Carbon metabolism in Streptococcus thermophilus regulation and diversity within the species

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Carbon metabolism in *Streptococcus thermophilus*: regulation and diversity within the species

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Context — *Streptococcus thermophilus*…

- A lactic acid bacterium widely used in dairy industry.
- Well adapted to the dairy environment thanks to a high efficient use of lactose.
- Used in new fermented products (dairy matrices supplemented with sugar or in plant-based food), containing a variety of carbohydrates in mixes.

Objectives

- What are the sugars consumed in *S. thermophilus*?
- How is sugar metabolism regulated?
- Is there a diversity?

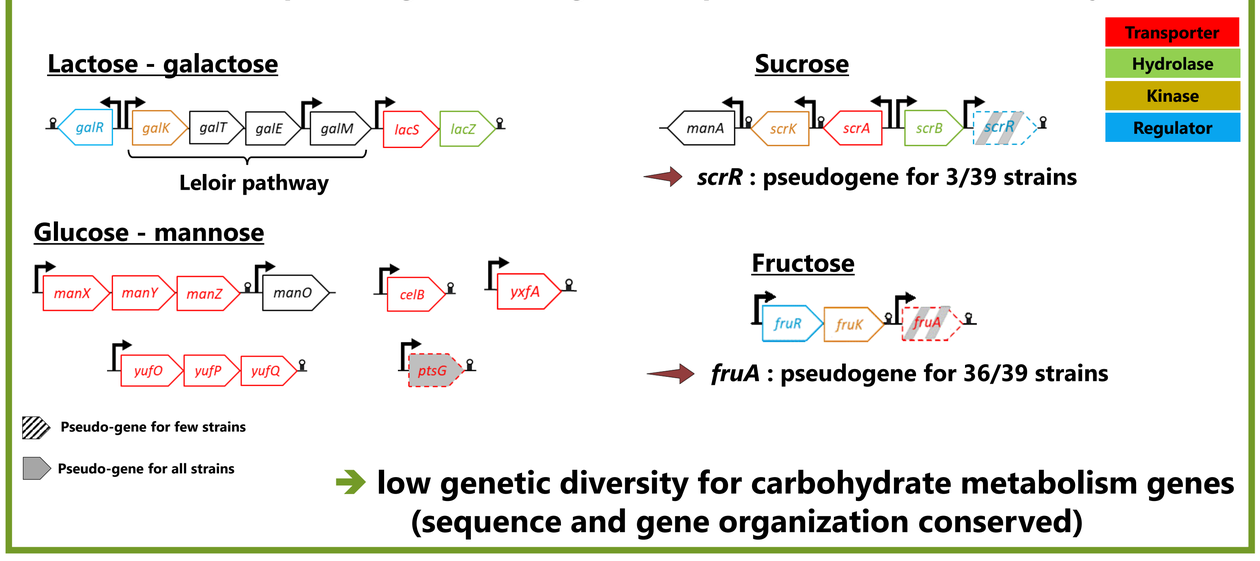
Methods

- Screen and comparison of genomes of 39 *S. thermophilus* strains for potential carbon metabolism (CM) genes.
- Growth and acidification assessment (M17 medium)
- CM gene promoter activities (transcriptional fusions)
- Dosage of sugars (HPLC)

carbon source:
single lactose, sucrose, glucose, galactose, fructose or sugar mixes

In silico analysis

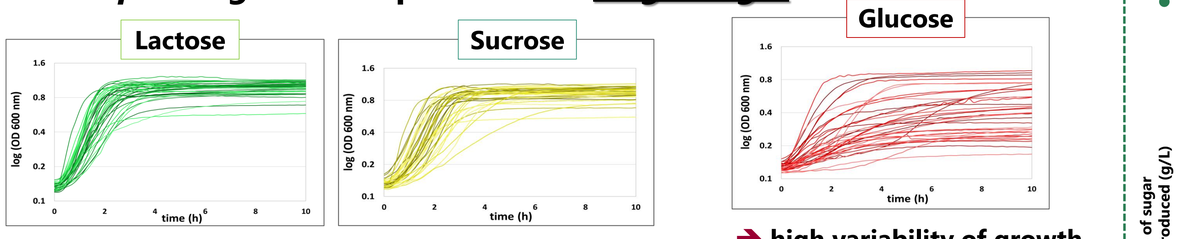
- The 39 strains possess genes coding for the potential use of 5/6 carbohydrates



➔ low genetic diversity for carbohydrate metabolism genes (sequence and gene organization conserved)

Bacterial growth and sugar consumption

- *S. thermophilus* growth in presence of <u>single sugar</u>



➔ ➔ growth of all strains – high final biomass

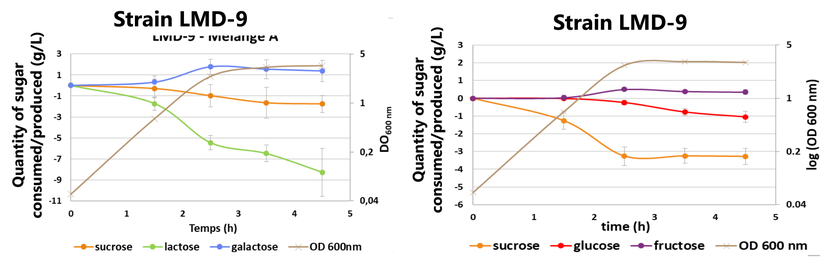
➔ high variability of growth despite of high conservation of all CM genes

