CLAIMS

1. An isolated polynucleotide encoding any one of the following amino acid sequences (A1), (A2) or (A4):
(A1) an amino acid sequence defined by SEQ ID NO: 1, 3, or 5,
(A2) an amino acid sequence i) having at least 95% sequence identity to an amino acid sequence defined by SEQ ID NO: 1, 3, or 5, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative,
or
(A4) an amino acid sequence i) defined by SEQ ID NO: 1, 3, or 5 in which one or plural amino acids are deleted, substituted, or added, wherein the plural amino acids are 2, 3, 4, 5, 6, 7, or 10 amino acids and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative.

2. The polynucleotide according to claim 1, which has a base sequence defined by SEQ ID NO: 2, 4, 6, 15, 16, or 17.

3. A polynucleotide comprising a promoter operably connected to the polynucleotide according to claim 1 or 2.

4. A recombinant vector comprising the polynucleotide according to any one of claims 1 to 3.

5. The recombinant vector according to claim 4, which further comprises a polynucleotide encoding an amino acid sequence of a leucine dehydrogenase, or a polynucleotide encoding an amino acid sequence of a leucine dehydrogenase operably connected to a promoter.

6. The recombinant vector according to claim 5, wherein the amino acid sequence of the protein having the ability to aminate an α-oxocarboxylic acid compound and convert the same into a corresponding L-α-amino acid compound is any one of the following amino acid sequences (B1) to (B3):
(B1) an amino acid sequence defined by SEQ ID NO: 7,
(B2) an amino acid sequence i) having at least 90% sequence identity to an amino acid sequence defined by SEQ ID NO: 7, and ii) having the ability to aminate a 2-oxo-4-(methylthio)butyric acid derivative and convert the same into a corresponding L-methionine derivative, or
(B3) an amino acid sequence i) defined by SEQ ID NO: 7 in which one or plural amino acids are deleted, substituted, or added, wherein the plural amino acids are 2, 3, 4, 5, 6, 7, 10, 15, 18, 20, 25, 30, 35, 36, or 40 amino acids, and ii) having the ability to aminate a 2-oxo-4-(methylthio)butyric acid derivative and convert the same into a corresponding L-methionine derivative.

7. A transformant in which the polynucleotide according to any one of claims 1 to 3 or the recombinant vector according to claim 4 is introduced into a host cell.

8. The transformant according to claim 7, wherein the host cell is a microorganism or E. coli.

9. A transformant in which the recombinant vector according to claim 5 or 6 is introduced into a host cell.

10. The transformant according to claim 9, wherein the host cell is a microorganism or E. coli.

11. A transformant having the polynucleotide according to any one of claims 1 to 3.

12. A transformant having the following:

i) a polynucleotide having a base sequence encoding an amino acid sequence of a leucine dehydrogenase, or a polynucleotide encoding an amino acid sequence of a leucine dehydrogenase operably connected to a promoter; and
ii) the polynucleotide according to any one of claims 1 to 3.

13. A method for producing a recombinant vector, which comprises the step of integrating the polynucleotide according to any one of claims 1 to 3 into a vector which can be replicated in a host cell.

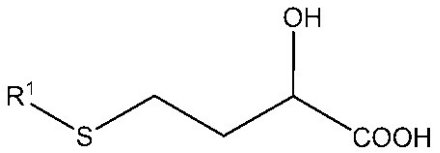
14. A method for producing a transformant, which comprises the step of introducing the polynucleotide according to any one of claims 1 to 3 or the recombinant vector according to any one of claims 4 to 6 into a host cell.

15. An isolated protein having any one of the following amino acid sequences (A1), (A2) or (A4):
(A1) an amino acid sequence defined by SEQ ID NO: 1, 3, or 5,
(A2) an amino acid sequence i) having at least 95% sequence identity to an amino acid sequence defined by SEQ ID NO: 1, 3, or 5, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative,
or
(A4) an amino acid sequence i) defined by SEQ ID NO: 1, 3, or 5 in which one or plural amino acids are deleted, substituted, or added, wherein the plural amino acids are 2, 3, 4, 5, 6, 7, or 10 amino acids, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative.

