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(19) **United States**(12) **Patent Application Publication****Izui et al.**(10) **Pub. No.: US 2007/0134773 A1**(43) **Pub. Date: Jun. 14, 2007**(54) **METHOD FOR PRODUCING L-GLUTAMIC ACID BY FERMENTATION ACCOMPANIED BY PRECIPITATION**(75) Inventors: **Hiroshi Izui**, Kawasaki-shi (JP); **Mika Moriya**, Kawasaki-shi (JP); **Seiko Hirano**, Kawasaki-shi (JP); **Yoshihiko Hara**, Kawasaki-shi (JP); **Hisao Ito**, Kawasaki-shi (JP); **Kazuhiko Matsui**, Kawasaki-shi (JP)

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Aug. 18, 2000, now Pat. No. 7,015,010.

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Mar. 21, 2000 (JP) 2000-78771**Publication Classification**(51) **Int. Cl.**
C12P 13/14 (2006.01)
C12N 1/21 (2006.01)
(52) **U.S. Cl.** **435/110; 435/252.3**(57) **ABSTRACT**

A microorganism which can metabolize a carbon source at a specific pH in a liquid medium containing L-glutamic acid at a saturation concentration and the carbon source, and has ability to accumulate L-glutamic acid in an amount exceeding the amount corresponding to the saturation concentration in the liquid medium at the pH; and a method for producing L-glutamic acid by fermentation, which comprises culturing the microorganism in a liquid medium of which pH is adjusted to a pH at which L-glutamic acid is precipitated, to produce and accumulate L-glutamic acid and precipitate L-glutamic acid in the medium.

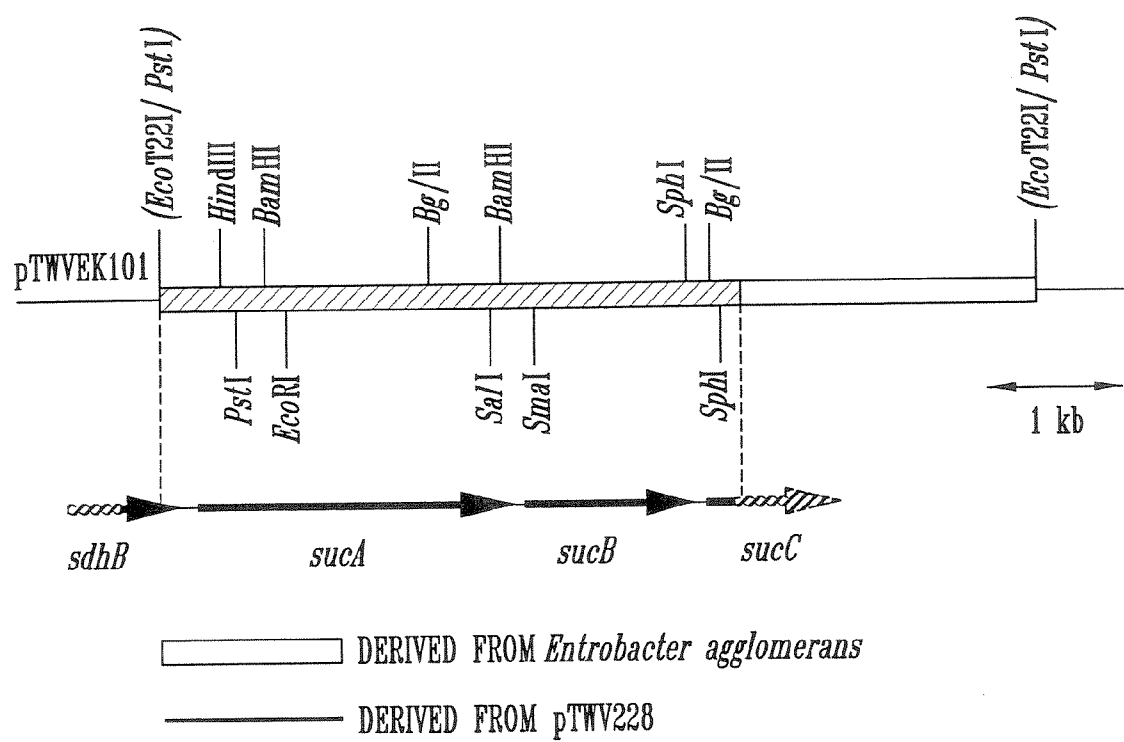


FIG. 1

[88.0% / 935 aa]

1' MQNSAMKPWLDSSWLAGANQSYIEQLYEDFLTPDSDAVWRSMFQQLPGTGVKPEQFHS

1" MQNSALKAWLDSSYLSGANQSWIEQLYEDFLTPDSDANWRSTFQQLPGTGVKPDQFHS
61' ATREYFRRLAKDASRYTSSVTDPATNSKQVKVLQLINAFRFRGHQEANLDPLGLWKQDRV

61" QTREYFRRLAKDASRYSSTISDPDTNVKQVKVLQLINAYRFRGHQHANLDPLGLWQQDKV
121' ADLDPAFHDLTDADFQESFNVGSAIGKETMKLADLFDALKQTYCGSIGAEYMHINNTEE

121" ADLDPFHDLTADFQETFNVGSAIGKETMKLGELLEALKQTYCGPIGAEYMHITSTEE
181' KRWIQQRIESGASQTSFSGEEKGFLKELTAAEGLEKYLGAKFPGAKRFSLEGGDALVPM

181" KRWIQQRIESG--RATFNSEKKRFLSELTAAGLERYLGAKFPGAKRFSLEGGDALIPM
241' LREMIRHAGKSGTREVVLGMAHRGRLNVLINVLGKKPQDLFDEFSGKHKEHLGTGDVKYH

239" LKEMIRHAGNSGTREVVLGMAHRGRLNVLINVLGKKPQDLFDEFAGKHKEHLGTGDVKYH
301' MGFSSDIETEGGLVHLALAFNPSHLEIVSPVVMGSVRARLDRLAEPVSNKVLPIITHGDA

299" MGFSSDFQTDGGLVHLALAFNPSHLEIVSPVVGSVRARLDRLDEPSSNKVLPIITHGDA
361' AVIGQGVVQETLNMSQARGYEVGGTVRIVINNQVGFTTSNPKDARSTPYCTDIGKMVLAP

359" AVTGQGVVQETLNMSKARGYEVGGTVRIVINNQVGFTTSNPLDARSTPYCTDIGKMVQAP
421 IFHVNADDPEAVAFVTRLALDYRNTFKRDVFIDLVCYRRHGHNEADEPSATQPLMYQKIK

419" IFHVNADDPEAVAFVTRLALDFRNTFKRDVFIDLVSYRRHGHNEADEPSATQPLMYQKIK

FIG. 2A

481' KHPTPRKIYADRLEGEVASQEDATEMVNLYRDALDAGECVVPEWRPMSLHSFTWSPYLN

479' KHPTPRKIYADKLEQEKVATLEDATEMVNLYRDALDAGDCVVAEWRPMMHSFTWSPYLN

541' HEWDEPYPQVDMKRLKELALRISQVPEQIEVQSRVAKIYNDRKLMAEGEKAFDWGGAEN

539' HEWDEEYPNKMVKRLQELAKRISTVPEAVEMQSRVAKIYGDRQAMAAGEKLFDWGGAEN

601' LAYATLVDEGIPVRLSGEDSGRGTFHHRHAVVHNQANGSTYTPLHHIHNSQGEFKVWDSV

599' LAYATLVDEGIPVRLSGEDSGRGTFHHRHAVIHNSNGSTYTPLQHHIHNGQGAFRVWDSV

661' LSEEAVLAFEYGYATAEPRVLTWEAQFGDFANGAQVVIDQFISSGEQKWGRMCGLVMLL

659' LSEEAVLAFEYGYATAEPRTLTWEAQFGDFANGAQVVIDQFISSGEQKWGRMCGLVMLL

721' PHGYEGQGPEHSSARLERYLQLCAEQNMQVCVPSTPAQVYHMLRRQALRGMRRPLVVMSP

719' PHGYEGQGPEHSSARLERYLQLCAEQNMQVCVPSTPAQVYHMLRRQALRGMRRPLVVMSP

781' KSLLRHPLATISSLELANGSFQPAIGEIDDLDPQGVKRVVLCSGKVYYDLLEQRRKDEKT

779' KSLLRHPLAVSSLEELANGTFLPAIGEIDELDPKGVKRVVMCSGKVYYDLLEQRRKNNQH

841' DVAIVRIEQLYPFPHQAVQEALKAYSHVQDFVWCQEEPLNQGAWYCSQHHRDVPFGAT

839' DVAIVRIEQLYPFPHKAMQEVLLQFAHVKDFVWCQEEPLNQGAWYCSQHHRFREVIPFGAS

901' LRYAGRPASASPAVGYSVHQQQQDLVNDALNVN

899' LRYAGRPASASPAVGYSVHQKQQQDLVNDALNVE

FIG. 2B

[88.2% / 407 aa]

1' MSSVDILVPDLPE SVADATVATWHKKPGDAVSRDEVIVEIETDKVVLEVPASADGVLEAV

1' MSSVDILVPDLPE SVADATVATWHKKPGDAVVRDEVLEIETDKVVLEVPASADGILDAV
61' LEDEGATVTSRQILGRLKEGNSAGKESSAKAESNDTTPAQRQTASLEEESDALS PAIRR

61' LEDEGTTVTSRQILGRLREGNSAGKETS AKSEEKASTPAQRQQASLEEQNNDALS PAIRR
121' LIAEHNLDAAQIKGTGVGGRLTREDVEKHLANKPQAEKAAAPAAGAATAQQPVANRSEKR

121' LLAEHNLDASA IKGTVGGRLTREDVEKHLAKAPAKE--SAPAAAAPAAQPALAA RSEKR
181' VPMTRLRK RVAERLLEAKNSTAMLTTFNEINMKPIMDLRKQYGD AFEKRHGVRLGFMSFY

179' VPMTRLRK RVAERLLEAKNSTAMLTTFNEVNMKPIMDLRKQYGE AFEKRHGIRLGFMSFY
241' IKAVVEALKRYPEVNASIDGEDVVYHNYFDVSI AVSTPRGLVTPVLRD VDALSMADIEKK

239' VKAVVEALKRYPEVNASIDGDDVVYHNYFDVSM AVSTPRGLVTPVLRD VDTLGMADIEKK
301' IKELAVKGRDGKLTVD DLTGGNFTITNGGVFGSLMSTPIINPPQSAILGMHAIKDRPMAV

299' IKELAVKGRDGKLTVE DLTGGNFTITNGGVFGSLMSTPIINPPQSAILGMHAIKDRPMAV
361' NGQVVILPMMYLALS YDHRLIDGRESVG YLVAVKEMLEDPARLLL DV

359' NGQVEILPMMYLALS YDHRLIDGRESVG FLVTIKELLEDPTRLLL DV

FIG. 3

[95.1% / 41 aa]

1' MNLHEYQAKQLFARYGMPAPTGYACTTPREAE EAASKIGAG

1' MNLHEYQAKQLFARYGLPAPVGYACTTPREAE EAASKIGAGPWVVKCQVHAGGRGKAGGV

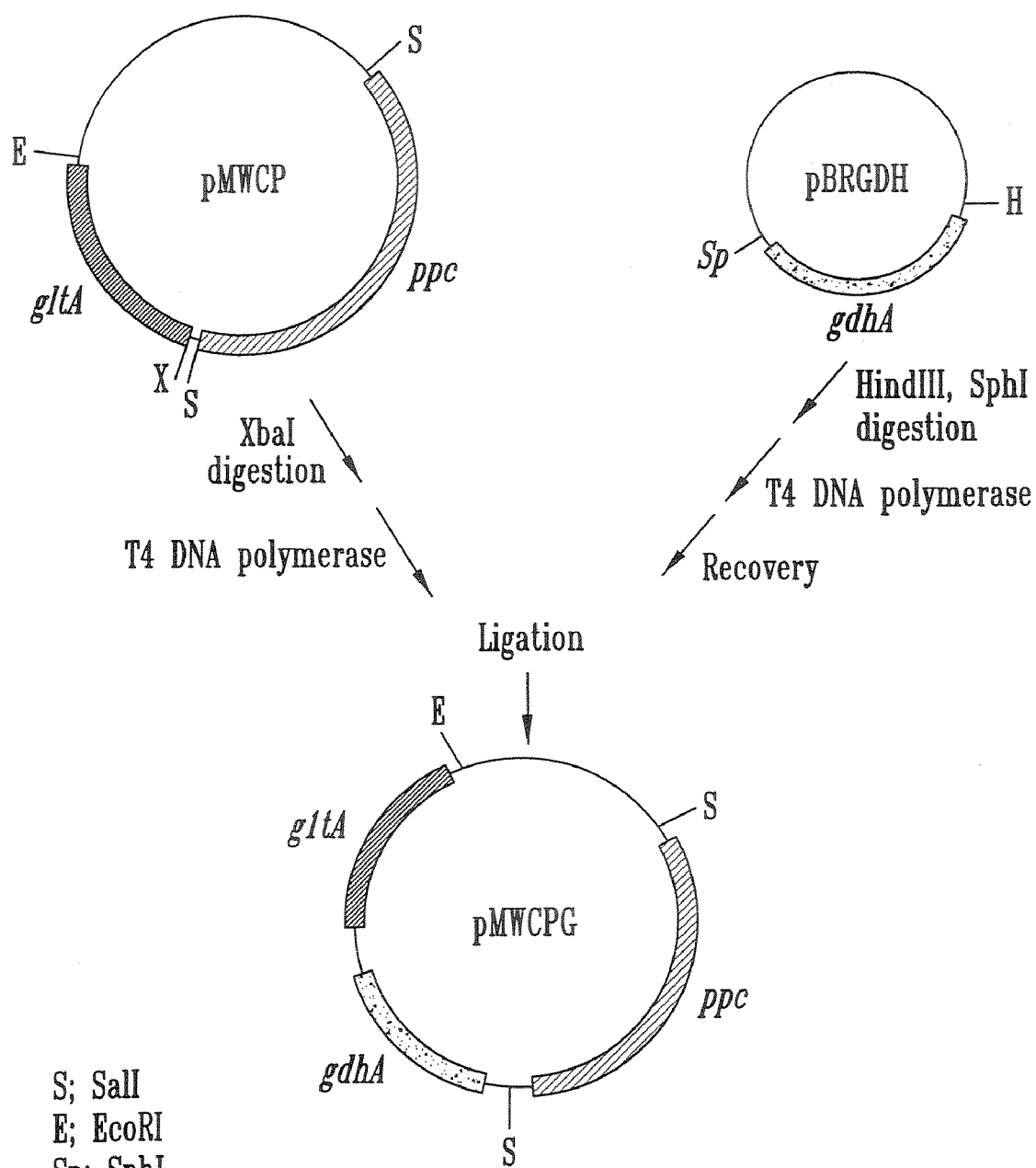
FIG. 4

[97.4% / 39 aa]

