Claims

1. A metabolically engineered organism for the production of at least one specialty product chosen from the group consisting of a saccharide, an activated saccharide, a nucleoside, a glycoside, a glycolipid and a glycoprotein, characterized in that:

a) said organism is genetically modified with the introduction of at least: i) a gene encoding for a carbohydrate hydrolase in combination with a gene encoding for a carbohydrate kinase, ii) a gene encoding for a carbohydrate synthase, or, iii) a gene encoding for a carbohydrate phosphorylase, so that said organism is capable to split a disaccharide, oligosaccharide, polysaccharide or a mixture thereof into an activated saccharide and a saccharide, and

b) said organism is further genetically modified so that at least one other gene than any of the introduced genes of step a) of said organism is rendered less- functional or non-functional and wherein said other gene encodes for an enzyme which converts said activated saccharide into biomass and/or bio-catalytic enzymes.

2. A metabolically engineered organism according to claim 1 wherein said organism is further genetically modified with the introduction of at least one other gene which converts said activated saccharide into a specialty product, or, wherein at least one other endogenous gene of said organism which converts said activated saccharide into a specialty product is over-expressed.

3. A metabolically engineered organism according to claims 1 to 2 wherein said organism is capable to grow on a disaccharide, oligosaccharide, polysaccharide or a mixture thereof as the main carbon source.

4. A metabolically engineered organism according to claims 1 to 3 wherein the genetic modification of step a) is optional, or, is replaced by over-expressing at least: i) an endogenous gene encoding for a carbohydrate hydrolase in combination with a gene encoding for carbohydrate kinase, ii) an endogenous gene encoding for a carbohydrate synthase, or, iii) an endogenous gene encoding for a carbohydrate phosphorylase, and wherein said organism is capable to split a disaccharide, oligosaccharide, polysaccharide or a mixture thereof into an activated saccharide and a saccharide.

5. A metabolically engineered organism according to claims 1-4 wherein said activated saccharide in step b) is replaced by said saccharide, and, wherein said activated saccharide in said further genetic modification according to claims 2-4 is replaced by said saccharide.

6. A metabolically engineered organism according to claims 1-4 wherein said gene in step a) splits a disaccharide, oligosaccharide, or polysaccharide in two activated saccharides or in two saccharides.

7. A metabolically engineered organism according to claims 1-6, wherein said organism is a microorganism chosen from the list consisting of a bacterium, a yeast , a fungus cell, or, is a plant cell or an animal cell.

8. A metabolically engineered organism according to claim 7, wherein said bacterium is *Escherichia coli* or wherein said yeast is *Saccharomyces cereviseae.*

9. A metabolically engineered organism according to claims 1-8, wherein said activated saccharide is selected from the group consisting of alpha-glucose-1-phosphate, alpha-galactose-1-phosphate, beta-glucose-1-phosphate, beta-galactose-1-phosphate, UDP-glucose, glucose-6-phosphate, fructose-6-phosphate and UDP-galactose and wherein said saccharide is selected from the group consisting of fructose, glucose, and galactose.

10. A metabolically engineered organism according to claims 1-9, wherein said carbohydrate hydrolase is a lactase, invertase, sucrase, maltase, trehalase, sucrose-6-phosphate hydrolase and/or amylase, and, wherein said carbohydrate kinase is a galactokinase, a fructokinase, a glucokinase and/or mannokinase.

11. A metabolically engineered organism according to claims 1-3, 6-10 wherein:

- said gene in step a) is encoding for a sucrose phosphorylase, and/or

- the following genes in step b) are rendered non-functional: a gene encoding for a beta-galactosidase, and/or, a gene encoding for a phosphoglucomutase, and/or, a gene encoding for a glucose-1-phosphate adenylyltransferase, and/or, a gene encoding for a phosphatase and/or, a gene encoding for a glucose-1-phosphate uridyltransferase, and/or, a gene encoding for a UDP-glucose-4-epimerase, and/or, a gene encoding for UDP-glucose:galactose-1-phosphate uridyltransferase, and/or, a gene encoding for UDP-

galactopyranose mutase, and/or, a gene encoding for UDP-galactose: (glucosyl)lipopolysaccharide-1,6-galactosyltransferase, and/or, a gene encoding for a UDP-galactosyltransferase, and/or, a gene encoding for a UDP-glucosyltransferase, and/or, a gene encoding for an UDP-glucuronate transferase, and/or, a gene encoding for an UDP-glucose lipid carrier transferase, and/or, a gene encoding for an UDP-sugar hydrolase, and/or, a gene encoding for an invertase, and/or, a gene incoding for a maltase, and/or, a gene encoding for a trehalase, and/or, a gene encoding for a sugar transporting phosphotransferase, and/or, a gene encoding for a hexokinase.

