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Alper et al.

(54) ENGINEERED XYLOSE TRANSPORTERS WITH REDUCED GLUCOSE INHIBITION

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 CPC C07K 14/40; C07K 14/39
 USPC 435/183, 252.3; 536/23.2
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(57) **ABSTRACT**

Provided herein are compositions and methods useful for reducing glucose inhibition in transporting xylose, arabinose and other monosaccharides, into a yeast cell.

9 Claims, 12 Drawing Sheets



FIG. 1











Sheet 5 of 12





8000	0000	8	8	8	8	8		
8.000	000	8	8	8	8	8		
8000	888	8	88	8	8	8		
8000	88	8	8	8	8	8		
or a constant	88	8	8	8	8	8		
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e	88	8	8	8	8	8		
ĕ	8	8	8	8	8	88	8	
0000000 000000 000000	88	8	8	8	8	8	8	
-98283 98280 982800 9828000 98280000	88	8	8	8	8	8	80000000000000000000000000000000000000	

FIG. 7 Extracellular

U.S. Patent







FIG. 9A

FIG. 9C



FIG. 9E



FIG. 9F





FIG. 10

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ENGINEERED XYLOSE TRANSPORTERS WITH REDUCED GLUCOSE INHIBITION

CROSS-REFERENCES TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 62/001,495, filed May 21, 2014, the disclosure of which is incorporated herein in its entirety and for all purposes.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

This invention was made with government support under grant no. CBET1067506, awarded by the National Science Foundation. The government has certain rights in the invention.

REFERENCE TO A "SEQUENCE LISTING," A TABLE, OR A COMPUTER PROGRAM LISTING APPENDIX SUBMITTED ON A COMPACT DISK

The Sequence Listing written in file 48932-525001US_ST25.TXT, created on May 21, 2015, 171,093 bytes, machine format IBM-PC, MS Windows operating system, is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

The quest for an optimal xylose pathway in yeast is of utmost importance along the way to realizing the potential of 35 lignocellulosic biomass conversion into fuels and chemicals. An often overlooked aspect of this catabolic pathway is the molecular transport of this sugar. Molecular transporter proteins facilitate monosaccharide uptake and serve as the first step in catabolic metabolism. In this capacity, the 40 preferences, regulation, and kinetics of these transporters ultimately dictate total carbon flux (1-3); and optimization of intracellular catabolic pathways only increases the degree to which transport exerts control over metabolic flux (4, 5). Thus, monosaccharide transport profiles and rates are impor- 45 tant design criteria and a driving force to enable metabolic engineering advances (6-10). Furthermore, the presence of other hexose sugars, such as glucose, can hamper efficient transport of xylose by inhibiting sugar transporters. There is a need in the art for efficient transport systems for xylose in 50 yeast when glucose is present. Provided herein are solutions to these and other problems in the art.

BRIEF SUMMARY OF THE INVENTION

Provided herein are compositions and methods useful for transporting xylose, arabinose, and galactose into a yeast cell in the presence of glucose.

Recombinant transporter proteins are provided herein that transport hexoses or pentoses. In one aspect, the recombi-60 nant transporter is a recombinant xylose transporter protein that includes a xylose transporter motif sequence and a glucose mitigation mutation. In another aspect, the recombinant transporter is a recombinant arabinose transporter protein that includes an arabinose transporter motif sequence 65 and a glucose mitigation mutation. In yet another aspect, the recombinant transporter protein is a recombinant galactose

transporter protein that includes a galactose transporter motif sequence and a glucose mitigation mutation.

Also provided herein are nucleic acids that encode recombinant transporter proteins described herein. Thus, in one aspect is a nucleic acid encoding a recombinant xylose transporter as described herein, including embodiments thereof. In another aspect is a nucleic acid encoding a recombinant arabinose transporter as described herein, including embodiments thereof. In yet another aspect is a nucleic acid encoding a recombinant galactose transporter as described herein, including embodiments thereof.

Recombinant yeast cells are described herein which include a recombinant transporter protein as described herein. In one aspect is a recombinant yeast cell that includes ¹⁵ a recombinant xylose transporter as described herein, including embodiments thereof. In another aspect is a recombinant yeast cell that includes a recombinant arabinose transporter as described herein, including embodiments thereof. In another aspect is a recombinant yeast cell that ²⁰ includes a recombinant galactose transporter as described herein, including embodiments thereof.

Methods of transporting xylose into a recombinant yeast cell are also described herein. In one aspect, the method includes contacting a recombinant yeast cell with a xylose compound, where the recombinant yeast cell includes a recombinant xylose transporter protein as described herein, including embodiments thereof. The recombinant xylose transporter protein transports the xylose compound into the recombinant yeast cell. In another aspect, the method includes contacting a recombinant yeast cell with a xylose compound, where the xylose compound is the only sugar (i.e. carbon source) in the media, and where the recombinant yeast cell includes a recombinant xylose transporter protein as described herein, including embodiments thereof.

In another aspect is a method of transporting arabinose into a recombinant yeast cell. The method includes contacting a recombinant yeast cell with an arabinose compound, where the recombinant yeast cell includes a recombinant arabinose transporter protein as described herein, including embodiments thereof. The recombinant arabinose transporter protein transports the arabinose compound into the recombinant yeast cell. In another aspect, the method includes contacting a recombinant yeast cell with an arabinose compound, where the arabinose compound is the only sugar (i.e. carbon source) in the media, and where the recombinant yeast cell includes a recombinant arabinose transporter protein as described herein, including embodiments thereof.

In another aspect is a method of transporting galactose into a recombinant yeast cell. The method includes contacting a recombinant yeast cell with a galactose compound, where the recombinant yeast cell includes a recombinant galactose transporter protein as described herein, including embodiments thereof. The recombinant galactose transporter protein transports the galactose compound into the recombinant yeast cell. In another aspect, the method includes contacting a recombinant yeast cell with a galactose compound, where the galactose compound is the only sugar (i.e. carbon source) in the media, and where the recombinant yeast cell includes a recombinant galactose transporter protein as described herein, including embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1: The growth of *S. cerevisiae* expressing mutants (78 and 105), FIM, wild-type CiGXS1 transporters on xylose medium supplemented with different concentration

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of glucose: X20: xylose 20 g/L, X20+G2.5: xylose 20 g/L+glucose 2.5 g/L, X20+G5: xylose 20 g/L+glucose 5 g/L, X20+G10: xylose 20 g/L+glucose 10 g/L, G20: glucose 20 g/L.

FIG. **2**: SACS HMMTOP Prediction of the mutant 105⁵ xylose transporter and mutant positions: mutations are indicated with arrows.

FIG. **3**: SACS HMMTOP Prediction of the mutant 78 xylose transporter and mutant positions: mutations are indicated with arrows.

FIG. 4: Mutations to residue N326 to convert to a histidine or phenylalanine were explored in the background of the gxs1 (FIM) mutant containing the xylose transporter motif sequence G-G-F-I-M-G (SEQ ID NO:107). Mutations in residue N326 improve assimilation rates and growth rates in pure xylose over the wild-type GXS1 and N326H is a better mutation than N326F.

FIG. **5**: Mutations to residue N326 to convert to a histidine or phenylalanine were explored in the background of ²⁰ the gxs1 (FIM) mutant containing the xylose transporter motif sequence G-G-F-I-M-G (SEQ ID NO:107). Mutations in residue N326 improve assimilation rates and growth rates in a mixture of 2% glucose and 2% xylose over the wild-type GXS1 and N326H is a better mutation than N326F.²⁵

FIG. **6**: Mutations to residue N326 to convert to a histidine (N326H) are compared with an additionally discovered mutation T170N in the background of the gxs1 (FIM) mutant containing the xylose transporter motif sequence G-G-F-I-M-G (SEQ ID NO:107). Both mutants improved xylose growth rates over the wild-type transporter with the mutation of N326H stronger than T170N.

FIG. 7: An additional round of mutagenesis and selection was completed in the background of gxs1 (FIM) containing N326H (SEQ ID NO:3). These experiments were conducted in the presence of 4% glucose and 2% xylose. Several mutations in the tail region of the transporter were identified including a stop codon (dark dots on schematic of tail with circle indicating location of stop codon). To assess the 40 potential inhibition of this tail region, several truncations of this transporter protein were created (see vertical lines in the sequence on the bottom).

FIG. 8: The gxs1 (FIM) strain with the N326H mutation was truncated at various amino acid residues (indicated by 45 number) and assessed for growth in the presence of 4% glucose, 2% xylose. Several truncations were superior with respect to growth over the starting transporter with a truncation after amino acid residue 497 giving the highest performance. Truncations before residue 487 were detrimen-50 tal to performance.

FIG. 9A-9F: Schematics of the transporter structures for the wild-type GXS1 and gxs1 mutant showing the location of the F-I-M xylose transporter sequence motif. FIG. 9A: WT CiGXS1 (SEQ ID NO:1). FIG. 9B: CiGXS1FIM (SEQ 55 ID NO:2). FIG. 9C: CiGXS1FIM N326H (SEQ ID NO:3). FIG. 9D: CiGXS1FIM T170N (SEQ ID NO:4). FIG. 9E: CiGXS1(FIMH) Δ 497 (SEQ ID NO:5). FIG. 9F: CiGXS1 (FIMH- Δ 497) with 1171F (SEQ ID NO:6).

FIG. **10**: The inhibition fraction (the ratio of the trans- 60 porter capacity in 4% glucose compared to the transporter capacity in pure xylose) for various mutants. The gxs1 mutant with the F-I-M xylose transporter sequence motif and the N326H mutation along with the tail region after truncating past residue 497 and the T171F mutation per- 65 formed best and was the least inhibited by high glucose levels.

DETAILED DESCRIPTION OF THE INVENTION

Unless defined otherwise, all technical and scientific terms used herein generally have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Generally, the nomenclature used herein and the laboratory procedures in cell culture, molecular genetics, organic chemistry, and nucleic acid chemistry and hybridization described below are those wellknown and commonly employed in the art. Standard techniques are used for nucleic acid and peptide synthesis. The techniques and procedures are generally performed according to conventional methods in the art and various general references (see generally, Sambrook et al. MOLECULAR CLONING: A LABORATORY MANUAL, 2d ed. (1989) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., which is incorporated herein by reference), which are provided throughout this document.

"Nucleic acid" refers to deoxyribonucleotides or ribonucleotides and polymers thereof in either single- or doublestranded form, and complements thereof. The term "polynucleotide" refers to a linear sequence of nucleotides. The term "nucleotide" typically refers to a single unit of a 25 polynucleotide, i.e., a monomer. Nucleotides can be ribonucleotides, deoxyribonucleotides, or modified versions thereof. Examples of polynucleotides contemplated herein include single and double stranded DNA, single and double stranded RNA (including siRNA), and hybrid molecules having mixtures of single and double stranded DNA and RNA. Nucleic acid as used herein also refers nucleic acids that have the same basic chemical structure as a naturally occurring nucleic acids. Such analogues have modified sugars and/or modified ring substituents, but retain the same basic chemical structure as the naturally occurring nucleic acid. A nucleic acid mimetic refers to chemical compounds that have a structure that is different the general chemical structure of a nucleic acid, but that functions in a manner similar to a naturally occurring nucleic acid. Examples of such analogues include, without limitation, phosphorothiolates, phosphoramidates, methyl phosphonates, chiralmethyl phosphonates, 2-O-methyl ribonucleotides, and peptide-nucleic acids (PNAs).

"Synthetic mRNA" as used herein refers to any mRNA derived through non-natural means such as standard oligonucleotide synthesis techniques or cloning techniques. Such mRNA may also include non-proteinogenic derivatives of naturally occurring nucleotides. Additionally, "synthetic mRNA" herein also includes mRNA that has been expressed through recombinant techniques or exogenously, using any expression vehicle, including but not limited to prokaryotic cells, eukaryotic cell lines, and viral methods. "Synthetic mRNA" includes such mRNA that has been purified or otherwise obtained from an expression vehicle or system.

The words "complementary" or "complementarity" refer to the ability of a nucleic acid in a polynucleotide to form a base pair with another nucleic acid in a second polynucleotide. For example, the sequence A-G-T is complementary to the sequence T-C-A. Complementarity may be partial, in which only some of the nucleic acids match according to base pairing, or complete, where all the nucleic acids match according to base pairing.

Nucleic acid is "operably linked" when it is placed into a functional relationship with another nucleic acid sequence. For example, DNA for a presequence or secretory leader is operably linked to DNA for a polypeptide if it is expressed as a preprotein that participates in the secretion of the

polypeptide; a promoter or enhancer is operably linked to a coding sequence if it affects the transcription of the sequence; or a ribosome binding site is operably linked to a coding 15 sequence if it is positioned so as to facilitate translation. Generally, "operably linked" means that the 5 DNA sequences being linked are near each other, and, in the case of a secretory leader, contiguous and in reading phase.

The terms "polypeptide," "peptide" and "protein" are used interchangeably herein to refer to a polymer of amino acid residues. The terms apply to amino acid polymers in 10 which one or more amino acid residue is an artificial chemical mimetic of a corresponding naturally occurring amino acid, as well as to naturally occurring amino acid polymers and non-naturally occurring amino acid polymer.

The term "amino acid" refers to naturally occurring and 15 synthetic amino acids, as well as amino acid analogs and amino acid mimetics that function in a manner similar to the naturally occurring amino acids. Naturally occurring amino acids are those encoded by the genetic code, as well as those amino acids that are later modified, e.g., hydroxyproline, 20 y-carboxyglutamate, and O-phosphoserine. Amino acid analogs refers to compounds that have the same basic chemical structure as a naturally occurring amino acid, i.e., an α carbon that is bound to a hydrogen, a carboxyl group, an amino group, and an R group, e.g., homoserine, norleucine, 25 methionine sulfoxide, methionine methyl sulfonium. Such analogs have modified R groups (e.g., norleucine) or modified peptide backbones, but retain the same basic chemical structure as a naturally occurring amino acid. Amino acid mimetics refers to chemical compounds that have a structure 30 that is different from the general chemical structure of an amino acid, but that functions in a manner similar to a naturally occurring amino acid.

Amino acids may be referred to herein by either their commonly known three letter symbols or by the one-letter 35 symbols recommended by the IUPAC-IUB Biochemical Nomenclature Commission. Nucleotides, likewise, may be referred to by their commonly accepted single-letter codes.

A "conservative substitution" as used with respect to amino acids, refers to the substitution of an amino acid with 40 a chemically similar amino acid. Amino acid substitutions which often preserve the structural and/or functional properties of the polypeptide in which the substitution is made are known in the art and are described, for example, by H. Neurath and R. L. Hill, 1979, in "The Proteins," Academic 45 Press, New York. The most commonly occurring exchanges are isoleucine/valine, tyrosine/phenylalanine, aspartic acid/ glutamic acid, lysine/arginine, methionine/leucine, aspartic acid/asparagine, glutamic acid/glutamine, leucine/isoleucine, methionine/isoleucine, threonine/serine, tryptophan/ 50 phenylalanine, tyrosine/histidine, tyrosine/tryptophan, glutamine/arginine, histidine/asparagine, histidine/glutamine, lysine/asparagine, lysine/glutamine, lysine/glutamic acid, phenylalanine/leucine, phenylalanine/methionine, serine/ alanine, serine/asparagine, valine/leucine, and valine/me- 55 thionine. The following eight groups each contain amino acids that are conservative substitutions for one another: 1) Alanine (A), Glycine (G); 2) Aspartic acid (D), Glutamic acid (E); 3) Asparagine (N), Glutamine (Q); 4) Arginine (R), Lysine (K); 5) Isoleucine (I), Leucine (L), Methionine (M), 60 Valine (V); 6) Phenylalanine (F), Tyrosine (Y), Tryptophan (W); 7) Serine (S), Threonine (T); and 8) Cysteine (C), Methionine (M) (see, e.g., Creighton, Proteins (1984)). In some embodiments, there may be at least 1, at least 2, at least 3, at least 4, at least 5, at least 6, at least 7, at least 8, at least 65 9, at least 10, at least 15, at least 20, at least 25, at least 30, at least 35, or at least 40 conservative substitutions. In some

embodiments, there may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, or 40 conservative substitutions.

As to amino acid sequences, one of skill will recognize that individual substitutions, deletions or additions to a nucleic acid, peptide, polypeptide, or protein sequence which alters, adds or deletes a single amino acid or a small percentage of amino acids in the encoded sequence is a "conservatively modified variant" where the alteration results in the substitution of an amino acid with a chemically similar amino acid. Conservative substitution tables providing functionally similar amino acids are well known in the art. Such conservatively modified variants are in addition to and do not exclude polymorphic variants, interspecies homologs, and alleles of the invention.

An amino acid or nucleotide base "position" is denoted by a number that sequentially identifies each amino acid (or nucleotide base) in the reference sequence based on its position relative to an N-terminus (or 5'-end). Due to deletions, insertions, truncations, fusions, and the like that must be taken into account when determining an optimal alignment, in general the amino acid residue number in a test sequence determined by simply counting from the N-terminus will not necessarily be the same as the number of its corresponding position in the reference sequence. For example, in a case where a variant has a deletion relative to an aligned reference sequence, there will be no amino acid in the variant that corresponds to a position in the reference sequence at the site of deletion. Where there is an insertion in an aligned reference sequence, that insertion will not correspond to a numbered amino acid position in the reference sequence. In the case of truncations or fusions there can be stretches of amino acids in either the reference or aligned sequence that do not correspond to any amino acid in the corresponding sequence.

The terms "numbered with reference to" or "corresponding to," when used in the context of the numbering of a given amino acid or polynucleotide sequence, refers to the numbering of the residues of a specified reference sequence when the given amino acid or polynucleotide sequence is compared to a reference sequence. In embodiments the reference sequence is a *Candida intermedia* GXS1 protein having SEQ ID NO: 1. In embodiments, the comparison to the reference sequence is a sequence alignment between the given amino acid or polynucleotide sequence and the reference sequence.

"GXS1 protein" or "Candida intermedia GXS1 protein" is used according to its common, ordinary meaning and refers to proteins of the same or similar names and functional fragments and homologs thereof. The term includes recombinant or naturally occurring forms of GXS1 protein (e.g. Genbank ID: CAI44932.1; GI: 85057135; SEQ ID NO: 1), or variants thereof that maintain GXS1 protein activity (e.g. within at least 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, or 100% as compared to SEQ ID NO: 1). The term includes recombinant or naturally occurring forms of GXS1 protein or variants thereof that have sequence identity to SEQ ID NO: 1 (e.g. about 65%, 70%, 75%, 80%, 85%, 90%, 95%, 99% or 100% identity to SEQ ID NO: 1). GXS1 protein may refer to variants having mutated amino acid residues that modulate (e.g. increase or decrease when compared to GXS1 protein) GXS1 protein activity, expression, cellular targeting, or protein translocation. GXS1 protein may be modified as described herein (e.g. modified with a transporter motif sequence and/or glucose mitigation mutation).

SEQ ID NO: 1: MGLEDNRMVK RFVNVGEKKA GSTAMAIIVG LFAASGGVLF GYDTGTISGV MTMDYVLARY PSNKHSFTAD ESSLIVSILS VGTFFGALCA PFLNDTLGRR WCLILSALIV FNIGAILQVI STAIPLLCAG RVIAGFGVGL ISATIPLYQS ETAPKWIRGA IVSCYQWAIT IGLFLASCVN KGTEHMTNSG SYRIPLAIQC LWGLILGIGM IFLPETPRFW ISKGNQEKAA ESLARLRKLP IDHPDSLEEL RDITAAYEFE TVYGKSSWSQ VFSHKNHQLK RLFTGVAIQA FQQLTGVNFI FYYGTTFFKR AGVNGFTISL ATNIV<u>N</u>VGST IPGILLMEVL GRRNMLMGGA TGM<u>S</u>LSQLIV ALVGVATSEN NKSSQSVLVA FSCIFIAFFA ATWGPCAWVV VGELFP<u>L</u>RR AKSVSLCTAS NWLWNWGIAY ATPYMVDEDK GNLGS<u>N</u>VFFI WGGFNLACVF FAWYFIYETK GLSLEQVDEL YEHVSKAWKS KGFVPSKHSF REQVDQQMDS KTEAIMSEEA

Residues corresponding to positions 36-41 are underlined ²⁵ and bolded for reference. Residues corresponding to positions 155, 225, 326, 354, 361, 407 and 446 are underlined for reference.

The term "recombinant" when used with reference to, for example, a cell, nucleic acid, or protein, indicates that the cell, nucleic acid, or protein, has been modified by the introduction of a heterologous nucleic acid or protein or the alteration of a native nucleic acid or protein, or that the cell is derived from a cell so modified. Thus, for example, 35 recombinant cells express genes that are not found within the native (non-recombinant) form of the cell or express genes otherwise modified from those found in the native form of a cell (e.g. genes encoding a mutation in a native or non-native transporter protein, such as a transporter motif 40 sequence as described herein). For example, a recombinant protein may be a protein that is expressed by a cell or organism that has been modified by the introduction of a heterologous nucleic acid (e.g. encoding the recombinant protein).