1' AFSVFRCHSIMNCVSVCPKGLNPTRAIGHIKSMLLQRSA

181' FLIDSRDTETDSRLDGLSDAFSVFRCHSIMNCVSVCPKGLNPTRAIGHIKSMLLQRNA

FIG. 5



S; SalI
E; EcoRI
Sp; SphI
X; XbaI
H; HindIII

FIG. 6

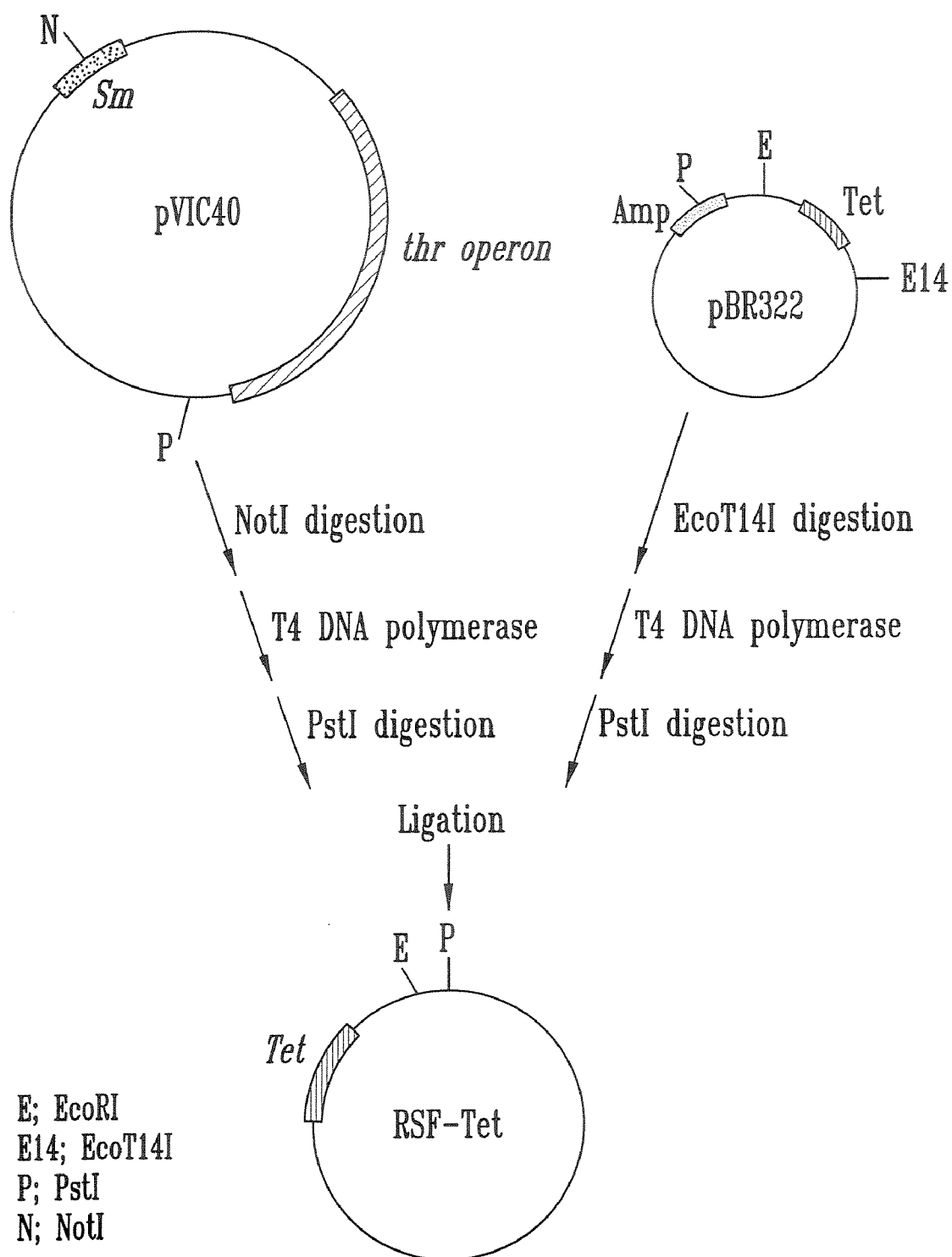
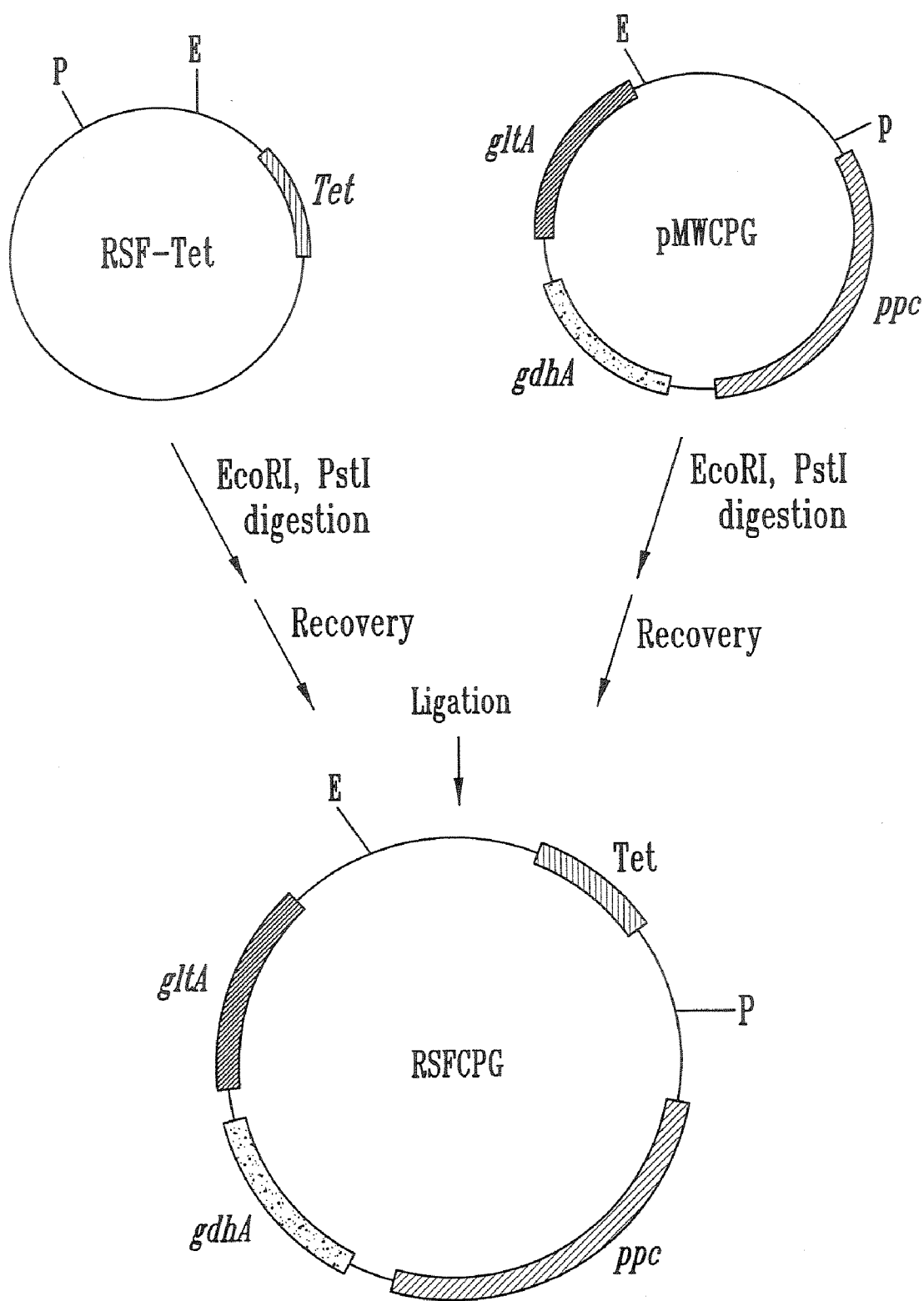


FIG. 7



E; EcoRI
P; PstI

FIG. 8

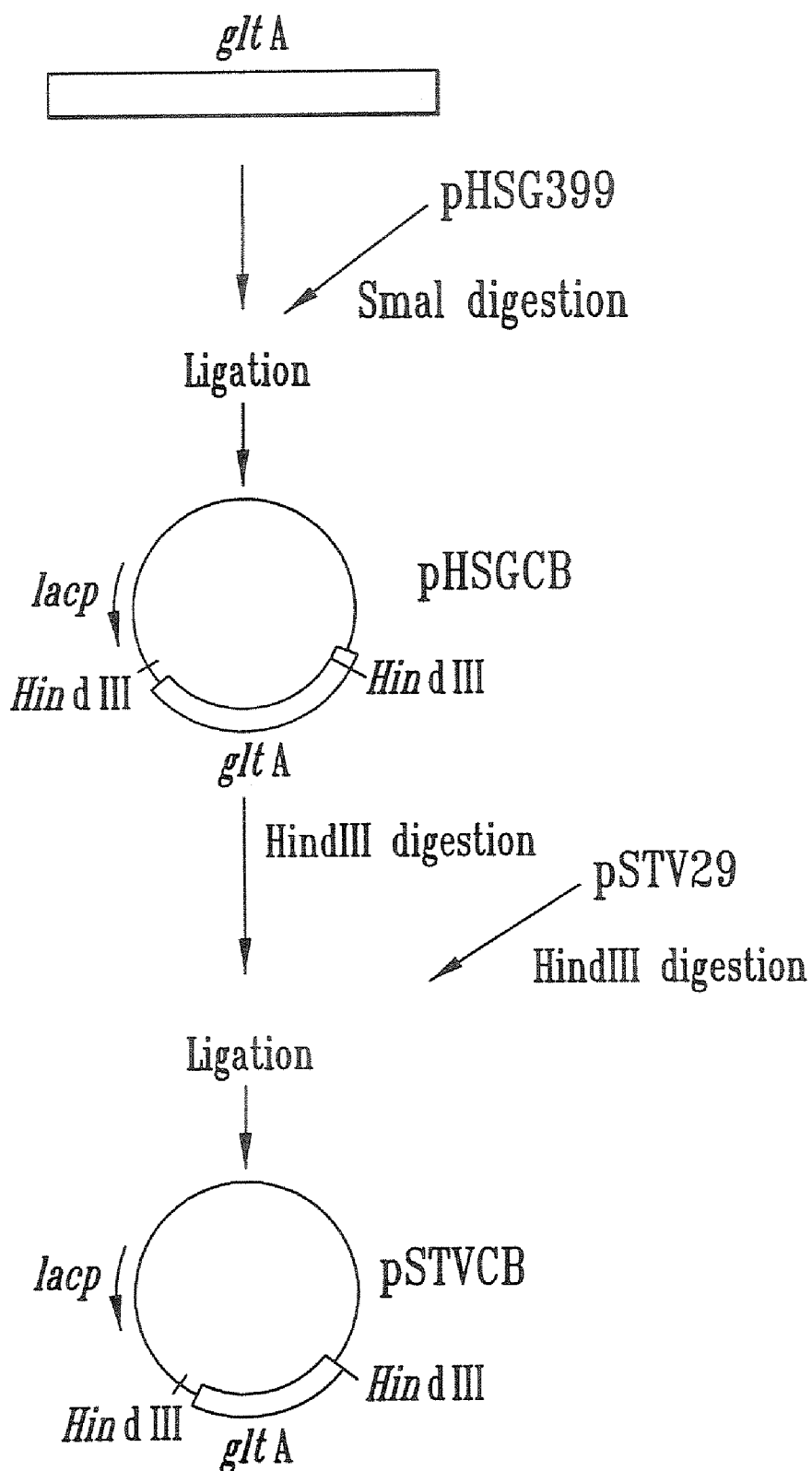


FIG. 9

METHOD FOR PRODUCING L-GLUTAMIC ACID BY FERMENTATION ACCOMPANIED BY PRECIPITATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Ser. No. 11/150,265, filed on Jun. 13, 2005, which is a continuation of U.S. Ser. No. 09/641,892 (now U.S. Pat. No. 7,015,010), filed on Aug. 18, 2000, which claims priority to JP 11-234806, filed on Aug. 20, 1999, and JP 2000-78771, filed on Mar. 21, 2000.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a method for producing L-glutamic acid by fermentation accompanied by precipitation. L-Glutamic acid is widely used as a material of seasonings and so forth.

[0003] L-Glutamic acid is mainly produced by fermentative methods using so-called coryneform bacteria producing L-glutamic acid and belonging to the genus *Brevibacterium*, *Corynebacterium* or *Microbacterium*, or mutant strains thereof (Amino Acid Fermentation, pp. 195-215, Gakkai Shuppan Center, 1986). As methods for producing L-glutamic acid by fermentation by using other bacterial strains, there are known a method using a microorganism belonging to the genus *Bacillus*, *Streptomyces*, *Penicillium* or the like (U.S. Pat. No. 3,220,929), a method using a microorganism belonging to the genus *Pseudomonas*, *Arthrobacter*, *Serratia*, *Candida* or the like (U.S. Pat. No. 3,563,857), a method using a microorganism belonging to the genus *Bacillus*, *Pseudomonas*, *Serratia*, *Aerobacter aerogenes* (currently referred to as *Enterobacter aerogenes*) or the like (Japanese Patent Publication (Kokoku) No. 32-9393), a method using a mutant strain of *Escherichia coli* (Japanese Patent Application Laid-open (Kokai) No. 5-244970) and so forth. In addition, the inventors of the present invention have proposed a method for producing L-glutamic acid by using a microorganism belonging to the genus *Klebsiella*, *Erwinia* or *Pantoea* (Japanese Patent Application Laid-open No. 2000-106869).

[0004] Further, there have been disclosed various techniques for improving L-glutamic acid-producing ability by enhancing activities of L-glutamic acid biosynthetic enzymes through use of recombinant DNA techniques. For example, it has been reported that introduction of a gene coding for citrate synthase derived from *Escherichia coli* or *Corynebacterium glutamicum* was effective for enhancement of L-glutamic acid-producing ability in *Corynebacterium* or *Brevibacterium* bacteria (Japanese Patent Publication No. 7-121228). In addition, Japanese Patent Application Laid-open No. 61-268185 discloses a cell harboring recombinant DNA containing a glutamate dehydrogenase gene derived from *Corynebacterium* bacteria. Further, Japanese Patent Application Laid-open No. 63-214189 discloses a technique for improving L-glutamic acid-producing ability by amplifying a glutamate dehydrogenase gene, an isocitrate dehydrogenase gene, an aconitate hydratase gene and a citrate synthase gene.

[0005] Although L-glutamic acid productivity has been considerably increased by breeding of the aforementioned microorganisms or improvement of production methods,

development of methods for more efficiently producing L-glutamic acid at a lower cost is required to respond to further increase of the demand in future.

[0006] There is known a method wherein fermentation is performed with crystallizing L-amino acid accumulated in culture (Japanese Patent Application Laid-open No. 62-288). In this method, the L-amino acid concentration in the culture is maintained below a certain level by precipitating the accumulated L-amino acid in the culture. Specifically, L-tryptophan, L-tyrosine or L-leucine is precipitated during fermentation by adjusting temperature and pH of the culture or adding a surface active agent to the medium.

[0007] While a fermentative method with precipitating L-amino acid is known as described above, amino acids suitable for this method are those of relatively low water solubility, and no example of applying the method to highly water-soluble amino acids such as L-glutamic acid is known. In addition, the medium must have low pH to precipitate L-glutamic acid. However, L-glutamic acid-producing bacteria such as those mentioned above cannot grow under acidic conditions, and therefore L-glutamic acid fermentation is performed under neutral conditions (U.S. Pat. Nos. 3,220,929 and 3,032,474; Chao K. C. & Foster J. W., J. Bacteriol., 77, pp. 715-725 (1959)). Thus, production of L-glutamic acid by fermentation accompanied by precipitation is not known. Furthermore, it is known that growth of most acidophile bacteria is inhibited by organic acids such as acetic acid, lactic acid and succinic acid (Yasuro Oshima Ed., "Extreme Environment Microorganism Handbook", p. 231, Science Forum; Borichewski R. M., J. Bacteriol., 93, pp. 597-599 (1967) etc.). Therefore, it is considered that many microorganisms are susceptible to L-glutamic acid, which is also an organic acid, under acidic conditions, and there has been no report that search of microorganisms showing L-glutamic acid-producing ability under acidic conditions was attempted.

SUMMARY OF THE INVENTION

[0008] In the aforementioned current situation, an object of the present invention is to search and breed a microorganism that produces L-glutamic acid under low pH conditions and to provide a method for producing L-glutamic acid using an obtained microorganism by fermentation with precipitating L-glutamic acid.

[0009] The inventors of the present invention considered during the study for improvement of L-glutamic acid productivity by fermentation that inhibition of the production by L-glutamic acid accumulated in a medium at a high concentration was one of obstructions to the improvement of productivity. For example, cells have an excretory system and an uptake system for L-glutamic acid. However, if L-glutamic acid once excreted into the medium is incorporated into cells again, not only the production efficiency falls, but also the L-glutamic acid biosynthetic reactions are inhibited as a result. In order to avoid the inhibition of production by such accumulation of L-glutamic acid at high concentration, the inventors of the present invention screened microorganisms that can proliferate under acidic conditions and in the presence of a high concentration of L-glutamic acid. As a result, they successfully isolated microorganisms having such properties from a soil, and thus accomplished the present invention.

[0010] Thus, the present invention provides the followings.

[0011] (1) A microorganism which can metabolize a carbon source at a specific pH in a liquid medium containing L-glutamic acid at a saturation concentration and the carbon source, and has ability to accumulate L-glutamic acid in an amount exceeding the amount corresponding to the saturation concentration in the liquid medium at the pH.

(2) The microorganism according to (1), which can grow in the liquid medium.

(3) The microorganism according to (1) or (2), wherein the pH is not more than 5.0.