16. A method for producing an α-oxocarboxylic acid compound, which comprises the step of reacting a protein having any one of the following amino acid sequences (A1), (A2) or (A4):
(A1) an amino acid sequence defined by SEQ ID NO: 1, 3, or 5,
(A2) an amino acid sequence i) having at least 95% sequence identity to an amino acid sequence defined by SEQ ID NO: 1, 3, or 5, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative,
or
(A4) an amino acid sequence i) defined by SEQ ID NO: 1, 3, or 5 in which one or plural amino acids are deleted, substituted, or added, wherein the plural amino acids are 2, 3, 4, 5, 6, 7, or 10 amino acids, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative;
with an α-hydroxycarboxylic acid compound.

17. The production method according to claim 16, wherein the α-hydroxycarboxylic acid compound is a sulfur-containing α-hydroxycarboxylic acid compound, and the corresponding α-oxocarboxylic acid compound is a sulfur-containing α-oxocarboxylic acid compound.

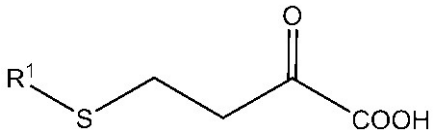
18. The production method according to claim 17, wherein the sulfur-containing α-hydroxycarboxylic acid compound is a compound represented by formula (1):



(1)

wherein R^1 represents a hydrogen atom or an optionally

substituted C1-8 alkyl group;
and the sulfur-containing α-oxocarboxylic acid compound is a compound represented by formula (2):



(2)

wherein R^1 is the same as defined above.

19. The production method according to any one of claims 16 to 18, wherein the protein having any one of the amino acid sequences (A1), (A2) or (A4) is provided in a reaction system in the form in which the protein is included in a transformant in which a polynucleotide encoding the protein is introduced into a host cell or in a treated product thereof.

20. The production method according to claim 19, wherein the transformant is the transformant according to any one of claims 7, 8, and 11.

21. The production method according to any one of claims 16 to 20, wherein the step is performed in the presence of a protein having the ability to convert hydrogen peroxide into molecular oxygen.

22. The production method according to claim 21, wherein the protein having the ability to convert hydrogen peroxide into molecular oxygen is a catalase.

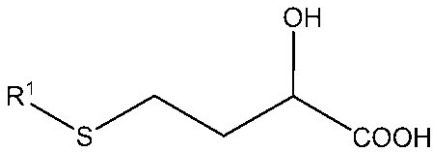
23. The production method according to claim 21 or 22, wherein the protein having the ability to convert hydrogen peroxide into molecular oxygen is provided in a reaction system in the form in which the protein is included in a transformant in which a polynucleotide encoding the protein is introduced into a host cell or in a treated product thereof.

24. A method for producing an L-α-amino acid compound, which comprises (1) the step of reacting a protein having any one of the following amino acid sequences (A1), (A2) or (A4):
(A1) an amino acid sequence defined by SEQ ID NO: 1, 3, or 5,
(A2) an amino acid sequence i) having at least 95% sequence identity to an amino acid sequence defined by SEQ ID NO: 1, 3, or 5, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative,
or
(A4) an amino acid sequence i) defined by SEQ ID NO: 1, 3, or 5 in which one or plural amino acids are deleted, substituted, or added, wherein the plural amino acids are 2, 3, 4, 5, 6, 7, or 10 amino acids, and ii) having the ability to oxidize a 2-hydroxy-4-(methylthio)butyric acid derivative and convert the same into a corresponding 2-oxo-4-(methylthio)butyric acid derivative;
with an α-hydroxycarboxylic acid compound to obtain a corresponding α-oxocarboxylic acid compound, and
(2) the step of reacting a leucine dehydrogenase with the α-oxocarboxylic acid compound obtained in the step (1) to obtain a corresponding L-α-amino acid compound.

25. The production method according to claim 24, wherein the α-hydroxycarboxylic acid compound is a sulfur-containing α-hydroxycarboxylic acid compound, the corresponding α-oxocarboxylic acid compound is a sulfur-containing α-oxocarboxylic acid compound, and the corresponding L-α-amino acid compound is a sulfur-containing L-α-amino acid compound.