The word "expression" or "expressed" as used herein in reference to a DNA nucleic acid sequence (e.g. a gene) means the transcriptional and/or translational product of that sequence. The level of expression of a DNA molecule in a cell may be determined on the basis of either the amount of 50 corresponding mRNA that is present within the cell or the amount of protein encoded by that DNA produced by the cell (Sambrook et al., 1989 *Molecular Cloning: A Laboratory Manual*, 18.1-18.88).

The term "gene" means the segment of DNA involved in 55 producing a protein; it includes regions preceding and following the coding region (leader and trailer) as well as intervening sequences (introns) between individual coding segments (exons). The leader, the trailer as well as the introns include regulatory elements that are necessary during 60 the transcription and the translation of a gene. Further, a "protein gene product" is a protein expressed from a particular gene.

The term "isolated" refers to a nucleic acid, polynucleotide, polypeptide, protein, or other component that is partially or completely separated from components with which it is normally associated (other proteins, nucleic acids, cells,

etc.). In embodiments, an isolated polypeptide or protein is a recombinant polypeptide or protein.

A "yeast cell" as used herein, refers to a eukaryotic unicellular microorganism carrying out metabolic or other

- 5 function sufficient to preserve or replicate its genomic DNA. Yeast cells may carry out fermentation of sugars described herein. In embodiments, fermentation may convert the sugar to a biofuel or biochemical as set forth herein. Yeast cells referenced herein include, for example, the following spe-
- 10 cies: Candida intermedia, Cryptococcos neoformans, Debaryomyces hansenii, Saccharomyces cerevisiae, Scheffersomyces stipitis, or Yarrowia lipolytica. A "recombinant yeast cell" is a yeast cell which expresses a recombinant transporter protein.
- 15 The term "biofuel" as used herein refers to a convenient energy containing substance produced from living organisms (e.g. biomass conversion to a fuel). Thus, biofuels may be produced through, for example, fermentation of carbohydrates (e.g. sugars) found in biomass (e.g. lignocellulosic 20 biomass). Biofuels may be solid, liquid, or gas forms.
 - Biofuels include, for example, ethanol, biodiesel, vegetable oil, ether (oxygenated fuels), or gas (e.g. methane).

The term "biochemical" as used herein refers to production of chemicals by living organisms. Biochemicals herein include production of alcohols (e.g. methanol, butanol, ethanol, isobutanol, 2,3-butanediol, propanol); sugars (e.g. erythritol, mannitol, riboflavin); carotenoids (e.g. β-carotene, lycopene, astaxanthin); fatty acids (e.g. ricinoleic acid, linolenic acid, tetracetyl phytosphingosine); amino acids (e.g. valine, lysine, threonine); aromatics (e.g. indigo, vanillin, sytrene, p-hydroxystyrene); flavonoids (e.g. naringenin, genistein, kaempferol, quercetin, chrysin, apigenin, luteolin); stillbenoids (e.g. resveratrol); terpenoids (e.g. β-amyrin, taxadiene, miltiradiene, paclitaxel, artemisinin, bisabolane); polyketides (e.g. aureothin, spectinabilin, lovastatin, geodin); acetone; or organic acids (e.g. citric acid, succinic acid, malic acid, lactic acid, polylactic acid, adipic acid, glucaric acid). See e.g. Curran K. A., Alper H. S., Metabolic Engineering 14:289-297 (2012).

A "transporter motif sequence" as used herein refers to an amino acid sequence that, when present in a protein (e.g. a sugar transporter protein such as a MFS transporter protein), increases the ability of the protein to transport a sugar or sugar-containing compound into a yeast cell. In embodi-45 ments, the transporter motif sequence imparts a hexose sugar transport preference or pentose sugar transport preference to the protein. Correspondingly, a transporter motif may refer to the specific sugar it transports into a yeast cell. For example, the transporter motif sequence may impart preference to hexose sugars to a transporter protein, thereby allowing the recombinant transporter protein to preferentially transport hexoses into a yeast cell. Such transporter motif sequences may be referred to herein as a "hexose transporter motif sequence." In embodiments the transporter motif sequence imparts preference to a single hexose. The hexose may be galactose or mannose. Such transporter motif sequences may be referred to herein as a "galactose transporter motif sequence" and a "mannose transporter motif sequence" respectively. In embodiments, the transporter motif sequence imparts preference to more than one hexose sugar.

The transporter motif sequence may impart preference to pentose sugars to a transporter protein, thereby allowing the recombinant transporter protein to preferentially transport pentose into a yeast cell. In embodiments the transporter motif sequence imparts preference to a single pentose (e.g. xylose). The pentose may be xylose or arabinose. Such transporter motif sequences may be referred to herein as a "xylose transporter motif sequence" and an "arabinose transporter motif sequence" respectively. In embodiments the transporter motif sequence imparts preference to more than one pentose sugar (e.g. xylose and arabinose). Such transporter motif sequences may be referred to as a "xylose/ arabinose transporter motif sequence."

In embodiments, the transporter motif sequence imparts preference to a hexose and a pentose. That is, in embodiments, the recombinant transporter protein having such a transporter motif sequence preferentially transports one hexose and/or one pentose. Such transporter motif sequences may be referred to by the sugars which are transported (e.g. galactose and arabinose). Accordingly, in embodiments, the transporter motif sequence imparts preference to galactose and arabinose. Such a transporter motif is herein referred to as a "galactose-arabinose transporter motif sequence" (i.e. a recombinant transporter protein that transports both galactose and arabinose, or transports galactose or arabinose).

The transporter motif sequence as described herein corresponds to residues corresponding to positions 36-41 of the Candida intermedia GXS1 protein ("GXS1 motif sequence"). One skilled in the art will immediately recognize the identity and location of residues corresponding to positions 36-41 of the Candida intermedia GXS1 protein in other transporter proteins with different numbering systems. For example, by performing a simple sequence alignment with Candida intermedia GXS1 protein the identity and location of residues corresponding to positions 36-41 of the Candida intermedia GXS1 protein are identified in other yeast transport proteins as illustrated in Table 1. Insertion (e.g. substitution) of a transporter motif sequence into a yeast transport protein may thereby be performed resulting in a functional yeast transporter protein with an altered sugar transport preference (e.g. changing a preference for hexoses to a preference for pentoses). For example, amino acid residue positions 75-81 of S. cerevisiae HXT7 protein correspond to amino acid residue positions 36-41 of the Candida intermedia GXS1 protein (see Table 1).

TABLE 1

Sequence alignment of 54 sequences from major facilitator superfamily sugar transporter proteins (SEQ ID NOs: 51-104, respectively in order of appearance in Table 1). Putative transporter motif sequences are illustrated in the box and corresponds as described herein to residue positions 36-41 of *C. intermedia GXS1* protein.

Dh2C02530p	KFRNFLDKTPNIYNVFVIASISCI	SGLM	FGIDISSMSLFIGDDKYIKYFHK	63
Dh2E01166p	KLRLFLDKLPNIYNIYVIATISCI	SGLM	FGIDISSMSAFLSNDAYLKYFGT	63
Dh2E01298p	KFRNFLDKFPNIHNVYIVVGISCI	SGMM	FGIDISSMSLFIGDDKYLDYFNS	63
SsHGT2	KFRTFLDRLPNIYNVYIIASISCI	SGMM	FGFDISSMSAFIGEDDYKNFFNN	63
Dh2A14300p	SLNKELDKFHTTYNIYVIAMITTI	SGMM	FGFDVSSISAFISEPSYRRFFNY	61
Y10B06391p	QVGALQHRFPKLHNPYLTAAVATM	GGLL	FGFDISSVSAFVDTKPYKEYFGY	59
Y10B01342p	MYKVHNPYLTAAVATM	GGML	FGFDISSVSAFVGEDNYMNYFGH	43
BmHGT2	MGRITNPYVLTALACT	GGLL	FGFDISSMSAIISSPNYLTYFGPKDLTVECPD	52
At5g59250	LASDAPESFSWSSVILPFIFP-AL	GGLL	FGYDIGATSGATLSLQSPALSGTTWFNF	139
At5g17010	HVPENYSVVAAILPFLFP-AL	GGLL	YGYEIGATSCATISLQEPMTLLSYYAVPFSAV	89
SsAUT1	LNAEATNKWHIPPRLIGVIALGSM	AAAV	QGMDESVINGANLFYPKAFGVDTMHNSD	161
Y10D00132	LNREITNKWDHPMKVYYLVVCCSL	AAAV	QGMDETVINGANI IFPAQFGI KEDSGVVSRKS	180
BmSTL1	FLGMRGIKLNWAIGFAASA	GFLL	FGYDQGVLGSLYTLPSWNAQFPEINTAAVGDS	73
SsXUT6	AKTNSYLGLRGHKLNFAVSCFAGV	GFLL	FGYDQGVMGSLLTLPSFENTFPAMK	75
Dh2E01386p	KTNTMGLRGKPLRVAITICCTI	GFSL	FGYDQGLMSGIITGKQFNEEPPTHGT	59
Dh2B05060p	RTNTMGLRGKRLRVMFTVVATL	GFSL	FGYDQGLMSGLITGEQFNAEFPPTAGK	60
SsSTL1	RRNRMGLRGKRLRVMFTVVATL	GFSL	FGYDQGLMSGLITGEQFNAEFPPTAGK	60
ScSTL1	RTSHWGLTGKKLRYFITIASMI	GFSL	FGYDQGLMASLITGKQFNYEFPATKENGD	70
BmHXT10	IDVGLRGNWLLTVITASCAA	GFLL	VGYDNGVMGGVVGLGEFNKTFNNPD	66
SsXUT2	GKQVSYAVTFTCEL	AFIL	FGIEQGIIGNLINNQDFLNTFGNPTG	53
CnBC3990p	HKTQRRLVGHNLLYSVSVFLSI	GVWL	FGYDQGVMSGIITGPYFKAYFNQPTS	62
Y10F06776p	MFSLTGKPLLYFTSVFVSL	GVFL	FGYDQGVMSGIITGFYFKEYPHEPTR	49
BmXUT3	VGATGAKGLIKNARTFAIAVFASM	GGLI	YGYNQGMFGQILSMHSFQEASGVKGIT	78
SsXUT1	AGKSGVAGLVANSRSFFIAVFASL	gglv	YGYNQGMFGQISGMYSFSKAIGVEKIQD	77
SsXUT3	AHGNVVTIMMKDPVVFLVILFASL	GGLL	FGYDQGVISGIVTMESFGAKFPRIFM	63
		I		
SsXUT3-A	AHGNVVTIMMKDPVVFLVILFASL	GGLL	FGYDQGVISGIVTMESFGAKFPRIFM	63
SsXUT3-B	AHGNVVTIMMKDPVVFLVILFASL	GGLL	FGYDQGVISGIVTMESFGAKFPRIFM	63
DhXy1HP	SKGNIITVMSKDPLVFCIIAFASI	GGLL	FGYDQGVISGIVTMESFAAKFPRIFS	64
ScGAL2	PIEIPKKPMSEYVTVSLLCLCVAF	GGFM	FGWDTGTISGFVVQTDFLRRFG-MKHKDGT	113
ScHXT8	EVVVPEKPASAYATVSIMCLCMAF	GGFM	SGWDTGTISGFVNQTDFLRRFGNYSHSKNT	109
ScHXT1	AVAPPNTGKGVYVTVSICCVMVAF	GGFI	FGWDTGTISGFVAQTDFLRRFG-MKHHDGS	107
ScHXT3	VLTNPNTGKGAYVTVSICCVMVAF	GGFV	FGWDTGTISGFVAQTDFLRRFG-MKHKDGS	104
ScHXT7	VVEIPKRPASAYVTVSIMCIMIAF	GGFV	FGWDTGTISGFINQTDFIRRFG-MKHKDGT	107
ScHXT9	PIDLPQKPLSAYTTVAILCLMIAF	GGFI	FGWDTGTISGFVNLSDFIRRFG-QKNDKGT	103
ScHXT2	NAELPAKPIAAYWTVICLCLMIAF	GGFV	FGWDTGTISGFVNQTDFKRRFG-QMKSDGT	98
ScHXT10	SLDIPYKPIIAYWTVMGLCLMIAF	GGFI	FGWDTGTISGFINQTDFKRRFG-ELORDGS	91
CiGXF1	QVDAPQKGFKDYIVISIFCFMVAF	GGFV	FGFDTGTISGFVNMSDFKDRFG-QHHADGT	86
ScHXT13	NVEPPKRGLIGYLVIYLLCYPISF	GGFL	PGWDSGITAGFINMDNFKMNFGSYKHSTGE	100
BmGXF1	-MVFQVRGTPIGALTLFIAMLASM	GGFL	FGWDTGQISGLTQMADFRQRFATVDNPDAIG-	58

TABLE	1-continued
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Sequence alignment of 54 sequences from major facilitator superfamily sugar transporter proteins (SEQ ID NOS: 51-104, respectively in order of appearance in Table 1). Putative transporter motif sequences are illustrated in the box and corresponds as described herein to residue positions 36-41 of *C. intermedia GXS1* protein.

			_
ScHXT14	GOAAKISHNASLHIPVLLCLVISLGGE	IFGWDIGTIGGMTNMVSFOEKFGTTNIIHDDET	105
BmGXS1	GPVARPASVKQSLPAILVAAASAFGGV	LEGYDTGTISGLIVMPNFQETFGKPVPGSTTGA	74
BmRGT2	GPVARPASVKQSLPAILVAAASAFGGV	LFGYDTGTISGLIVMPNFQETFGKPVPGSTTGA	74
CiGXS1	FVNVGEKKAGSTAMAI IVGLFAASGGV	LFGYDTGTISGVMTMDYVLARYPSNK-	64
CiGXS1-A	FVNVGEKKAGSTAMAI IVGLFAASGGV	LVGYDTGTISGVMTMDYVLARYPSNK-	64
CiGXS1-B	FVNVGEKKAGSTAMAI IVGLFAAFGGV	LSGYDTGTISGVMTMDYVLARYPSNK-	64
Dh2D01474	YVNVGEKRAGSASMGI FVGAFAAFGGV	LFGYDTGTISGIMAMNYVKGEFPANK-	64
Dh0D02167p	YVNVGEKRAGSASMGI FVGAFAAFGGV	LFGYDTGTISGIMAMNYVKGEFPANK-	64
SsRGT2	YINFGEKKAGSTTMGICVGLFAAFGGI	LFGYDTGTISGIMAMDYVTARFPSNH-	64
Y10C06424p	IINRGEKPEGSAFMAAFVAVFVAFGGI	LFGYDTGTISGVMAMPFVKKTFTDDG-	58
Y10C08943p	MAIIVAVFVAFGGI	LYGYDTGTIAGIMTMGYVKEHFTDFGK	41
Dh2B14278p	YYKKMQQKS-SSSAITVGLVAAVGGE	LYGYDTGLINDIMEMTYVKDNFPANG-	69
EcXy1E	MNTQYNSSYIFSITLVATLGGI	LFGYDTAVISGTVESLHTVFVAPQNLSESAAN-	54
SsXUT5	RSIGPLIPRNKHLFYGSVLLMSIVHPT	'IMGYDSMMVGSILNLDAYVNYFH	53
ScMAL11	KSMTLKQALLKYPKAALWSILVSTTLV	MEGYDTALLSALYALPVFQRKFGTLNGEGS	148

A "glucose mitigation mutation" as used herein refers to an amino acid mutation that, when present in a recombinant 25 transporter protein, reduces, minimizes, diminishes, or in certain embodiments, eliminates the inhibitory effect of glucose on the recombinant transporter when transporting a sugar other than glucose (e.g. xylose) into a yeast cell. A glucose mitigation mutation may, in embodiments, increase 30 the ability of a recombinant transporter protein to transport a preferred sugar or sugar-containing compound into a yeast cell. Thus, in embodiments, a glucose mitigation mutation may increase the ability of a recombinant transporter protein to transport xylose into a yeast cell. A glucose mitigation 35 mutation may include a single amino acid residue mutation (e.g. a "point mutation") in a recombinant transporter protein. A glucose mitigation mutation may include two or more mutations (e.g. a "substitution set") in a recombinant transporter protein. The glucose mitigation mutation may be in a 40 transmembrane domain, an extracellular loop, or cytoplasmic loop of a recombinant transporter protein. In embodiments, the glucose mitigation mutation may be localized (i.e. glucose mitigation mutations located within a specified domain or region of a recombinant transporter protein) or 45 distributed (i.e. glucose mitigation mutations located throughout the sequence of the recombinant transporter protein).

A "recombinant transporter protein" as used herein refers to a recombinantly expressed transmembrane protein which 50 transports a sugar or sugar-containing compound (e.g. hexoses and pentoses) into a yeast cell. In embodiments, the recombinant transporter protein is a yeast recombinant transporter protein. In embodiments, the recombinant transporter protein is a transporter protein belonging to the major 55 faciliator superfamily ("MFS") transporter proteins. In embodiments, a recombinant transporter protein may transport a hexose (e.g. galactose) into a yeast cell. In embodiments, a recombinant transporter protein may transport a pentose (e.g. xylose or arabinose) into a yeast cell. A 60 recombinant transporter protein may be engineered, using the transporter motif sequences described herein, to alter its sugar preference (e.g. a transporter protein having a preference to transport a hexose compound may be converted to a transporter protein having a preference to transport a pentose 65 compound). A recombinant transporter protein may be characterized by the sugar it transports. Thus, a recombinant

transporter protein transporting xylose is herein referred to a "recombinant xylose transporter protein." Likewise, recombinant transporter proteins transporting arabinose or galactose are herein referred to as a "recombinant arabinose transporter protein" and a "recombinant galactose transporter protein" respectively.

A recombinant transporter protein may be characterized as a transporter protein derived from a particular organism. Where a recombinant transporter protein is derived from a particular organism, the endogenous sequence of the recombinant transporter protein may be maintained and residues corresponding to positions 36-41 of the Candida intermedia GXS1 protein may be replaced with a transporter motif sequence. As an example, a C. intermedia gxs1 transporter protein is a gxs1 transporter protein, a homolog thereof, or a functional fragment thereof, found in C. intermedia. Amino acids 75-81 of S. cerevisiae hxt7 transporter protein may be replace with a transporter motif sequence thereby forming a recombinant transporter protein with desired sugar transport characteristics as described herein. In embodiments, the recombinant transporter protein is a protein, functional fragment, or homolog thereof, identified by the following NCBI gene ID or NCBI accession numbers: 836043, 831564, AJ937350.1, AJ875406.1, 2901237, 2913528, 8998057, 8999011, 50419288, 948529, 4839826, 4852047, 4851844, 4840896, 4840252, 4841106, 4851701, 2907283, 2906708, 2908504, 2909312, 2909701, 4935064, 851943, 856640, 851946, 856494, 8998297, 2902950, 2902912, 853207, 852149, 855023, 853216, 853236, 850536, 855398, 4836720, 4836632, 4840859, 2913215, 2902914, 2910370, and 4838168 (SEQ ID NOs:7-50, respectively in order of appearance). Such recombinant transporter proteins may further be characterized by the sugar preference conferred (e.g. a Candida intermedia GXS1 recombinant xylose transporter protein).

A "pentose compound" or "pentose" is a monosaccharidecontaining compound having 5 carbon atoms. Pentose compounds include aldopentoses (e.g. pentose compounds having an aldehyde moiety at carbon 1) and ketopentoses (e.g. pentose compounds having a ketone moiety at carbon 2 or carbon 3). Pentose compounds include, for example, D/Larabinose, D/L-lyxose, D/L-ribose, D/L-xylose, D/L-ribulose, and D/L-xylulose. The term "monosaccharide-containing" refers to a compound that includes at least one monosaccharide.

A "hexose compound" "or "hexose" is a monosaccharidecontaining compound having 6 carbon atoms. Hexose compounds include aldohexoses (e.g. hexose compounds having an aldehyde moiety at carbon 1) and ketohexoses (e.g. hexose compounds having a ketone moiety at carbon 2). 5 Hexose compounds include, for example, D/L-allose, D/Laltrose, D/L-glucose, D/L-mannose, D/L-glucose, D/Lidose, D/L-galactose, and D/L-talose.

A "xylose compound" is xylose or a xylose-containing compound including at least one xylose moiety. Thus as 10 used herein, the term xylose compound represents a single xylose, a chain including one or more xylose moieties, or a xylose moiety covalently or non-covalently bound to another chemical moiety (e.g. another sugar forming a xylose containing polysaccharide or xylose bound to lignin). 15 An "arabinose compound" is arabinose or an arabinosecontaining compound including at least one arabinose moiety. Thus as used herein, the term arabinose compound represents a single arabinose, a chain including one or more arabinose moieties, or an arabinose moiety covalently or 20 non-covalently bound to another chemical moiety (e.g. another sugar forming an arabinose containing polysaccharide or arabinose bound to lignin). A "galactose compound" is galactose or a galactose-containing compound including at least one galactose moiety. Thus as used herein, the term 25 galactose compound represents a single galactose, a chain including one or more galactose moieties, or a galactose moiety covalently or non-covalently bound to another chemical moiety (e.g. another sugar forming a galactose containing polysaccharide or bound to lignin).

