

R : 6 M 2015 / R : 17 J
© S - V B H 20

A , C3

A

Escherichia

E. coli L 43

D

glpK, HJ02 5.5

53.4 %

T
NADPH
(HJ04)

ptsG

HJ02 M

30 %

NADPH

NADPH/NADP⁺

C , HJ04

1.20 g/L

69.0 %

HJ02

RNA (HJ05)

gapA, HJ04

HJ05

1.82 g/L

2.1 1.5

R - PCR

HJ02 HJ04

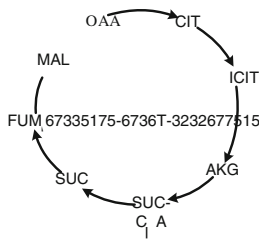
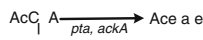
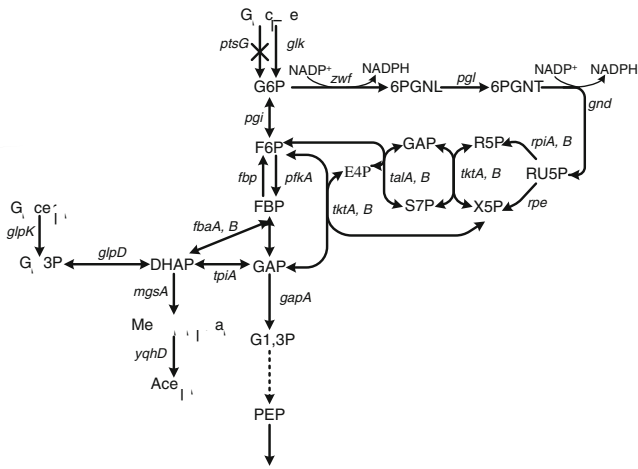
HJ05

(:10.1007/00253-015-6732-9)

✉ H . H
@

¹ K L M M , S L S
B , S J T U
S 200240, C

² D C E , P S U
U P , PA 16802-4400, USA



(P... 1996). N... FBP... EIIA^G...
 L 43 (P... 1996).
 O...
yqhD... 11.4... L 43
 (... 2013).
 A... D... NADPH...
yqhD... NADPH (C...
 G... 2011; J... 2011). S...
 NADPH, NADH
 NADPH...
 NADPH, (PP) (L...
 2010; J... 2013; S... 2013). T...
 NADPH...

PP... H...
 PP... 43 9%...
 (C... 2013). T...
 NADPH... O...
 NADPH... *pgi*
 (...), *pfkA* (6-...),
gapA (3-...),
zwf (6-...-1-...),
gnd (6-...)(L...
 2002; L... 2010; S... 2013). A...
gapA...
 PP... $\Delta gapA$
 NADPH (S... 2013).