12. A metabolically engineered organism according to claim 11 wherein:

- said gene in step a) is encoding for a sucrose phosphorylase

- said genes in step b) are : the gene *lacZ*, the gene *pgm*, the gene *ycjU*, the gene *glgC*, the gene *agp*, the gene *ptsG*, the gene *glk*, the gene *glf*, the gene *waaB,* the gene *ushA*, the gene *wcaA,* the gene *wcaC,* the gene *wcaE,* the gene *wcaI,* the gene *wcaL,* the gene *wcaJ,* the gene *galU,* the gene *galF*, the gene *galE,* the gene *galT,* the gene *malP*, and/or, the gene *malQ*.

13. A metabolically engineered organism according to claim 11 wherein:

-said gene in step a) is encoding for a sucrose phosphorylase

-said genes in step b) are: the gene PGM1, the gene PGM2, the gene GLG1, the gene GLG2, the gene INM1, the gene INM2, the gene GLK1, the gene HXK1, the gene HXK2, the gene GAL10, the gene GAL7, the gene YHL012W, the gene UGP1, the gene GSY1, the gene GSY2, the gene DIE2, the gene ALG8, the gene ATG26, the gene SUC2, the gene MAL32, the gene MAL12, the gene YJL216C, and/or, the gene YGR287C, and/or, FEN1, and/or, FKS1, and/or, GSC2, and/or, TPS1.

14. A metabolically engineered organism according to claim 12-13 wherein said sucrose phosphorylase originates from a Lactic acid bacterium and wherein said Lactic acid bacterium is *Bifidobacterium adolescentis*, *Leuconostoc mesenteroides*, *Lactobacillus acidophilus*, or *Streptococcus mutans.*

15. A metabolically engineered organism according to claims 11-14 wherein said sucrose phosphorylase of step a) is replaced by a sucrose synthase, a maltose phosphorylase or a maltose synthase.

16. A metabolically engineered organism according to claims 11-14 wherein said sucrose phosphorylase of step a) is replaced by a lactose phosphorylase or a lactose synthase.

17. A metabolically engineered organism according to claim 5 wherein:

-said gene in step a) is encoding for a sucrose phosphorylase, and/or

-the following genes in step b) are rendered non-functional: a gene encoding for a beta-galactosidase, and/or, a gene encoding for a glucose-6-phosphate isomerase, and/or a gene encoding for a glucose-1-phosphate adenylyltransferase, and/or, a gene encoding for a glucose-1-phosphatase, and/or, a gene encoding for a phosphofructokinase A, and/or, a gene encoding for a phosphofructokinase B, and/or, a gene encoding for phosphogluconate dehydratase, and/or, a gene encoding for 2-keto-3-deoxygluconate-6-phosphate aldolase ,and/or, a gene encoding for a glucose-1-phosphate uridyltransferase, and/or, a gene encoding for an UDP-glucose-4-epimerase, and/or, a gene encoding for an UDP-glucose:galactose-1-phosphate uridyltransferase, and/or, a gene encoding for an UDP-galactopyranose mutase, and/or, a gene encoding for an UDP-galactose: (glucosyl)lipopolysaccharide-1,6-galactosyltransferase, and/or, a gene encoding for an UDP-galactosyltransferase, and/or, a gene encoding for an UDP-glucosyltransferase, and/or, a gene encoding for an UDP-glucuronate transferase, and/or, a gene encoding for an UDP-glucose lipid carrier transferase, and/or, a gene encoding for a GDP-mannose hydrolase, and/or, a gene encoding for an UDP-sugar hydrolase, and/or, a gene encoding for a mannose-6-phosphate isomerase, and/or, a gene encoding for an UDP-N-acetylglucosamine enoylpyruvoyl transferase, and/or, a gene encoding for an UDP-N acetylglucosamine acetyltransferase, and/or, a gene encoding for an UDP-N-acetylglucosamine-2-epimerase, and/or, a gene encoding for an undecaprenyl-phosphate-alfa-N-acetylglucosaminyl transferase, and/or, a gene encoding for a glucose-6-phosphate-1-dehydrogenase, and/or, a gene encoding for a L-glutamine:D-fructose-6-phosphate aminotransferase, and/or, a gene encoding for a mannose-6-phosphate isomerase, and/or a gene encoding for a sorbitol-6-phosphate dehydrogenase, and/or, a gene encoding for a

mannitol-1-phosphate 5-dehydrogenase, and/or a gene encoding for a allulose-6-phosphate 3-epimerase, and/or, a gene encoding for an invertase, and/or, a gene incoding for a maltase, and/or, and/or a gene encoding for a trehalase, and/or, a gene encoding for a sugar transporting phosphotransferase, and/or, a gene encoding for a hexokinase.