A "sugar" as set forth herein, refers to monosaccharide and polysaccharide compounds metabolized by a yeast cell. In embodiments, a sugar may be a hexose sugar as described herein or a pentose sugar as described herein.

Polysaccharides herein include hexose-only polysaccha- 35 rides, pentose-only polysaccharides, and hexose-pentose mixture polysaccharides. In embodiments, the xylose compound, the arabinose compound, or the galactose compound may be derived from or form part of a lignocellulosic biomass (e.g. plant dry matter that may used in as a source 40 for pentose compounds or hexose compounds and for production of biofuels or biochemicals), hemicellulose, marine biomass (e.g. seaweeds or algae that may used in as a source for pentose compounds or hexose compounds and for production of biofuels or biochemicals) or other natural or 45 synthetic sources for xylose, arabinose, or galactose, including but not limited to xylan or pectin. "Derived from" refers to extraction, removal, purification, or otherwise freeing a xylose compound, arabinose compound, or galactose compound from a source (e.g. lignocellulosic biomass) by either 50 chemical processes (e.g. acid hydrolysis, ammonium explosion, or ionic liquids extraction) or through natural biological processes by organisms capable of using such sources for energy.

A "xylose growth media" refers to a yeast cell media 55 containing a xylose compound in amounts sufficient to serve as a nutrient for growing or culturing recombinant yeast cells. The term refers to a media substantially free of glucose, and, in embodiments, is "glucose free" (i.e. the media contains no glucose). In embodiments, a xylose 60 growth media includes trace amounts of glucose which are undetectable using known methods and which are insufficient to support significant growth of yeast cells. In embodiments, a xylose growth media includes trace amounts of glucose which are insufficient to cause inhibition of activity 65 containing a galactose compound in amounts sufficient to of a recombinant transporter protein (e.g. a recombinant xylose transporter protein) as described herein.

A "xylose-glucose growth media" refers to a yeast cell media containing a xylose compound in an amount sufficient to serve as a nutrient for growing or culturing recombinant yeast cells and a glucose compound. The term refers to a media that includes glucose in an amount sufficient to serve as a nutrient for growth or culturing recombinant yeast cells or in an amount sufficient to cause inhibition of activity of a recombinant transporter protein as described herein. The glucose may be present in the xylose-glucose growth media at a pre-determined concentration as described herein.

Xylose growth media and xylose-glucose growth media may be supplemented with other hexoses or pentoses described herein (e.g. mannose, galactose, or arabinose). Growth of a recombinant yeast cell in a xylose growth media may be compared to growth of a recombinant yeast cell in a xylose-glucose growth media. Thus, in embodiments, a recombinant xylose transporter protein may be selected for its xylose selectivity and/or its rate of transfer of a xylose compound into a yeast cell by comparing its growth in xylose growth media to its growth in xylose-glucose growth media. In embodiments, recombinant yeast cells having impaired growth in xylose-glucose growth media may indicate that the recombinant xylose transporter protein in the recombinant yeast is inhibited, at least in part, by glucose.

An "arabinose growth media" refers to a yeast cell media containing an arabinose compound in amounts sufficient to serve as a nutrient for growing or culturing recombinant yeast cells. The term refers to a media substantially free of glucose, and, in embodiments, is "glucose free" (i.e. the media contains no glucose). In embodiments, an arabinose growth media includes trace amounts of glucose which are undetectable using known methods and which are insufficient to support significant growth of yeast cells. In embodiments, an arabinose growth media includes trace amounts of glucose which are insufficient to cause inhibition of activity of a recombinant transporter protein (e.g. a recombinant arabinose transporter protein) as described herein.

An "arabinose-glucose growth media" refers to a yeast cell media containing an arabinose compound in an amount sufficient to serve as a nutrient for growing or culturing recombinant yeast cells and a glucose compound. The term refers to a media that includes glucose in an amount sufficient to serve as a nutrient for growth or culturing recombinant yeast cells or in an amount sufficient to cause inhibition of activity of a recombinant transporter protein as described herein. The glucose may be present in the arabinose-glucose growth media at a pre-determined concentration as described herein.

Arabinose growth media and arabinose-glucose growth media may be supplemented with other hexoses or pentoses described herein (e.g. mannose, galactose, or xylose). Growth of a recombinant yeast cell in an arabinose growth media may be compared to growth of a recombinant yeast cell in an arabinose-glucose growth media. Thus, in embodiments, a recombinant arabinose transporter may be selected for its arabinose selectivity and/or its rate of transfer of an arabinose compound into a yeast cell by comparing its growth in arabinose growth media to its growth in arabinose-glucose growth media. In embodiments, recombinant yeast cells having impaired growth in arabinose-glucose growth media may indicate that the recombinant arabinose transporter protein in the recombinant yeast is inhibited, at least in part, by glucose.

A "galactose growth media" refers to a yeast cell media serve as a nutrient for growing or culturing recombinant yeast cells. The term refers to a media substantially free of glucose, and, in embodiments, is "glucose free" (i.e. the media contains no glucose). In embodiments, a galactose growth media includes trace amounts of glucose which are undetectable using known methods and which are insufficient to support significant growth of yeast cells. In embodi-5 ments, a galactose growth media includes trace amounts of glucose which are insufficient to cause inhibition of activity of a recombinant transporter protein (e.g. a recombinant galactose transporter protein) as described herein.

A "galactose-glucose growth media" refers to a yeast cell 10 media containing a galactose compound in an amount sufficient to serve as a nutrient for growing or culturing recombinant yeast cells and a glucose compound. The term refers to a media that includes glucose in an amount sufficient to serve as a nutrient for growth or culturing recom- 15 binant yeast cells or in an amount sufficient to cause inhibition of activity of a recombinant transporter protein as described herein. The glucose may be present in the galactose-glucose growth media at a pre-determined concentration as described herein.

Galactose growth media and galactose-glucose growth media may be supplemented with other hexoses or pentoses described herein (e.g. mannose, arabinose, or xylose). Growth of a recombinant yeast cell in a galactose growth media may be compared to growth of a recombinant yeast 25 cell in a galactose-glucose growth media. Thus, in embodiments, a recombinant galactose transporter may be selected for its galactose selectivity and/or its rate of transfer of a galactose compound into a yeast cell by comparing its growth in galactose growth media to its growth in galactose- 30 glucose growth media. In embodiments, recombinant yeast cells having impaired growth in galactose-glucose growth media may indicate that the recombinant galactose transporter protein in the recombinant yeast is inhibited, at least in part, by glucose.

As defined herein, the term "inhibition", "inhibit", "inhibiting" and the like refers to negatively affecting (e.g. decreasing) the activity or function of a recombinant transporter protein (e.g. recombinant xylose transporter protein) relative to the activity or function of the protein in the 40 absence of the inhibitor (e.g. glucose). In embodiments, inhibition refers to a reduction in the growth rate of a recombinant yeast cell.

"Contacting" is used in accordance with its plain ordinary meaning and refers to the process of allowing at least two 45 distinct species (e.g. chemical compounds including sugars, biomolecules or cells) to become sufficiently proximal to react, interact or physically touch. The term "contacting" includes allowing two species to react, interact, or physically touch, where the two species may be a sugar as described 50 herein and a recombinant transporter protein as described herein. In embodiments contacting includes allowing a sugar described herein to interact with a recombinant transporter protein that is involved in transporting hexose or pentose compounds into a yeast cell.

I. Compositions

Provided herein are recombinant transporter proteins that include a transporter motif sequence and a glucose mitiga- 60 tion mutation. In one aspect, the recombinant transporter protein is a recombinant xylose transporter protein that includes a xylose transporter motif sequence and a glucose mitigation mutation.

1. Recombinant Xylose Transporter Protein

The xylose transporter motif sequence may correspond to amino acid residue positions 36, 37, 38, 39, 40, and 41 of

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Candida intermedia GXS1 protein (SEQ ID NO: 1). In embodiments, the xylose transporter motif sequence corresponds to amino acid residue positions 36, 37, 38, 39, 40, and 41 of SEQ ID NO:1. The transporter motif sequence may have the sequence $-G-G/F-X^1-X^2-X^3-G-X^1$ is D, C, G, H, I, L, or F. X² is A, D, C, E, G, H, or I. X³ is N, C, Q, F, G, L, M, S, T, or P. In embodiments, the transporter motif sequence is not -G-G-L-I-F-G- (SEQ ID NO:105) or -G-G-F-I-F-G- (SEQ ID NO:106).

 X^1 may be D, C, G, I, L, or F. X^1 may be D, C, G, H, or F. X^1 may be D. X^1 may be C. X^1 may be G. X^1 may be I. X^1 may be L. X^1 may be H. X^1 may be F. X^2 may be D, C, E, G, H, or I. X^2 may be E, G, H, or I. X^2 may be H or I. X^2 may be H. X² may be I. X³ may be N, Q, F, M, S, T, or P. X³ may be F, M, S, or T. X³ may be S, T, or M. X³ may be T. X^3 may be S. X^3 may be M. In embodiments, when X^1 is F, X^2 may be I and X^3 may be M or S.

The xylose transporter motif sequence may be -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), 20 -G-G-F-I-S-G- (SEO ID NO:109), -G-F-F-I-S-G- (SEO ID NO:110), -G-G-F-I-T-G- (SEQ ID NO:111), -G-F-F-I-T-G-(SEQ ID NO:112), -G-G-F-L-M-G- (SEQ ID NO:113), -G-F-F-L-M-G- (SEQ ID NO:114), -G-G-F-L-S-G- (SEQ ID NO:115), -G-F-F-L-S-G- (SEQ ID NO:116), -G-G-F-L-T-G- (SEQ ID NO:117), -G-F-F-L-T-G- (SEQ ID NO:118), -G-G-F-H-M-G- (SEQ ID NO:119), -G-F-F-H-M-G- (SEQ ID NO:120), -G-G-F-H-S-G- (SEQ ID NO:121), -G-F-F-H-S-G- (SEQ ID NO:122), -G-G-F-H-T-G- (SEQ ID NO:123) or -G-F-F-H-T-G- (SEQ ID NO:124). In embodiments, the xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), -G-F-F-I-S-G- (SEQ ID NO:110), -G-G-F-I-T-G- (SEQ ID NO:111), or -G-F-F-I-T-G- (SEQ ID NO:112). In embodiments, the xylose transporter motif 35 sequence is -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), or -G-F-F-I-S-G- (SEQ ID NO:110). In embodiments, the xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107), or -G-F-F-I-M-G- (SEQ ID NO:108). The xylose transporter motif sequence may be -G-G-F-I-M-G-(SEQ ID NO:107). The xylose transporter motif sequence may be -G-F-F-I-M-G- (SEQ ID NO:108). The xylose transporter motif sequence may be -G-G-F-I-S-G- (SEQ ID NO:109). The xylose transporter motif sequence may be -G-F-F-I-S-G- (SEQ ID NO:110). The xylose transporter motif sequence may be -G-G-F-I-T-G- (SEQ ID NO:111). The xylose transporter motif sequence may be -G-F-F-I-T-G- (SEQ ID NO:112). The xylose transporter motif sequence may be -G-G-F-L-M-G- (SEQ ID NO:113). The xylose transporter motif sequence may be -G-F-F-L-M-G-(SEQ ID NO:114). The xylose transporter motif sequence may be -G-G-F-L-S-G- (SEQ ID NO:115). The xylose transporter motif sequence may be -G-F-F-L-S-G- (SEQ ID NO:116). The xylose transporter motif sequence may be 55 -G-G-F-L-T-G- (SEQ ID NO:117). The xylose transporter motif sequence may be -G-F-F-L-T-G- (SEQ ID NO:118). The xylose transporter motif sequence may be -G-G-F-H-M-G- (SEQ ID NO:119). The xylose transporter motif sequence may be -G-F-F-H-M-G- (SEQ ID NO:120). The xylose transporter motif sequence may be -G-G-F-H-S-G-(SEQ ID NO:121). The xylose transporter motif sequence may be -G-F-F-H-S-G- (SEQ ID NO:122). The xylose transporter motif sequence may be -G-G-F-H-T-G- (SEQ ID NO:123). The xylose transporter motif sequence may be -G-F-F-H-T-G- (SEQ ID NO:124).

The glucose mitigation mutation may be within a protein domain corresponding to a transmembrane of a recombinant transporter protein (e.g. one or more of transmembrane domains 1-12). The glucose mitigation mutation may be within two or more protein domains corresponding to transmembranes of a recombinant transporter protein. The glucose mitigation mutation may be within a protein domain 5 corresponding to a transmembrane of Candida intermedia GXS1 protein. The transmembrane may be a protein domain corresponding to transmembrane 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 of Candida intermedia GXS1 protein. The transmembrane may be a protein domain corresponding to a 10 transmembrane a protein of SEQ ID NO:51-104. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 1 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 2 15 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 3 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 4 of Candida 20 intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 5 of Candida intermedia GXS1 protein.

In embodiments, the glucose mitigation mutation is within a protein domain corresponding to transmembrane 5 25 of SEQ ID NO:1. In embodiments, the glucose mitigation mutation is within a protein domain corresponding to residue 160-179 of SEQ ID NO:1. In embodiments, the glucose mitigation mutation is at a position corresponding to T170 or 1171 of SEQ ID NO:1. In embodiments, the glucose miti-30 gation mutation is a T170N mutation. In embodiments, the glucose mitigation mutation is a 1171F mutation.

The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 6 of Candida intermedia GXS1 protein. The glucose mitigation mutation 35 may be within a protein domain corresponding to transmembrane 7 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 8 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a 40 protein domain corresponding to transmembrane 9 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 8 or 9 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein 45 domain corresponding to transmembrane 8 and 9 of Candida intermedia GXS1 protein (e.g. amino acid residues about 347 to about 366 of Candida intermedia GXS1 amino acid sequence (SEQ ID NO: 1)). The glucose mitigation mutation may be within a protein domain corresponding to transmem- 50 brane 10 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 11 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 12 55 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to transmembrane 9 of Candida intermedia GXS1.

In embodiments, the glucose mitigation mutation is within a protein domain corresponding to an extracellular 60 domain of *Candida intermedia* GXS1 protein. The glucose mitigation mutation may be in a protein domain corresponding to the 11-12 extracellular domain of *Candida intermedia* GXS1 protein. The glucose mitigation mutation may be within a protein domain corresponding to a cytoplasmic 65 domain (i.e. intracellular) of *Candida intermedia* GXS1 protein. In embodiments, the glucose mitigation mutation is

in a protein domain corresponding to the 4-5 cytoplasmic domain (i.e. an intracellular domain between protein domains corresponding to transmembranes 4 and 5 of *Candida intermedia* GXS1 protein); the central cytoplasmic domain (i.e. an intracellular domain between protein domains corresponding to transmembranes 6 and 7 of *Candida intermedia* GXS1 protein); or the 10-11 cytoplasmic domain (i.e. an intracellular domain between protein domains corresponding to transmembranes 10 and 11 of *Candida intermedia* GXS1 protein) of *Candida intermedia* GXS1 protein) of *Candida intermedia* GXS1 protein.

The glucose mitigation mutation may be at a position corresponding to K155, T170, I171, N225, S354, A361, L407, or N446 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be at a position corresponding to T170 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be at a position corresponding to I171 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be at a position corresponding to K155 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 155 as described herein. In embodiments, the glucose mitigation mutation is a K155E mutation. The glucose mitigation mutation may be at a position corresponding to N225 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 225 as described herein. In embodiments, the glucose mitigation mutation is a N225D mutation. The glucose mitigation mutation may be at a position corresponding to S354 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 354 as described herein. In embodiments, the glucose mitigation mutation is a S354T mutation. The glucose mitigation mutation may be at a position corresponding to A361 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 361 as described herein. In embodiments, the glucose mitigation mutation is a A361T mutation. The glucose mitigation mutation may be at a position corresponding to L407 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 407 as described herein. In embodiments, the glucose mitigation mutation is a L407M mutation. The glucose mitigation mutation may be at a position corresponding to N446 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 446 as described herein. In embodiments, the glucose mitigation mutation is a N446S mutation. The glucose mitigation mutation may be at a position corresponding to N326 of Candida intermedia GXS1 protein. The glucose mitigation mutation may be a conservative mutation at position 326 as described herein. In embodiments, the glucose mitigation mutation is a N326S mutation. In embodiments, the glucose mitigation mutation is a N326H mutation.

The glucose mitigation mutation may include two or more positions corresponding to K155, T170, I171, N225, N326, S354, A361, L407, or N446 of *Candida intermedia* GXS1 protein as described hereinabove. The glucose mitigation mutation may include three or more positions corresponding to K155, T170, I171, N225, N326, S354, A361, L407, or N446 of *Candida intermedia* GXS1 protein as described hereinabove. The glucose mitigation mutation may include four or more positions corresponding to K155, T170, I171, N225, N326, S354, A361, L407, or N446 of *Candida intermedia* GXS1 protein as described hereinabove. The glucose mitigation mutation may include five or more positions corresponding to K155, T170, I171, N225, N326, S354, A361, L407, or N446 of Candida intermedia GXS1 protein as described hereinabove. The glucose mitigation mutation may include six or more positions corresponding to K155, T170, I171, N225, N326, S354, A361, L407, or N446 5 of Candida intermedia GXS1 protein as described hereinabove. The glucose mitigation mutation may include mutation at positions corresponding to K155, T170, I171, N225, N326, S354, A361, L407, and N446 of Candida intermedia GXS1 protein as described hereinabove. The glucose miti- 10 gation mutation may include mutation at positions corresponding to K155, T170, I171, N225, S354, A361, L407, and N446 of Candida intermedia GXS1 protein as described hereinabove.

herein including embodiments thereof may further include an amino acid deletion. An amino acid deletion as provided herein is a deletion of at least one amino acid residue of a Candida intermedia GXS1 protein as described hereinabove. Thus, the sequence of a Candida intermedia GXS1 20 protein including an amino acid deletion includes at least one amino acid residue less relative to the sequence of a Candida intermedia GXS1 protein lacking said deletion. In embodiments, the deletion is at least 5 amino acids in length. In embodiments, the deletion is at least 10 amino acids in 25 length. In embodiments, the deletion is at least 15 amino acids in length. In embodiments, the deletion is at least 20 amino acids in length. In embodiments, the deletion is at least 25 amino acids in length. In embodiments, the deletion is at least 30 amino acids in length. In embodiments, the 30 deletion is at least 35 amino acids in length. In embodiments, the deletion is at least 40 amino acids in length. In embodiments, the deletion is at least 45 amino acids in length. In embodiments, the deletion is at least 50 amino acids in length. In embodiments, the deletion is at least 55 amino 35 acids in length. In embodiments, the deletion is at least 60 amino acids in length. In embodiments, the deletion is at least 65 amino acids in length. In embodiments, the deletion is at least 70 amino acids in length. In embodiments, the deletion is at least 75 amino acids in length. In embodiments, 40 the deletion is at least 80 amino acids in length. In embodiments, the deletion is at least 85 amino acids in length. In embodiments, the deletion is at least 90 amino acids in length. In embodiments, the deletion is at least 95 amino acids in length. In embodiments, the deletion is at least 100 45 amino acids in length.

In embodiments, the deletion is less than 50 amino acids in length. In embodiments, the deletion is less than 45 amino acids in length. In embodiments, the deletion is less than 40 amino acids in length. In embodiments, the deletion is less 50 than 35 amino acids in length. In embodiments, the deletion is less than 30 amino acids in length. In embodiments, the deletion is less than 25 amino acids in length. In embodiments, the deletion is less than 20 amino acids in length. In embodiments, the deletion is less than 15 amino acids in 55 length. In embodiments, the deletion is less than 10 amino acids in length. In embodiments, the deletion is within a protein domain corresponding to residue 497-522 of SEQ ID NO:1. In embodiments, the deletion is within a protein domain corresponding to residue 497-522 of a Candida 60 intermedia GXS1 protein as described hereinabove.

2. Recombinant Arabinose Transporter Protein

Also provided herein is a recombinant arabinose transporter protein that includes an arabinose transporter motif sequence and a glucose mitigation mutation.

The arabinose transporter motif sequence may correspond to residue positions 36, 37, 38, 39, 40, and 41 of Candida

intermedia GXS1 protein. The arabinose transporter motif sequence may have the sequence -G-G/F-X⁴-X⁵-X⁶-G-. X⁴ is D, C, F, G, H, L, R, T, or P. X⁵ is A, C, E, F, H, K, S, P, or V. X⁶ is R, D, E, F, H, I, M, T, or Y. In embodiments, the arabinose transporter is not -G-G-L-V-Y-G- (SEQ ID NO:125), or -G-G-F-V-F-G- (SEQ ID NO:126).

 X^4 may be D, F, G, L, R, or T. X^4 may be R, T, H, or F. X^4 may be R. X^4 may be T. X^4 may be H. X^4 may be F. X^5 may be A, E, F, P, H, or V. X⁵ may be P, H, or V. X⁵ may be P. X^5 may be H. X^5 may be V. X^6 may be T, H, F, M, or Y. X^6 may be F or Y. X^6 may be T or M. X^6 may be T. X^6 may be H. X⁶ may be F. X⁶ may be M. X⁶ may be Y. In embodiments, X^4 is F or T, X^5 is P or I, and X^6 is M or T.