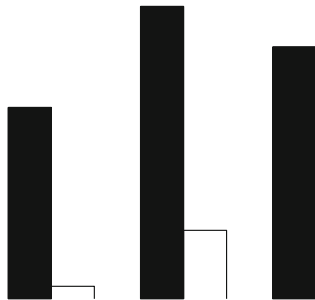
E. coli...
 NADPH... T...
 (1) *glpK*...
 L 43 (2) ...
 PTS, (3) *gapA*. T...
 (1) *glpK*...
 (2) *glpK*...
 (3) *glpK*...
 (4) *glpK*...
 (5) *glpK*...
 (6) *glpK*...
 (7) *glpK*...
 (8) *glpK*...
 (9) *glpK*...
 (10) *glpK*...
 (11) *glpK*...
 (12) *glpK*...
 (13) *glpK*...
 (14) *glpK*...
 (15) *glpK*...
 (16) *glpK*...
 (17) *glpK*...
 (18) *glpK*...
 (19) *glpK*...
 (20) *glpK*...
 (21) *glpK*...
 (22) *glpK*...
 (23) *glpK*...
 (24) *glpK*...
 (25) *glpK*...
 (26) *glpK*...
 (27) *glpK*...
 (28) *glpK*...
 (29) *glpK*...
 (30) *glpK*...
 (31) *glpK*...
 (32) *glpK*...
 (33) *glpK*...
 (34) *glpK*...
 (35) *glpK*...
 (36) *glpK*...
 (37) *glpK*...
 (38) *glpK*...
 (39) *glpK*...
 (40) *glpK*...
 (41) *glpK*...
 (42) *glpK*...
 (43) *glpK*...
 (44) *glpK*...
 (45) *glpK*...
 (46) *glpK*...
 (47) *glpK*...
 (48) *glpK*...
 (49) *glpK*...
 (50) *glpK*...
 (51) *glpK*...
 (52) *glpK*...
 (53) *glpK*...
 (54) *glpK*...
 (55) *glpK*...
 (56) *glpK*...
 (57) *glpK*...
 (58) *glpK*...
 (59) *glpK*...
 (60) *glpK*...
 (61) *glpK*...
 (62) *glpK*...
 (63) *glpK*...
 (64) *glpK*...
 (65) *glpK*...
 (66) *glpK*...
 (67) *glpK*...
 (68) *glpK*...
 (69) *glpK*...
 (70) *glpK*...
 (71) *glpK*...
 (72) *glpK*...
 (73) *glpK*...
 (74) *glpK*...
 (75) *glpK*...
 (76) *glpK*...
 (77) *glpK*...
 (78) *glpK*...
 (79) *glpK*...
 (80) *glpK*...
 (81) *glpK*...
 (82) *glpK*...
 (83) *glpK*...
 (84) *glpK*...
 (85) *glpK*...
 (86) *glpK*...
 (87) *glpK*...
 (88) *glpK*...
 (89) *glpK*...
 (90) *glpK*...
 (91) *glpK*...
 (92) *glpK*...
 (93) *glpK*...
 (94) *glpK*...
 (95) *glpK*...
 (96) *glpK*...
 (97) *glpK*...
 (98) *glpK*...
 (99) *glpK*...
 (100) *glpK*...

| S | R | S |
|---|---|--|
| B 25113 | $F^- \lambda^- rph^{-1} \Delta araBAD_{AH33} lac^f \Delta lacZ_{WJ16}$ | <i>E. coli</i> G S |
| L 43 | $rrnB_{T14} \Delta rhaBAD_{LD78} hsdR514$ H (PO2A) <i>fhuA22, \Delta phoA8, fadL701(T2R), relA1, glpR2(glp^c), pitA10, spoT1, glpK22(R), rrnB-2, mcrB1, creC510</i> | C U |
| (P g . 1996). F | g | g |
| K (B . 2006) | ASKA | (|
| (K g . 2005) | T <i>ptsG</i> | S |
| HJ02 | P1 (C | HJ01, HJ02, |
| g 1995). | | HJ04, HJ05 RNA 72 |
| | | T RNA g RNA E K |
| | | (ABg C , B g, C). C g DNA |
| | | RN - DN I(ABg C , |
| | | B g, C). T - DNA g |
| A | LB | P S™ II 1 S DNA S K (T C |
| T | | L ., D , C). QRT-PCR |
| g M9 | (6.81 g | S BR P E T™ K (T RN HP , T C |
| N ₂ HPO ₄ , 2.99 g | KH ₂ PO ₄ , 0.58 g N C, 5.94 g | L ., D , C). ABIS R -T PCR S - |
| (NH ₄) ₂ SO ₄ g | 2 g/L g 2 g/L | (A B , F , USA). T |
| g T | | T S1, g |
| | 500- L E | 16SRNA g T |
| 37. C 220 . T H | | PCR :95. C 4 , |
| 7. T | | 35 95. C 15 , g 57. C |
| | | 15 , 72. C 20 . T |
| | | T |
| | | g |
| B g | g | Sg |
| | 600 (OD ₆₀₀) g | S t , g SPSS 13.0. S |
| (UV-7504, , S g , C). C | | P < 0.05. |
| g g | | |
| g - (1260, | | |
| A, S C , USA) g - g | | S |
| (HP -87H, B -R , H , CA) | | HJ02, HJ03, |
| (RI) . A 5 M H ₂ SO ₄ | | HJ04, HJ05 NADP ⁺ /NADPH |
| 0.5 L/ | | 60 . I NADP ⁺ /NADPH g |
| 60. C | | E C NADP ⁺ /NADPH A (B. A S , |
| | | H , CA), g |

