Bacterium that switches from ethanol to propanediol production

Background

- Cocultures of engineered thermophilic bacteria can ferment lignocellulose without costly pretreatment or added enzymes - an ability that can be exploited for low-cost biofuel production from renewable feedstocks.
- Propanediol is an important industrial chemical but fermentation from renewable lignocellulosic feedstocks is not cost-competitive.
- The hemicellulose-fermenting species *Thermoanaerobacterium thermosaccharolyticum* was engineered for high ethanol yield. We found that the strains produced ethanol while growing, but their metabolism switched to production of acetate and 1,2-propanediol after growth stopped.

Approach

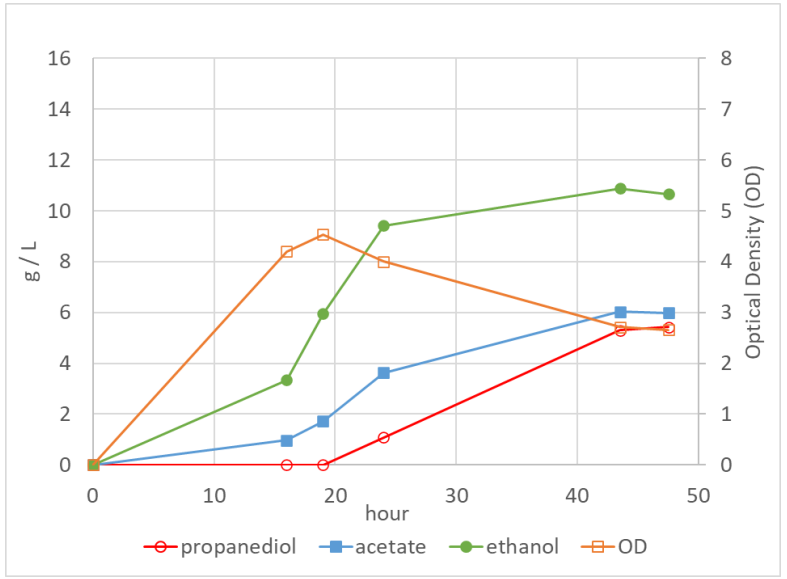
- Based on rational design principles we deleted three genes encoding methylglyoxal reductase, methylglyoxal synthase and glycerol dehydrogenase.
- To understand how carbon flux is redirected in this species, we hypothesized that high ATP levels during growth cessation downregulate the activity of alcohol and aldehyde dehydrogenase (a group of enzymes that catalyze the oxidation of aldehydes) activities.

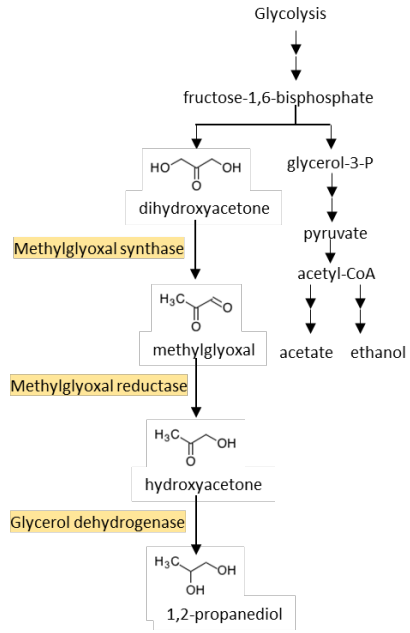
Results

- Deletion of genes for methylglyoxal synthase and glycerol dehydrogenase eliminated propanediol production.
- Measurements with cell free extracts show approximately 2-fold and 10-fold inhibition of alcohol and aldehyde dehydrogenase activities by ATP, supporting the hypothesized mechanism of metabolic redirection.

Significance

- This work may lead to improved ability to manipulate product formation and to extend product formation after cell growth stops.
- The genetic data shown here will be useful in applied efforts to improve 1,2-propanediol production.
- This work may have implications for efforts to direct and maximize flux through alcohol dehydrogenase in other species.





Left: Fermentations of 60 g/L cellobiose with a strain modified to produce ethanol. OD = cell density.
Right: Pathway for 1,2-propanediol. Enzymes targeted by gene knockouts are highlighted.

Herring CD et al., *Sci Rep.* 2023 13:2394. doi: 10.1038/s41598-023-29220-9.