The arabinose transporter motif sequence may be -G-G-The recombinant xylose transporter protein provided 15 F-H-M-G- (SEQ ID NO:119), -G-F-F-H-M-G- (SEQ ID NO:120), -G-G-R-P-T-G- (SEQ ID NO:127), -G-F-R-P-T-G- (SEQ ID NO:128), -G-G-T-P-T-G- (SEQ ID NO:129), or -G-F-T-P-T-G- (SEQ ID NO:130). The arabinose transporter motif sequence may be -G-G-F-H-M-G- (SEQ ID NO:119), or -G-F-F-H-M-G- (SEQ ID NO:120). The arabinose transporter motif sequence may be -G-G-R-P-T-G- (SEQ ID NO:127), -G-F-R-P-T-G- (SEQ ID NO:128). The arabinose transporter motif sequence may be -G-G-T-P-T-G- (SEQ ID NO:129) or -G-F-T-P-T-G- (SEQ ID NO:130). The arabinose transporter motif sequence may be -G-G-F-H-M-G-(SEQ ID NO:119). The arabinose transporter motif sequence may be -G-F-F-H-M-G- (SEQ ID NO:120). The arabinose transporter motif sequence may be -G-G-R-P-T-G- (SEQ ID NO:127). The arabinose transporter motif sequence may be -G-F-R-P-T-G- (SEQ ID NO:128). The arabinose transporter motif sequence may be -G-G-T-P-T-G- (SEQ ID NO:129). The arabinose transporter motif sequence may be -G-F-T-P-T-G- (SEQ ID NO:130).

> The glucose mitigation mutation of the recombinant arabinose transporter protein is as described hereinabove for the "recombinant xylose transporter protein" and includes embodiments thereof.

3. Recombinant Galactose Transporter Protein

Provided herein is a recombinant galactose transporter protein that includes an galactose transporter motif sequence and a glucose mitigation mutation.

The galactose transporter motif sequence is as described hereinabove for the "arabinose transporter motif sequence" and includes embodiments thereof. The glucose mitigation mutation of the recombinant arabinose transporter protein is as described hereinabove for the "recombinant xylose transporter protein" and includes embodiments thereof.

Also provided herein is a recombinant galactose-arabinose transporter protein that includes a galactose-arabinose transporter motif sequence and a glucose mitigation mutation. The galactose-arabinose transporter motif sequence may be as described hereinabove for the "arabinose transporter motif sequence" and includes embodiments thereof. The glucose mitigation mutation of the recombinant galactose-arabinose transporter protein is as described hereinabove for the "recombinant xylose transporter protein" and includes embodiments thereof.

II. Nucleic Acids

In another aspect is a nucleic acid encoding a recombinant xylose transporter protein described herein, including embodiments thereof. In yet another aspect is a nucleic acid encoding a recombinant arabinose transporter protein described herein, including embodiments thereof. In still another aspect is a nucleic acid encoding a recombinant galactose transporter protein described herein, including embodiments thereof. In another aspect is a nucleic acid encoding a recombinant galactose-arabinose transporter protein described herein, including embodiments thereof. The nucleic acids may be RNA or DNA. The nucleic acids may be cDNA. The nucleic acids may be single- or doublestranded RNA or single- or double-stranded DNA. The nucleic acids may be located on a plasmid or other vector. The nucleic acids may be introduced and expressed by a yeast cell using conventional techniques known to those in the art.

III. Recombinant Yeast Cells

Provided herein are recombinant yeast cells that include a recombinant transporter protein as described herein, includ- 15 ing embodiments thereof. Also provided herein are recombinant yeast cells that include a nucleic acid encoding a recombinant xylose transporter protein described herein, including embodiments thereof.

1. Recombinant Yeast Cell Including a Recombinant 20 Xylose Transporter Protein

In one aspect is a recombinant yeast cell that includes a recombinant xylose transporter protein as described herein, including embodiments thereof. In embodiments, the growth rate of the recombinant yeast cell including a recombinant 25 transporter protein as described herein can be measured. The growth rate may be determined in xylose growth media (i.e. in the absence of glucose). The growth rate may be determined in xylose-glucose growth media. In embodiments, the growth rates (i.e. growth rate in the absence and presence of 30 glucose) are compared to determine the differential growth rate of the recombinant yeast cells. If the growth rate of recombinant yeast cells grown in xylose-glucose growth media is less than the growth rate of recombinant yeast cells grown in xylose growth media, the differential growth rate 35 may indicate the presence of glucose inhibition of the recombinant transporter protein. As described herein, inclusion of a glucose mitigating mutation decreases, minimizes, or may eliminate glucose inhibition of a recombinant xylose transporter protein.

In embodiments, the growth rate of the recombinant yeast cell in a xylose-glucose growth media is about 5% to about 150% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 45 5% to about 140% of the growth rate of the recombinant veast cell in xvlose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 130% of the growth rate of the recombinant yeast cell in xylose growth media. The growth 50 rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 120% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 110% of the growth 55 rate of the recombinant yeast cell in xylose growth media.

The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 100% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant 60 yeast cell in a xylose-glucose growth media may be about 5% to about 90% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 80% of the growth rate of the recombi- 65 nant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media

may be about 5% to about 70% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 60% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 50% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xyloseglucose growth media may be about 5% to about 40% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 30% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 20% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% to about 10% of the growth rate of the recombinant yeast cell in xylose growth media.

The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 150% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 140% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 130% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 120% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 110% of the growth rate of the recombinant yeast cell in xylose growth media.

The growth rate of the recombinant yeast cell in a 40 xylose-glucose growth media may be about 10% to about 100% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 90% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 80% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 70% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 60% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xyloseglucose growth media may be about 10% to about 50% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 40% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 30% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% to about 20% of the growth rate of the recombinant yeast cell in xylose growth media.

The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 5% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 10% of the 5 growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 20% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a 10 xylose-glucose growth media may be about 30% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 40% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 50% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 60% of the 20 growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 70% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a 25 xylose-glucose growth media may be about 80% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 90% of the growth rate of the recombinant yeast cell in xylose growth 30 media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 100% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about equal to the 35 growth rate of the recombinant yeast cell in xylose growth media. Thus, in embodiments, the growth rate of the recombinant yeast cell is not inhibited in the presence of glucose. The growth rate of the recombinant yeast cell in a xyloseglucose growth media may be greater than the growth rate 40 of the recombinant yeast cell in xylose growth media.

The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 110% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a 45 xylose-glucose growth media may be about 120% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 130% of the growth rate of the recombinant yeast cell in xylose growth 50 media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 140% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 150% of the 55 growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 160% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a 60 xylose-glucose growth media may be about 170% of the growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 180% of the growth rate of the recombinant yeast cell in xylose growth 65 media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 190% of the

growth rate of the recombinant yeast cell in xylose growth media. The growth rate of the recombinant yeast cell in a xylose-glucose growth media may be about 200% of the growth rate of the recombinant yeast cell in xylose growth media.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr^{-1} to about 0.05 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.04 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.03 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.005 hr⁻¹ to about 0.025 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.0225 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.02 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.0175 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.015 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.0125 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.01 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} to about 0.0075 hr^{-1} . In embodiments, the recombinant yeast cells are cultured in a xylose growth media and the growth rate is measured in the xylose growth media. In embodiments, the recombinant yeast cells are cultured in lignocellulosic biomass, hemicellulose, or xylan and the growth rate is measured in the lignocellulosic biomass, hemicellulose, or xylan respectively.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0175 hr⁻¹. The recombinant veast cells may have a growth rate of about 0.02 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0225 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.025 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0275 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.03 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0325 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.035 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.04 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0425 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0475 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} . In embodiments, the recombinant yeast cells are cultured in a xylose growth media and the growth rate is measured in the xylose growth media. In embodiments, the recombinant yeast cells are cultured in lignocellulosic biomass, hemicellulose, or xylan and the growth rate is measured in the lignocellulosic biomass, hemicellulose, or xylan respectively.

In embodiments, the recombinant yeast cells have a growth rate of about 0.05 hr^{-1} to about 0.1 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.125 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.15 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.15 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.15 hr^{-1} .

may have a growth rate of about 0.05 hr^{-1} to about 0.2 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.225 hr^{-1}. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.25 hr^{-1} . The recombinant yeast cells may have a growth rate of about 5 0.05 hr⁻¹ to about 0.275 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.3 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.325 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.35 hr^{-1} . 10 The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.375 hr^{-1}. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.4 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.425 hr^{-1}. The recombinant yeast cells 15 may have a growth rate of about 0.05 hr^{-1} to about 0.45 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.475 hr^{-1}. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.5 hr^{-1} . The recombinant yeast cells may have a growth rate of about 20 0.05 hr^{-1} to about 0.525 hr^{-1}. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.5 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.575 hr^{-1}. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.6 hr^{-1} . 25 The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.65 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.7 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.75 hr^{-1}. The recombinant yeast cells 30 may have a growth rate of about 0.05 hr^{-1} to about 0.8 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ to about 0.85 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 0.9 hr^{-1} . The recombinant yeast cells may have a growth rate of about 35 0.05 hr⁻¹ to about 0.95 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} to about 1 hr^{-1} . In embodiments, the recombinant yeast cells are cultured in a xylose growth media and the growth rate is measured in the xylose growth media. In embodiments, the recombinant 40 yeast cells are cultured in lignocellulosic biomass, hemicellulose, or xylan and the growth rate is measured in the lignocellulosic biomass, hemicellulose, or xylan respectively.

In embodiments, the recombinant yeast cells have a 45 growth rate of about 0.1 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.175 hr^{-1} . The recombinant yeast cells may have a growth 50 rate of about 0.2 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.225 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} . The recombinant yeast cells may have a growth 55 rate of about 0.3 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.325 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.35 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.375 hr^{-1} . The recombinant yeast cells may have a growth 60 rate of about 0.4 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.425 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.45 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.475 hr^{-1} . The recombinant yeast cells may have a growth 65 rate of about 0.5 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.525 hr⁻¹. The recombinant yeast

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cells may have a growth rate of about 0.5 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.575 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.75 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.85 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.9 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.95 hr^{-1} . The recombinant yeast cells may have a growth rate of about 1 hr^{-1} . In embodiments, the recombinant yeast cells are cultured in a xylose growth media and the growth rate is measured in the xylose growth media. In embodiments, the recombinant yeast cells are cultured in lignocellulosic biomass, hemicellulose, or xylan and the growth rate is measured in the lignocellulosic biomass, hemicellulose, or xylan respectively.

The recombinant yeast cells may have a growth rate of about 0.005 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0475 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast

cells may have a growth rate of about 0.125 hr⁻¹ in xyloseglucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth 5 rate of about 0.175 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in xylose-glucose 15 growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr^{-1} in xylose-glucose growth media that includes 2.5 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombi- 25 nant yeast cells may have a growth rate of about 0.4 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth 30 rate of about 0.45 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in 35 xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in xylose-glucose growth media that 40 includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. 45 The recombinant yeast cells may have a growth rate of about 0.65 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr⁻¹ in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may 50 have a growth rate of about 0.75 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 55 0.85 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in xylose-glucose 60 growth media that includes 2.5 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr^{-1} in xylose-glucose growth media that includes 2.5 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr^{-1} in xylose-glucose growth 65 media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in

xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0475 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr⁻¹ in xyloseglucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant veast cells may have a growth rate of about 0.225 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant veast cells may have a growth rate of about 0.325 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may

have a growth rate of about 0.4 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 5 0.45 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 5 g/L 15 glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant 20 yeast cells may have a growth rate of about 0.65 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate 25 of about 0.75 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr⁻¹ in 30 xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in xylose-glucose growth media that 35 includes 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr⁻¹ in xylose-glucose growth media that includes 5 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in xylose-glucose growth 40 media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in xylose-glucose growth media that includes 10 45 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr^{-1} in xyloseglucose growth media that includes 10 g/L glucose. The 50 recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may 55 have a growth rate of about 0.0225 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 60 0.0275 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr⁻¹ in xylose-glucose 65 growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr^{-1} in

xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr⁻¹ in xyloseglucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in xylose-glucose growth media that 10 includes 10 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr⁻¹ in xylose-glucose growth media that includes 10 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in xylose-glucose growth 15 media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr^{-1} in xylose-glucose growth media that includes 20 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xyloseglucose growth media that includes 20 g/L glucose. The 25 recombinant yeast cells may have a growth rate of about $0.0175\ hr^{-1}$ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may 30 have a growth rate of about 0.0225 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 35 $0.0275 \ hr^{-1}$ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr^{-1} in xylose-glucose 40 growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.035 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in xylose-glucose growth media that includes 20 $_{45}$ g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant 50 yeast cells may have a growth rate of about 0.045 hr^{-1} . The recombinant yeast cells may have a growth rate of about $0.0475\ hr^{-1}$ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in xylose-glucose growth media that 55 media that includes 20 g/L glucose. includes 20 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in xylose- 60 glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr^{-1} in xylose-glucose growth media that 65 includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr^{-1} in xylose-glucose

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growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.225 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.325 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.425 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.65 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹ in xylose-glucose growth media that includes 20 g/L glucose. The recombinant veast cells may have a growth rate of about 0.85 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr^{-1} in xylose-glucose growth media that includes 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr⁻¹ in xylose-glucose growth

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose are observed. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose growth media that includes 30 g/L glucose. The glucose gluco

recombinant yeast cells may have a growth rate of about 0.0175 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr⁻¹ in growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr^{-1} in 10 xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr^{-1} in xylose-glucose growth media 15 that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr⁻¹ in xyloseglucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in xylose-glucose growth media that includes 30 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant 25 yeast cells may have a growth rate of about 0.045 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0475 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} in xylose-glucose growth media that 30 includes 30 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in xylose- 35 glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr^{-1} in xylose-glucose growth media that 40 includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. 45 The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may 50 have a growth rate of about 0.3 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 55 0.35 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in xylose-glucose 60 growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in xylose-glucose growth media that includes 30 65 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in xylose-glucose growth media that

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includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in xylose-glucose growth media that includes 30 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr^{-1} in xylose-glucose growth media that includes 30 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr^{-1} in xyloseglucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant veast cells may have a growth rate of about 0.0225 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant

yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0475 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in xylose-glucose growth media that 5 includes 50 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in xylose-10 glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr^{-1} in xylose-glucose growth media that 15 includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. 20 The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may 25 have a growth rate of about 0.3 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 30 0.35 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in xylose-glucose 35 growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in xylose-glucose growth media that includes 50 40 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant 45 yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate 50 of about 0.575 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹ in 55 xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr⁻¹ in xylose-glucose growth media that 60 includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr^{-1} in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. 65 The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 50 g/L

glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr⁻¹ in xylose-glucose growth media that includes 50 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in xyloseglucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant veast cells may have a growth rate of about 0.025 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant veast cells may have a growth rate of about 0.035 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0475 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in xyloseglucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may

have a growth rate of about 0.3 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 5 0.35 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in xylose-glucose 10 growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in xylose-glucose growth media that includes 75 15 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant 20 yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate 25 of about 0.575 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹ in 30 xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr⁻¹ in xylose-glucose growth media that 35 includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. 40 The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose. The recombinant yeast cells may 45 have a growth rate of about 1 hr⁻¹ in xylose-glucose growth media that includes 75 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast 50 cells may have a growth rate of about 0.0075 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth 55 rate of about 0.0125 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr^{-1} in xyloseglucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 60 0.0175 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr⁻¹ in 65 xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about

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 0.025 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr^{-1} . The recombinant veast cells may have a growth rate of about 0.0475 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr⁻¹ in xyloseglucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in xylose-glucose growth media that

includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. 5 The recombinant yeast cells may have a growth rate of about 0.65 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may 10 have a growth rate of about 0.75 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 15 0.85 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in xylose-glucose growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr^{-1} in xylose-glucose 20 growth media that includes 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr⁻¹ in xylose-glucose growth media that includes 100 g/L glucose.

In embodiments, the growth rate of the recombinant yeast cell in xylose-glucose growth media is about 0.1× fold 25 greater than a wildtype yeast cell (i.e. a yeast cell without a recombinant transporter protein described herein) in xyloseglucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $0.2 \times$ fold greater than a wildtype yeast cell in xylose-glucose 30 growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 0.3× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $0.4 \times$ fold greater 35 than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xyloseglucose growth media may be about $0.5 \times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose 40 growth media may be about $0.6 \times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 0.7× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the 45 recombinant yeast cell in xylose-glucose growth media may be about $0.8 \times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $0.9 \times$ fold greater than a wildtype yeast cell in xylose- 50 glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 1× fold greater than a wildtype yeast cell in xylose-glucose growth media.

The growth rate of the recombinant yeast cell in xyloseglucose growth media may be about $2\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $3\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate 60 of the recombinant yeast cell in xylose-glucose growth media may be about $4\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $5\times$ fold greater than a wildtype yeast cell in 65 xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be 40

about $6\times$ fold greater than a wildtype yeast cell in xyloseglucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $7\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $8\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $9\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xyloseglucose growth media may be about $9\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xyloseglucose growth media may be about $10\times$ fold greater than a wildtype yeast cell in xylose-glucose growth media.

The growth rate of the recombinant yeast cell in xyloseglucose growth media may be about 11× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 12× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about $13 \times$ fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 14× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 15× fold greater than a wildtype yeast cell in xyloseglucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 16× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 17× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 18× fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xyloseglucose growth media may be about 19x fold greater than a wildtype yeast cell in xylose-glucose growth media. The growth rate of the recombinant yeast cell in xylose-glucose growth media may be about 20× fold greater than a wildtype yeast cell in xylose-glucose growth media.

In embodiments, the recombinant xylose transporter transports a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 5% to about 150% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 5% to about 140% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 5% to about 130% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 5% to about 120% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 5%

to about 110% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media.

The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose- 5 glucose growth media at a rate of about 5% to about 100% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a 10 xylose-glucose growth media at a rate of about 5% to about 90% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast 15 in a xylose-glucose growth media at a rate of about 5% to about 80% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 20 yeast in a xylose-glucose growth media at a rate of about 5% to about 70% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 25 yeast in a xylose-glucose growth media at a rate of about 5% to about 60% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 30 yeast in a xylose-glucose growth media at a rate of about 5% to about 50% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 35 yeast in a xylose-glucose growth media at a rate of about 5% to about 40% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 40 yeast in a xylose-glucose growth media at a rate of about 5% to about 30% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 45 yeast in a xylose-glucose growth media at a rate of about 5% to about 20% of the rate the recombinant xvlose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant 50 yeast in a xylose-glucose growth media at a rate of about 5% to about 10% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media.

The recombinant xylose transporter may transport a 55 xylose compound into a recombinant yeast in a xyloseglucose growth media at a rate of about 5% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose 60 compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 10% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose-glucose growth media at a rate of about 10% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose 65 compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 20% of the rate the 42

recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 30% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 40% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 50% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 60% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 70% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 80% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 90% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 100% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. In embodiments, a recombinant xylose transporter transports a xylose compound into a recombinant yeast in a xyloseglucose growth media at a rate about equal to the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. In embodiments, a recombinant xylose transporter transports a xylose compound into a recombinant yeast in a xyloseglucose growth media at a rate greater to the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media.

The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 110% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 120% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose-glucose growth media at a rate of about 120% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 130% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media.

The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 140% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 150% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 160% of the rate the recombinant xylose transporter transports the xylose compound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 170% of the rate the recombinant xylose transporter transports the xylose com- 20 pound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 180% of the rate the recombinant xylose transporter transports the xylose com- 25 pound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate of about 190% of the rate the recombinant xylose transporter transports the xylose com- 30 pound into the recombinant yeast in a xylose growth media. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast in a xylose-glucose growth media at a rate about 200% of the rate the recombinant xylose transporter transports the xylose compound 35 into the recombinant yeast in a xylose growth media.

In embodiments, the xylose growth media includes xylose at a concentration of about 0.05 g/L to about 100 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 90 g/L. The xylose growth media 40 may include xylose at a concentration of about 0.05 g/L to about 80 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 70 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 60 g/L. The xylose growth media 45 may include xylose at a concentration of about 0.05 g/L to about 50 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 40 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 30 g/L. The xylose growth media 50 may include xylose at a concentration of about 0.05 g/L to about 25 g/L.

In embodiments, the xylose growth media includes xylose at a concentration of about 0.05 g/L to about 20 g/L. The xylose growth media may include xylose at a concentration 55 of about 0.05 g/L to about 15 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 10 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 5 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 4 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 4 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 3 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 2 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 1 g/L. The xylose growth media may include xylose at a concentration 65 of about 0.05 g/L to about 1 g/L. The xylose growth media may include xylose at a concentration 65 of about 0.05 g/L to about 1 g/L. The xylose growth media may include xylose at a concentration 65 of about 0.05 g/L to about 1 g/L. The xylose growth media

about 0.5 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 0.1 g/L.