(4) The microorganism according to any one of (1) to (3), which has at least one of the following characteristics:

(a) the microorganism is enhanced in activity of an enzyme that catalyzes a reaction for biosynthesis of L-glutamic acid; and

(b) the microorganism is decreased in or deficient in activity of an enzyme that catalyzes a reaction branching from a biosynthetic pathway of L-glutamic acid and producing a compound other than L-glutamic acid.

(5) The microorganism according to (4), wherein the enzyme that catalyzes the reaction for biosynthesis of L-glutamic acid is at least one selected from citrate synthase, phosphoenolpyruvate carboxylase and glutamate dehydrogenase.

[0012] (6) The microorganism according to (4) or (5), wherein the enzyme that catalyzes the reaction branching from the biosynthetic pathway of L-glutamic acid and producing a compound other than L-glutamic acid is α -ketoglutarate dehydrogenase.

(7) The microorganism according to any one of (1) to (6), wherein the microorganism belongs to the genus *Enterobacter*.

(8) The microorganism according to (7), which is *Enterobacter agglomerans*.

(9) The microorganism according to (8), which has a mutation that causes less extracellular secretion of a viscous material compared with a wild strain when cultured in a medium containing a saccharide.

[0013] (10) A method for producing L-glutamic acid by fermentation, which comprises culturing a microorganism as defined in any one of (1) to (9) in a liquid medium of which pH is adjusted to a pH at which L-glutamic acid is precipitated, to produce and accumulate L-glutamic acid and precipitate L-glutamic acid in the medium.

[0014] (11) A method for screening a microorganism suitable for producing L-glutamic acid by fermentation with precipitating L-glutamic acid in a liquid medium, which comprises inoculating a sample containing microorganisms into an acidic medium containing L-glutamic acid at a saturation concentration and a carbon source, and selecting a strain that can metabolize the carbon source.

(12) The method according to (11), wherein a strain that can grow in the medium is selected as the strain that can metabolize the carbon source.

(13) The method according to (11) or (12), wherein a pH of the medium is not more than 5.0.

[0015] According to the method of the present invention, L-glutamic acid can be produced by fermentation with precipitating L-glutamic acid. As a result, L-glutamic acid in the medium is maintained below a certain concentration, and L-glutamic acid can be produced without suffering from the product inhibition by L-glutamic acid at a high concentration.

BRIEF EXPLANATION OF THE DRAWINGS

[0016] FIG. 1 shows a restriction map of a DNA fragment derived from *Enterobacter agglomerans* pTWVEK101.

[0017] FIG. 2 shows comparison of the amino acid sequence deduced from the nucleotide sequence of the *sucA* gene derived from *Enterobacter agglomerans* and that derived from *Escherichia coli*. Upper sequence: *Enterobacter agglomerans*, lower sequence: *Escherichia coli* (the same shall apply hereafter).

[0018] FIG. 3 shows comparison of the amino acid sequence deduced from the nucleotide sequence of the *sucB* gene derived from *Enterobacter agglomerans* and that derived from *Escherichia coli*.

[0019] FIG. 4 shows comparison of the amino acid sequence deduced from the nucleotide sequence of the *sucC* gene derived from *Enterobacter agglomerans* and that derived from *Escherichia coli*.

[0020] FIG. 5 shows comparison of the amino acid sequence deduced from the nucleotide sequence of the *sdhB* gene derived from *Enterobacter agglomerans* and that derived from *Escherichia coli*.

[0021] FIG. 6 shows construction of plasmid pMWCPG having a *gltA* gene, a *ppc* gene and a *gdhA* gene.

[0022] FIG. 7 shows construction of plasmid RSF-Tet having the replication origin of the broad host spectrum plasmid RSF1010 and a tetracycline resistance gene.

[0023] FIG. 8 shows construction of plasmid RSFCPG having the replication origin of the broad host spectrum plasmid RSF1010, a tetracycline resistance gene, a *gltA* gene, a *ppc* gene and a *gdhA* gene.

[0024] FIG. 9 shows construction of plasmid pSTVCB having a *gltA* gene.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Hereafter, the present invention will be explained in detail.

[0026] The microorganism of the present invention is a microorganism that (1) can metabolize a carbon source at a specific pH in a liquid medium containing L-glutamic acid at a saturation concentration and the carbon source and (2) has ability to accumulate L-glutamic acid in an amount exceeding the amount corresponding to the saturation concentration in the liquid medium at the pH.

[0027] The term "saturation concentration" means a concentration of L-glutamic acid dissolved in a liquid medium when the liquid medium is saturated with L-glutamic acid.

[0028] Hereafter, a method for screening a microorganism that can metabolize a carbon source in a liquid medium containing L-glutamic acid at a saturation concentration and the carbon source at a specific pH will be described. A sample containing microorganisms is inoculated into a liquid medium containing L-glutamic acid at a saturation concentration and a carbon source at a specific pH, and a strain that can metabolize the carbon source is selected. The specific pH is not particularly limited, but is usually not more than about 5.0, preferably not more than about 4.5, more preferably not more than about 4.3. The microorganism of the present invention is used to produce L-glutamic acid by fermentation with precipitating L-glutamic acid. If the pH is too high, it becomes difficult to allow the microorganism to produce L-glutamic acid enough for precipitation. Therefore, pH is preferably in the aforementioned range.

[0029] If pH of an aqueous solution containing L-glutamic acid is lowered, the solubility of L-glutamic acid significantly falls around pKa of γ -carboxyl group (4.25, 25° C.). The solubility becomes the lowest at the isoelectric point (pH3.2) and L-glutamic acid exceeding the amount corresponding to the saturation concentration is precipitated. While it depends on the medium composition, L-glutamic acid is usually dissolved in an amount of 10 to 20 g/L at pH 3.2, 30 to 40 g/L at pH 4.0 and 50 to 60 g/L at pH 4.7, at about 30° C. Usually pH does not need to be made below 3.0, because the L-glutamic acid precipitating effect plateaus when pH goes below a certain value. However, pH may be below 3.0.

[0030] In addition, the expression that a microorganism "can metabolize the carbon source" means that it can proliferate or can consume the carbon source even though it cannot proliferate, that is, it indicates that it catabolizes carbon sources such as saccharides or organic acids. Specifically, for example, if a microorganism proliferates when cultured in a liquid medium containing L-glutamic acid at a saturation concentration at pH 5.0 to 4.0, preferably pH 4.5 to 4.0, more preferably pH 4.3 to 4.0, still more preferably pH 4.0 at an appropriate temperature, for example, 28° C., 37° C. or 50° C. for 2 to 4 days, this microorganism can metabolize the carbon source in the medium. Further, for example, even if a microorganism does not proliferate when it is cultured in a liquid medium containing L-glutamic acid at a saturation concentration at pH 5.0 to 4.0, preferably pH 4.5 to 4.0, more preferably pH4.3 to 4.0, still more preferably pH4.0 at an appropriate temperature, for example, 28° C., 37° C. or 50° C. for 2 to 4 days, the microorganism which consumes the carbon source in the medium is that can metabolize the carbon source in the medium.

[0031] The microorganism which can metabolize the carbon source includes a microorganism which can grow in the liquid medium.

[0032] The expression that a microorganism "can grow" means that it can proliferate or can produce L-glutamic acid even though it cannot proliferate. Specifically, for example, if a microorganism proliferates when cultured in a liquid medium containing L-glutamic acid at a saturation concentration at pH 5.0 to 4.0, preferably pH 4.5 to 4.0, more preferably pH 4.3 to 4.0, still more preferably pH 4.0 at an appropriate temperature, for example, 28° C., 37° C. or 50° C. for 2 to 4 days, this microorganism can grow in the

medium. Further, for example, even if a microorganism does not proliferate when it is cultured in a liquid synthetic medium containing L-glutamic acid at a saturation concentration at pH 5.0 to 4.0, preferably pH 4.5 to 4.0, more preferably pH 4.3 to 4.0, still more preferably pH 4.0 at an appropriate temperature, for example, 28° C., 37° C. or 50° C. for 2 to 4 days, the microorganism which increases the amount of L-glutamic acid in the medium is that can grow in the medium.

[0033] The selection described above may be repeated two or more times under the same conditions or with changing pH or the concentration of L-glutamic acid. An initial selection can be performed in a medium containing L-glutamic acid at a concentration lower than the saturation concentration, and thereafter a subsequent selection can be performed in a medium containing L-glutamic acid at a saturation concentration. Further, strains with favorable properties such as superior proliferation rate may be selected.

[0034] In addition to the property described above, the microorganism of the present invention has ability to accumulate L-glutamic acid in an amount exceeding the amount corresponding to the saturation concentration of L-glutamic acid in a liquid medium. The pH of the aforementioned liquid medium is preferably the same as or close to that of the medium used for screening a microorganism having the aforementioned property (1). Usually, a microorganism becomes susceptible to L-glutamic acid at a high concentration as pH becomes lower. Therefore, it is preferred that pH is not low from the viewpoint of resistance to L-glutamic acid, but low pH is preferred from the viewpoint of production of L-glutamic acid with precipitating it. To satisfy these conditions, pH may be in the range of 3 to 5, preferably 4 to 5, more preferably 4.0 to 4.7, still more preferably 4.0 to 4.5, particularly preferably 4.0 to 4.3.

[0035] As the microorganism of the present invention or breeding materials therefor, there can be mentioned, for example, microorganisms belonging to the genus *Enterobacter*, *Klebsiella*, *Serratia*, *Pantoea*, *Erwinia*, *Escherichia*, *Corynebacterium*, *Alicyclobacillus*, *Bacillus*, *Saccharomyces* or the like. Among these, microorganisms belonging to the genus *Enterobacter* are preferred. Hereafter, the microorganism of the present invention will be explained mainly for microorganisms belonging to the genus *Enterobacter*, but the present invention can be applied to microorganism belonging to other genera and not limited to the genus *Enterobacter*.

[0036] As microorganisms belonging to the *Enterobacter*, there can be specifically mentioned *Enterobacter agglomerans*, preferably the *Enterobacter agglomerans* AJ13355 strain. This strain was isolated from a soil in Iwata-shi, Shizuoka, Japan as a strain that can proliferate in a medium containing L-glutamic acid and a carbon source at low pH.

[0037] The physiological properties of AJ13355 are as follows:

[0038] (1) Gram staining: negative

[0039] (2) Behavior against oxygen: facultative anaerobic

[0040] (3) Catalase: positive

[0041] (4) Oxidase: negative

- [0042] (5) Nitrate-reducing ability: negative
- [0043] (6) Voges-Proskauer test: positive
- [0044] (7) Methyl Red test: negative
- [0045] (8) Urease: negative
- [0046] (9) Indole production: positive
- [0047] (10) Motility: motile
- [0048] (11) H₂S production in TSI medium: weakly active
- [0049] (12) β -galactosidase: positive
- [0050] (13) Saccharide-assimilating property:
 - [0051] Arabinose: positive
 - [0052] Sucrose: positive
 - [0053] Lactose: positive
 - [0054] Xylose: positive
 - [0055] Sorbitol: positive
 - [0056] Inositol: positive
 - [0057] Trehalose: positive
 - [0058] Maltose: positive
 - [0059] Glucose: positive
 - [0060] Adonitol: negative
 - [0061] Raffinose: positive
 - [0062] Salicin: negative
 - [0063] Melibiose: positive
- [0064] (14) Glycerol-assimilating property: positive
- [0065] (15) Organic acid-assimilating property:
 - [0066] Citric acid: positive
 - [0067] Tartaric acid: negative
 - [0068] Gluconic acid: positive
 - [0069] Acetic acid: positive
 - [0070] Malonic acid: negative
- [0071] (16) Arginine dehydratase: negative
- [0072] (17) Ornithine decarboxylase: negative
- [0073] (18) Lysine decarboxylase: negative
- [0074] (19) Phenylalanine deaminase: negative
- [0075] (20) Pigment formation: yellow
- [0076] (21) Gelatin liquefaction ability: positive
- [0077] (22) Growth pH: growth is possible at pH 4.0, good growth at pH 4.5 to 7
- [0078] (23) Growth temperature: good growth at 25° C., good growth at 30° C., good growth at 37° C., growth is possible at 42° C., growth is not possible at 45° C.
- [0079] Based on these bacteriological properties, AJ13355 was determined as *Enterobacter agglomerans*.
- [0080] The *Enterobacter agglomerans* AJ13355 was deposited at the National Institute of Bioscience and Human-Technology, Agency of Industrial Science and Tech-

nology, Ministry of International Trade and Industry (postal code: 305-8566, 1-3, Higashi 1-chome, Tsukuba-shi, Ibaraki, Japan) on Feb. 19, 1998 and received an accession number of FERM P-16644. It was then transferred to an international deposition under the provisions of Budapest Treaty on Jan. 11, 1999 and received an accession number of FERM BP-6614.

[0081] The microorganism of the present invention may be a microorganism originally having L-glutamic acid-producing ability or one having L-glutamic acid-producing ability imparted or enhanced by breeding through use of mutation treatment, recombinant DNA techniques or the like.

[0082] L-Glutamic acid-producing ability can be imparted or enhanced by, for example, increasing activity of an enzyme that catalyzes a reaction for biosynthesis of L-glutamic acid. L-Glutamic acid-producing ability can also be enhanced by decreasing activity of an enzyme that catalyzes a reaction branching from the biosynthetic pathway of L-glutamic acid and producing a compound other than L-glutamic acid, or making the activity deficient.

[0083] As enzymes that catalyze a reaction for biosynthesis of L-glutamic acid, there can be mentioned glutamate dehydrogenase (hereafter, also referred to as "GDH"), glutamine synthetase, glutamate synthase, isocitrate dehydrogenase, aconitate hydratase, citrate synthase (hereafter, also referred to as "CS"), phosphoenolpyruvate carboxylase (hereafter, also referred to as "PEPC"), pyruvate dehydrogenase, pyruvate kinase, enolase, phosphoglyceromutase, phosphoglycerate kinase, glyceraldehyde-3-phosphate dehydrogenase, triosephosphate isomerase, fructose biphosphate aldolase, phosphofructokinase, glucose phosphate isomerase and so forth. Among these enzymes, one, two or three of CS, PEPC and GDH are preferred. Further, it is preferred that the activities of all the three enzymes, CS, PEPC and GDH, are enhanced in the microorganism of the present invention. In particular, CS of *Brevibacterium lactofermentum* is preferred, because it does not suffer from inhibition by α -ketoglutaric acid, L-glutamic acid and NADH.

[0084] In order to enhance the activity of CS, PEPC or GDH, for example, a gene coding for CS, PEPC or GDH may be cloned on an appropriate plasmid and a host microorganism may be transformed with the obtained plasmid. The copy number of the gene coding for CS, PEPC or GDH (hereafter, abbreviated as "gltA gene", "ppc gene" and "gdhA gene", respectively) in the transformed strain cell increases, resulting in the increase of the activity of CS, PEPC or GDH.

[0085] The cloned gltA gene, ppc gene and gdhA gene are introduced into the aforementioned starting parent strain solely or in combination of arbitrary two or three kinds of them. When two or three kinds of the genes are introduced, two or three kinds of the genes may be cloned on one kind of plasmid and introduced into the host, or separately cloned on two or three kinds of plasmids that can coexist and introduced into the host.

[0086] Two or more kinds of genes coding for enzymes of the same kind, but derived from different microorganisms may be introduced into the same host.

[0087] The plasmids described above are not particularly limited so long as they are autonomously replicable in cells

of a microorganism belonging to, for example, the genus *Enterobacter* or the like, but, for example, there can be mentioned pUC19, pUC18, pBR322, pHSG299, pHSG298, pHSG399, pHSG398, RSF1010, pMW119, pMW118, pMW219, pMW218, pACYC177, pACYC184 and so forth. Besides these, vectors of phage DNA can also be used.

[0088] Transformation can be performed by, for example, the method of D. M. Morrison (Methods in Enzymology, 68, 326 (1979)), the method wherein permeability of DNA is increased by treating recipient bacterium cells with calcium chloride (Mandel M. and Higa A., J. Mol. Biol., 53, 159 (1970)), the electroporation (Miller J. H., "A Short Course in Bacterial Genetics", Cold Spring Harbor Laboratory Press, U.S.A. 1992) or the like.