18. A metabolically engineered organism according to claim 17 wherein:

- said gene in step a) is a gene encoding for a sucrose phosphorylase

- said genes in step b) are: the gene *lacZ*, the gene *pgi*, the gene *glgC*, the gene *agp*, the gene *pfkA*, the gene *pfkB*, the gene *waaB*, the gene *ushA*, the gene *eda*, the gene *edd*, the gene *wcaA*, the gene *wcaC*, the gene *wcaE*, the gene *wcaI*, the gene *wcaL*, the gene *wcaJ*, the gene wcaB, the gene *wcaF*, the gene *wcaK*, the gene *wcaD*, the gene *galU*, the gene *galF*, the gene *galE*, the gene *gmm*, the gene *galT*, the gene *manA*, the gene *murA*, the gene *lpxA*, the gene *rffE*, the gene *rfe*, the gene *glmS*, the gene *srlD*, the gene *mtlD*, the gene *alsE* and/or, *zwf*.

19. A metabolically engineered organism according to claim 18 wherein:

-said gene in step a) is a gene encoding for a sucrose phosphorylase

-said genes in step b) are: the gene pgi1, the gene PFK1, the gene PFK2, the gene PFK26, the gene PFK26, the gene PFK27, the gene GND1, the gene GND2, the gene PMI40, the gene ZWF1, the gene GFA1, the gene GLG1, the gene GLG2, the gene INM1, the gene INM2, the gene GLK1, the gene HXK1, the gene HXK2, the gene GAL10, the gene GAL7, the gene YHL012W, the gene UGP1, the gene GSY1, the gene GSY2, the gene DIE2, the gene ALG8, the gene ATG26, the gene SUC2, the gene MAL32, the gene MAL12, the gene YJL216C, and/or, the gene YGR287C, and/or, FEN1, and/or, FKS1, and/or, GSC2, and/or, TPS1.

20. A metabolically engineered organism according to claim 18-19 wherein said sucrose phosphorylase originates from a Lactic acid bacterium and wherein said Lactic acid bacterium is *Bifidobacterium adolescentis*, *Leuconostoc mesenteroides*, *Lactobacillus acidophilus*, or *Streptococcus mutants*.

21. A metabolically engineered organism according to claims 2-20 wherein the gene which converts said activated saccharide into a specialty product codes for an epimerase, a transferase, a reductase, a (pyro)phosphorylase, a (de)carboxylase, a dehydratase, a permease, a synthase, a dehydrogenase, an oxidase or an isomerase.

22. A metabolically engineered organism according to claim 21 wherein said epimerase is UDP-galactose-4-epimerase or UDP-*N*-acetylglucosamine epimerase, and/or, wherein said transferase is a glycosyltransferase, a fucosyltransferase, a sialyltransferase or a sulfotransferase.

23. A metabolically engineered organism according to claims 1-22 wherein said specialty product is a monosaccharide, a disaccharide, a trisaccharide, a tetrasaccharide, a pentasaccharide, a polysaccharide, a nucleoside, an O-glycoside, an S-glycoside, an N-glycoside, a C-glycoside, a glycoprotein, a glycolipid or an activated carbohydrate.

24. A method to produce a specialty product according to any of claims 1-23 comprising:

i) metabolically engineering a microorganism according to in any of claims 1-23, and

ii) cultivating said genetically engineered microorganism, and

iii) extracting and purifying said specialty product.

25. Use of a 2-fucosyltransferase originating from *Dictyostellium discoideum* having an amino acid sequence given by SEQ ID N° 1, or, a fragment thereof having 2-fucosyltransferase activity, or, a variant thereof having a sequence identity of at least 75 % and having 2-fucosyltransferase activity to produce fucosyllactose.

26. Use according to claim 25 wherein said fragment having 2-fucosyltransferase activity has an amino acid sequence as given by SEQ ID N° 4.

27. Use of a nucleic acid encoding for a 2-fucosyltransferase according to any of claim 25 and 26 to produce fucosyllactose.