The xylose growth media may include xylose at a concentration of about 0.05 g/L. The xylose growth media may include xylose at a concentration of about 0.1 g/L. The xylose growth media may include xylose at a concentration of about 0.5 g/L. The xylose growth media may include xylose at a concentration of about 1 g/L. The xylose growth media may include xylose at a concentration of about 2 g/L. The xylose growth media may include xylose at a concentration of about 3 g/L. The xylose growth media may include xylose at a concentration of about 4 g/L. The xylose growth media may include xylose at a concentration of about 5 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L. The xylose growth media may include xylose at a concentration of about 15 g/L. The xylose growth media may include xylose at a concentration of about 20 g/L. The xylose growth media may include xylose at a concentration of about 25 g/L. The xylose growth media may include xylose at a concentration of about 30 g/L. The xylose growth media may include xylose at a concentration of about 40 g/L. The xylose growth media may include xylose at a concentration of about 50 g/L. The xylose growth media may include xylose at a concentration of about 60 g/L. The xylose growth media may include xylose at a concentration of about 70 g/L. The xylose growth media may include xylose at a concentration of about 80 g/L. The xylose growth media may include xylose at a concentration of about 90 g/L. The xylose growth media may include xylose at a concentration of about 100 g/L.

In embodiments, the xylose growth media includes xylose at a concentration of about 0.05 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 250 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 200 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 150 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 100 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 50 g/L. The xylose growth media may include xylose at a concentration of about 0.05 g/L to about 25 g/L. The xylose growth media may include xylose at a concentration of about 1 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 20 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 30 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 40 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 50 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 75 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 100 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 125 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 150 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 175 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 200 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 225 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 250 g/L to about 300 g/L. The xylose growth media may include xylose at a concentration of about 275 g/L to about 300 g/L.

In embodiments, the xylose growth media includes xylose at a concentration of about 10 g/L to about 275 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 250 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to 5 about 225 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 200 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 175 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to 10 about 150 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 125 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 100 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to 15 about 75 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 50 g/L. The xylose growth media may include xylose at a concentration of about 10 g/L to about 25 g/L.

The xylose growth media may include xylose at a con- 20 centration of about 125 g/L. The xylose growth media may include xylose at a concentration of about 150 g/L. The xylose growth media may include xylose at a concentration of about 175 g/L. The xylose growth media may include xylose at a concentration of about 200 g/L. The xylose 25 growth media may include xylose at a concentration of about 225 g/L. The xylose growth media may include xylose at a concentration of about 250 g/L. The xylose growth media may include xylose at a concentration of about 275 g/L. The xylose growth media may include xylose at a 30 concentration of about 300 g/L.

In embodiments, the xylose-glucose growth media includes xylose at a concentration as described herein for xylose growth media. In embodiments, the xylose-glucose growth media includes glucose at a concentration of about 35 0.05 g/L to about 20 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 15 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 10 g/L. The xylose-glucose growth media may include glucose at a 40 a recombinant arabinose transporter protein as described concentration of about 0.05 g/L to about 5 g/L. The xyloseglucose growth media may include glucose at a concentration of about 0.05 g/L to about 4 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 3 g/L. The xylose-glucose growth 45 media may include glucose at a concentration of about 0.05 g/L to about 2 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 1 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 0.5 g/L. 50 The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 0.1 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.1 55 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.5 g/L. The xylose-glucose growth media may include glucose at a concentration of about 1 g/L. The xylose-glucose growth media may include glucose at a concentration of about 2 g/L. The xylose- 60 glucose growth media may include glucose at a concentration of about 3 g/L. The xylose-glucose growth media may include glucose at a concentration of about 4 g/L. The xylose-glucose growth media may include glucose at a concentration of about 5 g/L. The xylose-glucose growth 65 media may include glucose at a concentration of about 10 g/L. The xylose-glucose growth media may include glucose

at a concentration of about 15 g/L. The xylose-glucose growth media may include glucose at a concentration of about 20 g/L.

In embodiments, the xylose-glucose growth media includes glucose at a concentration of about 0.05 g/L to about 100 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 90 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 80 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 70 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 60 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 50 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 40 g/L. The xylose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 30 g/L. The xvlose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 25 g/L.

The xylose-glucose growth media may include glucose at a concentration of about 25 g/L. The xylose-glucose growth media may include glucose at a concentration of about 30 g/L. The xylose-glucose growth media may include glucose at a concentration of about 40 g/L. The xylose-glucose growth media may include glucose at a concentration of about 50 g/L. The xylose-glucose growth media may include glucose at a concentration of about 60 g/L. The xyloseglucose growth media may include glucose at a concentration of about 70 g/L. The xylose-glucose growth media may include glucose at a concentration of about 80 g/L. The xylose-glucose growth media may include glucose at a concentration of about 90 g/L. The xylose-glucose growth media may include glucose at a concentration of about 100 g/L.

2. Recombinant Yeast Cell Including a Recombinant Arabinose Transporter Protein

In another aspect is a recombinant yeast cell that includes herein, including embodiments thereof. In embodiments, the growth rate of the recombinant yeast cell including a recombinant arabinose transporter protein as described herein can be measured. The growth rate may be determined in arabinose growth media (i.e. in the absence of glucose). The growth rate may be determined in arabinose-glucose growth media. In embodiments, the growth rates (i.e. growth rate in the absence and presence of glucose) are compared to determine the differential growth rate of the recombinant yeast cells. If the growth rate of recombinant yeast cells grown in arabinose-glucose growth media is less than the growth rate of recombinant yeast cells grown in arabinose growth media, the differential growth rate may indicate glucose inhibits the activity of the recombinant arabinose transporter protein. As described herein, inclusion of a glucose mitigating mutation decreases, minimizes, or may eliminate glucose inhibition of the recombinant arabinose transporter protein.

In embodiments, the growth rate of the recombinant yeast cell in an arabinose-glucose growth media is about 5% to about 150% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 140% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinoseglucose growth media may be about 5% to about 130% of
the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 120% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 110% of the growth rate of the recombinant yeast cell in arabinose growth media.

The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 10 100% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 90% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate 15 of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 80% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinoseglucose growth media may be about 5% to about 70% of the 20 growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 60% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recom- 25 binant yeast cell in an arabinose-glucose growth media may be about 5% to about 50% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinoseglucose growth media may be about 5% to about 40% of the 30 growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% to about 30% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recom- 35 binant yeast cell in an arabinose-glucose growth media may be about 5% to about 20% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinoseglucose growth media may be about 5% to about 10% of the 40 growth rate of the recombinant yeast cell in arabinose growth media.

The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 150% of the growth rate of the recombinant yeast cell in 45 arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 140% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth 50 media may be about 10% to about 130% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 120% of the growth rate of the recombinant yeast cell in 55 of the growth rate of the recombinant yeast cell in arabinose arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 110% of the growth rate of the recombinant yeast cell in arabinose growth media.

The growth rate of the recombinant yeast cell in an 60 arabinose-glucose growth media may be about 10% to about 100% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 90% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth **48**

media may be about 10% to about 80% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 70% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 60% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 50% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 40% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 30% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% to about 20% of the growth rate of the recombinant yeast cell in arabinose growth media.

The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 5% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 10% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 20% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 30% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 40% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 50% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 60% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 70% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant veast cell in an arabinose-glucose growth media may be about 80% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 90% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 100% growth media.

The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 110% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 120% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 120% of the growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 130% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 130% of the growth rate of the recombinant yeast cell in an arabinose growth media.

of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 150% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell 5 in an arabinose-glucose growth media may be about 160% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 170% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 180% of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 190% 15 of the growth rate of the recombinant yeast cell in arabinose growth media. The growth rate of the recombinant yeast cell in an arabinose-glucose growth media may be about 200% of the growth rate of the recombinant yeast cell in arabinose growth media.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in arabinose-glucose growth media that includes 25 about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in arabinoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr^{-1} in arabinose-glucose growth media 30 that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in ${\rm 35}$ arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 40 0.0225 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a 45 growth rate of about 0.0275 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombi- 50 nant yeast cells may have a growth rate of about 0.0325 hr in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L 55 glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 60 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have 65 a growth rate of about 0.0475 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L

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glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in arabinoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr⁻¹ in arabinoseglucose growth media that includes about 2.5, 5, 10, or 20 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr⁻¹ in arabinoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr⁻¹ in arabinoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in arabinoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr⁻¹ in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 5 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr^{-1} in arabinose-glucose growth media that includes about 2.5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 1.5, 10, or 20 g/L glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose.

The recombinant yeast cells may have a growth rate of 15 about 0.005 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may 20 have a growth rate of about 0.01 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombi- 25 nant yeast cells may have a growth rate of about 0.015 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L 30 glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr⁻¹ in arabinose-glucose growth media that includes about 25 to 35 about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr^{-1} in arabinose-glucose growth media that 40 includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr⁻¹ in arabinose-glucose 45 growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr^{-1} 50 in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate 55 of about 0.0425 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr^{-1} . The recombinant yeast cells may have a growth rate of about 0.0475 hr^{-1} in arabinose-glucose growth media that includes 60 about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr^{-1} in arabinoseglucose growth media that includes about 25 to about 100 g/L glucose.

In embodiments, the recombinant yeast cells have a $_{65}$ growth rate of about 0.1 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The

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recombinant yeast cells may have a growth rate of about 0.125 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in arabinoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr^{-1} in arabinoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr^{-1} in arabinoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr⁻¹ in arabinoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr⁻¹ in arabinoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹ in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may

have a growth rate of about 0.9 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr^{-1} in arabinose-glucose growth media that includes about 25 to about 100 g/L glucose.

In embodiments, the growth rate of the recombinant yeast cell in arabinose-glucose growth media is about $0.1 \times$ fold greater than a wildtype yeast cell (i.e. a yeast cell without a recombinant transporter protein described herein) in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 0.2× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about $0.3 \times$ fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recom- 20 binant yeast cell in arabinose-glucose growth media may be about 0.4× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 0.5× fold greater than a wildtype yeast cell in arab- 25 inose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 0.6× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 0.7× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 0.8× fold greater than a wildtype yeast cell in arab-35 inose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 0.9× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be $_{40}$ about 1× fold greater than a wildtype yeast cell in arabinoseglucose growth media.

The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 2× fold greater than a wildtype yeast cell in arabinose-glucose growth 45 media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 3× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 4× fold 50 greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 5× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell 55 in arabinose-glucose growth media may be about 6x fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 7× fold greater than a wildtype yeast cell in arabinose-glucose 60 growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 8× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 9× fold 65 greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell

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in arabinose-glucose growth media may be about $10 \times$ fold greater than a wildtype yeast cell in arabinose-glucose growth media.

The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 11× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 12× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 13× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 14× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 15× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 16x fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 17× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 18× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 19× fold greater than a wildtype yeast cell in arabinose-glucose growth media. The growth rate of the recombinant yeast cell in arabinose-glucose growth media may be about 20× fold greater than a wildtype yeast cell in arabinose-glucose growth media.

In embodiments, the recombinant arabinose transporter transports an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 150% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 140% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant veast in an arabinose-glucose growth media at a rate of about 5% to about 130% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 120% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 110% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media.

The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 100% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 90% of the rate the recombinant arabinose transporter transports the arabinose 5 compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 80% of the rate the recombinant arabinose transporter 10 transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 70% of the rate the 15 recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to 20 about 60% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth 25 media at a rate of about 5% to about 50% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in 30 an arabinose-glucose growth media at a rate of about 5% to about 40% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound 35 into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 30% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may 40 transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 20% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant ara- 45 binose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% to about 10% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose 50 growth media.

The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 5% of the rate the recombinant arabinose transporter transports the arab- 55 inose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 10% of the rate the recombinant arabinose transporter transports the 60 arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 20% of the rate the recombinant arabinose trans- 65 porter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant

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arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 30% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 40% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 50% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 60% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 70% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 80% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 90% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 100% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media.

The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 110% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 120% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 130% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 140% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate

of about 150% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 160% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 170% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 180% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. The recombinant 20 arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate of about 190% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose growth media. 25 The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast in an arabinose-glucose growth media at a rate about 200% of the rate the recombinant arabinose transporter transports the arabinose compound into the recombinant yeast in an arabinose 30 growth media.

In embodiments, the arabinose growth media includes arabinose at a concentration of about 0.05 g/L to about 20 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 15 g/L. The 35 arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 10 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 5 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L 40to about 4 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 3 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 2 g/L. The arabinose growth media may include arabinose at a concentra- 45 tion of about 0.05 g/L to about 1 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 0.5 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 0.1 g/L.

The arabinose growth media may include arabinose at a concentration of about 0.05 g/L. The arabinose growth media may include arabinose at a concentration of about 0.1 g/L. The arabinose growth media may include arabinose at a concentration of about 0.5 g/L. The arabinose growth 55 media may include arabinose at a concentration of about 1 g/L. The arabinose growth media may include arabinose at a concentration of about 2 g/L. The arabinose growth media may include arabinose at a concentration of about 3 g/L. The arabinose growth media may include arabinose at a concen- 60 tration of about 4 g/L. The arabinose growth media may include arabinose at a concentration of about 5 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L. The arabinose growth media may include arabinose at a concentration of about 15 g/L. The 65 arabinose growth media may include arabinose at a concentration of about 20 g/L.

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In embodiments, the arabinose growth media includes arabinose at a concentration of about 0.05 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 250 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 200 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 150 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 100 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 50 g/L. The arabinose growth media may include arabinose at a concentration of about 0.05 g/L to about 25 g/L. The arabinose growth media may include arabinose at a concentration of about 1 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 20 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 30 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 40 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 50 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 75 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 100 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 125 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 150 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 175 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 200 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 225 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 250 g/L to about 300 g/L. The arabinose growth media may include arabinose at a concentration of about 275 g/L to about 300 g/L.

In embodiments, the arabinose growth media includes arabinose at a concentration of about 10 g/L to about 275 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 250 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 225 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 200 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 175 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 150 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 125 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 100 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 75 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 50 g/L. The arabinose growth media may include arabinose at a concentration of about 10 g/L to about 25 g/L.

The arabinose growth media may include arabinose at a concentration of about 25 g/L. The arabinose growth media may include arabinose at a concentration of about 50 g/L. The arabinose growth media may include arabinose at a concentration of about 75 g/L. The arabinose growth media may include arabinose at a concentration of about 75 g/L.

The arabinose growth media may include arabinose at a concentration of about 125 g/L. The arabinose growth media may include arabinose at a concentration of about 150 g/L. The arabinose growth media may include arabinose at a concentration of about 175 g/L. The arabinose growth media 5 may include arabinose at a concentration of about 200 g/L. The arabinose growth media may include arabinose at a concentration of about 225 g/L. The arabinose growth media may include arabinose at a concentration of about 250 g/L. The arabinose growth media may include arabinose at a 10 concentration of about 275 g/L. The arabinose growth media may include arabinose at a concentration of about 300 g/L.

In embodiments, the arabinose-glucose growth media includes arabinose at a concentration described herein for an arabinose growth media. In embodiments, the arabinose- 15 glucose growth media includes glucose at a concentration of about 0.05 g/L to about 100 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 90 g/L. The arabinose-glucose growth media may include glucose at a concentration of 20 a recombinant galactose transporter protein as described about 0.05 g/L to about 80 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 70 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 60 g/L. The arabinose-glucose 25 growth media may include glucose at a concentration of about 0.05 g/L to about 50 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 40 g/L. The arabinose-glucose growth media may include glucose at a concentration of 30 about 0.05 g/L to about 30 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 25 g/L.

The arabinose-glucose growth media may include glucose at a concentration of about 25 g/L. The arabinose-glucose 35 growth media may include glucose at a concentration of about 30 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 40 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 50 g/L. The arabinose-glucose 40 cell in a galactose-glucose growth media is about 5% to growth media may include glucose at a concentration of about 60 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 70 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 80 g/L. The arabinose-glucose 45 growth media may include glucose at a concentration of about 90 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 100 g/L.

In embodiments, the arabinose-glucose growth media includes glucose at a concentration of about 0.05 g/L to 50 about 20 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 15 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 10 g/L. The arabinose-glucose growth media may include glucose at 55 a concentration of about 0.05 g/L to about 5 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 4 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 3 g/L. The arabinose- 60 glucose growth media may include glucose at a concentration of about 0.05 g/L to about 2 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 1 g/L. The arabinoseglucose growth media may include glucose at a 65 concentration of about 0.05 g/L to about 0.5 g/L. The arabinose-glucose growth media may include glucose at a

concentration of about 0.05 g/L to about 0.1 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 0.5 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 1 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 2 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 3 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 4 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 5 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 10 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 15 g/L. The arabinose-glucose growth media may include glucose at a concentration of about 20 g/L.

3. Recombinant Yeast Cell Including a Recombinant Galactose Transporter Protein

In another aspect is a recombinant yeast cell that includes herein, including embodiments thereof. In embodiments, the growth rate of the recombinant yeast cell including a recombinant transporter protein as described herein can be measured. The growth rate may be determined in galactose growth media (i.e. in the absence of glucose). The growth rate may be determined in galactose-glucose growth media. In embodiments, the growth rates (i.e. growth rate in the absence and presence of glucose) are compared to determine the differential growth rate of the recombinant yeast cells. If the growth rate of recombinant yeast cells grown in galactose-glucose growth media is less than the growth rate of recombinant yeast cells grown in galactose growth media, the differential growth rate may indicate glucose inhibits the activity of the recombinant galactose transporter protein. As described herein, inclusion of a glucose mitigating mutation decreases, minimizes, or may eliminate glucose inhibition experienced by the recombinant galactose transporter protein.

In embodiments, the growth rate of the recombinant yeast about 150% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 140% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactoseglucose growth media may be about 5% to about 130% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 120% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 110% of the growth rate of the recombinant yeast cell in galactose growth media.

The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 100% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 90% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 80% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactoseglucose growth media may be about 5% to about 70% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 60% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recom- 5 binant yeast cell in a galactose-glucose growth media may be about 5% to about 50% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactoseglucose growth media may be about 5% to about 40% of the 10 growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% to about 30% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recom- 15 binant yeast cell in a galactose-glucose growth media may be about 5% to about 20% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactoseglucose growth media may be about 5% to about 10% of the 20 growth rate of the recombinant yeast cell in galactose growth media.

The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 150% of the growth rate of the recombinant yeast cell in 25 galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 140% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media 30 may be about 10% to about 130% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactoseglucose growth media may be about 10% to about 120% of the growth rate of the recombinant yeast cell in galactose 35 growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 110% of the growth rate of the recombinant yeast cell in galactose growth media.

The growth rate of the recombinant yeast cell in a 40 galactose-glucose growth media may be about 10% to about 100% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 90% of the growth rate of the recombinant 45 yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 80% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose- 50 glucose growth media may be about 10% to about 70% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 60% of the growth rate of the recombinant yeast cell 55 in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 50% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose- 60 glucose growth media may be about 10% to about 40% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% to about 30% of the growth rate of the recombinant yeast cell 65 in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may

be about 10% to about 20% of the growth rate of the recombinant yeast cell in galactose growth media.

The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 5% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 10% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 20% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 30% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 40% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 50% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 60% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 70% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 80% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 90% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 100% of the growth rate of the recombinant yeast cell in galactose growth media.

The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 110% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 120% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 130% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 140% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 150% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 160% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 170% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 180% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 190% of the growth rate of the recombinant yeast cell in galactose growth media. The growth rate of the recombinant yeast cell in a galactose-glucose growth media may be about 200% of the growth rate of the recombinant yeast cell in galactose growth media.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in galactose-glucose growth media that includes 5 about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.01 hr⁻¹ in galactoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr⁻¹ in 15 galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 20 0.0225 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a 25 growth rate of about 0.0275 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombi- 30 nant yeast cells may have a growth rate of about 0.0325 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L 35 glucose. The recombinant yeast cells may have a growth rate of about 0.0375 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr^{-1} in galactose-glucose growth media that includes about 2.5, 40 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0425 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have 45 a growth rate of about 0.0475 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.1 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in galactose-glucose growth media that includes 55 about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.15 hr^{-1} in galactoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in galactose-glucose growth media 60 that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.2 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr⁻¹ in galactose- 65 glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth

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rate of about 0.25 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr⁻¹ in galactoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in galactoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr^{-1} in galactoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹ in galactose-glucose growth media that includes about 50 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr^{-1} in galactoseglucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr⁻¹ in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr^{-1} in galactose-glucose growth media that includes about 2.5, 5, 10, or 20 g/L glucose.