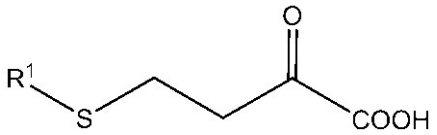
26. The production method according to claim 25, wherein

the sulfur-containing α-hydroxycarboxylic acid compound is a compound represented by formula (1):



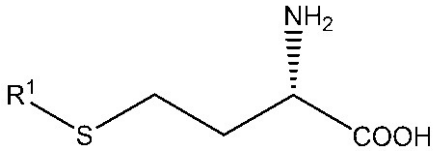
(1)

wherein R^1 represents a hydrogen atom or an optionally substituted C1-8 alkyl group;
the sulfur-containing α-oxocarboxylic acid compound is a compound represented by formula (2):



(2)

wherein R^1 is the same as defined above;
and the sulfur-containing L-α-amino acid compound is a compound represented by formula (3):



(3)

wherein R^1 is the same as defined above.

27. The production method according to any one of claims 24 to claim 26, wherein the leucine dehydrogenase is a leucine dehydrogenase derived from Bacillus sphaericus.

28. The production method according to any one of claims 24 to 26, wherein the amino acid sequence of a protein having the ability to aminate an α-oxocarboxylic acid compound and convert the same into a corresponding L-α-amino acid compound is any one of the following amino acid sequences (B1) to (B3):
(B1) an amino acid sequence defined by SEQ ID NO: 7,
(B2) an amino acid sequence i) having at least 90% sequence identity to an amino acid sequence defined by SEQ ID NO: 7, and ii) having the ability to aminate a 2-oxo-4-

(methylthio)butyric acid derivative and convert the same into a corresponding L-methionine derivative, or
(B3) an amino acid sequence i) defined by SEQ ID NO: 7 in which one or plural amino acids are deleted, substituted, or added, wherein the plural amino acids are 2, 3, 4, 5, 6, 7, 10, 15, 18, 20, 25, 30, 35, 36, or 40 amino acids, and ii) having the ability to aminate a 2-oxo-4-(methylthio)butyric acid derivative and convert the same into a corresponding L-methionine derivative.

29. The production method according to any one of claims 24 to 28, wherein the protein having any one of the amino acid sequences (A1), (A2) or (A4) is provided in a reaction system in the form in which the protein is included in a transformant in which a polynucleotide encoding the protein is introduced into a host cell or in a treated product thereof.

30. The production method according to claim 29, wherein the transformant is the transformant according to any one of claims 7 to 12.

31. The production method according to any one of claims 24 to 30, wherein the protein having the ability to aminate an α-oxocarboxylic acid compound and convert the same into a corresponding L-α-amino acid compound is provided in a reaction system in the form in which the protein is included in a transformant in which a polynucleotide encoding the protein is introduced into a host cell or in a treated product thereof.

32. The production method according to claim 31, wherein the transformant is the transformant according to any one of claims 9, 10, and 12.

33. The production method according to any one of claims

24 to 32, wherein the step (1) is performed in the presence of a protein having the ability to convert hydrogen peroxide into molecular oxygen.

34. The production method according to claim 33, wherein the protein having the ability to convert hydrogen peroxide into molecular oxygen is a catalase.

35. The production method according to claim 33 or 34, wherein the protein having the ability to convert hydrogen peroxide into molecular oxygen is provided in a reaction system in the form in which the protein is included in a transformant in which a polynucleotide encoding the protein is introduced into a host cell or in a treated product thereof.

36. The production method according to any one of claims 24 to 35, wherein the step (2) is performed in the presence of a protein having the ability to convert an oxidized β-nicotinamide adenine dinucleotide or an oxidized β-nicotinamide adenine dinucleotide phosphate into its reduced form.

37. The production method according to claim 36, wherein the protein having the ability to convert an oxidized β-nicotinamide adenine dinucleotide or an oxidized β-nicotinamide adenine dinucleotide phosphate into its reduced form is a formate dehydrogenase.

38. The production method according to claim 36 or 37, wherein the protein having the ability to convert an oxidized β-nicotinamide adenine dinucleotide or an oxidized β-nicotinamide adenine dinucleotide phosphate into its reduced form is provided in a reaction system in the form in which the protein is included in a transformant in which a polynucleotide encoding the protein is introduced into a

host cell or in a treated product thereof.

39. The production method according to any one of claims 24 to 38, wherein the step (1) and the step (2) are performed in one reaction system.