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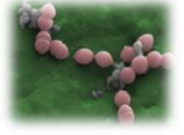
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Carbon metabolism in *Streptococcus thermophilus*: co-utilization in mixtures and role of sugar nature and concentration in gene regulation



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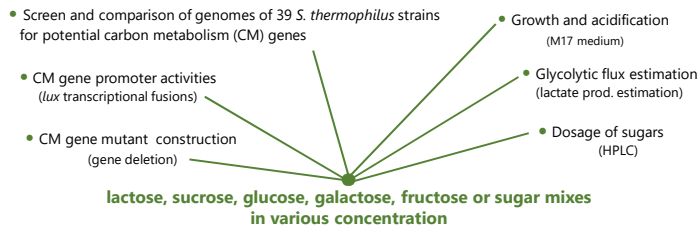
Context

Streptococcus thermophilus is a bacterium widely used in the production of yogurts and cheeses, where it efficiently ferments lactose, the saccharide naturally present in milk. However, when used in sweetened dairy products or plant-based products, *S. thermophilus* may encounter other saccharides (i.e. alone or in mixtures). To date, *S. thermophilus* growth and metabolic capacities in such contexts as well as carbon metabolism regulation mechanisms remain poorly characterized.

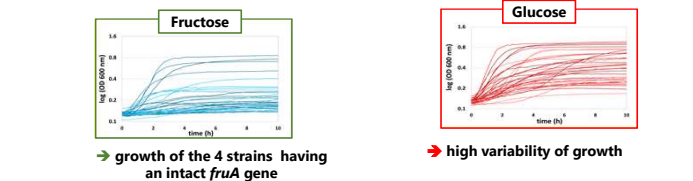
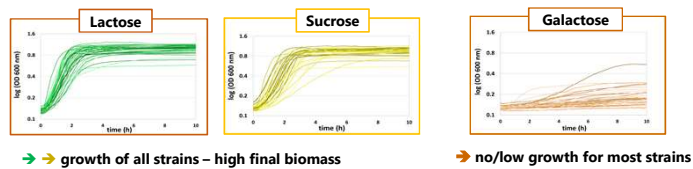
Questions

- Is there genetic and/or phenotypic diversity of sugar use in *S. thermophilus*?
 - What are the sugars consumed?
 - How is sugar metabolism regulated?
- in presence of single or mix sugars

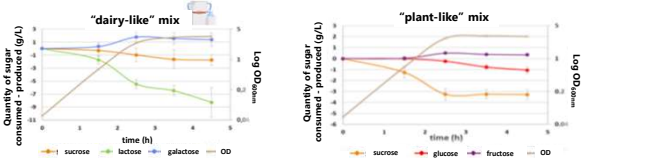
Methods



Bacterial growth, sugar consumption and glycolytic flux

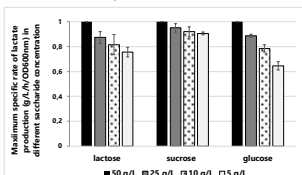


- S. thermophilus* LMD-9 first consumes
 - lactose over sucrose
 - sucrose over glucose
 when sugars are mixed



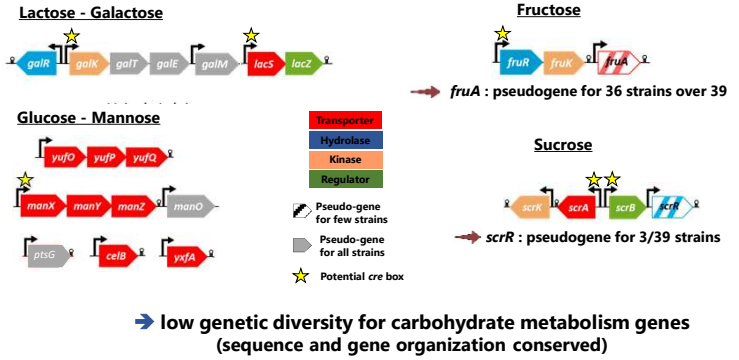
Lactate production

- is higher in presence of lactose or glucose, compared to sucrose
- decreases as lactose or glucose concentration decrease
- is not affected by sucrose concentration



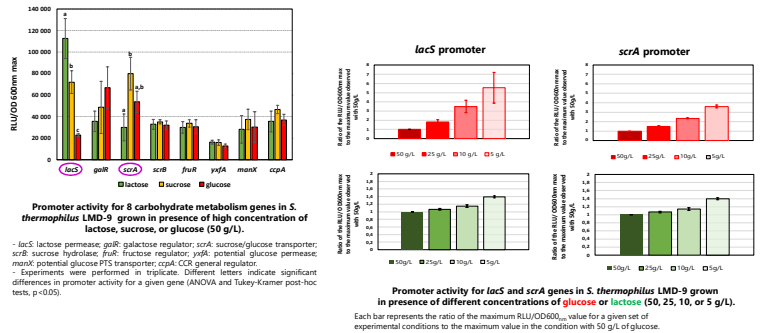
In silico analysis

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



Regulation of carbon metabolism genes

- All promoters of CM genes tested are active in presence of lactose, glucose or sucrose and the activities of only *lacS* and *scrA* ones are modulated by the nature of the sugar



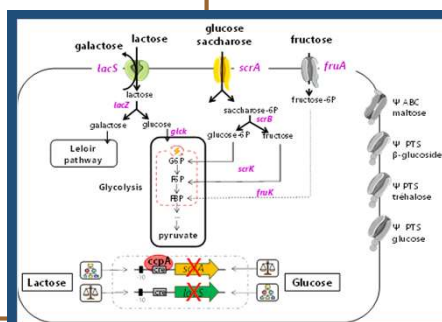
- Glucose and lactose repress promoter activity for transporter-encoding genes *lacS* and *scrA* in a concentration-dependent manner, whereas sucrose not

- Glucose maintains its repressive effects in mixed-saccharide media on *lacS* and *scrA* promoter activities



- lacS* promoter activity is no more repressed in a Δ cpA mutant, whatever the lactose or glucose concentration (10, 25 or 50 g/L)
- the promoter profil activity for *scrA* is similar in a Δ scrR mutant than in the wild-type strain, in glucose, lactose or sucrose (whatever their concentration)

- The sucrose transporter *ScrA* is necessary for growth in LMD-9 strain in presence of glucose or sucrose as a single carbon source (no growth in a Δ scrA mutant)
 - \Rightarrow *ScrA* is responsible for the transport of glucose and sucrose in LMD-9 strain
 - \Rightarrow An explanation for the effect of glucose on *scrA* promoter activity modulation?



Conclusions

- S. thermophilus* is able to co-consume several sugars when mixed
- Carbohydrate metabolism regulation principally involves lactose and sucrose transporter gene expression via the general regulator CcpA
- Regulatory profiles for *lacS* and *scrA* genes according to sugar concentration and glycolytic flux are similar in LMD-9
- Catabolic repression in *S. thermophilus* LMD-9 does not strictly represses the consumption of less preferred sugars; instead, saccharides are jointly consumed

References:

- Gasser et al. Co-utilization of saccharides in mixtures: moving toward a new understanding of carbon metabolism in *Streptococcus thermophilus*, Int J Food Microbiol, doi 10.1016/j.fm.2022.104800
- Gasser et al, New insight on carbohydrate metabolism in *S. thermophilus*: role of sugar nature and concentration in operon regulation via carbon catabolite control, under review.