In embodiments, the recombinant yeast cells have a growth rate of about 0.005 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0075 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast

cells may have a growth rate of about 0.01 hr⁻¹ in galactoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0125 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The 5 recombinant yeast cells may have a growth rate of about 0.015 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0175 hr^{-1} in galactose-glucose growth media that includes about 25 to 10 about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.02 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0225 hr^{-1} in galactose-glucose growth media that 15 includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.025 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0275 hr^{-1} in galactose-glucose 20 growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.03 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.0325 hr^{-1} 25 in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.035 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate 30 of about 0.0375 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.04 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may 35 have a growth rate of about 0.0425 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.045 hr⁻¹. The recombinant yeast cells may have a growth rate of about 0.0475 hr⁻¹ in galactose-glucose 40 growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.05 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose.

In embodiments, the recombinant yeast cells have a 45 growth rate of about 0.1 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.125 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast 50 cells may have a growth rate of about 0.15 hr^{-1} in galactoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.175 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The 55 recombinant yeast cells may have a growth rate of about 0.2 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.225 hr^{-1} in galactoseglucose growth media that includes about 25 to about 100 60 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.25 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.275 hr^{-1} in galactose-glucose growth media that includes 65 about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.3 hr^{-1} in galactose66

glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.325 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.35 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.375 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.4 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.425 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.45 hr^{-1} in galactoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.475 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.525 hr⁻¹ in galactoseglucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.5 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.575 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.6 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.65 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.7 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.75 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.8 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.85 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.9 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 0.95 hr⁻¹ in galactose-glucose growth media that includes about 25 to about 100 g/L glucose. The recombinant yeast cells may have a growth rate of about 1 hr^{-1} in galactose-glucose growth media that includes about 25 to about 100 g/L glucose.

In embodiments, the growth rate of the recombinant yeast cell in galactose-glucose growth media is about $0.1\times$ fold greater than a wildtype yeast cell (i.e. a yeast cell without a recombinant transporter protein described herein) in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about $0.2\times$ fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media.

about 0.4× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 0.5× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recom- 5 binant yeast cell in galactose-glucose growth media may be about 0.6× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about $0.7 \times$ fold greater than a wildtype yeast cell in galac- 10 tose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 0.8× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be 15 about 0.9× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 1× fold greater than a wildtype yeast cell in galactoseglucose growth media.

The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 2× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 3x fold 25 greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 4× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell 30 in galactose-glucose growth media may be about 5x fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 6x fold greater than a wildtype yeast cell in galactose-glucose 35 growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 7× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 8x fold 40 greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 9× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell 45 in galactose-glucose growth media may be about 10× fold greater than a wildtype yeast cell in galactose-glucose growth media.

The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 11× fold greater 50 than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 12× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell 55 in galactose-glucose growth media may be about 13× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 14× fold greater than a wildtype yeast cell in galactose-glucose 60 growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 15× fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about 16x fold 65 greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell

in galactose-glucose growth media may be about $17\times$ fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about $18\times$ fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about $19\times$ fold greater than a wildtype yeast cell in galactose-glucose growth media may be about $19\times$ fold greater than a wildtype yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media. The growth rate of the recombinant yeast cell in galactose-glucose growth media may be about $20\times$ fold greater than a wildtype yeast cell in galactose-glucose growth media.

In embodiments, the recombinant galactose transporter transports an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 150% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a 20 recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 140% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactoseglucose growth media at a rate of about 5% to about 130% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 120% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactoseglucose growth media at a rate of about 5% to about 110% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media.

The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactoseglucose growth media at a rate of about 5% to about 100% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 90% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 80% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 70% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 60% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactoseglucose growth media at a rate of about 5% to about 50% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galac- 5 tose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 40% of the rate the recombinant galactose transporter transports the galactose compound into the 10 recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 30% of the rate the recombinant galactose transporter transports the galac- 15 tose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 20% of the rate the recombinant galactose transporter 20 transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 5% to about 10% of the rate the recombinant 25 galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media.

The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactoseglucose growth media at a rate of about 5% of the rate the 30 recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 10% of the rate 35 the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 20% of 40 the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 45 30% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of 50 about 40% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a 55 rate of about 50% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose 60 growth media at a rate of about 60% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galac- 65 tose-glucose growth media at a rate of about 70% of the rate the recombinant galactose transporter transports the galac70

tose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 80% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 90% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 100% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media.

The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactoseglucose growth media at a rate of about 110% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 120% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 130% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 140% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 150% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 160% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 170% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 180% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate of about 190% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media. The recombinant galactose transporter may transport an galactose compound into a recombinant yeast in a galactose-glucose growth media at a rate about 200% of the rate the recombinant galactose transporter transports the galactose compound into the recombinant yeast in a galactose growth media.

In embodiments, the galactose growth media includes galactose a concentration of about 0.05 g/L to about 20 g/L. 5 The galactose growth media may include galactose a concentration of about 0.05 g/L to about 15 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 10 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to 10 about 5 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 4 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 3 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 2 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 1 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 0.5 g/L. The galactose growth media may include galactose a con- 20 centration of about 0.05 g/L to about 0.1 g/L.

The galactose growth media may include galactose a concentration of about 0.05 g/L. The galactose growth media may include galactose a concentration of about 0.1 g/L. The galactose growth media may include galactose a 25 concentration of about 0.5 g/L. The galactose growth media may include galactose a concentration of about 1 g/L. The galactose growth media may include galactose a concentration of about 2 g/L. The galactose growth media may include galactose a concentration of about 3 g/L. The galactose 30 growth media may include galactose a concentration of about 4 g/L. The galactose growth media may include galactose a concentration of about 5 g/L. The galactose growth media may include galactose a concentration of about 10 g/L. The galactose growth media may include 35 galactose a concentration of about 15 g/L. The galactose growth media may include galactose a concentration of about 20 g/L.

In embodiments, the galactose growth media includes galactose a concentration of about 0.05 g/L to about 300 g/L. 40 The galactose growth media may include galactose a concentration of about 0.05 g/L to about 250 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 200 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to 45 about 150 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 100 g/L. The galactose growth media may include galactose a concentration of about 0.05 g/L to about 50 g/L. The galactose growth media may include galactose a concentration of 50 about 0.05 g/L to about 25 g/L. The galactose growth media may include galactose a concentration of about 1 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 300 g/L. The galactose growth media may include galactose a con- 55 centration of about 20 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 30 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 40 g/L to about 300 g/L. The galactose growth media may include 60 galactose a concentration of about 50 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 75 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 100 g/L to about 300 g/L. The galactose growth media 65 may include galactose a concentration of about 125 g/L to about 300 g/L. The galactose growth media may include

galactose a concentration of about 150 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 175 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 200 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 200 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 200 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 250 g/L to about 300 g/L. The galactose growth media may include galactose a concentration of about 250 g/L to about 300 g/L. The galactose a concentration of about 250 g/L to about 300 g/L.

In embodiments, the galactose growth media includes galactose a concentration of about 10 g/L to about 275 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 250 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 225 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 200 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 175 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 150 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 125 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 100 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 75 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 50 g/L. The galactose growth media may include galactose a concentration of about 10 g/L to about 25 g/L.

The galactose growth media may include galactose a concentration of about 25 g/L. The galactose growth media may include galactose a concentration of about 50 g/L. The galactose growth media may include galactose a concentration of about 75 g/L. The galactose growth media may include galactose a concentration of about 100 g/L. The galactose growth media may include galactose a concentration of about 125 g/L. The galactose growth media may include galactose a concentration of about 150 g/L. The galactose growth media may include galactose a concentration of about 175 g/L. The galactose growth media may include galactose a concentration of about 200 g/L. The galactose growth media may include galactose a concentration of about 225 g/L. The galactose growth media may include galactose a concentration of about 250 g/L. The galactose growth media may include galactose a concentration of about 275 g/L. The galactose growth media may include galactose a concentration of about 300 g/L.

In embodiments, the galactose-glucose growth media includes galactose at a concentration as described herein for a galactose growth media. In embodiments, the galactoseglucose growth media includes glucose at a concentration of about 0.05 g/L to about 100 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 90 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 80 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 70 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 60 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 50 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 40 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 30 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 25 g/L.

The galactose-glucose growth media may include glucose at a concentration of about 25 g/L. The galactose-glucose growth media may include glucose at a concentration of ⁵ about 30 g/L. The galactose-glucose growth media may include glucose at a concentration of about 40 g/L. The galactose-glucose growth media may include glucose at a concentration of about 50 g/L. The galactose-glucose growth media may include glucose at a concentration of ¹⁰ about 60 g/L. The galactose-glucose growth media may include glucose at a concentration of ¹⁰ about 60 g/L. The galactose-glucose growth media may include glucose at a concentration of about 70 g/L. The galactose-glucose growth media may include glucose at a concentration of about 80 g/L. The galactose-glucose growth media may include glucose at a concentration of ¹⁵ about 90 g/L. The galactose-glucose growth media may include glucose at a concentration of ¹⁵ about 90 g/L. The galactose-glucose growth media may include glucose at a concentration of ¹⁵ about 90 g/L. The galactose-glucose growth media may include glucose at a concentration of ¹⁵

In embodiments, the galactose-glucose growth media includes glucose at a concentration of about 0.05 g/L to about 20 g/L. The galactose-glucose growth media may 20 include glucose at a concentration of about 0.05 g/L to about 15 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 10 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 5 g/L. The $^{\rm 25}$ galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 4 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 3 g/L. The galactoseglucose growth media may include glucose at a 30 concentration of about 0.05 g/L to about 2 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 1 g/L. The galactoseglucose growth media may include glucose at a concentration of about 0.05 g/L to about 0.5 g/L. The 35 galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L to about 0.1 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.05 g/L. The galactose-glucose growth media may include glucose at a concentration of 40 about 0.1 g/L. The galactose-glucose growth media may include glucose at a concentration of about 0.5 g/L. The galactose-glucose growth media may include glucose at a concentration of about 1 g/L. The galactose-glucose growth media may include glucose at a concentration of about 2 g/L. 45 The galactose-glucose growth media may include glucose at a concentration of about 3 g/L. The galactose-glucose growth media may include glucose at a concentration of about 4 g/L. The galactose-glucose growth media may include glucose at a concentration of about 5 g/L. The 50 galactose-glucose growth media may include glucose at a concentration of about 10 g/L. The galactose-glucose growth media may include glucose at a concentration of about 15 g/L. The galactose-glucose growth media may include glucose at a concentration of about 20 g/L.

IV. Methods

Also provided herein are methods of transporting xylose into a recombinant yeast cell. In one aspect, the method 60 includes contacting a recombinant yeast cell with a xylose compound described herein, where the recombinant yeast cell includes a recombinant xylose transporter protein as described herein, including embodiments thereof. The recombinant xylose transporter protein transports the xylose 65 compound into the recombinant yeast cell. In embodiments, the only sugar (i.e. carbon source) present is a xylose

compound. The recombinant xylose transporter protein is as described herein, including embodiments thereof. By extension, the xylose transporter motif sequence and the glucose mitigation mutation are as described herein, including embodiments thereof.

In another aspect, the method includes contacting a recombinant yeast cell with a xylose compound, where the xylose compound is the only sugar (i.e. carbon source) in the media, and where the recombinant yeast cell includes a recombinant xylose transporter protein as described herein, including embodiments thereof.

1. Transporting Xylose into a Recombinant Yeast Cell

The xylose compound may be derived from lignocellulosic biomass, hemicellulose, or xylan. Thus, in embodiments, the xylose compound is not the only sugar (i.e. carbon source) present. The xylose compound may be derived from lignocellulosic biomass. The xylose compound may be derived from hemicellulose. The xylose compound may be derived from xylan. In embodiments, the recombinant veast cell metabolizes the xylose compound. The xylose compound may be present at a concentration as described hereinabove for the "xylose growth media". In embodiments, the recombinant yeast cell converts the xylose compound to a biofuel as described herein (e.g. ethanol) or to a biochemical as described herein. The recombinant yeast cell may convert the xylose compound to a biofuel as described herein (e.g. ethanol). The recombinant yeast cell may convert the xylose compound to a biochemical as described herein. In embodiments, the only sugar (i.e. carbon source) available is the xylose compound.

In embodiments, the recombinant xylose transporter transports a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 1 nmol min^{-1} gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The term "gDCW" provided herein is well known in the art and refers to gram dry cell weight. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 2 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 3 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 4 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 6 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose com-55 pound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 7 nmol min^{-1} gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 8 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 9 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹.

The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 11 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant 5 yeast cell in a xylose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose transporter may transport a xylose transporter may transport a xylose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant yeast cell in a xylose-glucose growth media at a rate of at least 13 nmol min⁻¹ gDCW⁻¹ to 10 15 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 14 nmol min⁻¹ gDCW⁻¹.

The recombinant xylose transporter may transport a 15 xylose compound into a recombinant yeast cell in a xyloseglucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 2 nmol 20 min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 3 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in 25 a xylose-glucose growth media at a rate of at least 4 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may 30 transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 6 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 7 nmol 35 min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 8 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in 40 a xylose-glucose growth media at a rate of at least 9 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may 45 transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 11 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 12 nmol 50 min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 13 nmol \min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in 55 a xylose-glucose growth media at a rate of at least 14 nmol \min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 15 nmol min⁻¹ gDCW⁻¹

In embodiments, the recombinant xylose transporter transports a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 1 nmol \min^{-1} gDCW⁻¹ to 50 nmol \min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound 65 into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 2.5 nmol \min^{-1} gDCW⁻¹ to 50

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nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 15 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 20 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 25 nmol min^{-1} gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 35 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 40 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 45 nmol min⁻¹ gDCW⁻¹ to $50 \text{ nmol min}^{-1} \text{ gDCW}^{-1}$.

The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xyloseglucose growth media at a rate of at least 2.5 nmol min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 17 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 18 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 19 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 20 nmol \min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 22 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 25 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in 60 a xylose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 35 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 40 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may

transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 45 nmol min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 50 nmol 5 min^{-1} gDCW⁻¹.

In embodiments, the recombinant xylose transporter transports a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 10 nmol \min^{-1} gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombi- 10 nant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 20 nmol min^{-1} gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast 15 cell in a xylose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 40 nmol min⁻¹ $gDCW^{-1}$ to 20 min⁻¹ $gDCW^{-1}$. 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 50 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose 25 compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 60 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at 30 least 70 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 80 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose trans- 35 porter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 90 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose 40 growth media at a rate of at least 100 nmol min⁻¹ gDCW⁻ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 110 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. 45 The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 120 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant 50 yeast cell in a xylose-glucose growth media at a rate of at least 130 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 140 nmol min⁻¹ gDCW⁻¹ 55 to 150 nmol min⁻¹ gDCW⁻¹.

The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 60 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport 60 a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 70 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 80 nmol 65 min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a transport a xylose growth media at a rate of at least 80 nmol 65 min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in

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a xylose-glucose growth media at a rate of at least 90 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 100 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 110 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 120 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 130 nmol min⁻¹ gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 140 nmol \min^{-1} gDCW⁻¹. The recombinant xylose transporter may transport a xylose compound into a recombinant yeast cell in a xylose-glucose growth media at a rate of at least 150 nmol

2. Transporting Arabinose into a Recombinant Yeast Cell Also provided herein are methods of transporting arabinose into a recombinant yeast cell. In one aspect, the method includes contacting a recombinant yeast cell with an arabinose compound described herein, where the recombinant yeast cell includes a recombinant arabinose transporter protein as described herein, including embodiments thereof. The recombinant arabinose transporter protein transports the arabinose compound into the recombinant yeast cell. In embodiments, the only sugar (i.e. carbon source) present is an arabinose compound. The recombinant arabinose transporter protein is as described herein, including embodiments thereof. By extension, the arabinose transporter motif sequence and the glucose mitigation mutation are as described herein, including embodiments thereof.

In another aspect, the method includes contacting a recombinant yeast cell with an arabinose compound, where the arabinose compound is the only sugar (i.e. carbon source) in the media, and where the recombinant yeast cell includes a recombinant arabinose transporter protein as described herein, including embodiments thereof.

The arabinose compound may be derived from lignocellulosic biomass, hemicellulose, pectin, or xylan. Thus, in embodiments, the arabinose compound is not the only sugar (i.e. carbon source) present. The arabinose compound may be derived from lignocellulosic biomass. The arabinose compound may be derived from hemicellulose. The arabinose compound may be derived from pectin. The arabinose compound may be derived from xylan. In embodiments, the recombinant yeast cell metabolizes the arabinose compound. The arabinose compound may be present at a concentration as described hereinabove for the "arabinose growth media". In embodiments, the recombinant yeast cell converts the arabinose compound to a biofuel (e.g. ethanol) or to a biochemical as described herein, including embodiments thereof. The recombinant yeast cell may convert the arabinose compound to a biofuel (e.g. ethanol). The recombinant yeast cell may convert the arabinose compound to a biochemical as described herein, including embodiments thereof.

In embodiments, the recombinant arabinose transporter transports an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 2 nmol min⁻¹

gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 3 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may 5 transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 4 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arab- 10 inose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 6 nmol min⁻¹ gDCW⁻¹ to 15 nmol 15 min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 7 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arab- 20 inose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 8 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth 25 media at a rate of at least 9 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The 30recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose glucose growth media at a rate of at least 11 nmol \min^{-1} gDCW⁻¹ to 15 nmol \min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose com- 35 pound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a 40 rate of at least 13 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 14 nmol min⁻¹ gDCW⁻¹ to 15 nmol min⁻¹ gDCW⁻¹.

The recombinant arabinose transporter may transport an arabinose compound into a recombinant veast cell in an arabinose-glucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast 50 cell in an arabinose-glucose growth media at a rate of at least 2 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 3 nmol min⁻¹ gDCW⁻¹. The recombinant 55 arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 4 nmol min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arab- 60 inose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW-1. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 6 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose trans- 65 porter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a

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rate of at least 7 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 8 nmol min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 9 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 11 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 13 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 14 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 15 nmol min⁻¹ gDCW⁻¹.

In embodiments, the recombinant arabinose transporter transports an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 2.5 nmol \min^{-1} gDCW⁻¹ to 50 nmol \min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in 45 an arabinose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 15 nmol \min^{-1} gDCW⁻¹ to 50 nmol \min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 20 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 25 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 35 nmol \min^{-1} gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose

growth media at a rate of at least 40 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 45 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹.

The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 2.5 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 17 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a 15 rate of at least 18 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 19 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arab- 20 inose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 20 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 25 22 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 25 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound 30 into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 35 nmol 35 \min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 40 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recom- 40 binant yeast cell in an arabinose-glucose growth media at a rate of at least 45 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 50 nmol min⁻¹ gDCW⁻¹. 45

In embodiments, the recombinant arabinose transporter transports an arabinose compound into a recombinant veast cell in an arabinose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arab- 50 inose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 20 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose 55 growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 40 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ 60 gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 50 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arab- 65 inose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 60 nmol

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min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 70 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 80 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 90 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 100 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 110 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 120 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 130 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 140 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹.

The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 60 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 70 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 80 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 90 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 100 nmol \min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 110 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 120 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 130 nmol min⁻¹ gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 140 nmol min^{-1} gDCW⁻¹. The recombinant arabinose transporter may transport an arabinose compound into a recombinant yeast cell in an arabinose-glucose growth media at a rate of at least 150 nmol min⁻¹ $gDCW^{-1}$.

3. Transporting Galactose into a Recombinant Yeast Cell Also provided herein are methods of transporting galactose into a recombinant yeast cell. In one aspect, the method includes contacting a recombinant yeast cell with a galactose compound described herein, where the recombinant yeast cell includes a recombinant galactose transporter protein as described herein, including embodiments thereof. The recombinant galactose transporter protein transports the 5 galactose compound into the recombinant yeast cell. In embodiments, the only sugar (i.e. carbon source) present is a galactose compound. The recombinant galactose transporter protein is as described herein, including embodiments thereof. By extension, the galactose transporter motif 10 sequence and the glucose mitigation mutation are as described herein, including embodiments thereof.

In another aspect, the method includes contacting a recombinant yeast cell with a galactose compound, where the galactose compound is the only sugar (i.e. carbon 15 source) in the media, and where the recombinant yeast cell includes a recombinant galactose transporter protein as described herein, including embodiments thereof.

The galactose compound may be derived from lignocellulosic biomass, hemicellulose, or marine biomass. Thus, in 20 embodiments, the galactose compound is not the only sugar (i.e. carbon source) present. The galactose compound may be derived from lignocellulosic biomass. The galactose compound may be derived from hemicellulose. The galactose compound may be derived from marine biomass. In 25 embodiments, the recombinant yeast cell metabolizes the galactose compound. The galactose compound may be present at a concentration as described hereinabove for the "galactose growth media". In embodiments, the recombinant yeast cell converts the galactose compound to a biofuel 30 (e.g. ethanol) or to a biochemical as described herein, including embodiments thereof. The recombinant yeast cell may convert the galactose compound to a biofuel (e.g. ethanol). The recombinant yeast cell may convert the galactose compound to a biochemical as described herein, includ- 35 ing embodiments thereof.