28. Use according to claim 27 wherein said nucleic acids have a nucleic acid sequence as given by SEQ ID N° 2, SEQ ID N° 3, SEQ ID N° 5 or SEQ ID N° 6.

Claims

1. A metabolically engineered bacterium or yeast for the production of at least one specialty product chosen from the group consisting of a saccharide, an activated saccharide, a nucleoside, a glycoside, a glycolipid and a glycoprotein, characterized in that:

   a) said bacterium or yeast is genetically modified with the introduction of at least: i) a gene encoding for a carbohydrate hydrolase in combination with a gene encoding for a carbohydrate kinase, ii) a gene encoding for a carbohydrate synthase, or, iii) a gene encoding for a carbohydrate phosphorylase, so that said bacterium or yeast is capable to split a disaccharide, oligosaccharide, polysaccharide or a mixture thereof into an activated saccharide and a saccharide, and

   b) said bacterium or yeast is further genetically modified so that at least one other gene than any of the introduced genes of step a) of said bacterium or yeast is rendered less-functional or non-functional and wherein said other gene encodes for an enzyme which converts said activated saccharide into biomass and/or bio-catalytic enzymes.

2. A metabolically engineered bacterium or yeast according to claim 1 wherein said bacterium or yeast is further genetically modified with the introduction of at least one other gene which converts said activated saccharide into a specialty product, or, wherein at least one other endogenous gene of said bacterium or yeast which converts said activated saccharide into a specialty product is over-expressed.

3. A metabolically engineered bacterium or yeast according to claims 1 to 2 wherein said bacterium or yeast is capable to grow on a disaccharide, oligosaccharide, polysaccharide or a mixture thereof as the main carbon source.

4. A metabolically engineered bacterium or yeast according to claims 1 to 3 wherein the genetic modification of step a) is optional, or, is replaced by over-expressing at least: i) an endogenous gene encoding for a carbohydrate hydrolase in combination with a gene encoding for carbohydrate kinase, ii) an endogenous gene encoding for a carbohydrate synthase, or, iii) an endogenous gene encoding for a carbohydrate phosphorylase, and wherein said bacterium or yeast is capable to split a disaccharide, oligosaccharide, polysaccharide or a mixture thereof into an activated saccharide and a saccharide.

5. A metabolically engineered bacterium or yeast according to claims 1-4 wherein said activated saccharide in step b) is replaced by said saccharide, and, wherein said activated saccharide in said further genetic modification according to claims 2-4 is replaced by said saccharide.

6. A metabolically engineered bacterium or yeast according to claims 1-4 wherein said gene in step a) splits a disaccharide, oligosaccharide, or polysaccharide in two activated saccharides or in two saccharides.

7. A metabolically engineered bacterium or yeast according to claim 1, wherein said bacterium is *Escherichia coli* or wherein said yeast is *Saccharomyces cereviseae.*

8. A metabolically engineered bacterium or yeast according to claims 1-7, wherein said activated saccharide is selected from the group consisting of alpha-glucose-1-phosphate, alpha-galactose-1-phosphate, beta-glucose-1-phosphate, beta-galactose-1-phosphate, UDP-glucose, glucose-6-phosphate, fructose-6-phosphate and UDP-galactose and wherein said saccharide is selected from the group consisting of fructose, glucose, and galactose.

9. A metabolically engineered bacterium or yeast according to claims 1-8, wherein said carbohydrate hydrolase is a lactase, invertase, sucrase, maltase, trehalase, sucrose-6-phosphate hydrolase and/or amylase, and, wherein said carbohydrate kinase is a galactokinase, a fructokinase, a glucokinase and/or mannokinase.

10. A metabolically engineered bacterium or yeast according to claims 1-3, 6-9 wherein:

- said gene in step a) is encoding for a sucrose phosphorylase, and/or

- the following genes in step b) are rendered non-functional: a gene encoding for a beta-galactosidase, and/or, a gene encoding for a phosphoglucomutase, and/or, a gene encoding for a glucose-1-phosphate adenylyltransferase, and/or, a gene encoding for a phosphatase and/or, a gene encoding for a glucose-1-phosphate uridyltransferase, and/or, a gene encoding for a UDP-glucose-4-epimerase, and/or, a gene encoding for UDP-glucose:galactose-1-phosphate uridyltransferase, and/or, a gene encoding for UDP-galactopyranose mutase, and/or, a gene encoding for UDP-galactose: (glucosyl)lipopolysaccharide-1,6-galactosyltransferase, and/or, a gene encoding for a UDP-galactosyltransferase, and/or, a gene encoding for a UDP-glucosyltransferase, and/or, a gene encoding for an UDP-glucuronate transferase, and/or, a gene encoding for an UDP-glucose lipid carrier transferase, and/or, a gene encoding for an UDP-sugar hydrolase, and/or, a gene encoding for an invertase, and/or, a gene incoding for a maltase, and/or, a gene encoding for a trehalase, and/or, a gene encoding for a sugar transporting phosphotransferase, and/or, a gene encoding for a hexokinase.

