

# Diversity of carbohydrate utilization and uptake regulation in *Streptococcus thermophilus*

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## Context and objectives

### *Streptococcus thermophilus*



- A lactic acid bacterium widely used in dairy industry.
- A wide diversity of strains used in various products.



- Has evolved and adapted to the dairy environment through a very efficient use of lactose.



- Is used in new fermented products (dairy matrices supplemented with sugar or in plant-based food), containing a variety of carbohydrates in mixes.

## Methods

- Genomes of 39 strains were compared by searching for genes potentially involved in carbon metabolism.
- Utilization of galactose, fructose, glucose, sucrose and lactose, in mixture or not, was established by simultaneous monitoring of growth/acidification of the medium (M17) and dosage of the carbohydrates (HPLC) during growth.
- Promoter activities were studied with transcriptional fusions, in lactose, sucrose & glucose at 50, 25, 10, 5 and 1 g/L.

How are sugars consumed in *S. thermophilus* species?  
How is sugar metabolism regulated?

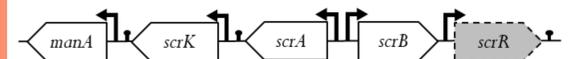
## Results: *in silico* analysis, growth and sugar consumption

- The 39 strains have operons coding for the use of 5 carbohydrates

### lactose/galactose operon



### sucrose operon

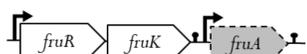


→ *scrR* : pseudogene for 3/39 strains

### glucose operon

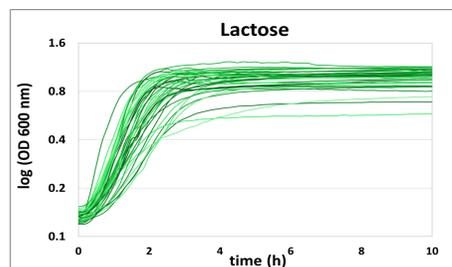


### fructose operon

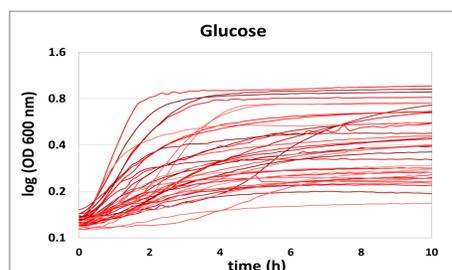
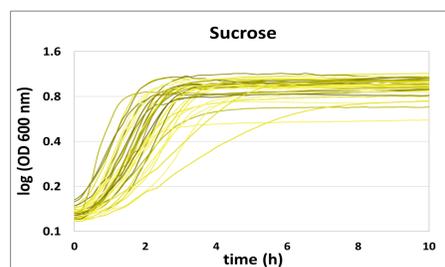


→ *fruA* : pseudogene for 36/39 strains

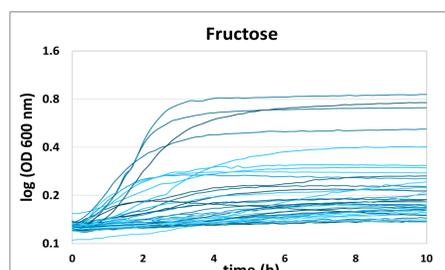
- The only genetic diversity between strains is localized in the sucrose operon repressor *scrR* and the fructose PTS transporter *fruA*



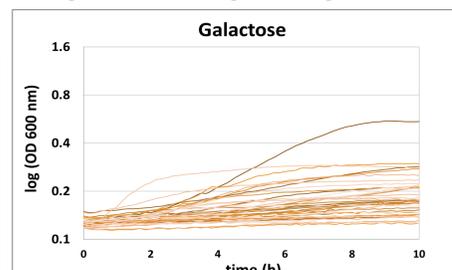
• lactose and sucrose: growth for all strains – high final biomass



• glucose: heterogeneous growths

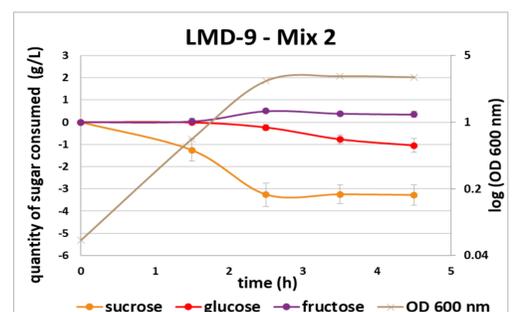
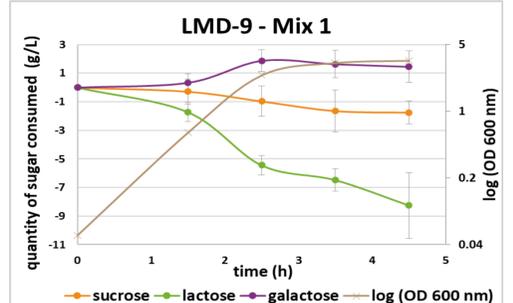


• fructose: growth for 3 strains (intact *fruA* gene)



• galactose: no/low growth

Sugar consumption by strain LMD-9 in dairy-like mix (up) and in a plant-like mix (down)

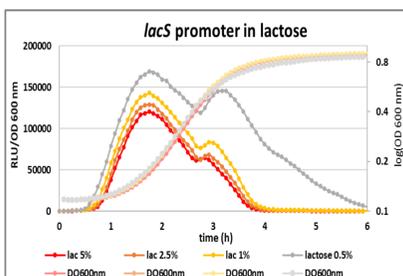


- Higher consumption of lactose over sucrose in mix 1
- Higher consumption of sucrose over glucose in mix 2

## Results : regulation

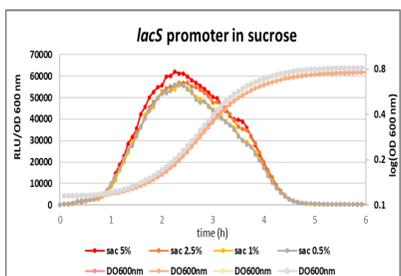
Lactose operon promoter activity, in presence of :

- lactose



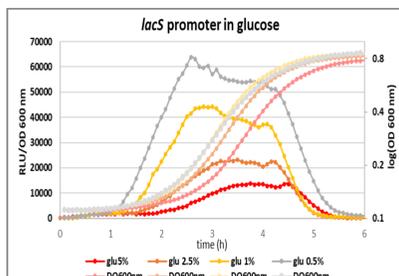
Activation, especially at low lactose concentration (0.5%)

- sucrose



No influence of sucrose concentration

- glucose



Repression, proportional to the glucose concentration

Identical scheme for sucrose (*scrA*) promoter activity

## Conclusion

- *S. thermophilus* ferments 4 carbohydrates, with different efficiency for growth according to strains
- In sugar mixes, lactose is preferentially consumed
- Sucrose is always consumed, whatever the sugars present in its environment
- Regulation by glucose :
  - high repression of lactose and sucrose promoter activity
  - catabolic repression ?
  - no modulation of *galR/scrB* promoter activity

The better comprehension of the carbon metabolism and regulations involved in will allow to better control and orient *S. thermophilus* physiology in dairy or plant matrices