[0089] The activity of CS, PEPC or GDH can also be increased by allowing multiple copies of a *gltA* gene, a *ppc* gene or a *gdhA* gene to be present on chromosomal DNA of the aforementioned starting parent strain to be a host. In order to introduce multiple copies of the *gltA* gene, the *ppc* gene or the *gdhA* gene on chromosomal DNA of a microorganism belonging to the genus *Enterobacter* or the like, a sequence of which multiple copies are present on the chromosomal DNA, such as repetitive DNA and inverted repeats present at termini of a transposable element, can be used. Alternatively, multiple copies of the genes can be introduced onto chromosomal DNA by utilizing transfer of a transposon containing the *gltA* gene, the *ppc* gene or the *gdhA* gene. As a result, the copy number of the *gltA* gene, the *ppc* gene or the *gdhA* gene in a transformed strain cell is increased, and thus the activity of CS, PEPC or GDH is increased.

[0090] As organisms to be a source of the *gltA* gene, the *ppc* gene or the *gdhA* gene of which copy number is increased, any organism can be used so long as it has activity of CS, PEPC or GDH. Inter alia, bacteria, which are prokaryotes, for example, those belonging to the genus *Enterobacter*, *Klebsiella*, *Erwinia*, *Pantoea*, *Serratia*, *Escherichia*, *Corynebacterium*, *Brevibacterium* and *Bacillus* are preferred. As specific examples, there can be mentioned *Escherichia coli*, *Brevibacterium lactofermentum* and so forth. The *gltA* gene, the *ppc* gene and the *gdhA* gene can be obtained from chromosomal DNA of the microorganisms described above.

[0091] The *gltA* gene, the *ppc* gene and the *gdhA* gene can be obtained by using a mutant strain which is deficient in the activity of CS, PEPC or GDH to isolate a DNA fragment which complements the auxotrophy from chromosomal DNA of the aforementioned microorganisms. Since the nucleotide sequences of these genes of *Escherichia* and *Corynebacterium* bacteria have already been elucidated (Biochemistry, 22, pp. 5243-5249 (1983); J. Biochem., 95, pp. 909-916 (1984); Gene, 27, pp. 193-199 (1984); Microbiology, 140, pp. 1817-1828 (1994); Mol. Gen. Genet., 218, pp. 330-339 (1989); Molecular Microbiology, 6, pp. 317-326 (1992)), they can also be obtained by PCR utilizing primers synthesized based on each nucleotide sequence and chromosomal DNA as a template.

[0092] The activity of CS, PEPC or GDH can also be increased by enhancing the expression of the *gltA* gene, the *ppc* gene or the *gdhA* gene besides the aforementioned amplification of the genes. For example, the expression can be enhanced by replacing a promoter for the *gltA* gene, the *ppc* gene or the *gdhA* gene with other stronger promoters.

For example, *lac* promoter, *trp* promoter, *trc* promoter, *tac* promoter, P_R promoter and P_L promoter of the lambda phage and so forth are known as strong promoters. The *gltA* gene, the *ppc* gene and the *gdhA* gene of which promoter is replaced are cloned on a plasmid and introduced into the host microorganism, or introduced onto the chromosomal DNA of the host microorganism by using repetitive DNA, inverted repeats, transposon or the like.

[0093] The activity of CS, PEPC or GDH can also be enhanced by replacing the promoter of the *gltA* gene, the *ppc* gene or the *gdhA* gene on the chromosome with other stronger promoters (see WO 87/03006 and Japanese Patent Application Laid-open No. 61-268183), or inserting a strong promoter in the upstream of the coding sequence of each gene (see Gene, 29, pp. 231-241 (1984)). Specifically, homologous recombination can be performed between DNA containing the *gltA* gene, the *ppc* gene or the *gdhA* gene of which promoter is replaced with a stronger one or a part thereof and the corresponding gene on the chromosome.

[0094] Examples of the enzyme which catalyze a reaction branching from the biosynthetic pathway of the L-glutamic acid and producing a compound other than L-glutamic acid include α -ketoglutarate dehydrogenase (hereafter, also referred to as " α KGDH"), isocitrate lyase, phosphate acetyltransferase, acetate kinase, acetohydroxy acid synthase, acetolactate synthase, formate acetyltransferase, lactate dehydrogenase, glutamate decarboxylase, 1-pyrroline dehydrogenase and so forth. Among these enzymes, α KGDH is preferred.

[0095] In order to obtain decrease or deficiency of the activity of the aforementioned enzyme in a microorganism belonging to the genus *Enterobacter* or the like, mutation causing decrease or deficiency of the intracellular activity of the enzyme can be introduced into the gene of the aforementioned enzyme by a usual mutagenesis or genetic engineering method.

[0096] Examples of the mutagenesis method include, for example, methods utilizing irradiation with X-ray or ultraviolet ray, methods utilizing treatment with a mutagenic agent such as N-methyl-N'-nitro-N-nitrosoguanidine, and so forth. The site where the mutation is introduced to the gene may be in a coding region coding for an enzyme protein, or a region for regulating expression such as a promoter.

[0097] Examples of the genetic engineering methods include, for example, methods utilizing gene recombination, transduction, cell fusion and so forth. For example, a drug resistance gene is inserted into a cloned target gene to prepare a gene that has lost its function (defective gene). Subsequently, this defective gene is introduced into a cell of a host microorganism, and the target gene on the chromosome is replaced with the aforementioned defective gene by utilizing homologous recombination (gene disruption).

[0098] Decrease or deficiency of intracellular activity of the target enzyme and the degree of decrease of the activity can be determined by measuring the enzyme activity of a cell extract or a purified fraction thereof obtained from a candidate strain and comparing with that of a wild strain. For example, the α KGDH activity can be measured by the method of Reed et al. (Reed L. J. and Mukherjee B. B., Methods in Enzymology, 13, pp. 55-61 (1969)).

[0099] Depending on the target enzyme, the target mutant strain can be selected based on the phenotype of the mutant

strain. For example, a mutant strain which is deficient in the α KGDH activity or decreases in the α KGDH activity cannot proliferate or shows a markedly reduced proliferation rate in a minimal medium containing glucose or a minimal medium containing acetic acid or L-glutamic acid as an exclusive carbon source under aerobic conditions. However, normal proliferation is enabled even under the same condition by adding succinic acid or lysine, methionine and diaminopimelic acid to a minimal medium containing glucose. By utilizing these phenomena as indicators, mutant strains with decreased α KGDH activity or deficient in the activity can be selected.

[0100] A method for preparing the α KGDH gene deficient strain of *Brevibacterium lactofermentum* by utilizing homologous recombination is described in detail in WO95/34672. Similar methods can be applied to the other microorganisms.

[0101] Further, techniques such as cloning of genes and cleavage and ligation of DNA, transformation and so forth are described in detail in Molecular Cloning, 2nd Edition, Cold Spring Harbor Press, 1989 and so forth.

[0102] As a specific example of a mutant strain deficient in α KGDH activity or with decreased α KGDH activity obtained as described above, there can be mentioned *Enterobacter agglomerans* AJ13356. *Enterobacter agglomerans* AJ13356 was deposited at the National Institute of Bioscience and Human-Technology, Agency of Industrial Science and Technology, Ministry of International Trade and Industry (postal code: 305-8566, 1-3, Higashi 1-chome, Tsukuba-shi, Ibaraki, Japan) on Feb. 19, 1998 and received an accession number of FERM P-16645. It was then transferred to an international deposition under the provisions of Budapest Treaty on Jan. 11, 1999 and received an accession number of FERM BP-6615. The *Enterobacter agglomerans* AJ13356 is deficient in α KGDH activity as a result of disruption of the α KGDH-E1 subunit gene (sucA).

[0103] When *Enterobacter agglomerans*, an example of the microorganism used in the present invention, is cultured in a medium containing a saccharide, a viscous material is extracellularly secreted, resulting in low operation efficiency. Therefore, when *Enterobacter agglomerans* having such a property of secreting the viscous material is used, it is preferable to use a mutant strain that secretes less the viscous material compared with a wild strain. Examples of mutagenesis methods include, for example, methods utilizing irradiation with X ray or ultraviolet ray, method utilizing treatment with a mutagenic agent such as N-methyl-N'-nitro-N-nitrosoguanidine and so forth. A mutant strain with decreased secretion of the viscous material can be selected by inoculating mutagenized bacterial cells in a medium containing a saccharide, for example, LB medium plate containing 5 g/L of glucose, culturing them with tilting the plate about 45 degrees and selecting a colony which does not show flowing down of liquid.

[0104] In the present invention, impartation or enhancement of L-glutamic acid-producing ability and impartation of other favorable properties such as mutation for less viscous material secretion described above can be carried out in an arbitrary order.

[0105] By culturing the microorganism of the present invention in a liquid medium of which pH is adjusted to a pH

at which L-glutamic acid is precipitated, L-glutamic acid can be produced and accumulated with precipitating it in the medium. L-Glutamic acid can also be precipitated by starting the culture at a neutral pH and then ending it at a pH at which L-glutamic acid is precipitated.

[0106] The pH at which L-glutamic acid is precipitated means one at which L-glutamic acid is precipitated when the microorganism produces and accumulates L-glutamic acid.

[0107] As the aforementioned medium, a usual nutrient medium containing a carbon source, a nitrogen source, mineral salts and organic trace nutrients such as amino acids and vitamins as required can be used so long as pH is adjusted to a pH at which L-glutamic acid is precipitated. Either a synthetic medium or a natural medium can be used. The carbon source and the nitrogen source used in the medium can be any ones so long as they can be used by the cultured strain.

[0108] As the carbon source, saccharides such as glucose, glycerol, fructose, sucrose, maltose, mannose, galactose, starch hydrolysate and molasses are used. In addition, organic acids such as acetic acid and citric acid may be used each alone or in combination with another carbon source.

[0109] As the nitrogen source, ammonia, ammonium salts such as ammonium sulfate, ammonium carbonate, ammonium chloride, ammonium phosphate and ammonium acetate, nitrates and so forth are used.

[0110] As the organic trace nutrients, amino acids, vitamins, fatty acids, nucleic acids, those containing these substances such as peptone, casamino acid, yeast extract and soybean protein decomposition products are used. When an auxotrophic mutant strain that requires an amino acid and so forth for metabolization or growth is used, the required nutrient must be supplemented.

[0111] As mineral salts, phosphates, magnesium salts, calcium salts, iron salts, manganese salts and so forth are used.

[0112] As for the culture method, aeration culture is usually performed with controlling the fermentation temperature to be 20 to 42° C. and pH to be 3 to 5, preferably 4 to 5, more preferably 4 to 4.7, particularly preferably 4 to 4.5. Thus, after about 10 hours to 4 days of culture, a substantial amount of L-glutamic acid is accumulated in the culture. Accumulated L-glutamic acid exceeding the amount corresponding to the saturation concentration is precipitated in the medium.

[0113] After completion of the culture, L-glutamic acid precipitated in the culture can be collected by centrifugation, filtration or the like. L-Glutamic acid dissolved in the medium can be collected according to known methods. For example, the L-glutamic acid can be isolated by concentrating the culture broth to crystallize it or isolated by ion exchange chromatography or the like. L-Glutamic acid precipitated in the culture broth may be isolated together with L-glutamic acid that have been dissolved in the medium after it is crystallized.

[0114] According to the method of the present invention, L-glutamic acid exceeding the amount corresponding to the saturation concentration is precipitated, and the concentration of L-glutamic acid dissolved in the medium is maintained at a constant level. Therefore, influence of L-glutamic

acid at a high concentration on microorganisms can be reduced. Accordingly, it becomes possible to breed a microorganism having further improved L-glutamic acid-producing ability. Further, since L-glutamic acid is precipitated as crystals, acidification of the culture broth by accumulation of L-glutamic acid is suppressed, and therefore the amount of alkali used for maintaining pH of the culture can significantly be reduced.

EXAMPLES

[0115] Hereafter, the present invention will be more specifically explained with reference to the following examples.

<1> Screening of Microorganism Having L-Glutamic Acid Resistance in Acidic Environment

[0116] Screening of a microorganism having L-glutamic acid resistance in an acidic environment was performed as follows. Each of about 500 samples obtained from nature including soil, fruits, plant bodies, river water in an amount of 1 g was suspended in 5 mL of sterilized water, of which 200 μ L was coated on 20 mL of solid medium of which pH was adjusted to 4.0 with HCl. The composition of the medium was as follows: 3 g/L of glucose, 1 g/L of $(\text{NH}_4)_2\text{SO}_4$, 0.2 g/L of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 0.5 g/L of KH_2PO_4 , 0.2 g/L of NaCl, 0.1 g/L of $\text{CaCl}_2 \cdot 7\text{H}_2\text{O}$, 0.01 g/L of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 0.01 g/L of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, 0.72 mg/L of $\text{ZnSO}_4 \cdot 2\text{H}_2\text{O}$, 0.64 mg/L of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 0.72 mg/L of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 0.4 mg/L of boric acid, 1.2 mg/L of $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, 50 μ g/L of biotin, 50 μ g/L of calcium pantothenate, 50 μ g/L of folic acid, 50 μ g/L of inositol, 50 μ g/L of niacin, 50 μ g/L of p-aminobenzoic acid, 50 μ g/L of pyridoxine hydrochloride, 50 μ g/L of riboflavin, 50 μ g/L of thiamine hydrochloride, 50 mg/L of cycloheximide, 20 g/L of agar.

[0117] The media plated on which the above samples were plated were incubated at 28° C., 37° C. or 50° C. for 2 to 4 days and 378 strains each forming a colony were obtained.

[0118] Subsequently, each of the strains obtained as described above was inoculated in a test tube of 16.5 cm in length and 14 mm in diameter containing 3 mL of liquid medium (adjusted to pH 4.0 with HCl) containing a saturation concentration of L-glutamic acid and cultured at 28° C., 37° C. or 50° C. for 24 hours to 3 days with shaking. Then, the grown strains were selected. The composition of the aforementioned medium was follows: 40 g/L of glucose, 20 g/L of $(\text{NH}_4)_2\text{SO}_4$, 0.5 g/L of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 2 g/L of KH_2PO_4 , 0.5 g/L of NaCl, 0.25 g/L of $\text{CaCl}_2 \cdot 7\text{H}_2\text{O}$, 0.02 g/L of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 0.02 g/L of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, 0.72 mg/L of $\text{ZnSO}_4 \cdot 2\text{H}_2\text{O}$, 0.64 mg/L of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 0.72 mg/L of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 0.4 mg/L of boric acid, 1.2 mg/L of $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, 2 g/L of yeast extract.

[0119] Thus, 78 strains of microorganisms having L-glutamic acid resistance in an acidic environment were successfully obtained.

<2> Selection of Strains with Superior Growth Rate in Acidic Environment from Microorganisms Having L-Glutamic Acid Resistance

[0120] The various microorganisms having L-glutamic acid resistance in an acidic environment obtained as described above were each inoculated into a test tube of 16.5 cm in length and 14 mm in diameter containing 3 mL of

medium (adjusted to pH 4.0 with HCl) obtained by adding 20 g/L of glutamic acid and 2 g/L of glucose to M9 medium (Sambrook, J., Fritsh, E. F. and Maniatis, T., "Molecular Cloning", Cold Spring Harbor Laboratory Press, 1989), and the turbidity of the medium was measured in the time course to select strains with a favorable growth rate. As a result, as a strain showing favorable growth, the AJ13355 strain was obtained from a soil in Iwata-shi, Shizuoka, Japan. This strain was determined as *Enterobacter agglomerans* based on its bacteriological properties described above.

<3> Acquisition of Strain with Less Viscous Material Secretion from *Enterobacter agglomerans* AJ13355 Strain

[0121] Since the *Enterobacter agglomerans* AJ13355 strain extracellularly secretes a viscous material when cultured in a medium containing a saccharide, operation efficiency is not favorable. Therefore, a strain with less viscous material secretion was obtained by the ultraviolet irradiation method (Miller, J. H. et al., "A Short Course in Bacterial Genetics; Laboratory Manual", p. 150, Cold Spring Harbor Laboratory Press, 1992).

[0122] The *Enterobacter agglomerans* AJ13355 strain was irradiated with ultraviolet ray for 2 minutes at the position 60 cm away from a 60-W ultraviolet lamp and cultured in LB medium overnight to fix mutation. The mutagenized strain was diluted and inoculated in LB medium containing 5 g/L of glucose and 20 g/L of agar so that about 100 colonies per plate would emerge and cultured at 30° C. overnight with tilting the plate about 45 degrees, and then 20 colonies showing no flowing down of the viscous material were selected.

