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Gad Acid Resistance System Plays a Critical Role in *Escherichia Coli* Growth, Significantly Influencing the Extracellular pH During Fermentation

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ABSTRACT

Enterobacteria possess acid resistance (AR) systems to survive in acidic environments. *Escherichia coli* have four proton-consuming AR systems, three of which are inducible: the glutamate-dependent AR2 (Gad), arginine-dependent AR3 (Adi), and lysine-dependent AR4 (Cad). Among these, the Gad system exhibits superior efficiency under highly acidic conditions. This study examined the role of the Gad system in specific growth rate (μ) and extracellular pH (pH_{ex}) regulation during fermentation. *E. coli* MG1655 wild-type (WT) and a Δ*gadE* mutant strain (lacking the acid-responsive transcriptional activator GadE, essential for *gadA* and *gadBC* expression) were cultured in LB medium supplemented with 4 g L^{-1} glucose at initial pH values of 7.6, 6.5, 5.8, and 5.4. In WT, μ was 0.52 h^{-1} at pH 7.6, which was decreased by ~55% and ~70% at pH 5.8 and 5.4, respectively. In the *gadE* strain, μ was consistently lower, with reductions of ~30% at pH 7.6, ~25% at pH 6.5 and 5.8, and ~30% at pH 5.4, compared to WT. This indicates that the promoting effect of GadE on growth is more prominent at pH 7.6 and 5.4. pH_{ex} of growth medium was acidified in WT at all pH conditions due to fermentative acid production. In contrast, the *gadE* strain showed extracellular alkalization during the logarithmic phase (5–6 h), with pH_{ex} increases of ~ 0.79, ~ 0.18, and ~ 0.23 units at pH 7.6, 6.5, and 5.4, respectively. This variation is attributed to the absence of glutamate decarboxylation and proton consumption via the GadC antiporter. Taken together, the Gad system has an important role in bacterial growth, influencing the modulation of pH_{ex}.

Keywords: acid resistance, Gad system, specific growth rate, extracellular pH

References:

1. Schwarz, J.; Schumacher, K.; Brameyer, S.; Jung, K. Bacterial battle against acidity. *FEMS Microbiol. Rev.* **2022,** *46*, fuac037. DOI:10.1093/femsre/fuac037
2. Brameyer, S.; Schumacher, K.; Kuppermann, S.; Jung, K. Division of labor and collective functionality in *Escherichia coli* under acid stress. *Commun. Biol.* **2022,** *5*, 327. DOI:10.1038/s42003-022-03281-4

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