In embodiments, the recombinant galactose transporter transports a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. 40 The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 2 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose 45 compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 3 nmol min^{-1} gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose 50 growth media at a rate of at least 4 nmol min^{-1} gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 5 nmol \min^{-1} gDCW⁻¹ to about 15 nmol 55 \min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 6 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a 60 galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 7 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose- 65 glucose growth media at a rate of at least 8 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombi84

nant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 9 nmol min^{-1} gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 11 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 13 nmol min⁻¹ gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 14 nmol min^{-1} gDCW⁻¹ to about 15 nmol min⁻¹ gDCW⁻¹.

The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 2 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 3 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 4 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 5 nmol min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 6 nmol min⁻¹ $gDCW^{-1}$. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 7 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant veast cell in a galactose-glucose growth media at a rate of at least 8 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 9 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 11 nmol min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 12 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 13 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate

of at least 14 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 15 nmol min⁻¹ gDCW⁻¹.

In embodiments, the recombinant galactose transporter 5 transports a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 1 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose- 10 glucose growth media at a rate of at least 2.5 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹ to 50 nmol 15 min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose 20 compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 12 nmol min^{-1} gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth 25 media at a rate of at least 15 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant veast cell in a galactose-glucose growth media at a rate of at least 20 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The 30 recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 25 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound 35 into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 40 35 nmol min⁻¹ gDCW⁻¹ to 50 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 40 nmol min⁻¹ $gDCW^{-1}$ to 50 nmol min⁻¹ $gDCW^{-1}$. The recombinant 45 galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 45 nmol min⁻¹ gDCW⁻¹ to 50 nmol \min^{-1} gDCW⁻¹.

The recombinant galactose transporter may transport a 50 galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 2.5 nmol \min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 55 17 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 18 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a 60 recombinant yeast cell in a galactose-glucose growth media at a rate of at least 19 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 20 nmol min⁻¹ gDCW⁻¹. 65 The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a

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galactose-glucose growth media at a rate of at least 22 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 25 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 35 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 40 nmol min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 45 nmol \min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 50 nmol min⁻¹ gDCW⁻¹.

In embodiments, the recombinant galactose transporter transports a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 10 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 20 nmol min⁻¹ $gDCW^{-1}$ to 150 nmol min⁻¹ $gDCW^{-1}$. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 30 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 40 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 50 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 60 nmol min^{-1} gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 70 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 80 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 90 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 100 nmol min^{-1} gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 110 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 120 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 130 nmol min⁻¹ gDCW⁻¹ to 150 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose- 5 glucose growth media at a rate of at least 140 nmol min^{-1} $gDCW^{-1}$ to 150 nmol min⁻¹ $gDCW^{-1}$.

The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 60 nmol \min^{-1} gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 70 nmol min⁻¹ gDCW⁻¹. The recombinant galactose trans-15porter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 80 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media 20 at a rate of at least 90 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 100 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a 25 1. Reijenga K A, et al. (2001) Control of glycolytic dynamgalactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 110 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 30 120 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 130 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound 35 into a recombinant yeast cell in a galactose-glucose growth media at a rate of at least 140 nmol min⁻¹ gDCW⁻¹. The recombinant galactose transporter may transport a galactose compound into a recombinant yeast cell in a galactoseglucose growth media at a rate of at least 150 nmol min⁻¹ 40 $gDCW^{-1}$.

V. Examples

In previous research, was developed a xylose specific 45 transporter hereafter termed "CiGXS1-FIM" ("FIM"), based on a hexose transporter from C. intermedia, GXS1. The FIM mutation imparted specificity in transporting xylose over glucose. (11) The presence of glucose, however, inhibited the performance of FIM in transporting xylose. Herein 50 7. Hahn-Hagerdal B, Karhumaa K, Fonseca C, Spencerdirected evolution was conducted to reduce the observed glucose inhibition.

A library of randomly mutated FIM was generated by error-prone PCR with a library size of over 1×10^5 mutants (as measured by independent E. coli colonies post-transfor- 55 mation). The mutant FIM was then transformed into S. cerevisiae ETKXG strain, a triple hexokinase knockout strain which is not able to grow on glucose, and screened on the xylose dependent growth based advantage on the dropout plates with 20 g/L of xylose and 2.5 g/L of glucose. The 60 140 selected mutants from the plates were then tested for the growth on the medium with 20 g/L of xylose and 2.5 g/L glucose using Bioscreen C and the top 6 mutants were selected for further confirmation. The growth rates of the selected mutants on xylose in the presence of various 65 concentration of glucose were then confirmed using Bioscreen C (FIG. 1).

The mutant 105, which has 6 mutations: K155E, N225D, S354T, A361T, L407M, N446S (FIG. 2), showed reduced glucose inhibition. Indeed, the mutant 105 showed significantly higher growth rates in the all tested conditions compared to FIM and wild-type transporters. Mutant 105 shows nearly a 30-fold increase in the growth rate on a xvlose medium with the presence of glucose. The growth rate of the mutant 105 in the xylose 20 g/L+glucose 2.5 g/L medium was slightly higher than the growth rate of the wild-type transporter in the xylose only medium. Though the mutant 105 showed the highest reduction in glucose inhibition, the growth rate on xylose only was slightly reduced compared to FIM and wild-type. See FIG. 1

The mutant 78, which has a single mutation, N326S, showed reduced glucose inhibition without decrease in xylose transport capability. In contrast to mutant 105, mutant 78 showed no reduction in the xylose transport performance. This suggests the mutant 78 represents a promising candidate for further round of directed evolution to develop xylose transporters with reduced glucose inhibition.

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VI. P Embodiments

Embodiment P 1

A recombinant xylose transporter protein comprising a 5 xylose transporter motif sequence and a glucose mitigation mutation.

Embodiment P 2

10The recombinant xylose transporter protein of embodiment P 1, wherein said xylose transporter motif sequence corresponds to amino acid residue positions 36, 37, 38, 39, 40, and 41 of Candida intermedia GXS1 protein, and wherein said xylose transporter motif sequence is -G-G/F-15 X^1 - X^2 - X^3 -G-; wherein, X^1 is D, C, G, H, Î, L, or F; X^2 is A, D, C, E, G, H, or I; and X³ is N, C, Q, F, G, L, M, S, T, or P.

Embodiment P 3

The recombinant xylose transporter protein of embodiment P1 or embodiment P2, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), -G-F-F-I-S-G- (SEQ ID NO:110), -G-G-F-I-T-G-25 (SEQ ID NO:111), -G-F-F-I-T-G- (SEQ ID NO:112), -G-G-F-L-M-G- (SEQ ID NO:113), -G-F-F-L-M-G- (SEQ ID NO:114), -G-G-F-L-S-G- (SEQ ID NO:115), -G-F-F-L-S-G- (SEQ ID NO:116), -G-G-F-L-T-G- (SEQ ID NO:117), -G-F-F-L-T-G- (SEQ ID NO:118), -G-G-F-H-M-G- (SEQ 30 ID NO:119), -G-F-F-H-M-G- (SEQ ID NO:120), -G-G-F-H-S-G- (SEQ ID NO:121), -G-F-F-H-S-G- (SEQ ID NO:122), -G-G-F-H-T-G- (SEQ ID NO:123) or -G-F-F-H-T-G- (SEQ ID NO:124).

Embodiment P 4

The recombinant xylose transporter protein of any one of embodiments P1 to 3, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-40 M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), or -G-F-F-I-S-G- (SEQ ID NO:110).

Embodiment P 5

The recombinant xylose transporter protein of any one of 45 embodiments P1 to 4, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107).

Embodiment P 6

The recombinant xylose transporter protein of any one of embodiments P 1 to 5, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 9 of Candida intermedia GXS1 protein.

Embodiment P 7

The recombinant xylose transporter protein of any one of embodiments P 1 to 6, wherein said glucose mitigation mutation is at a position corresponding to K155, N225, 60 the growth rate of said recombinant yeast cell in a xylose-S354, A361, L407, or N446 of Candida intermedia GXS1 protein.

Embodiment P 8

The recombinant xylose transporter protein of any one of embodiments P 1 to 5, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 8 of Candida intermedia GXS1 protein.

Embodiment P 9

The recombinant xylose transporter protein of any one of embodiments P 1 to 5, or embodiment P 8, wherein said glucose mitigation mutation is at a position corresponding N326 of Candida intermedia GXS1 protein.

Embodiment P 10

The recombinant xylose transporter protein of embodiment P 9, wherein said glucose mitigation mutation is a N326S mutation.

Embodiment P 11

A recombinant yeast cell comprising a recombinant xylose transporter protein of any one of embodiments P 1 to 20 10

Embodiment P 12

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 10% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 13

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 20% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 14

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 30% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 15

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 40% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 16

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 50% of the growth ⁵⁵ rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 17

The recombinant yeast cell of embodiment P 11, wherein glucose growth media is at least about 60% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 18

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xylose-

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glucose growth media is at least about 70% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 19

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 80% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 20

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 90% of the growth ¹⁵ rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 21

The recombinant yeast cell of embodiment P 11, wherein ²⁰ the growth rate of said recombinant yeast cell in a xylose-glucose growth media is at least about 100% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 22

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 110% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 23

The recombinant yeast cell of embodiment P 11, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 120% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment P 24

The recombinant yeast cell of any one of embodiments P 11 to 23, wherein said xylose-glucose growth media comprises about 0.05 g/L to about 20 g/L glucose.

Embodiment P 25

The recombinant yeast cell of any one of embodiments P 11 to 24, wherein said xylose-glucose growth media comprises about 2.5 g/L glucose.

Embodiment P 26

The recombinant yeast cell of any one of embodiments P 11 to 25, wherein said xylose-glucose growth media comprises about 5 g/L glucose.

Embodiment P 27

The recombinant yeast cell of any one of embodiments P 11 to 26, wherein said xylose-glucose growth media com- 60 prises about 10 g/L glucose.

Embodiment P 28

The recombinant yeast cell of any one of embodiments P 65 11 to 27, wherein said xylose-glucose growth media comprises about 20 g/L glucose.

Embodiment P 29

The recombinant yeast cell of any one of embodiments P 11 to 28, wherein said xylose-glucose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment P 30

The recombinant yeast cell of any one of embodiments P 11 to 29, wherein said xylose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment P 31

The recombinant yeast cell of any one of embodiments P 11 to 30, wherein said xylose growth media comprises about 20 g/L xylose.

Embodiment P 32

A method of transporting xylose into a recombinant yeast cell, said method comprising: i) contacting a recombinant 25 yeast cell with a xylose compound, wherein said recombinant yeast cell comprises a recombinant xylose transporter protein, said recombinant xylose transporter protein comprising a xylose transporter motif sequence and a glucose mitigation mutation; and ii) allowing said recombinant 30 xylose transporter protein to transport said xylose compound into said recombinant yeast cell.

Embodiment P 33

The method of embodiment P 32, wherein said xylose transporter motif sequence corresponds to amino acid residue positions 36, 37, 38, 39, 40, and 41 of *Candida intermedia* GXS1 protein, and wherein said xylose transporter motif sequence is -G-G/F-X¹-X²-X³-G-; wherein, X¹ is D, C, G, H, I, L, or F; X² is A, D, C, E, G, H, or I; and X³ is N, C, Q, F, G, L, M, S, T, or P.

Embodiment P 34

The method of embodiment P 32 or embodiment P 33, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), -G-F-F-I-S-G-(SEQ ID NO:110), -G-G-F-I-T-G- (SEQ ID NO:111), -G-F-F-I-T-G- (SEQ ID NO:112), -G-G-F-L-M-G- (SEQ ID NO:113), -G-F-F-L-M-G- (SEQ ID NO:114), -G-G-F-L-S-G- (SEQ ID NO:115), -G-F-F-L-S-G- (SEQ ID NO:116), -G-G-F-L-T-G- (SEQ ID NO:117), -G-F-F-L-T-G- (SEQ ID NO:118), -G-G-F-H-M-G- (SEQ ID NO:119), -G-F-F-H-M-G- (SEQ ID NO:120), -G-G-F-H-S-G- (SEQ ID NO:121), -G-F-F-H-S-G- (SEQ ID NO:122), -G-G-F-H-T-G- (SEQ ID NO:123) or -G-F-F-H-T-G- (SEQ ID NO:124).

Embodiment P 35

The method of any one of embodiments P 32 to 34, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), or -G-F-F-I-S-G- (SEQ ID NO:110).

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Embodiment P 36

The method of any one of embodiments P 32 to 35, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107).

Embodiment P 37

The method of any one of embodiments P 32 to 36, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 9 of *Candida*¹⁰ *intermedia* GXS1 protein.

Embodiment P 38

The method of any one of embodiments P 32 to 37, ¹⁵ wherein said glucose mitigation mutation is at a position corresponding to K155, N225, S354, A361, L407, or N446 of *Candida intermedia* GXS1 protein.

Embodiment P 39

The method of any one of embodiments P 32 to 36, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 8 of *Candida intermedia* GXS1 protein. 25

Embodiment P 40

The method of any one of embodiments P 32 to 36, or embodiment P 39, wherein said glucose mitigation mutation is at a position corresponding N326 of *Candida intermedia* ³⁰ GXS1 protein.

Embodiment P 41

The method of embodiment P 40, wherein said glucose 35 mitigation mutation is a N326S mutation.

Embodiment P 42

The method of any one of embodiments P 32 to 41, $_{40}$ wherein said recombinant yeast cell metabolizes said xylose compound.

Embodiment P 43

The method of any one of embodiments P 32 to 42, ⁴⁵ wherein said recombinant yeast cell converts said xylose compound to a biofuel.

Embodiment P 44

The method of any one of embodiments P 32 to 43, wherein said xylose compound forms part of lignocellulosic biomass, hemicellulose, or xylan.

Embodiment P 45

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 10% of the rate said recom- ⁶⁰ binant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 46

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said

xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 20% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 47

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 30% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 48

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 40% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 49

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 50% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 50

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 60% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 51

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 70% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 52

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 80% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 53

The method of any one of embodiments P 32 to 44, 65 wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 90% of the rate said recom-

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binant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 54

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 100% of the rate said recombinant xylose transporter transports said xylose compound ¹⁰ into said yeast in a xylose growth media.

Embodiment P 55

The method of any one of embodiments P 32 to 44, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 110% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 56

The method of any one of embodiments P 32 to 44, ²⁵ wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 120% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment P 57

The method of any one of embodiments P 45 to 56, wherein said xylose-glucose growth media comprises about $_{35}$ 0.05 g/L to about 20 g/L glucose.

Embodiment P 58

The method of any one of embodiments P 45 to 57, 40 wherein said xylose-glucose growth media comprises about 2.5 g/L glucose.

Embodiment P 59

The method of any one of embodiments P 45 to 58, wherein said xylose-glucose growth media comprises about 5 g/L glucose.

Embodiment P 60

The method of any one of embodiments P 45 to 59, wherein said xylose-glucose growth media comprises about 10 g/L glucose.

Embodiment P 61

The method of any one of embodiments P 45 to 60, wherein said xylose-glucose growth media comprises about 20 g/L glucose.

Embodiment P 62

The method of any one of embodiments P 45 to 61, 65 wherein said xylose-glucose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment P 63

The method of any one of embodiments P 45 to 62, wherein said xylose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment P 64

The method of any one of embodiments P 45 to 63, wherein said xylose growth media comprises about 20 g/L xylose.

Embodiment P 65

The method of any one of embodiments P 32 to 64, ¹⁵ wherein said recombinant xylose transporter protein transports said xylose compound into said recombinant yeast cell in a xylose-glucose growth media growth media at a rate of at least 5 nmol min⁻¹ gDCW⁻¹.

Embodiment P 66

A nucleic acid encoding the recombinant xylose transporter protein of one of embodiments P 1 to 10.

VII. Further Embodiments

Embodiment 1

A recombinant xylose transporter protein comprising a xylose transporter motif sequence and a glucose mitigation ³⁰ mutation.

Embodiment 2

The recombinant xylose transporter protein of embodiment 1, wherein said xylose transporter motif sequence corresponds to amino acid residue positions 36, 37, 38, 39, 40, and 41 of *Candida intermedia* GXS1 protein.

Embodiment 3

The recombinant xylose transporter protein of embodiment 1 or embodiment 2, wherein said xylose transporter motif sequence is -G-G/F-X¹-X²-X³-G-; wherein, X¹ is D, C, G, H, I, L, or F; X² is A, D, C, E, G, H, or I; and X³ is ⁴⁵ N, C, Q, F, G, L, M, S, T, or P.

Embodiment 4

The recombinant xylose transporter protein of one of
embodiments 1-3, wherein said xylose transporter motif
sequence is G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109),
-G-F-F-I-S-G- (SEQ ID NO:110), -G-G-F-I-T-G- (SEQ ID NO:111), -G-F-F-I-T-G- (SEQ ID NO:112), -G-G-F-L-MG- (SEQ ID NO:113), -G-F-F-L-M-G- (SEQ ID NO:114),
-G-G-F-L-S-G- (SEQ ID NO:115), -G-F-F-L-S-G- (SEQ ID NO:116), -G-G-F-L-T-G- (SEQ ID NO:115), -G-F-F-L-T-G- (SEQ ID NO:118), -G-G-F-H-M-G- (SEQ ID NO:119),
-G-F-F-H-M-G- (SEQ ID NO:120), -G-G-F-H-S-G- (SEQ ID NO:121), -G-F-F-H-S-G- (SEQ ID NO:122), -G-G-F-H-T-G- (SEQ ID NO:123) or -G-F-F-H-T-G- (SEQ ID NO:124).

Embodiment 5

The recombinant xylose transporter protein of any one of embodiments 2 to 4, wherein said xylose transporter motif

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sequence is G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), or -G-F-F-I-S-G- (SEQ ID NO:110).

Embodiment 6

The recombinant xylose transporter protein of any one of embodiments 1 to 5, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ ID NO:107).

Embodiment 7

The recombinant xylose transporter protein of any one of embodiments 1 to 6, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 9 of *Candida intermedia* GXS1 protein. ¹⁵

Embodiment 8

The recombinant xylose transporter protein of any one of embodiments 1 to 7, wherein said glucose mitigation mutation is at a position corresponding to K155, N225, S354, A361, L407, or N446 of *Candida intermedia* GXS1 protein.

Embodiment 9

The recombinant xylose transporter protein of any one of embodiments 1 to 6, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 8 of *Candida intermedia* GXS1 protein.

Embodiment 10

The recombinant xylose transporter protein of any one of embodiments 1 to 6, or embodiment 9, wherein said glucose mitigation mutation is at a position corresponding to N326 of *Candida intermedia* GXS1 protein. 35

Embodiment 11

The recombinant xylose transporter protein of embodiment 10, wherein said glucose mitigation mutation is a N326H mutation.

Embodiment 12

The recombinant xylose transporter protein of embodiment 10, wherein said glucose mitigation mutation is a N326S mutation.

Embodiment 13

The recombinant xylose transporter protein of any one of embodiments 1 to 6, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 5 of *Candida intermedia* GXS1 protein.

Embodiment 14

The recombinant xylose transporter protein of any one of embodiments 1 to 6, or embodiment 13, wherein said glucose mitigation mutation is within a protein domain ⁶⁰ corresponding to residue 160-179 of *Candida intermedia* GXS1 protein.

Embodiment 15

The recombinant xylose transporter protein of any one of embodiments 1 to 6, 13 or 14, wherein said glucose mitigation mutation is at a position corresponding to T170 or I171 of *Candida intermedia* GXS1 protein.

Embodiment 16

The recombinant xylose transporter protein of embodiment 15, wherein said glucose mitigation mutation is a T170N mutation.

Embodiment 17

The recombinant xylose transporter protein of embodiment 15, wherein said glucose mitigation mutation is a 1171F mutation.

Embodiment 18

The recombinant xylose transporter protein of one of embodiments 1-17 further comprising an amino acid deletion.

Embodiment 19

The recombinant xylose transporter protein of embodiment 18, wherein said deletion is within a protein domain corresponding to residue 497-522 of *Candida intermedia* GXS1 protein.

Embodiment 20

The recombinant xylose transporter protein of embodi-³⁰ ment 18 or embodiment 19, wherein said deletion is at least 10 amino acids in length.

Embodiment 21

A recombinant yeast cell comprising a recombinant xylose transporter protein of any one of embodiments 1 to 20

Embodiment 22

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 10% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 23

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 20% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 24

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xylose-⁵⁵ glucose growth media is at least about 30% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 25

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 40% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 26

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xylose-

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glucose growth media is at least about 50% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 27

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 60% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 28

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xylose-15 glucose growth media is at least about 70% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 29

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 80% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 30

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 90% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 31

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 100% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 32

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 110% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 33

The recombinant yeast cell of embodiment 21, wherein the growth rate of said recombinant yeast cell in a xyloseglucose growth media is at least about 120% of the growth rate of said recombinant yeast cell in a xylose growth media.

Embodiment 34

The recombinant yeast cell of any one of embodiments 21 to 33, wherein said xylose-glucose growth media comprises about 0.05 g/L to about 20 g/L glucose.

Embodiment 35

The recombinant yeast cell of any one of embodiments 21 65 to 34, wherein said xylose-glucose growth media comprises about 2.5 g/L glucose.