[0123] As a strain satisfying conditions that no revertant emerged even after 5 times of subculture in LB medium containing 5 g/L of glucose and 20 g/L of agar, and that there should be observed growth equivalent to the parent strain in LB medium, LB medium containing 5 g/L of glucose and M9 medium (Sambrook, J. et al., Molecular Cloning, 2nd Edition, Cold Spring Harbor Press, 1989) to which 20 g/L of L-glutamic acid and 2 g/L of glucose were added and of which pH was adjusted to 4.5 with HCl, SC17 strain was selected from the strains selected above.

<4> Construction of Glutamic Acid-Producing Bacterium from *Enterobacter agglomerans* SC17 Strain

(1) Preparation of α KGDH Deficient Strain from *Enterobacter agglomerans* SC17 Strain

[0124] A strain deficient in α KGDH and with enhanced L-glutamic acid biosynthetic system was prepared from the *Enterobacter agglomerans* SC17 strain.

(i) Cloning of α KGDH Gene (Hereafter, Referred to as "sucAB") of *Enterobacter agglomerans* AJ13355 Strain

[0125] The sucAB gene of the *Enterobacter agglomerans* AJ13355 strain was cloned by selecting a DNA fragment complementing the acetic acid-unassimilating property of the α KGDH-E1 subunit gene (hereafter, referred to as "sucA") deficient strain of *Escherichia coli* from chromosomal DNA of the *Enterobacter agglomerans* AJ13355 strain.

[0126] The chromosomal DNA of the *Enterobacter agglomerans* AJ13355 strain was isolated by a method usually employed when chromosomal DNA is extracted from

Escherichia coli (Text for Bioengineering Experiments, Edited by the Society for Bioscience and Bioengineering, Japan, pp. 97-98, Baifukan, 1992). The pTWV228 (resistant to ampicillin) used as a vector was commercially available one from Takara Shuzo Co., Ltd.

[0127] The chromosomal DNA of the AJ13355 strain digested with EcoT221 and pTWV228 digested with PstI were ligated by using T4 ligase and used to transform the sucA deficient *Escherichia coli* JRG465 strain (Herbert, J. et al., Mol. Gen. Genetics, 105, 182 (1969)). A strain growing in an acetate minimal medium was selected from the transformant strains obtained above, and a plasmid was extracted from it and designated as pTWVEK101. The *Escherichia coli* JRG465 strain harboring pTWVEK101 recovered auxotrophy for succinic acid or L-lysine and L-methionine besides the acetic acid-assimilating property. This suggests that pTWVEK101 contains the sucA gene of *Enterobacter agglomerans*.

[0128] FIG. 1 shows the restriction map of a DNA fragment derived from *Enterobacter agglomerans* in pTWVEK101. The determined nucleotide sequence of the hatched portion in FIG. 1 is shown as SEQ ID NO: 1. In this sequence, nucleotide sequences considered to be two full length ORFs and two nucleotide sequences considered to be partial sequences of the ORFs were found. SEQ ID NOS: 2 to 5 show amino acid sequences that can be encoded by these ORFs or partial sequences in an order from the 5' end. As a result of homology search for these, it was revealed that the portion of which nucleotide sequences were determined contained a 3'-end partial sequence of the succinate dehydrogenase iron-sulfur protein gene (sdhB), full length sucA and α KGDH-E2 subunit gene (sucb), and 5'-end partial sequence of the succinyl CoA synthetase β subunit gene (sucC). The results of comparison of the amino acid sequences deduced from these nucleotide sequences with those derived from *Escherichia coli* (Eur. J. Biochem., 141, pp. 351-359 (1984); Eur. J. Biochem., 141, pp. 361-374 (1984); Biochemistry, 24, pp. 6245-6252 (1985)) are shown in FIGS. 2 to 5. Thus, the amino acid sequences each showed very high homology. In addition, it was found that a cluster of sdhB-sucA-sucB-sucC was constituted on the chromosome of *Enterobacter agglomerans* as in *Escherichia coli* (Eur. J. Biochem., 141, pp. 351-359 (1984); Eur. J. Biochem., 141, pp. 361-374 (1984); Biochemistry, 24, pp. 6245-6252 (1985)).

(ii) Acquisition of α KGDH Deficient Strain Derived from *Enterobacter agglomerans* SC17 Strain

[0129] The homologous recombination was performed by using the sucAB gene of *Enterobacter agglomerans* obtained as described above to obtain an α KGDH deficient strain of *Enterobacter agglomerans*.

[0130] After pTWVEK101 was digested with SphI to excise a fragment containing sucA, the fragment was blunt-ended with Klenow fragment (Takara Shuzo Co., Ltd.) and ligated with pBR322 digested with EcoRI and blunt-ended with Klenow fragment, by using T4 DNA ligase (Takara Shuzo Co., Ltd.). The obtained plasmid was digested at the restriction enzyme BglII recognition site positioned substantially at the center of sucA by using this enzyme, blunt-ended with Klenow fragment, and then ligated again by using T4 DNA ligase. It was considered that the sucA gene

did not function because a frameshift mutation was introduced into sucA of the plasmid newly constructed through the above procedure.

[0131] The plasmid constructed as described above was digested with a restriction enzyme ApaLI, and subjected to agarose gel electrophoresis to recover a DNA fragment containing sucA into which the frameshift mutation was introduced and a tetracycline resistance gene derived from pBR322. The recovered DNA fragment was ligated again by using T4 DNA ligase to construct a plasmid for disrupting the α KGDH gene.

[0132] The plasmid for disrupting the α KGDH gene obtained as described above was used to transform the *Enterobacter agglomerans* SC17 strain by electroporation (Miller, J. H., "A Short Course in Bacterial Genetics; Handbook", p. 279, Cold Spring Harbor Laboratory Press, U.S.A., 1992), and a strain wherein sucA on the chromosome was replaced with a mutant type one by homologous recombination of the plasmid was obtained by using the tetracycline resistance as an indicator. The obtained strain was designated as SC17sucA strain.

[0133] In order to confirm that the SC17sucA strain was deficient in the α KGDH activity, the enzyme activity was measured by the method of Reed et al. (Reed, L. J. and Mukherjee, B. B., Methods in Enzymology, 13, pp. 55-61, (1969)) by using cells of the strain cultured in LB medium until the logarithmic growth phase. As a result, α KGDH activity of 0.073 (Δ ABS/min/mg protein) was detected from the SC17 strain, whereas no α KGDH activity was detected from the SC17sucA strain, and thus it was confirmed that the sucA was deficient as purposed.

(2) Enhancement of L-Glutamic Acid Biosynthetic System of *Enterobacter agglomerans* SC17sucA Strain

[0134] Subsequently, a citrate synthase gene, a phosphoenolpyruvate carboxylase gene and a glutamate dehydrogenase gene derived from *Escherichia coli* were introduced into the SC17sucA strain.

(i) Preparation of Plasmid Having gltA Gene, ppc Gene and gdhA Gene Derived from *Escherichia coli*

[0135] The procedures of preparing a plasmid having a gltA gene, a ppc gene and a gdhA gene will be explained by referring to FIGS. 6 and 7.

[0136] A plasmid having a gdhA gene derived from *Escherichia coli*, pBRGDH (Japanese Patent Application Laid-open No. 7-203980), was digested with HindIII and SphI, the both ends were blunt-ended by the T4 DNA polymerase treatment, and then the DNA fragment having the gdhA gene was purified and recovered. Separately, a plasmid having a gltA gene and a ppc gene derived from *Escherichia coli*, pMWCP (WO 97/08294), was digested with XbaI, and then the both ends were blunt-ended by using T4 DNA polymerase. This was mixed with the above purified DNA fragment having the gdhA gene and ligated by using T4 ligase to obtain a plasmid PMWCPG, which corresponded to pMWCP further containing the gdhA gene (FIG. 6).

[0137] At the same time, the plasmid pVIC40 (Japanese Patent Application Laid-open No. 8-047397) having the replication origin of the broad host spectrum plasmid RSF1010 was digested with NotI, treated with T4 DNA

polymerase and digested with PstI. pBR322 was digested with EcoT14I, treated with T4 DNA polymerase and digested with PstI. The both products were mixed and ligated by using T4 ligase to obtain a plasmid RSF-Tet having the replication origin of RSF1010 and a tetracycline resistance gene (FIG. 7).

[0138] Subsequently, pMWCPG was digested with EcoRI and PstI, and a DNA fragment having the *gltA* gene, the *ppc* gene and the *gdhA* gene was purified and recovered. RSF-Tet was similarly digested with EcoRI and PstI, and a DNA fragment having the replication origin of RSF1010 was purified and recovered. The both products were mixed and ligated by using T4 ligase to obtain a plasmid RSFCPG, which corresponded to RSF-Tet containing the *gltA* gene, the *ppc* gene and the *gdhA* gene (FIG. 8). It was confirmed that the obtained plasmid RSFCPG expressed the *gltA* gene, the *ppc* gene and the *gdhA* gene, by the complementation of the auxotrophy of the *gltA*, *ppc* or *gdhA* gene deficient strain derived from *Escherichia coli* and measurement of each enzyme activity.

(ii) Preparation of Plasmid Having *gltA* Gene Derived from *Brevibacterium lactofermentum*

[0139] A plasmid having the *gltA* gene derived from *Brevibacterium lactofermentum* was constructed as follows. PCR was performed by using the primer DNAs having the nucleotide sequences represented by SEQ ID NOS: 6 and 7, which were prepared based on the nucleotide sequence of the *Corynebacterium glutamicum* *gltA* gene (Microbiology, 140, pp. 1817-1828 (1994)), and chromosomal DNA of *Brevibacterium lactofermentum* ATCC13869 as a template to obtain a *gltA* gene fragment of about 3 kb. This fragment inserted into a plasmid pHSG399 (purchased from Takara Shuzo Co., Ltd.) digested with SmaI to obtain a plasmid pHSGCB (FIG. 9). Subsequently, pHSGCB was digested with HindIII, and the excised *gltA* gene fragment of about 3 kb was inserted into a plasmid pSTV29 (purchased from Takara Shuzo Co., Ltd.) digested with HindIII to obtain a plasmid pSTVCB (FIG. 9). It was confirmed that the obtained plasmid pSTVCB expressed the *gltA* gene, by measuring the enzyme activity in the *Enterobacter agglomerans* AJ13355 strain.

(iii) Introduction of RSFCPG and pSTVCB into SC17sucA Strain

[0140] The *Enterobacter agglomerans* SC17sucA strain was transformed with RSFCPG by electroporation to obtain a transformant SC17sucA/RSFCPG strain having tetracycline resistance. Further, the SC17sucA/RSFCPG strain was transformed with pSTVCB by electroporation to obtain a transformant SC17sucA/RSFCPG+pSTVCB strain having chloramphenicol resistance.

<4> Acquisition of Strain with Improved Resistance to L-Glutamic Acid in Low pH Environment

[0141] A strain with improved resistance to L-glutamic acid at a high concentration in a low pH environment (hereafter, also referred to as "high-concentration Glu-resistant strain at low pH") was isolated from the *Enterobacter agglomerans* SC17sucA/RSFCPG+pSTVCB strain.

[0142] The SC17sucA/RSFCPG+pSTVCB strain was cultured overnight at 30° C. in LBG medium (10 g/L of tryptone, 5 g/L of yeast extract, 10 g/L of NaCl, 5 g/L of

glucose), and the cells washed with saline was appropriately diluted and plated on an M9-E medium (4 g/L of glucose, 17 g/L of Na₂HPO₄·12H₂O, 3 g/L of KH₂PO₄, 0.5 g/L of NaCl, 1 g/L of NH₄Cl, 10 mM of MgSO₄, 10 μM of CaCl₂, 50 mg/L of L-lysine, 50 mg/L of L-methionine, 50 mg/L of DL-diaminopimelic acid, 25 mg/L of tetracycline, 25 mg/L of chloramphenicol, 30 g/L of L-glutamic acid, adjusted to pH 4.5 with aqueous ammonia) plate. The colony emerged after culture at 32° C. for 2 days was obtained as a high-concentration Glu-resistant strain at low pH.

[0143] For the obtained strain, growth level in M9-E liquid medium was measured and L-glutamic acid-producing ability was tested in a 50-ml volume large test tube containing 5 ml of L-glutamic acid production test medium (40 g/L of glucose, 20 g/L of (NH₄)₂SO₄, 0.5 g/L of MgSO₄·7H₂O, 2 g/L of KH₂PO₄, 0.5 g/L of NaCl, 0.25 g/L of CaCl₂·7H₂O, 0.02 g/L of FeSO₄·7H₂O, 0.02 g/L of MnSO₄·4H₂O, 0.72 mg/L of ZnSO₄·2H₂O, 0.64 mg/L of CuSO₄·5H₂O, 0.72 mg/L of CoCl₂·6H₂O, 0.4 mg/L of boric acid, 1.2 mg/L of Na₂MoO₄·2H₂O, 2 g/L of yeast extract, 200 mg/L of L-lysine hydrochloride, 200 mg/L of L-methionine, 200 mg/L of DL-α,ε-diaminopimelic acid, 25 mg/L of tetracycline hydrochloride, 25 mg/L of chloramphenicol). A strain that exhibited the best growth level and the same L-glutamic acid producing ability as that of its parent strain, the SC17/RSFCPG+pSTVCB strain, was designated as *Enterobacter agglomerans* AJ13601. The AJ13601 strain was deposited at the National Institute of Bioscience and Human-Technology, Agency of Industrial Science and Technology, Ministry of International Trade and Industry (postal code: 305-8566, 1-3, Higashi 1-chome, Tsukuba-shi, Ibaraki, Japan) on Aug. 18, 1999 and received an accession number of FERM P-17516. It was then transferred to an international deposition under the provisions of Budapest Treaty on Jul. 6, 2000 and received an accession number of FERM BP-7207.

<5> Culture of *Enterobacter agglomerans* AJ13601 Strain for L-Glutamic Acid Production (1)

[0144] The *Enterobacter agglomerans* AJ13601 strain was inoculated into a 1-L jar fermenter containing 300 ml of medium containing 40 g/L of glucose, 20 g/L of (NH₄)₂SO₄, 0.5 g/L of MgSO₄·7H₂O, 2 g/L of KH₂PO₄, 0.5 g/L of NaCl, 0.25 g/L of CaCl₂·7H₂O, 0.02 g/L of FeSO₄·7H₂O, 0.02 g/L of MnSO₄·4H₂O, 0.72 mg/L of ZnSO₄·2H₂O, 0.64 mg/L of CuSO₄·5H₂O, 0.72 mg/L of CoCl₂·6H₂O, 0.4 mg/L of boric acid, 1.2 mg/L of Na₂MoO₄·2H₂O, 2 g/L of yeast extract, 200 mg/L of L-lysine hydrochloride, 200 mg/L of L-methionine, 200 mg/L of DL-α,ε-diaminopimelic acid, 25 mg/L of tetracycline hydrochloride and 25 mg/L of chloramphenicol, and cultured at 34° C. and pH6.0 for 14 hours. The culture pH was controlled by introducing ammonia gas into the medium.

[0145] The culture obtained as described above was centrifuged at 5000 rpm for 10 minutes, and the collected cells were inoculated into a 1-L jar fermenter containing 300 ml of medium containing 40 g/L of glucose, 5 g/L of (NH₄)₂SO₄, 1.5 g/L of MgSO₄·7H₂O, 6 g/L of KH₂PO₄, 1.5 g/L of NaCl, 0.75 g/L of CaCl₂·7H₂O, 0.06 g/L of FeSO₄·7H₂O, 0.06 g/L of MnSO₄·4H₂O, 2.16 mg/L of ZnSO₄·2H₂O, 1.92 mg/L of CuSO₄·5H₂O, 2.16 mg/L of CoCl₂·6H₂O, 1.2 mg/L of boric acid, 3.6 mg/L of Na₂MoO₄·2H₂O, 6 g/L of yeast extract, 600 mg/L of

L-lysine hydrochloride, 600 mg/L of L-methionine, 600 mg/L of DL- α,ϵ -diaminopimelic acid, 25 mg/L of tetracycline hydrochloride and 25 mg/L of chloramphenicol and cultured at 34° C. and pH 4.5 to perform culture for L-glutamic acid production. The culture pH was controlled by introducing ammonia gas into the medium. As the initially added glucose was depleted, 600 g/L of glucose was continuously added.