11. A metabolically engineered bacterium or yeast according to claim 10 wherein:

- said gene in step a) is encoding for a sucrose phosphorylase

- said genes in step b) are : the gene *lacZ*, the gene *pgm*, the gene *ycjU*, the gene *glgC*, the gene *agp*, the gene *ptsG*, the gene *glk*, the gene *glf*, the gene *waaB,* the gene *ushA*, the gene *wcaA,* the gene *wcaC,* the gene *wcaE,* the gene *wcaI,* the gene *wcaL,* the gene *wcaJ,* the gene *galU,* the gene *galF*, the gene *galE,* the gene *galT,* the gene *malP*, and/or, the gene *malQ*.

12. A metabolically engineered bacterium or yeast according to claim 10 wherein:

- said gene in step a) is encoding for a sucrose phosphorylase

- said genes in step b) are: the gene PGM1, the gene PGM2, the gene GLG1, the gene GLG2, the gene INM1, the gene INM2, the gene GLK1, the gene HXK1, the gene HXK2, the gene GAL10, the gene GAL7, the gene YHL012W, the gene UGP1, the gene GSY1, the gene GSY2, the gene DIE2, the gene ALG8, the gene ATG26, the gene SUC2, the gene MAL32, the gene MAL12, the gene YJL216C, and/or, the gene YGR287C, and/or, FEN1, and/or, FKS1, and/or, GSC2, and/or, TPS1.

13. A metabolically engineered bacterium or yeast according to claim 11-12 wherein said sucrose phosphorylase originates from a Lactic acid bacterium and wherein said Lactic acid bacterium is *Bifidobacterium adolescentis*, *Leuconostoc mesenteroides*, *Lactobacillus acidophilus*, or *Streptococcus mutans.*

14. A metabolically engineered bacterium or yeast according to claims 10-13 wherein said sucrose phosphorylase of step a) is replaced by a sucrose synthase, a maltose phosphorylase or a maltose synthase.

15. A metabolically engineered bacterium or yeast according to claims 10-13 wherein said sucrose phosphorylase of step a) is replaced by a lactose phosphorylase or a lactose synthase.

16. A metabolically engineered bacterium or yeast according to claim 5 wherein:

- said gene in step a) is encoding for a sucrose phosphorylase, and/or

- the following genes in step b) are rendered non-functional: a gene encoding for a beta-galactosidase, and/or, a gene encoding for a glucose-6-phosphate isomerase, and/or a gene encoding for a glucose-1-phosphate adenylyltransferase, and/or, a gene encoding for a glucose-1-phosphatase, and/or, a gene encoding for a phosphofructokinase A, and/or, a gene encoding for a phosphofructokinase B, and/or, a gene encoding for phosphogluconate dehydratase, and/or, a gene encoding for 2-keto-3-deoxygluconate-6-phosphate aldolase ,and/or, a gene encoding for a glucose-1-phosphate uridyltransferase, and/or, a gene encoding for an UDP-glucose-4-epimerase, and/or, a gene encoding for an UDP-glucose:galactose-1-phosphate uridyltransferase, and/or, a gene encoding for an UDP-galactopyranose mutase, and/or, a gene encoding for an UDP-galactose: (glucosyl)lipopolysaccharide-1,6-galactosyltransferase, and/or, a gene encoding for an UDP-galactosyltransferase, and/or, a gene encoding for an UDP-glucosyltransferase, and/or, a gene encoding for an UDP-glucuronate transferase, and/or, a gene encoding for an UDP-glucose lipid carrier transferase, and/or, a gene encoding for a GDP-mannose hydrolase, and/or, a gene encoding for an UDP-sugar hydrolase, and/or, a gene encoding for a mannose-6-phosphate isomerase, and/or, a gene encoding for an UDP-N-acetylglucosamine enoylpyruvoyl transferase, and/or, a gene encoding for an