D. *g* *S* *M* *E* 2013. *M* *(AVOVA)* *g* $P < 0.05$.

glpK

I. *yqhD* *E. coli* B 25113 *glpK* *glpK22* L 43 *HJ01* *HJ02* *HJ01* *HJ02* *Fg. 2. A* *HJ02* 72 53.4 % *HJ01. T* *HJ01* 0.08 *g/L* *HJ02* 0.44 *g/L* , 5.5 *HJ01* *glpK* *mgsA* *HJ01* *HJ02 (Fg. 3)* *M* *A* *DHAP* *(Fg. 1)* *R* *glpK* *L* 43 *glpK* 1.7- ($P < 0.01$) *mgsA* *g* 2.5- *HJ02 (P < 0.01)*.



T *glpK* *NADPH* *HJ02* *NADPH/NADP⁺* *HJ03 (HJ02* *CA24N)* *A* *yqhD* *NADPH* 35.8 % ($P < 0.01$) *NADPH/NADP⁺* 25.1 % ($P < 0.05$) *HJ02* *(T 2)* *T* *g* *NADPH*

ptsG *S* *NADPH (S* *2013)* *2g/L* *Fg. 4* *E. coli* *HJ02* *g* *g* *g*

G (24 h). T (CCR) (D 2006). T 0.71g/L, 61% S HJ02 (). I zwf ($P < 0.01$) (G6PDH) -6- PP (Fig. 3). F NADPH NADPH/NADP⁺ 1.72- 1.43- (T 2). C (2009) 60% NADPH I ; NADPH D. T NADPH D T ptsG, CCR HJ02, HJ04. T ptsG (EIICB^G), (G 2005). A Fig. 4, ptsG, T HJ02. M 1.20g/L, 69.0% HJ02. I NADPH NADPH/NADP⁺ 30% ptsG ($P < 0.05$) (T 2).

gapA

D gapA *Corynebacterium glutamicum* PP NADPH (S 2013). H gapA *E. coli*

(S 1997). T RNA (2009) gapA, E. coli PP T HJ05, gapA HJ04, (Fig. 4). A HJ04, gapA A

- 6.9- (P < 0.01) HJ05. T *zwf* (1970). I
 2.2- (P < 0.01). T NADPH HJ05 *mgsA* HJ02 (1970). I
 72.4 % HJ02 32.3 % *mgsA*
 HJ04 (P < 0.01 P < 0.05,) (T 2).
 T NADPH/NADP⁺ HJ05
 HJ02 HJ04 (P < 0.01 P < 0.05,
).
- G
 (A 2012; C G 2013). T (L 2010; 2014). I
 NADPH
 M *E. coli* (C G 2013; NADPH *E. coli*
 2013; G 2014). H TCA (R 1968),
E. coli (C 2014), PP (S 2004). P
 (2013). S G K-G D NADPH (S 2004). H
glpK glpD *E. coli* (C 2013; M 1991). T
 (M 2013; 2014; 2014). I NADPH RT-PCR
 L 43 *glpK* NADPH NADPH/NADP⁺ *zwf*
 HJ02, NADPH (2010) *zwf*
 HJ01, NADPH NADPH/
 5.5 HJ01, L 43 NADPH NADPH/
glpK L 43 NADP⁺ *pgi*. T
 (F 2). F *glpK* HJ02 NADPH
 G K FBP EIIA^G G K *ptsG*
 HJ02. T L 43, NADPH NADPH/NADP⁺
 FBP EIIA^G, (2008) PTS
 (F 1971). T *ptsG* I
 G K (F 1971). $\Delta ptsG$, HJ04, *ptsG*
 HJ02 *glpK* L 43 HJ04 T
 HJ02 *mgsA* NADPH T
 L 43. U NADPH *ptsG*
mgsA D, *ptsG*
 (C G 2011; J 2014). O T *gapA* 12
 HJ02 NADPH *gapA* 6-
mgsA. I *E. coli* 6- *ptsG* 3-
 (B 2003). T L 43 S 2003). S (2013). $\Delta gapA$
C. glutamicum (R)-