[0146] As a result of the culture for L-glutamic acid production performed for 50 hours as described above, a substantial amount of L-glutamic acid crystals were precipitated in the jar fermenter. Table 1 shows the concentration of L-glutamic acid dissolved in the culture broth at that time and the L-glutamic acid concentration measured by dissolving the crystals in 2 M potassium hydroxide. L-Glutamic acid crystals were collected from the culture by decantation after the culture was left stood.

TABLE 1

Concentration of L-glutamic acid dissolved in culture broth	51 g/L
Amount of L-glutamic acid precipitated as crystals	67 g/L
Concentration of L-glutamic acid measured by dissolving crystals	118 g/L

<6> Culture of *Enterobacter agglomerans* AJ13601 Strain for L-Glutamic Acid Production (2)

[0147] The following experiment was performed in order to confirm that the *Enterobacter agglomerans* AJ13601 strain still had L-glutamic acid-producing ability even under the condition that L-glutamic acid crystals were present.

[0148] The *Enterobacter agglomerans* AJ13601 strain was inoculated into a 1-L jar fermenter containing 300 ml of medium containing 40 g/L of glucose, 20 g/L of $(\text{NH}_4)_2\text{SO}_4$, 0.5 g/L of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 2 g/L of KH_2PO_4 , 0.5 g/L of NaCl, 0.25 g/L of $\text{CaCl}_2 \cdot 7\text{H}_2\text{O}$, 0.02 g/L of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 0.02 g/L of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, 0.72 mg/L of $\text{ZnSO}_4 \cdot 2\text{H}_2\text{O}$, 0.64 mg/L of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 0.72 mg/L of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 0.4 mg/L of boric acid, 1.2 mg/L of $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, 2 g/L of yeast extract, 200 mg/L of L-lysine hydrochloride, 200 mg/L of L-methionine, 200 mg/L of DL- α,ϵ -diaminopimelic acid, 25 mg/L of tetracycline hydrochloride and 25 mg/L of chloramphenicol, and cultured at 34° C. at pH 6.0 for 14 hours. The culture pH was controlled by bubbling the medium with ammonia gas. The culture obtained as described above was centrifuged at 5000 rpm for 10 minutes, and then the collected cells were cultured in a medium where L-glutamic acid was present as crystals. The used medium contained 40 g/L of glucose, 5 g/L of $(\text{NH}_4)_2\text{SO}_4$, 1.5 g/L of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 6 g/L of KH_2PO_4 , 1.5 g/L of NaCl, 0.75 g/L of $\text{CaCl}_2 \cdot 7\text{H}_2\text{O}$, 0.06 g/L of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 0.06 g/L of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, 2.16 mg/L of $\text{ZnSO}_4 \cdot 2\text{H}_2\text{O}$, 1.92 mg/L of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 2.16 mg/L of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 1.2 mg/L of boric acid, 3.6 mg/L of $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, 6 g/L of yeast extract, 600 mg/L of L-lysine hydrochloride, 600 mg/L of L-methionine, 600 mg/L of DL- α,ϵ -diaminopimelic acid, 25 mg/L of tetracycline hydrochloride and 25 mg/L of chloramphenicol and L-glutamic acid crystals were added to 40 g/L. The cells were inoculated in a 1-L jar fermenter containing 300 ml of this medium and cultured at 34° C. and pH 4.3 to perform culture for L-glutamic acid production. The culture

pH was controlled by introducing ammonia gas into the medium. As the initially added glucose was depleted, 600 g/L of glucose was continuously added. In this medium, only 39 g/L of the added L-glutamic acid was dissolved at pH 4.3 and the remaining 1 g/L was present as crystals.

[0149] As a result of the culture for L-glutamic acid production performed for 53 hours as described above, a substantial amount of L-glutamic acid crystals were precipitated in the jar fermenter. Table 2 shows the concentration of L-glutamic acid dissolved in the culture broth, the amount of L-glutamic acid present as crystals at that time and the L-glutamic acid concentration measured by dissolving the crystals in 2 M KOH solution. L-Glutamic acid crystals were collected from the culture by decantation after the culture was left stood. The results showed that the *Enterobacter agglomerans* AJ13601 strain accumulated L-glutamic acid and precipitated crystals thereof even under the condition that L-glutamic acid crystals were present.

Concentration of L-glutamic acid dissolved in culture broth	39 g/L
Amount of L-glutamic acid precipitated as crystals	119 g/L
Concentration of L-glutamic acid measured by dissolving crystals	158 g/L
Amount of L-glutamic acid crystals newly produced by main culture	118 g/L

<7> Culture of *Enterobacter agglomerans* AJ13601 Strain for L-Glutamic Acid Production (3)

[0150] The *Enterobacter agglomerans* AJ13601 strain can grow not only at an acidic pH, but also at a neutral pH. Therefore, it was confirmed as follows that L-glutamic acid crystals could also be precipitated by starting the culture at a neutral pH and allowing production of L-glutamic acid during the culture so that pH of the culture should spontaneously be lowered.

[0151] Cells of one plate (8.5 cm in diameter) of the *Enterobacter agglomerans* AJ13601 strain, cultured on LBG agar medium (10 g/ of L tryptone, 5 g/L of yeast extract, 10 g/L of NaCl, 5 g/L of glucose, 15 g/L of agar) containing 25 mg/L of tetracycline hydrochloride and 25 mg/L of chloramphenicol at 30° C. for 14 hours, were inoculated into a 1-L jar fermenter containing 300 ml of medium containing 40 g/L of glucose, 5 g/L of $(\text{NH}_4)_2\text{SO}_4$, 1.5 g/L of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 6 g/L of KH_2PO_4 , 1.5 g/L of NaCl, 0.75 g/L of $\text{CaCl}_2 \cdot 7\text{H}_2\text{O}$, 0.06 g/L of $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 0.06 g/L of $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$, 2.16 mg/L of $\text{ZnSO}_4 \cdot 2\text{H}_2\text{O}$, 1.92 mg/L of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 2.16 mg/L of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 1.2 mg/L of boric acid, 3.6 mg/L of $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$, 6 g/L of yeast extract, 600 mg/L of L-lysine hydrochloride, 600 mg/L of L-methionine, 600 mg/L of DL- α,ϵ -diaminopimelic acid, 25 mg/L of tetracycline hydrochloride and 25 mg/L of chloramphenicol and the culture was started at 34° C. and pH 7.0. The culture pH was controlled by introducing ammonia gas into the medium. As the initially added glucose was depleted, 600 g/L of glucose was continuously added.

[0152] As L-glutamic acid is accumulated, pH lowers spontaneously. The amount of the introduced ammonia gas was adjusted so that pH should be gradually lowered from 7.0 to 4.5 during the period between 15 hours and 24 hours

after the start of the culture, and 24 hours after the start of the culture, pH became 4.5. Afterward, cultivation was continued for 12 hours.

[0153] As a result of the culture for L-glutamic acid production conducted for 36 hours as described above, a substantial amount of L-glutamic acid crystals were precipitated in the jar fermenter. Table 3 shows the concentration of L-glutamic acid dissolved in the culture broth, the amount of L-glutamic acid present as crystals at that time and the L-glutamic acid concentration measured by dissolving the crystals in 2 M KOH solution. L-Glutamic acid crystals were collected from the culture by decantation after the culture was left stood.

TABLE 3

Concentration of L-glutamic acid dissolved in culture broth	45 g/L
Amount of L-glutamic acid precipitated as crystals	31 g/L
Concentration of L-glutamic acid measured by dissolving crystals	76 g/L

[0154]

SEQUENCE LISTING

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      35

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cca ctg gcg atc tcg tcg ctg gat gaa ctg gca aac ggc agt ttc cag Pro Leu Ala Ile Ser Ser Leu Asp Glu Leu Ala Asn Gly Ser Phe Gln 830 835 840	2727
ccg gcc att ggt gag atc gac gat ctg gat ccg cag ggc gtg aaa cgc Pro Ala Ile Gly Glu Ile Asp Asp Leu Asp Pro Gln Gly Val Lys Arg 845 850 855	2775
gtc gtg ctg tgc tcc ggt aag gtt tac tac gat ctg ctg gaa cag cgt Val Val Leu Cys Ser Gly Lys Val Tyr Tyr Asp Leu Leu Glu Gln Arg 860 865 870	2823
cgt aaa gac gag aaa acc gat gtt gcc atc gtg cgc atc gaa cag ctt Arg Lys Asp Glu Lys Thr Asp Val Ala Ile Val Arg Ile Glu Gln Leu 875 880 885	2871
tac ccg ttc ccg cat cag gcg gta cag gaa gca ttg aaa gcc tat tct Tyr Pro Phe Pro His Gln Ala Val Gln Glu Ala Leu Lys Ala Tyr Ser 890 895 900 905	2919
cac gta cag gac ttt gtc tgg tgc cag gaa gag cct ctg aac cag ggc His Val Gln Asp Phe Val Trp Cys Gln Glu Glu Pro Leu Asn Gln Gly 910 915 920	2967
gcc tgg tac tgt agc cag cat cat ttc cgt gat gtc gtg ccg ttt ggt Ala Trp Tyr Cys Ser Gln His His Phe Arg Asp Val Val Pro Phe Gly 925 930 935	3015
gcc acc ctg cgt tat gca ggt cgc ccg gca tcg gct tct ccg gcc gtg Ala Thr Leu Arg Tyr Ala Gly Arg Pro Ala Ser Ala Ser Pro Ala Val 940 945 950	3063
ggt tat atg tcc gta cac caa caa cag cag caa gac ctg gtt aat gac Gly Tyr Met Ser Val His Gln Gln Gln Gln Asp Leu Val Asn Asp 955 960 965	3111
gca ctg aac gtc aat taa ttaaaaggaa agata atg agt agc gta gat att Ala Leu Asn Val Asn Met Ser Ser Val Asp Ile 970 975 980	3162
ctc gtt ccc gac ctg cct gaa tcg gtt gca gat gcc aca gta gca acc Leu Val Pro Asp Leu Pro Glu Ser Val Ala Asp Ala Thr Val Ala Thr 985 990 995	3210
tgg cac aag aaa cca ggc gat gca gtc agc cgc gat gaa gtc atc Trp His Lys Lys Pro Gly Asp Ala Val Ser Arg Asp Glu Val Ile 1000 1005 1010	3255

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gtc gaa att gaa act gac aaa gtc gtg ctg gaa gtg ccg gca tct	3300
Val Glu Ile Glu Thr Asp Lys Val Val Leu Glu Val Pro Ala Ser	
1015 1020 1025	
gcc gat ggc gtg ctg gaa gcc gtg ctg gaa gac gaa ggg gca acc	3345
Ala Asp Gly Val Leu Glu Ala Val Leu Glu Asp Glu Gly Ala Thr	
1030 1035 1040	
gtt acg tcc cgc cag atc ctg ggt cgc ctg aaa gaa ggc aac agt	3390
Val Thr Ser Arg Gln Ile Leu Gly Arg Leu Lys Glu Gly Asn Ser	
1045 1050 1055	
gcg ggt aaa gaa agc agt gcc aaa gcg gaa agc aat gac acc acg	3435
Ala Gly Lys Glu Ser Ser Ala Lys Ala Glu Ser Asn Asp Thr Thr	
1060 1065 1070	
cca gcc cag cgt cag aca gcg tcg ctt gaa gaa gag agc agc gat	3480
Pro Ala Gln Arg Gln Thr Ala Ser Leu Glu Glu Glu Ser Ser Asp	
1075 1080 1085	
gcg ctc agc ccg gcg atc cgt cgc ctg att gcg gag cat aat ctt	3525
Ala Leu Ser Pro Ala Ile Arg Arg Leu Ile Ala Glu His Asn Leu	
1090 1095 1100	
gac gct gcg cag atc aaa ggc acc ggc gta ggc gga cgt tta acg	3570
Asp Ala Ala Gln Ile Lys Gly Thr Gly Val Gly Gly Arg Leu Thr	
1105 1110 1115	
cgt gaa gac gtt gaa aaa cat ctg gcg aac aaa ccg cag gct gag	3615
Arg Glu Asp Val Glu Lys His Leu Ala Asn Lys Pro Gln Ala Glu	
1120 1125 1130	
aaa gcc gcc gcg cca gcg gcg ggt gca gca acg gct cag cag cct	3660
Lys Ala Ala Ala Pro Ala Ala Gly Ala Ala Thr Ala Gln Gln Pro	
1135 1140 1145	
gtt gcc aac cgc agc gaa aaa cgt gtt ccg atg acg cgt tta cgt	3705
Val Ala Asn Arg Ser Glu Lys Arg Val Pro Met Thr Arg Leu Arg	
1150 1155 1160	
aag cgc gtc gcg gag cgt ctg ctg gaa gcc aag aac agc acc gcc	3750
Lys Arg Val Ala Glu Arg Leu Leu Glu Ala Lys Asn Ser Thr Ala	
1165 1170 1175	
atg ttg acg acc ttc aac gaa atc aac atg aag ccg att atg gat	3795
Met Leu Thr Thr Phe Asn Glu Ile Asn Met Lys Pro Ile Met Asp	
1180 1185 1190	
ctg cgt aag cag tac ggc gat gcg ttc gag aag cgt cac ggt gtg	3840
Leu Arg Lys Gln Tyr Gly Asp Ala Phe Glu Lys Arg His Gly Val	
1195 1200 1205	
cgt ctg ggc ttt atg tct ttc tac atc aag gcc gtg gtc gaa gcg	3885
Arg Leu Gly Phe Met Ser Phe Tyr Ile Lys Ala Val Val Glu Ala	
1210 1215 1220	
ctg aag cgt tat cca gaa gtc aac gcc tct atc gat ggc gaa gac	3930
Leu Lys Arg Tyr Pro Glu Val Asn Ala Ser Ile Asp Gly Glu Asp	
1225 1230 1235	
gtg gtg tac cac aac tat ttc gat gtg agt att gcc gtc tct acg	3975
Val Val Tyr His Asn Tyr Phe Asp Val Ser Ile Ala Val Ser Thr	
1240 1245 1250	
cca cgc gga ctg gtg acg cct gtc ctg cgt gac gtt gat gcg ctg	4020
Pro Arg Gly Leu Val Thr Pro Val Leu Arg Asp Val Asp Ala Leu	
1255 1260 1265	
agc atg gct gac atc gag aag aaa att aaa gaa ctg gca gtg aaa	4065
Ser Met Ala Asp Ile Glu Lys Lys Ile Lys Glu Leu Ala Val Lys	
1270 1275 1280	
ggc cgt gac ggc aag ctg acg gtt gac gat ctg acg ggc ggt aac	4110
Gly Arg Asp Gly Lys Leu Thr Val Asp Asp Leu Thr Gly Gly Asn	
1285 1290 1295	

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ttt acc atc acc aac ggt ggt gtg ttc ggt tcg ctg atg tct acg	4155
Phe Thr Ile Thr Asn Gly Gly Val Phe Gly Ser Leu Met Ser Thr	
1300 1305 1310	
cca atc atc aac ccg cca cag agc gcg att ctg ggc atg cac gcc	4200
Pro Ile Ile Asn Pro Pro Gln Ser Ala Ile Leu Gly Met His Ala	
1315 1320 1325	
att aaa gat cgt cct atg gcg gtc aat ggt cag gtt gtg atc ctg	4245
Ile Lys Asp Arg Pro Met Ala Val Asn Gly Gln Val Val Ile Leu	
1330 1335 1340	
cca atg atg tac ctg gct ctc tcc tac gat cac cgt tta atc gat	4290
Pro Met Met Tyr Leu Ala Leu Ser Tyr Asp His Arg Leu Ile Asp	
1345 1350 1355	
ggt cgt gaa tct gtc ggc tat ctg gtc gcg gtg aaa gag atg ctg	4335
Gly Arg Glu Ser Val Gly Tyr Leu Val Ala Val Lys Glu Met Leu	
1360 1365 1370	
gaa gat ccg gcg cgt ctg ctg ctg gat gtc tga ttcatcactg	4378
Glu Asp Pro Ala Arg Leu Leu Leu Asp Val	
1375 1380	
ggcagcggtt gcgtgccaa tctcaatact cttttcagat ctgaatggat agaacatc	4436
atg aac tta cac gaa tac cag gct aaa cag ctg ttt gca cgg tat	4481
Met Asn Leu His Glu Tyr Gln Ala Lys Gln Leu Phe Ala Arg Tyr	
1385 1390 1395	
ggc atg cca gca ccg acc ggc tac gcc tgt act aca cca cgt gaa	4526
Gly Met Pro Ala Pro Thr Gly Tyr Ala Cys Thr Thr Pro Arg Glu	
1400 1405 1410	
gca gaa gaa gcg gca tcg aaa atc ggt gca	4556
Ala Glu Glu Ala Ala Ser Lys Ile Gly Ala	
1415 1420	

