmonella* contamination in foods.

Publication

A Mannose Family Phosphotransferase System Permease and Associated Enzymes Are Required for Utilization of Fructoselysine and Glucoselysine in Salmonella enterica Serovar Typhimurium.
Miller KA, Phillips RS, Kilgore PB, Smith GL, Hoover TR
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