3- *gapA* *E. coli* (7.9 /). A .
 RNA (S .
 1997), RNA *gapA* HJ05
 1.82g/L
 HJ02 HJ04. C HJ04, *zwf*
gapA *gapA* PP . T -
 NADPH *gapA* *glpK*
 I L 43
 D. N .
 NADPH . F -
 PTS *ptsG*
 NADPH D. F ,
gapA PP ,
 NADPH

- L SJ, J, M, S, HD, L, H (2002) A NADPH-PHB *E. coli* zwf gnd phbCAB. J B B 93(6):543–549. doi:10.1016/S1389-1723(02)80235-3
- L ECC (1976) G A R M 30(1):535–578
- M AG (1991) G *Escherichia coli*. M R 55(2):316–333. doi:10.146-0749/91/020316-18\$02.00/0
- M K, A, R, H, G, E, A, G, G, R, OT, B, FG (2008) C *Escherichia coli*. M C F 7(1):1. doi:10.1186/1475-2859-7-1
- M S, B, MD, C, JM, G, R (2013) E *Escherichia coli*. M C F 12(1):7. doi:10.1186/1475-2859-12-7
- M MH, A, R, M (2011) A A J A S 8. doi:10.3844/2011.1135.1139
- N N, T, T (2009) C RNA *Escherichia coli*. N A R 37(15):103. doi:10.1093/498
- P D, M, DP, C, CA, J, JR (1988) *Escherichia coli* glpK. J B C 263(5):135–139
- P D, L, H, C, H, C, M, ND, R, S (1996) A *Escherichia coli*. J B 178(10):2846–2852
- R HC, B, BA, A, SJ (1968) M NADP- S 162(3851):359–360. doi:10.1126/162.3851.359
- S S, A, M, T, R, H, T, I, K, M (2008) V A C 347(2):186–191. doi:10.1016/2008.06.013
- S U, C, F, H, S, P, A, F, E (2004) T U A P AB NADPH *Escherichia coli*. J B C 279(8):6613–6619. doi:10.1074/M311657200
- S FD, B, -M, S, V, M, B, G (1997) C *Escherichia coli* gapA gapB. J B 179(16):5218–5221. doi:10.1007/978-1-4020-0021-9_16
- S S, L, SN, B, S, VF, B, M (2013) R *Corynebacterium glutamicum*: NADPH, pfkA, gapA. A M B 97(1):143–152. doi:10.1007/00253-012-4314-7
- S P, M, -S, I, V, F, Fgg, R (2008) M O 2008/116853
- S P, V, F, Fgg, R (2008) M O 2008/116851
- S ST (2013) P *Propionibacterium freudenreichii shermanii*. B T 137(0):116–123. doi:10.1016/2013.03.012
- S MS, L, M, B, R, L, TQ, P, S, C, P, M, DJ (2014) M *Escherichia coli*. A E M 80(10):3276–3282. doi:10.1128/AEM.03863-13
- H, K, M, S, K (2014) M *Escherichia coli*. M E 25:82–91. doi:10.1016/2014.06.009
- S A, H, N, S, O, S, M (2010) D T C 53(7):487–491. doi:10.1007/11244-010-9476-6
- S C, D, J, H, H, F, H, C (2014) R *Escherichia coli* glpK glpD. J B 178(10):2846–2852. doi:10.1007/11274-014-1753-6
- H, L, H, H, TK, (2013) P *Escherichia coli*. B T 149:238–243. doi:10.1016/2013.09.062
- S N, K, S, L, EC (1970) G *Escherichia coli*. J B 102(3):753–759