<210> SEQ ID NO 2

<211> LENGTH: 39

<212> TYPE: PRT

<213> ORGANISM: Enterobacter agglomerans

<400> SEQUENCE: 2

Ala Phe Ser Val Phe Arg Cys His Ser Ile Met Asn Cys Val Ser Val
 1 5 10 15

Cys Pro Lys Gly Leu Asn Pro Thr Arg Ala Ile Gly His Ile Lys Ser
 20 25 30

Met Leu Leu Gln Arg Ser Ala
 35

<210> SEQ ID NO 3

<211> LENGTH: 935

<212> TYPE: PRT

<213> ORGANISM: Enterobacter agglomerans

<400> SEQUENCE: 3

Met Gln Asn Ser Ala Met Lys Pro Trp Leu Asp Ser Ser Trp Leu Ala
 1 5 10 15

Gly Ala Asn Gln Ser Tyr Ile Glu Gln Leu Tyr Glu Asp Phe Leu Thr
 20 25 30

Asp Pro Asp Ser Val Asp Ala Val Trp Arg Ser Met Phe Gln Gln Leu
 35 40 45

Pro Gly Thr Gly Val Lys Pro Glu Gln Phe His Ser Ala Thr Arg Glu
 50 55 60

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Tyr	Phe	Arg	Arg	Leu	Ala	Lys	Asp	Ala	Ser	Arg	Tyr	Thr	Ser	Ser	Val
65					70					75					80
Thr	Asp	Pro	Ala	Thr	Asn	Ser	Lys	Gln	Val	Lys	Val	Leu	Gln	Leu	Ile
				85					90					95	
Asn	Ala	Phe	Arg	Phe	Arg	Gly	His	Gln	Glu	Ala	Asn	Leu	Asp	Pro	Leu
		100						105					110		
Gly	Leu	Trp	Lys	Gln	Asp	Arg	Val	Ala	Asp	Leu	Asp	Pro	Ala	Phe	His
	115						120					125			
Asp	Leu	Thr	Asp	Ala	Asp	Phe	Gln	Glu	Ser	Phe	Asn	Val	Gly	Ser	Phe
	130					135					140				
Ala	Ile	Gly	Lys	Glu	Thr	Met	Lys	Leu	Ala	Asp	Leu	Phe	Asp	Ala	Leu
145					150					155					160
Lys	Gln	Thr	Tyr	Cys	Gly	Ser	Ile	Gly	Ala	Glu	Tyr	Met	His	Ile	Asn
				165					170					175	
Asn	Thr	Glu	Glu	Lys	Arg	Trp	Ile	Gln	Gln	Arg	Ile	Glu	Ser	Gly	Ala
		180						185					190		
Ser	Gln	Thr	Ser	Phe	Ser	Gly	Glu	Glu	Lys	Lys	Gly	Phe	Leu	Lys	Glu
		195					200					205			
Leu	Thr	Ala	Ala	Glu	Gly	Leu	Glu	Lys	Tyr	Leu	Gly	Ala	Lys	Phe	Pro
	210					215					220				
Gly	Ala	Lys	Arg	Phe	Ser	Leu	Glu	Gly	Gly	Asp	Ala	Leu	Val	Pro	Met
225					230					235					240
Leu	Arg	Glu	Met	Ile	Arg	His	Ala	Gly	Lys	Ser	Gly	Thr	Arg	Glu	Val
			245						250					255	
Val	Leu	Gly	Met	Ala	His	Arg	Gly	Arg	Leu	Asn	Val	Leu	Ile	Asn	Val
		260						265					270		
Leu	Gly	Lys	Lys	Pro	Gln	Asp	Leu	Phe	Asp	Glu	Phe	Ser	Gly	Lys	His
	275					280						285			
Lys	Glu	His	Leu	Gly	Thr	Gly	Asp	Val	Lys	Tyr	His	Met	Gly	Phe	Ser
	290					295					300				
Ser	Asp	Ile	Glu	Thr	Glu	Gly	Gly	Leu	Val	His	Leu	Ala	Leu	Ala	Phe
305					310					315					320
Asn	Pro	Ser	His	Leu	Glu	Ile	Val	Ser	Pro	Val	Val	Met	Gly	Ser	Val
			325						330					335	
Arg	Ala	Arg	Leu	Asp	Arg	Leu	Ala	Glu	Pro	Val	Ser	Asn	Lys	Val	Leu
			340					345					350		
Pro	Ile	Thr	Ile	His	Gly	Asp	Ala	Ala	Val	Ile	Gly	Gln	Gly	Val	Val
	355						360					365			
Gln	Glu	Thr	Leu	Asn	Met	Ser	Gln	Ala	Arg	Gly	Tyr	Glu	Val	Gly	Gly
	370					375					380				
Thr	Val	Arg	Ile	Val	Ile	Asn	Asn	Gln	Val	Gly	Phe	Thr	Thr	Ser	Asn
385				390						395					400
Pro	Lys	Asp	Ala	Arg	Ser	Thr	Pro	Tyr	Cys	Thr	Asp	Ile	Gly	Lys	Met
			405						410					415	
Val	Leu	Ala	Pro	Ile	Phe	His	Val	Asn	Ala	Asp	Asp	Pro	Glu	Ala	Val
		420						425					430		
Ala	Phe	Val	Thr	Arg	Leu	Ala	Leu	Asp	Tyr	Arg	Asn	Thr	Phe	Lys	Arg
	435					440						445			
Asp	Val	Phe	Ile	Asp	Leu	Val	Cys	Tyr	Arg	Arg	His	Gly	His	Asn	Glu
	450				455						460				
Ala	Asp	Glu	Pro	Ser	Ala	Thr	Gln	Pro	Leu	Met	Tyr	Gln	Lys	Ile	Lys

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465		470		475		480
Lys His Pro Thr	Pro Arg Lys Ile Tyr	Ala Asp Arg Leu Glu Gly Glu				
	485	490			495	
Gly Val Ala Ser	Gln Glu Asp Ala Thr	Glu Met Val Asn Leu Tyr Arg				
	500	505			510	
Asp Ala Leu Asp	Ala Gly Glu Cys Val Val	Pro Glu Trp Arg Pro Met				
	515	520			525	
Ser Leu His Ser	Phe Thr Trp Ser Pro Tyr	Leu Asn His Glu Trp Asp				
	530	535			540	
Glu Pro Tyr Pro	Ala Gln Val Asp Met Lys	Arg Leu Lys Glu Leu Ala				
	545	550			555	560
Leu Arg Ile Ser	Gln Val Pro Glu Gln Ile	Glu Val Gln Ser Arg Val				
	565	570			575	
Ala Lys Ile Tyr	Asn Asp Arg Lys Leu Met	Ala Glu Gly Glu Lys Ala				
	580	585			590	
Phe Asp Trp Gly	Gly Ala Glu Asn Leu Ala Tyr	Ala Thr Leu Val Asp				
	595	600			605	
Glu Gly Ile Pro	Val Arg Leu Ser Gly Glu	Asp Ser Gly Arg Gly Thr				
	610	615			620	
Phe Phe His Arg	His Ala Val Val His Asn	Gln Ala Asn Gly Ser Thr				
	625	630			635	640
Tyr Thr Pro Leu	His His Ile His Asn Ser	Gln Gly Glu Phe Lys Val				
	645	650			655	
Trp Asp Ser Val	Leu Ser Glu Glu Ala Val	Leu Ala Phe Glu Tyr Gly				
	660	665			670	
Tyr Ala Thr Ala	Glu Pro Arg Val Leu Thr	Ile Trp Glu Ala Gln Phe				
	675	680			685	
Gly Asp Phe Ala	Asn Gly Ala Gln Val Val	Ile Asp Gln Phe Ile Ser				
	690	695			700	
Ser Gly Glu Gln	Lys Trp Gly Arg Met Cys	Gly Leu Val Met Leu Leu				
	705	710			715	720
Pro His Gly Tyr	Glu Gly Gln Gly Pro Glu	His Ser Ser Ala Arg Leu				
	725	730			735	
Glu Arg Tyr Leu	Gln Leu Cys Ala Glu Gln	Asn Met Gln Val Cys Val				
	740	745			750	
Pro Ser Thr Pro	Ala Gln Val Tyr His Met	Leu Arg Arg Gln Ala Leu				
	755	760			765	
Arg Gly Met Arg	Arg Pro Leu Val Val Met	Ser Pro Lys Ser Leu Leu				
	770	775			780	
Arg His Pro Leu	Ala Ile Ser Ser Leu Asp	Glu Leu Ala Asn Gly Ser				
	785	790			795	800
Phe Gln Pro Ala	Ile Gly Glu Ile Asp Asp	Leu Asp Pro Gln Gly Val				
	805	810			815	
Lys Arg Val Val	Leu Cys Ser Gly Lys Val	Tyr Tyr Asp Leu Leu Glu				
	820	825			830	
Gln Arg Arg Lys	Asp Glu Lys Thr Asp Val	Ala Ile Val Arg Ile Glu				
	835	840			845	
Gln Leu Tyr Pro	Phe Pro His Gln Ala Val	Gln Glu Ala Leu Lys Ala				
	850	855			860	
Tyr Ser His Val	Gln Asp Phe Val Trp Cys	Gln Glu Glu Pro Leu Asn				
	865	870			875	880

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Gln Gly Ala Trp Tyr Cys Ser Gln His His Phe Arg Asp Val Val Pro
 885 890 895

Phe Gly Ala Thr Leu Arg Tyr Ala Gly Arg Pro Ala Ser Ala Ser Pro
 900 905 910

Ala Val Gly Tyr Met Ser Val His Gln Gln Gln Gln Gln Asp Leu Val
 915 920 925

Asn Asp Ala Leu Asn Val Asn
 930 935

<210> SEQ ID NO 4

<211> LENGTH: 407

<212> TYPE: PRT

<213> ORGANISM: Enterobacter agglomerans

<400> SEQUENCE: 4

Met Ser Ser Val Asp Ile Leu Val Pro Asp Leu Pro Glu Ser Val Ala
 1 5 10 15

Asp Ala Thr Val Ala Thr Trp His Lys Lys Pro Gly Asp Ala Val Ser
 20 25 30

Arg Asp Glu Val Ile Val Glu Ile Glu Thr Asp Lys Val Val Leu Glu
 35 40 45

Val Pro Ala Ser Ala Asp Gly Val Leu Glu Ala Val Leu Glu Asp Glu
 50 55 60

Gly Ala Thr Val Thr Ser Arg Gln Ile Leu Gly Arg Leu Lys Glu Gly
 65 70 75 80

Asn Ser Ala Gly Lys Glu Ser Ser Ala Lys Ala Glu Ser Asn Asp Thr
 85 90 95

Thr Pro Ala Gln Arg Gln Thr Ala Ser Leu Glu Glu Glu Ser Ser Asp
 100 105 110

Ala Leu Ser Pro Ala Ile Arg Arg Leu Ile Ala Glu His Asn Leu Asp
 115 120 125

Ala Ala Gln Ile Lys Gly Thr Gly Val Gly Gly Arg Leu Thr Arg Glu
 130 135 140

Asp Val Glu Lys His Leu Ala Asn Lys Pro Gln Ala Glu Lys Ala Ala
 145 150 155 160

Ala Pro Ala Ala Gly Ala Ala Thr Ala Gln Gln Pro Val Ala Asn Arg
 165 170 175

Ser Glu Lys Arg Val Pro Met Thr Arg Leu Arg Lys Arg Val Ala Glu
 180 185 190

Arg Leu Leu Glu Ala Lys Asn Ser Thr Ala Met Leu Thr Thr Phe Asn
 195 200 205

Glu Ile Asn Met Lys Pro Ile Met Asp Leu Arg Lys Gln Tyr Gly Asp
 210 215 220

Ala Phe Glu Lys Arg His Gly Val Arg Leu Gly Phe Met Ser Phe Tyr
 225 230 235 240

Ile Lys Ala Val Val Glu Ala Leu Lys Arg Tyr Pro Glu Val Asn Ala
 245 250 255

Ser Ile Asp Gly Glu Asp Val Val Tyr His Asn Tyr Phe Asp Val Ser
 260 265 270

Ile Ala Val Ser Thr Pro Arg Gly Leu Val Thr Pro Val Leu Arg Asp
 275 280 285

Val Asp Ala Leu Ser Met Ala Asp Ile Glu Lys Lys Ile Lys Glu Leu

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290	295	300
Ala Val Lys Gly Arg Asp Gly Lys Leu Thr Val Asp Asp Leu Thr Gly		
305	310	315 320
Gly Asn Phe Thr Ile Thr Asn Gly Gly Val Phe Gly Ser Leu Met Ser		
	325	330 335
Thr Pro Ile Ile Asn Pro Pro Gln Ser Ala Ile Leu Gly Met His Ala		
	340	345 350
Ile Lys Asp Arg Pro Met Ala Val Asn Gly Gln Val Val Ile Leu Pro		
	355	360 365
Met Met Tyr Leu Ala Leu Ser Tyr Asp His Arg Leu Ile Asp Gly Arg		
	370	375 380
Glu Ser Val Gly Tyr Leu Val Ala Val Lys Glu Met Leu Glu Asp Pro		
	385	390 395 400
Ala Arg Leu Leu Leu Asp Val		
	405	

<210> SEQ ID NO 5
 <211> LENGTH: 40
 <212> TYPE: PRT
 <213> ORGANISM: Enterobacter agglomerans

<400> SEQUENCE: 5

Met Asn Leu His Glu Tyr Gln Ala Lys Gln Leu Phe Ala Arg Tyr Gly		
1	5	10 15
Met Pro Ala Pro Thr Gly Tyr Ala Cys Thr Thr Pro Arg Glu Ala Glu		
	20	25 30
Glu Ala Ala Ser Lys Ile Gly Ala		
	35	40

<210> SEQ ID NO 6
 <211> LENGTH: 30
 <212> TYPE: DNA
 <213> ORGANISM: Artificial Sequence
 <220> FEATURE:
 <221> NAME/KEY: misc_feature
 <223> OTHER INFORMATION: Artificial Sequence: synthetic DNA

<400> SEQUENCE: 6

gtcgacaata gccygaatct gttctggtcg

30

<210> SEQ ID NO 7
 <211> LENGTH: 30
 <212> TYPE: DNA
 <213> ORGANISM: Artificial Sequence
 <220> FEATURE:
 <221> NAME/KEY: misc_feature
 <223> OTHER INFORMATION: Artificial Sequence: synthetic DNA

<400> SEQUENCE: 7

aagcttatcg acgctccct cccaccgtt

30

<210> SEQ ID NO 8
 <211> LENGTH: 936
 <212> TYPE: PRT
 <213> ORGANISM: Escherichia coli