➔ no/low growth for most srains

➔ growth of the 4 strains having an intact *fruA* gene

➔ Growth of one strain Gal+, which presents a specific mutation in the promoter region

- High growth of *S. thermophilus* in "dairy-like" ( ) and "plant-like" ( ) <u>sugar mixes</u>



- when mixed:

➔ lactose is preferentially consumed over sucrose

➔ sucrose is préferentially consumed over glucose

- For St310 strain

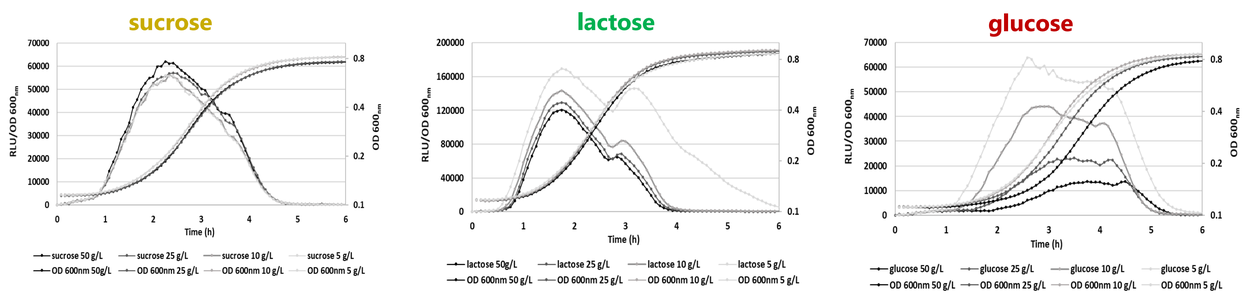
➔ lactose and sucrose are consumed, at a lower level than LMD-9 strain in "dairy-like" mix

➔ no glucose consumption in "plant-like" mix, contrary to LMD-9 strain

Regulation of carbohydrate metabolism genes

- *lacS* promoter activity, in presence of various amount of:

single sugar



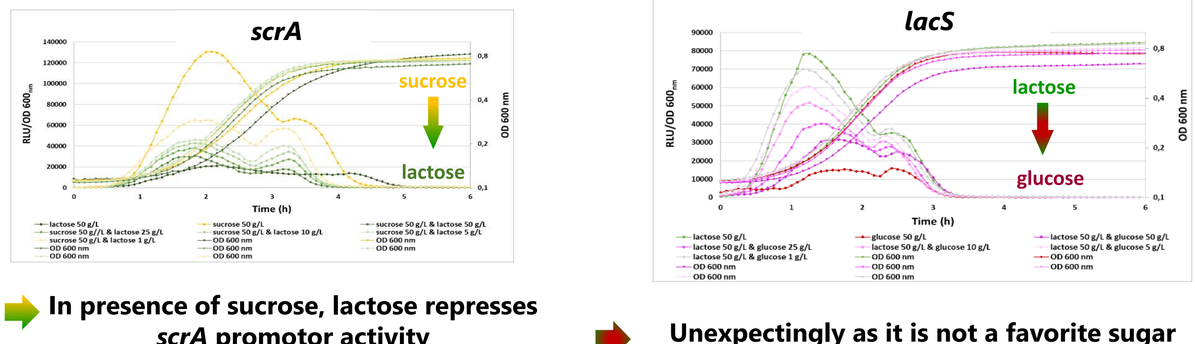
➔ No effect of sucrose concentration

➔ Repression, proportional to the lactose concentration, especially at low concentration

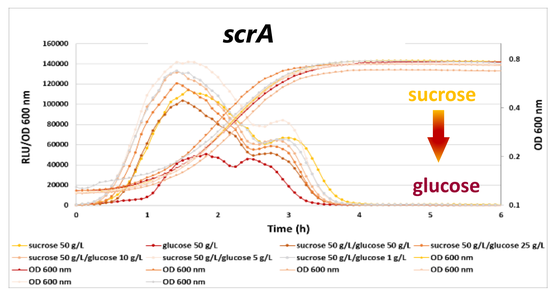
➔ Marked repression, proportional to the glucose concentration

- *scrA* and *lacS* promoter activities in presence of 2 sugars

sugar mixes



➔ In presence of sucrose, lactose represses *scrA* promotor activity



➔ Unexpectingly as it is not a favorite sugar compared to lactose, glucose represses *lacS* promoter activity in presence of lactose

➔ Surprisingly, in presence of sucrose, glucose activates *scrA* promoter activity when present at concentrations < 25g/L

- Identical pattern for *scrA* promoter activity: repression by lactose and glucose
- Correlation between promoter activities of the *lacS* and *scrA* genes and the glycolytic flux (data not shown)

Conclusions

- *S. thermophilus* ferments 4 carbohydrates, conducting to different growth level according to strains and sugars.
- *S. thermophilus* is able to co-consume several sugars: lactose & sucrose / sucrose & glucose.
- Glucose is transported by the sucrose transporter ScrA in LMD-9 strain (data not shown).
- Lactose represses the promoter activity of its own transporter gene and that of sucrose transporter gene *scrA*.
- The regulatory effect of glucose on carbohydrate metabolism genes is unexpected and complex; it is not explained yet.

A low genetic diversity of carbohydrate metabolism genes in *S. thermophilus* in contrast with a high phenotypic diversity, that could be related to different gene regulations

Reference: Gasser et al. Co-utilization of saccharides in mixtures: moving toward a new understanding of carbon metabolism in *Streptococcus thermophilus*, Int J Food Microbiol, in revision.

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