UDP-N acetylglucosamine acetyltransferase, and/or, a gene encoding for an UDP-N-acetylglucosamine-2-epimerase, and/or, a gene encoding for an undecaprenyl-phosphate-alfa-N-acetylglucosaminyl transferase, and/or, a gene encoding for a glucose-6-phosphate-1-dehydrogenase, and/or, a gene encoding for a L-glutamine:D-fructose-6-phosphate aminotransferase, and/or, a gene encoding for a mannose-6-phosphate isomerase, and/or a gene encoding for a sorbitol-6-phosphate dehydrogenase, and/or, a gene encoding for a mannitol-1-phosphate 5-dehydrogenase, and/or a gene encoding for a allulose-6-phosphate 3-epimerase, and/or, a gene encoding for an invertase, and/or, a gene incoding for a maltase, and/or, and/or a gene encoding for a trehalase, and/or, a gene encoding for a sugar transporting phosphotransferase, and/or, a gene encoding for a hexokinase.

17. A metabolically engineered bacterium or yeast according to claim 16 wherein:

- said gene in step a) is a gene encoding for a sucrose phosphorylase

- said genes in step b) are: the gene *lacZ*, the gene *pgi*, the gene *glgC*, the gene *agp*, the gene *pfkA*, the gene *pfkB,* the gene *waaB*, the gene *ushA*, the gene *eda*, the gene *edd*, the gene *wcaA,* the gene *wcaC,* the gene *wcaE,* the gene *wcaI,* the gene *wcaL*, the gene *wcaJ,* the gene wcaB, the gene *wcaF*, the gene *wcaK*, the gene *wcaD*, the gene *galU,* the gene *galF*, the gene *galE,* the gene *gmm*, the gene *galT*, the gene *manA*, the gene *murA*, the gene *lpxA*, the gene *rffE*, the gene *rfe*, the gene *glmS*, the gene *srlD*, the gene *mtlD*, the gene *alsE* and/or, *zwf.*

18. A metabolically engineered bacterium or yeast according to claim 17 wherein:

- said gene in step a) is a gene encoding for a sucrose phosphorylase

- said genes in step b) are: the gene pgi1, the gene PFK1, the gene PFK2, the gene PFK26, the gene PFK26, the gene PFK27, the gene GND1, the gene GND2, the gene PMI40, the gene ZWF1, the gene GFA1, the gene GLG1, the gene GLG2, the gene INM1, the gene INM2, the gene GLK1, the gene HXK1, the gene HXK2, the gene GAL10, the gene GAL7, the gene YHL012W, the gene UGP1, the gene GSY1, the gene GSY2, the gene DIE2, the gene ALG8, the gene ATG26, the gene SUC2, the gene MAL32, the gene MAL12, the gene YJL216C, and/or, the gene YGR287C, and/or, FEN1, and/or, FKS1, and/or, GSC2, and/or, TPS1.

19. A metabolically engineered bacterium or yeast according to claim 17-18 wherein said sucrose phosphorylase originates from a Lactic acid bacterium and wherein said Lactic acid bacterium is *Bifidobacterium adolescentis*, *Leuconostoc mesenteroides*, *Lactobacillus acidophilus*, or *Streptococcus mutants.*

20. A metabolically engineered bacterium or yeast according to claims 2-19 wherein the gene which converts said activated saccharide into a specialty product codes for an epimerase,

a transferase, a reductase, a (pyro)phosphorylase, a (de)carboxylase, a dehydratase, a permease, a synthase, a dehydrogenase, an oxidase or an isomerase.

21. A metabolically engineered bacterium or yeast according to claim 20 wherein said epimerase is UDP-galactose-4-epimerase or UDP-*N*-acetylglucosamine epimerase, and/or, wherein said transferase is a glycosyltransferase, a fucosyltransferase, a sialyltransferase or a sulfotransferase.

22. A metabolically engineered bacterium or yeast according to claims 1-21 wherein said specialty product is a monosaccharide, a disaccharide, a trisaccharide, a tetrasaccharide, a pentasaccharide, a polysaccharide, a nucleoside, an O-glycoside, an S-glycoside, an N-glycoside, a C-glycoside, a glycoprotein, a glycolipid or an activated carbohydrate.

23. A method to produce a specialty product according to any of claims 1-22 comprising:

i) metabolically engineering a bacterium or yeast according to in any of claims 1-23, and

ii) cultivating said genetically engineered bacterium or yeast, and

iii) extracting and purifying said specialty product.