<400> SEQUENCE: 8

Met Gln Asn Ser Ala Leu Lys Ala Trp Leu Asp Ser Ser Tyr Leu Ser		
1	5	10 15

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Gly	Ala	Asn	Gln	Ser	Trp	Glu	Ile	Glu	Gln	Leu	Tyr	Glu	Asp	Phe	Leu
		20						25					30		
Thr	Asp	Pro	Asp	Ser	Val	Asp	Ala	Asn	Trp	Arg	Ser	Thr	Phe	Gln	Gln
		35					40					45			
Leu	Pro	Gly	Thr	Gly	Val	Lys	Pro	Asp	Gln	Phe	His	Ser	Gln	Thr	Arg
	50					55					60				
Glu	Tyr	Phe	Arg	Arg	Leu	Ala	Lys	Asp	Ala	Ser	Arg	Tyr	Ser	Ser	Thr
65					70					75					80
Ile	Ser	Asp	Pro	Asp	Thr	Asn	Val	Lys	Gln	Val	Lys	Val	Leu	Gln	Leu
				85					90					95	
Ile	Asn	Ala	Tyr	Arg	Phe	Arg	Gly	His	Gln	His	Ala	Asn	Leu	Asp	Pro
		100						105					110		
Leu	Gly	Leu	Trp	Gln	Gln	Asp	Lys	Val	Ala	Asp	Leu	Asp	Pro	Ser	Phe
	115						120					125			
His	Asp	Leu	Thr	Glu	Ala	Asp	Phe	Gln	Glu	Thr	Phe	Asn	Val	Gly	Ser
	130						135					140			
Phe	Ala	Ser	Gly	Lys	Glu	Thr	Met	Lys	Leu	Gly	Glu	Leu	Leu	Glu	Ala
145					150					155					160
Leu	Lys	Gln	Thr	Tyr	Cys	Gly	Pro	Ile	Gly	Ala	Glu	Tyr	Met	His	Ile
				165					170					175	
Thr	Ser	Thr	Glu	Lys	Arg	Trp	Ile	Gln	Gln	Arg	Ile	Glu	Ser	Gly	
		180					185						190		
Arg	Ala	Thr	Phe	Asn	Ser	Glu	Glu	Lys	Lys	Arg	Phe	Leu	Ser	Glu	Leu
		195					200					205			
Thr	Ala	Ala	Glu	Gly	Leu	Glu	Arg	Tyr	Leu	Gly	Ala	Lys	Phe	Pro	Gly
	210						215				220				
Ala	Lys	Arg	Phe	Ser	Leu	Glu	Gly	Gly	Asp	Ala	Leu	Ile	Pro	Met	Leu
225					230					235					240
Lys	Glu	Met	Ile	Arg	His	Ala	Gly	Asn	Ser	Gly	Thr	Arg	Glu	Val	Val
			245						250					255	
Leu	Gly	Met	Ala	His	Arg	Gly	Arg	Leu	Asn	Val	Leu	Asn	Val	Leu	Gly
		260						265					270		
Lys	Lys	Pro	Gln	Asp	Leu	Phe	Asp	Glu	Phe	Ala	Gly	Lys	His	Lys	Glu
		275					280					285			
His	Leu	Gly	Thr	Gly	Asp	Val	Lys	Tyr	His	Met	Gly	Phe	Ser	Ser	Asp
	290						295				300				
Phe	Gln	Thr	Asp	Gly	Gly	Leu	Val	His	Leu	Ala	Leu	Ala	Phe	Asn	Pro
305					310					315					320
Ser	His	Leu	Glu	Ile	Val	Ser	Pro	Val	Val	Ile	Gly	Ser	Val	Arg	Ala
				325						330				335	
Arg	Leu	Asp	Arg	Leu	Asp	Glu	Pro	Ser	Ser	Asn	Lys	Val	Leu	Pro	Ile
		340						345					350		
Thr	Ile	His	Gly	Asp	Ala	Ala	Val	Thr	Gly	Gln	Gly	Val	Val	Gln	Glu
		355					360					365			
Thr	Leu	Asn	Met	Ser	Lys	Ala	Arg	Gly	Tyr	Glu	Val	Gly	Gly	Thr	Val
	370						375					380			
Arg	Ile	Val	Ile	Asn	Asn	Gln	Val	Gly	Phe	Thr	Thr	Ser	Asn	Pro	Leu
385					390					395					400
Asp	Ala	Arg	Ser	Thr	Pro	Tyr	Cys	Thr	Asp	Ile	Gly	Lys	Met	Val	Gln
				405					410					415	

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Ala	Pro	Ile	Phe	His	Val	Asn	Ala	Asp	Asp	Pro	Glu	Ala	Val	Ala	Phe
			420					425					430		
Val	Thr	Arg	Leu	Ala	Leu	Asp	Phe	Arg	Asn	Thr	Phe	Lys	Arg	Asp	Val
		435					440					445			
Phe	Ile	Asp	Leu	Val	Ser	Tyr	Arg	Arg	His	Gly	His	Asn	Asn	Glu	Ala
	450					455					460				
Asp	Glu	Pro	Ser	Ala	Thr	Gln	Pro	Leu	Met	Tyr	Gln	Lys	Ile	Lys	Lys
465					470					475				480	
His	Pro	Thr	Pro	Arg	Lys	Ile	Tyr	Ala	Asp	Lys	Leu	Glu	Gln	Glu	Lys
				485					490					495	
Val	Ala	Thr	Leu	Glu	Asp	Ala	Thr	Glu	Met	Val	Asn	Leu	Tyr	Arg	Asp
		500						505					510		
Ala	Leu	Asp	Ala	Gly	Asp	Cys	Val	Val	Ala	Glu	Trp	Arg	Pro	Met	Asn
		515					520					525			
Met	His	Ser	Phe	Thr	Trp	Ser	Pro	Tyr	Leu	Asn	His	Glu	Trp	Asp	Glu
	530					535					540				
Glu	Tyr	Pro	Asn	Lys	Val	Glu	Met	Lys	Arg	Leu	Gln	Glu	Leu	Ala	Lys
545				550						555				560	
Arg	Ile	Ser	Thr	Val	Pro	Glu	Ala	Val	Glu	Met	Gln	Ser	Arg	Val	Ala
				565					570					575	
Lys	Ile	Tyr	Gly	Asp	Arg	Gln	Ala	Met	Ala	Ala	Gly	Glu	Lys	Leu	Phe
		580						585					590		
Asp	Trp	Gly	Gly	Ala	Glu	Asn	Leu	Ala	Tyr	Ala	Thr	Leu	Val	Asp	Glu
	595					600						605			
Gly	Ile	Pro	Val	Arg	Leu	Ser	Gly	Glu	Asp	Ser	Gly	Arg	Gly	Thr	Phe
	610				615						620				
Phe	His	Arg	His	Ala	Val	Ile	His	Asn	Gln	Ser	Asn	Gly	Ser	Thr	Tyr
625				630						635				640	
Thr	Pro	Leu	Gln	His	Ile	His	Asn	Gly	Gln	Gly	Ala	Phe	Arg	Val	Trp
			645						650					655	
Asp	Ser	Val	Leu	Ser	Glu	Glu	Ala	Val	Leu	Ala	Phe	Glu	Tyr	Gly	Tyr
		660						665					670		
Ala	Thr	Ala	Glu	Pro	Arg	Thr	Leu	Thr	Ile	Trp	Glu	Ala	Gln	Phe	Gly
		675					680					685			
Asp	Phe	Ala	Asn	Gly	Ala	Gln	Val	Val	Ile	Asp	Gln	Phe	Ile	Ser	Ser
	690					695					700				
Gly	Glu	Gln	Lys	Trp	Gly	Arg	Met	Cys	Gly	Leu	Val	Met	Leu	Leu	Pro
705					710					715				720	
His	Gly	Tyr	Glu	Gly	Gln	Gly	Pro	Glu	His	Ser	Ser	Ala	Arg	Leu	Glu
			725						730					735	
Arg	Tyr	Leu	Gln	Leu	Cys	Ala	Glu	Gln	Asn	Asn	Gln	Val	Cys	Val	Pro
		740						745					750		
Ser	Thr	Pro	Ala	Gln	Val	Tyr	His	Met	Leu	Arg	Arg	Gln	Ala	Leu	Arg
		755					760					765			
Gly	Met	Arg	Arg	Pro	Leu	Val	Val	Met	Ser	Pro	Lys	Ser	Leu	Leu	Arg
	770					775					780				
His	Pro	Leu	Ala	Val	Ser	Ser	Leu	Glu	Glu	Leu	Ala	Asn	Gly	Thr	Phe
785				790						795				800	
Leu	Pro	Ala	Ile	Gly	Glu	Glu	Ile	Asp	Glu	Leu	Asp	Pro	Lys	Gly	Val
			805						810					815	
Lys	Arg	Val	Val	Met	Cys	Ser	Ser	Gly	Lys	Val	Tyr	Tyr	Asp	Leu	Leu

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820					825					830						
Glu	Gln	Arg	Arg	Lys	Asn	Asn	Gln	His	Asp	Val	Ala	Ile	Val	Arg	Ile	
835					840					845						
Glu	Gln	Leu	Tyr	Pro	Phe	Pro	His	Lys	Ala	Met	Gln	Glu	Val	Leu	Gln	
850					855					860						
Gln	Phe	Ala	His	Val	Lys	Asp	Phe	Val	Trp	Cys	Gln	Glu	Glu	Pro	Leu	
865					870					875					880	
Asn	Gln	Gly	Ala	Trp	Tyr	Cys	Ser	Gln	His	His	Phe	Arg	Glu	Val	Ile	
885					890					895						
Pro	Phe	Gly	Ala	Ser	Leu	Arg	Tyr	Ala	Gly	Arg	Pro	Ala	Ser	Ala	Ser	
900					905					910						
Pro	Ala	Val	Gly	Tyr	Met	Ser	Val	His	Gln	Lys	Gln	Gln	Gln	Asp	Leu	
915					920					925						
Val	Asn	Asp	Ala	Leu	Asn	Val	Glu									
930					935											

<210> SEQ ID NO 9
 <211> LENGTH: 405
 <212> TYPE: PRT
 <213> ORGANISM: Escherichia coli

<400> SEQUENCE: 9

Met	Ser	Ser	Val	Asp	Ile	Leu	Val	Pro	Asp	Leu	Pro	Glu	Ser	Val	Ala
1			5					10					15		
Asp	Ala	Thr	Val	Ala	Thr	Trp	His	Lys	Lys	Pro	Gly	Asp	Ala	Val	Val
		20					25					30			
Arg	Asp	Glu	Val	Leu	Val	Glu	Ile	Glu	Thr	Asp	Lys	Val	Val	Leu	Glu
		35				40					45				
Val	Pro	Ala	Ser	Ala	Asp	Gly	Ile	Leu	Asp	Ala	Val	Leu	Glu	Asp	Glu
	50				55					60					
Gly	Thr	Thr	Val	Thr	Ser	Arg	Gln	Ile	Leu	Gly	Arg	Leu	Arg	Glu	Gly
65				70				75						80	
Asn	Ser	Ala	Gly	Lys	Glu	Thr	Ser	Ala	Lys	Ser	Glu	Glu	Lys	Ala	Ser
			85					90						95	
Thr	Pro	Ala	Gln	Arg	Gln	Gln	Ala	Ser	Leu	Glu	Glu	Gln	Asn	Asn	Asp
		100					105						110		
Ala	Leu	Ser	Pro	Ala	Ile	Arg	Arg	Leu	Leu	Ala	Glu	His	Asn	Leu	Asp
		115				120					125				
Ala	Ser	Ala	Ile	Lys	Gly	Thr	Gly	Val	Gly	Gly	Arg	Leu	Thr	Arg	Glu
	130				135					140					
Asp	Val	Glu	Lys	His	Leu	Ala	Lys	Ala	Pro	Ala	Lys	Glu	Ser	Ala	Pro
145				150				155						160	
Ala	Ala	Ala	Ala	Pro	Ala	Ala	Gln	Pro	Ala	Leu	Ala	Ala	Arg	Ser	Glu
			165				170							175	
Lys	Arg	Val	Pro	Met	Thr	Arg	Leu	Arg	Lys	Arg	Val	Ala	Glu	Arg	Leu
		180					185						190		
Leu	Glu	Ala	Lys	Asn	Ser	Thr	Ala	Met	Leu	Thr	Thr	Phe	Asn	Glu	Val
	195					200						205			
Asn	Met	Lys	Pro	Ile	Met	Asp	Leu	Arg	Lys	Gln	Tyr	Gly	Glu	Ala	Phe
210					215					220					
Glu	Lys	Arg	His	Gly	Ile	Arg	Leu	Gly	Phe	Met	Ser	Phe	Tyr	Val	Lys
225				230					235					240	

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Ala Val Val Glu Ala Leu Lys Arg Tyr Pro Glu Val Asn Ala Ser Ile
245 250 255

Asp Gly Asp Asp Val Val Tyr His Asn Tyr Phe Asp Val Ser Met Ala
260 265 270

Val Ser Thr Pro Arg Gly Leu Val Thr Pro Val Leu Arg Asp Val Asp
275 280 285

Thr Leu Gly Met Ala Asp Ile Glu Lys Lys Ile Lys Glu Leu Ala Val
290 295 300

Lys Gly Arg Asp Gly Lys Leu Thr Val Glu Asp Leu Thr Gly Gly Asn
305 310 315 320

Phe Thr Ile Thr Asn Gly Gly Val Phe Gly Ser Leu Met Ser Thr Pro
325 330 335

Ile Ile Asn Pro Pro Gln Ser Ala Ile Leu Gly Met His Ala Ile Lys
340 345 350

Asp Arg Pro Met Ala Val Asn Gly Gln Val Glu Ile Leu Pro Met Met
355 360 365

Tyr Leu Ala Leu Ser Tyr Asp His Arg Leu Ile Asp Gly Arg Glu Ser
370 375 380

Val Gly Phe Leu Val Thr Ile Lys Glu Leu Leu Glu Asp Pro Thr Arg
385 390 395 400

Leu Leu Leu Asp Val
405

<210> SEQ ID NO 10
<211> LENGTH: 41
<212> TYPE: PRT
<213> ORGANISM: Enterobacter agglomerans

<400> SEQUENCE: 10

Met Asn Leu His Glu Tyr Gln Ala Lys Gln Leu Phe Ala Arg Tyr Gly
1 5 10 15

Met Pro Ala Pro Thr Gly Tyr Ala Cys Thr Thr Pro Arg Glu Ala Glu
20 25 30

Glu Ala Ala Ser Lys Ile Gly Ala Gly
35 40

<210> SEQ ID NO 11
<211> LENGTH: 60
<212> TYPE: PRT
<213> ORGANISM: Escherichia coli

<400> SEQUENCE: 11

Met Asn Leu His Glu Tyr Gln Ala Lys Gln Leu Phe Ala Arg Tyr Gly
1 5 10 15

Leu Pro Ala Pro Val Gly Tyr Ala Cys Thr Thr Pro Arg Glu Ala Glu
20 25 30

Glu Ala Ala Ser Lys Ile Gly Ala Gly Pro Trp Val Val Lys Cys Gln
35 40 45

Val His Ala Gly Gly Arg Gly Lys Ala Gly Gly Val
50 55 60

<210> SEQ ID NO 12
<211> LENGTH: 58
<212> TYPE: PRT
<213> ORGANISM: Escherichia coli

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<400> SEQUENCE: 12

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Phe Leu Ile Asp Ser Arg Asp Thr Glu Thr Asp Ser Arg Leu Asp Gly
1           5           10          15
Leu Ser Asp Ala Phe Ser Val Phe Arg Cys His Ser Ile Met Asn Cys
          20          25          30
Val Ser Val Cys Pro Lys Gly Leu Asn Pro Thr Arg Ala Ile Gly His
          35          40          45
Ile Lys Ser Met Leu Leu Gln Arg Asn Ala
          50          55

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What is claimed is:

1. A method for producing L-glutamic acid by fermentation, which comprises culturing an isolated microorganism in a liquid medium of which pH is adjusted to the pH at which L-glutamic acid is precipitated, to produce and accumulate L-glutamic acid and precipitate L-glutamic acid in the medium,

wherein said microorganism can metabolize a carbon source at a specific pH in a liquid medium containing the carbon source and L-glutamic acid at a saturation concentration, and has the ability to accumulate L-glutamic acid in an amount exceeding the amount corresponding to the saturation concentration in the liquid medium at the pH,

wherein the microorganism belongs to the genus *Enterobacter*, the genus *Klebsiella*, the genus *Pantoea*, or the genus *Erwinia*, and

wherein said microorganism has at least one of the following characteristics: (a) the microorganism has increased activity, as compared to a corresponding wild-type microorganism, of an enzyme that catalyzes a reaction for biosynthesis of L-glutamic acid; and (b) the microorganism has decreased activity, as compared to a corresponding wild-type microorganism, or defi-

cient activity of an enzyme that catalyzes a reaction of a pathway branching from a biosynthetic pathway of L-glutamic acid and producing a compound other than L-glutamic acid.

2. The method according to claim 1, wherein said microorganism can grow in the liquid medium.

3. The method according to claim 1, wherein the pH is not more than 5.0.

4. The method according to claim 1, wherein in said microorganism an activity of at least one enzyme selected from the group consisting of citrate synthase, phosphoenolpyruvate carboxylase and glutamate dehydrogenase, is increased.

5. The method according to claim 1, wherein in said microorganism the enzyme that catalyzes the reaction of the pathway branching from the biosynthetic pathway of L-glutamic acid and producing the compound other than L-glutamic acid is α -ketoglutarate dehydrogenase.

6. The method according to claim 1, wherein said microorganism belongs to the genus *Enterobacter*.

7. The method according to claim 6, wherein said microorganism has a mutation that causes less extracellular secretion of a viscous material compared with a wild strain when cultured in a medium containing a saccharide.

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