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Embodiment 36

The recombinant yeast cell of any one of embodiments 21 to 35, wherein said xylose-glucose growth media comprises about 5 g/L glucose.

Embodiment 37

The recombinant yeast cell of any one of embodiments 21 to 36, wherein said xylose-glucose growth media comprises about 10 g/L glucose.

Embodiment 38

The recombinant yeast cell of any one of embodiments 21 to 37, wherein said xylose-glucose growth media comprises about 20 g/L glucose.

Embodiment 39

The recombinant yeast cell of any one of embodiments 21 to 38, wherein said xylose-glucose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment 40

The recombinant yeast cell of any one of embodiments 21 to 39, wherein said xylose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment 41

The recombinant yeast cell of any one of embodiments 21 to 40, wherein said xylose growth media comprises about 20 g/L xylose.

Embodiment 42

A method of transporting xylose into a recombinant yeast 40 cell, said method comprising: i) contacting a recombinant yeast cell with a xylose compound, wherein said recombinant yeast cell comprises a recombinant xylose transporter protein, said recombinant xylose transporter protein comprising a xylose transporter motif sequence and a glucose 45 mitigation mutation; and ii) allowing said recombinant xylose transporter protein to transport said xylose compound into said recombinant yeast cell.

Embodiment 43

The method of embodiment 42, wherein said xylose transporter motif sequence corresponds to amino acid residue positions 36, 37, 38, 39, 40, and 41 of *Candida intermedia* GXS1 protein.

Embodiment 44

The method of embodiment 42 or embodiment 43, wherein said xylose transporter motif sequence is -G-G/F- X^1 - X^2 - X^3 -G-; wherein, X^1 is D, C, G, H, I, L, or F; X^2 is A, D, C, E, G, H, or I; and X^3 is N, C, Q, F, G, L, M, S, T, or P.

Embodiment 45

The method of one of embodiments 42-44, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- (SEQ

ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), -G-F-F-I-S-G- (SEQ ID NO:110), -G-G-F-I-T-G- (SEQ ID NO:111), -G-F-F-I-T-G- (SEQ ID NO:112), -G-G-F-L-M-G- (SEQ ID NO:113), -G-F-F-L-M-G- (SEQ ID NO:114), -G-G-F-L-S-G- (SEQ ID NO:115), 5-G-F-F-L-S-G- (SEQ ID NO:116), -G-G-F-L-T-G- (SEQ ID NO:117), -G-F-F-L-T-G- (SEQ ID NO:118), -G-G-F-H-M-G- (SEQ ID NO:119), -G-F-F-H-M-G- (SEQ ID NO:120), -G-G-F-H-S-G- (SEQ ID NO:121), -G-F-F-H-S-G- (SEQ ID NO:122), -G-G-F-H-T-G- (SEQ ID NO:123) or -G-F-F- 10 H-T-G- (SEQ ID NO:124).

Embodiment 46

The method of any one of embodiments 42 to 45, wherein said xylose transporter motif sequence is -G-G-F-I-M-G-(SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), -G-G-F-I-S-G- (SEQ ID NO:109), or -G-F-F-I-S-G- (SEQ ID NO:110).

Embodiment 47

The method of any one of embodiments 42 to 46, wherein said xylose transporter motif sequence is -G-G-F-I-M-G- 25 (SEQ ID NO:107).

Embodiment 48

The method of any one of embodiments 42 to 47, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 9 of *Candida intermedia* GXS1 protein.

Embodiment 49

The method of any one of embodiments 42 to 48, wherein said glucose mitigation mutation is at a position corresponding to K155, N225, S354, A361, L407, or N446 of *Candida* 40 *intermedia* GXS1 protein.

Embodiment 50

The method of any one of embodiments 42 to 47, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 8 of *Candida intermedia* GXS1 protein.

Embodiment 51

The method of any one of embodiments 42 to 47, or embodiment 50, wherein said glucose mitigation mutation is at a position corresponding N326 of *Candida intermedia* 55 GXS1 protein.

Embodiment 52

The method of embodiment 51, wherein said glucose 60 mitigation mutation is a N326H mutation.

Embodiment 53

The method of embodiment 51, wherein said glucose mitigation mutation is a N326S mutation.

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Embodiment 54

The method of any one of embodiments 42 to 47, wherein said glucose mitigation mutation is within a protein domain corresponding to transmembrane 5 of *Candida intermedia* GXS1 protein.

Embodiment 55

The method of one of embodiments 42 to 47, or embodiment 54, wherein said glucose mitigation mutation is within a protein domain corresponding to residue 160-179 of *Candida intermedia* GXS1 protein.

Embodiment 56

The method of embodiment 54 or 55, wherein said glucose mitigation mutation is at a position corresponding to 20 T170 or I171 of *Candida intermedia* GXS1 protein.

Embodiment 57

The method of embodiment 56, wherein said glucose mitigation mutation is a T170N mutation.

Embodiment 58

The method of embodiment 56, wherein said glucose mitigation mutation is a I171F mutation.

Embodiment 59

The method of any one of embodiments 42 to 58, further comprising an amino acid deletion.

Embodiment 60

The method of embodiment 59, wherein said deletion is within a protein domain corresponding to residue 497-522 of *Candida intermedia* GXS1 protein.

Embodiment 61

The method of any one of embodiments 42 to 53, wherein said recombinant yeast cell metabolizes said xylose compound.

Embodiment 62

⁵⁰ The method of any one of embodiments 42 to 61, wherein said recombinant yeast cell converts said xylose compound to a biofuel.

Embodiment 63

The method of any one of embodiments 42 to 62, wherein said xylose compound forms part of lignocellulosic biomass, hemicellulose, or xylan.

Embodiment 64

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 10% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

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Embodiment 65

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media ⁵ at a rate at least about 20% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 66

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 30% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 67

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 40% of the rate said recombinant xylose transporter transports said xylose compound into said ²⁵ yeast in a xylose growth media.

Embodiment 68

The method of any one of embodiments 42 to 63, wherein ³⁰ said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 50% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media. ³⁵

Embodiment 69

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 60% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 70

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media ⁵⁰ at a rate at least about 70% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 71

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 80% of the rate said recombinant ⁶⁰ xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 72

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 90% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 73

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 100% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 74

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 110% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 75

The method of any one of embodiments 42 to 63, wherein said recombinant xylose transporter transports said xylose compound into said yeast in a xylose-glucose growth media at a rate at least about 120% of the rate said recombinant xylose transporter transports said xylose compound into said yeast in a xylose growth media.

Embodiment 76

The method of any one of embodiments 64 to 75, wherein said xylose-glucose growth media comprises about 0.05 g/L to about 20 g/L glucose.

Embodiment 77

The method of any one of embodiments 64 to 76, wherein said xylose-glucose growth media comprises about 2.5 g/L ₄₀ glucose.

Embodiment 78

The method 1 of any one of embodiments 64 to 77, wherein said xylose-glucose growth media comprises about ⁴⁵ 5 g/L glucose.

Embodiment 79

The method of any one of embodiments 64 to 78, wherein said xylose-glucose growth media comprises about 10 g/L glucose.

Embodiment 80

The method of any one of embodiments 64 to 79, wherein ⁵⁵ said xylose-glucose growth media comprises about 20 g/L glucose.

Embodiment 81

The method of any one of embodiments 64 to 80, wherein said xylose-glucose growth media comprises about 0.05 g/L to about 300 g/L xylose.

Embodiment 82

The method of any one of embodiments 64 to 81, wherein said xylose growth media comprises about 0.05 g/L to about 300 g/L xylose.

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Embodiment 83

The method of any one of embodiments 64 to 82, wherein said xylose growth media comprises about 20 g/L xylose.

Embodiment 84

The method of any one of embodiments 42 to 83, wherein said recombinant xylose transporter protein transports said

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 Ile Pro Leu Tyr Gln Ser Glu Thr Ala Pro Lys Trp Ile Arg Gly Ala

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 150
 155
 160
 Ile Val Ser Cys Tyr Gln Trp Ala Ile Thr Ile Gly Leu Phe Leu Ala 165 170 Ser Cys Val Asn Lys Gly Thr Glu His Met Thr Asn Ser Gly Ser Tyr 185 180 190 Arg Ile Pro Leu Ala Ile Gln Cys Leu Trp Gly Leu Ile Leu Gly Ile 195 200 205 Gly Met Ile Phe Leu Pro Glu Thr Pro Arg Phe Trp Ile Ser Lys Gly 210 215 220 Asn Gln Glu Lys Ala Ala Glu Ser Leu Ala Arg Leu Arg Lys Leu Pro 230 225 235 240 Ile Asp His Pro Asp Ser Leu Glu Glu Leu Arg Asp Ile Thr Ala Ala 245 250 255 Tyr Glu Phe Glu Thr Val Tyr Gly Lys Ser Ser Trp Ser Gln Val Phe 265 260 270 Ser His Lys Asn His Gln Leu Lys Arg Leu Phe Thr Gly Val Ala Ile 280 275 285 Gln Ala Phe Gln Gln Leu Thr Gly Val Asn Phe Ile Phe Tyr Tyr Gly 295 290 300

xylose compound into said recombinant yeast cell in a xylose-glucose growth media growth media at a rate of at least 5 nmol min^{-1} gDCW⁻¹

Embodiment 85

A nucleic acid encoding the recombinant xylose transporter protein of one of embodiments 1 to 21.

-continued

Thr 305	Thr	Phe	Phe	Lys	Arg 310	Ala	Gly	Val	Asn	Gly 315	Phe	Thr	Ile	Ser	Leu 320
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Met	Ser	Leu 355	Ser	Gln	Leu	Ile	Val 360	Ala	Ile	Val	Gly	Val 365	Ala	Thr	Ser
Glu	Asn 370	Asn	Lys	Ser	Ser	Gln 375	Ser	Val	Leu	Val	Ala 380	Phe	Ser	Суз	Ile
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Val	Gly	Glu	Leu	Phe 405	Pro	Leu	Arg	Thr	Arg 410	Ala	Lys	Ser	Val	Ser 415	Leu
Суз	Thr	Ala	Ser 420	Asn	Trp	Leu	Trp	Asn 425	Trp	Gly	Ile	Ala	Tyr 430	Ala	Thr
Pro	Tyr	Met 435	Val	Asp	Glu	Asp	Lys 440	Gly	Asn	Leu	Gly	Ser 445	Asn	Val	Phe
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Tyr	Glu	His	Val	Ser 485	Lys	Ala	Trp	Lys	Ser 490	Lys	Gly	Phe	Val	Pro 495	Ser
Lys	His	Ser	Phe 500	Arg	Glu	Gln	Val	Asp 505	Gln	Gln	Met	Asp	Ser 510	Lys	Thr
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-continued

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Ala	Thr	Asn	Ile	Val 325	His	Val	Gly	Ser	Thr 330	Ile	Pro	Gly	Ile	Leu 335	Leu
Met	Glu	Val	Leu 340	Gly	Arg	Arg	Asn	Met 345	Leu	Met	Gly	Gly	Ala 350	Thr	Gly
Met	Ser	Leu 355	Ser	Gln	Leu	Ile	Val 360	Ala	Ile	Val	Gly	Val 365	Ala	Thr	Ser
Glu	Asn 370	Asn	Lys	Ser	Ser	Gln 375	Ser	Val	Leu	Val	Ala 380	Phe	Ser	Суз	Ile
Phe 385	Ile	Ala	Phe	Phe	Ala 390	Ala	Thr	Trp	Gly	Pro 395	Cys	Ala	Trp	Val	Val 400
Val	Gly	Glu	Leu	Phe	Pro	Leu	Arg	Thr	Arg	Ala	Lys	Ser	Val	Ser	Leu

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Сүз	Thr	Ala	Ser 420	Asn	Trp	Leu	Trp	Asn 425	Trp	Gly	Ile	Ala	Tyr 430	Ala	Thr
Pro	Tyr	Met 435	Val	Asp	Glu	Asp	Lys 440	Gly	Asn	Leu	Gly	Ser 445	Asn	Val	Phe
Phe	Ile 450	Trp	Gly	Gly	Phe	Asn 455	Leu	Ala	Суз	Val	Phe 460	Phe	Ala	Trp	Tyr
Phe 465	Ile	Tyr	Glu	Thr	Lys 470	Gly	Leu	Ser	Leu	Glu 475	Gln	Val	Asp	Glu	Leu 480
Tyr	Glu	His	Val	Ser 485	ГЛа	Ala	Trp	ГЛа	Ser 490	Lys	Gly	Phe	Val	Pro 495	Ser
Lys	His	Ser	Phe 500	Arg	Glu	Gln	Val	Asp 505	Gln	Gln	Met	Asp	Ser 510	Lys	Thr
Glu	Ala	Ile 515	Met	Ser	Glu	Glu	Ala 520	Ser	Val						
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<400 Met	U> SI Gly	EQUE1 Leu	Glu	4 Asp	Asn	Arg	Met	Val	Lys	Arg	Phe	Val	Asn	Val	Gly
1 Glu	Lys	Lys	Ala	5 Gly	Ser	Thr	Ala	Met	10 Ala	Ile	Ile	Val	Gly	15 Leu	Phe
Ala	Ala	Ser	20 Glv	- Glv	Phe	Ile	Met.	25 Glv	Tvr	Asp	Thr	Glv	30 Thr	Ile	Ser
a	a	35 Mot	о⊥у т⊾	∪⊥у ма+	7	т	40	5±y	-y-	7.0D	тт	45 Pr-			1
GIY	Va1 50	Met	Thr	Met	Asp	Tyr 55	Val	Leu	Ala	Arg	fyr 60	Pro	Ser	Asn	ГЛа
His 65	Ser	Phe	Thr	Ala	Asp 70	Glu	Ser	Ser	Leu	Ile 75	Val	Ser	Ile	Leu	Ser 80
Val	Gly	Thr	Phe	Phe 85	Gly	Ala	Leu	Сүз	Ala 90	Pro	Phe	Leu	Asn	Asp 95	Thr
Leu	Gly	Arg	Arg 100	Trp	Суз	Leu	Ile	Leu 105	Ser	Ala	Leu	Ile	Val 110	Phe	Asn
Ile	Gly	Ala 115	Ile	Leu	Gln	Val	Ile 120	Ser	Thr	Ala	Ile	Pro 125	Leu	Leu	Сүз
Ala	Gly 130	Arg	Val	Ile	Ala	Gly 135	Phe	Gly	Val	Gly	Leu 140	Ile	Ser	Ala	Thr
Ile 145	Pro	Leu	Tyr	Gln	Ser 150	Glu	Thr	Ala	Pro	Lys 155	Trp	Ile	Arg	Gly	Ala 160
Ile	Val	Ser	Суз	Tyr 165	Gln	Trp	Ala	Ile	Asn 170	Ile	Gly	Leu	Phe	Leu 175	Ala
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Arg	Ile	Pro 195	Leu	Ala	Ile	Gln	Cys 200	Leu	Trp	Gly	Leu	Ile 205	Leu	Gly	Ile
Gly	Met 210	Ile	Phe	Leu	Pro	Glu 215	Thr	Pro	Arg	Phe	Trp 220	Ile	Ser	Lys	Gly
Asn	Gln	Glu	ГЛа	Ala	Ala	Glu	Ser	Leu	Ala	Arg	Leu	Arg	Lys	Leu	Pro
∠∠5 Ile	Asp	His	Pro	Asp	∠30 Ser	Leu	Glu	Glu	Leu	∠35 Ara	Asp	Ile	Thr	Ala	∠40 Ala
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245 250 255 Tyr Glu Phe Glu Thr Val Tyr Gly Zes Ser Sr Tr Ser Gln Val Phe Ser His Lyr Ann His Gln Leu Lyr Ann Phe The Gln Val Phe Gln Ala Phe Gln Gln Leu Tyr Gly Val Ann Phe The Phe Tyr Gly Gln Thr Phe Phe His Lyr Gly Ala Phe Tyr Gly Gln Thr Phe Phe His Lyr Ann Gly Ser Thr Fhe Tyr Gly Ala Thr Ann Lyr Ann Ann Tyr Gly Gly	_															
Tyr Glu Phe Glu Thr Val Tyr Gly Yar Phe Thr Ser Gln Gln Val Phe Thr Gly Val And Phe Thr T					245					250					255	
Ser. His Lys Ann His Clu Lys Arg Leu Pie	ту	r Glu	Phe	Glu 260	Thr	Val	Tyr	Gly	Lys 265	Ser	Ser	Trp	Ser	Gln 270	Val	Phe
Gin Ala Phe Gin Gin Leu Thr Giy Vai Asn Phe Jie Phe Tyr Tyr Giy Thr Thr Phe Phe Lyg Arg Ala Gly Vai Asn Giy Phe Thr IIe Ser Leu Jais Thr Asn IIe Vai Asn Vai Gly Ser Thr IIe Pro Gly IIe Leu Leu Jais Thr Asn IIe Vai Asn Vai Gly Ser Thr IIe Pro Gly Gly Ala Thr Gly Ala Thr Asn IIe Vai Cly Arg Arg An Met Leu Met Gly Gly Ala Thr Gly Met Gu Vai Leu Gly Arg Arg An Met Leu Met Gly Gly Ala Thr Gly Met Ser Leus Ser Gln Leu IIe Vai Ala IIe Vai Gly Vai An Thr Ser Glu Asn Asn Lys Ser Ser Gln Ser Vai Leu Vai Ala Phe Ser Cys IIe Jaro N Jaro Phe Ala Ala Thr Trp Gly Pro Cys Ala Trp Vai 400 Vai Gly Glu Leu Phe Pro Leu Arg Thr Arg Ala Lys Ser Vai Ser Vai 415 Cys Thr Ala Ser Asn Trp Leu Trp Asn Trp Gly IIe Ala Tyr Ala Thr 450 Phe IIe Trp Gly Gly Phe Asn Leu Ala Cys Vai Phe Phe Ala Trp Tyr 450 Phe He Trp Gly Gly Phe Asn Leu Ala Cys Vai Phe Phe Ala Trp Tyr 450 Phe He Ser Phe Alg Glu Asp Lys Ser Vai Ser Vai Ser Vai 450 Cys Thr Ala Ser Clu Glu Ala Trp Lys Ser Lys Gly Phe Vai Asp Ser Lys Thr 510 Glu Ala IIe Wet Ser Glu Glu Ala Ser Vai Ser Vai 510 Cys The Ser Phe Alg Glu Glu Ala Ser Vai Ser Vai 520 Cys Thr Ser Phe Alg Glu Glu Ala Ser Vai 520 Cys Thr Ser Phe Alg Glu Glu Ala Ser Vai 520 Cys The Her Ser Glu Glu Ala Ser Vai 520 Cys The Her Ser Glu Glu Ala Ser Vai 520 Cys The Her Ser Clu Glu Ala S	Se	r His	Lys 275	Asn	His	Gln	Leu	Lys 280	Arg	Leu	Phe	Thr	Gly 285	Val	Ala	Ile
The The Phe Lys Arg Ala Gly Val Asn Gly Phe The Ile Ser Leu 320 Ala The Asn Ile Val Asn Val Gly Ser The Ile Pro Gly Ile Leu Leu 325 Net Glu Val Leu Gly Arg Arg Asn Met Leu Met Gly Gly Ala The Gly 340 Ala The Ser Leu Ser Gln Leu Ile Val Ala Ile Val Gly Val Ala The Ser 365 Glu Asn Asn Lys Ser Ser Gln Ser Val Leu Val Ala Phe Ser Cys Ile 370 And Gly Glu Leu Phe Phe Ala Ala The Trp Gly Pro Cys Ala Trp Val Val 386 Phe Ile Ala Phe Phe Ala Ala The Trp Gly Pro Cys Ala Trp Val Val 400 Val Gly Glu Leu Phe Pro Leu Arg The Arg Ala Lys Ser Val Ser Leu 415 Cys The Ala Ser Asn Trp Leu Trp Asn Trp Gly Ile Ala Tyr Ala The 405 Phe Ile Trp Gly Gly Phe Asn Leu Ala Cys Val Phe Phe Ala Trp Try 440 Val Gly Glu Leu 405 Cys The Ala Ser Lys Ala Trp Leu Ser Leu Glu Gln Val Asp Glu Leu 405 Phe 1le Trp Gly Gly Phe Asn Leu Ala Cys Val Phe Phe Ala Trp Try 445 Phe Ile Trp Glu The Lys Gly Leu Ser Leu Glu Gln Val Asp Glu Leu 405 Cys The Ala Ser Lys Ala Trp Lys Ser Lys Gly Phe Val Pro Ser 485 Lys His Ser Phe Arg Glu Gln Val Asp Gln Gln Met Asp Ser Lys The 500 Solut Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu First Solut Ser Cys Ala Trp Lys 625 Val First 630 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 525 Clu Val NFTH: 496 Clu Chrotter: 496 Clu Chrotter: 496 Clu Chrotter Clu Chrots 5 Clu Chrotter Clu Chrots 5 Clu Lys Lys Ala Gly Ser The Ala Met Val Lys Arg Phe Val Asn Val Gly Leu Phe 40 Clu Lys Lys Ala Gly Ser The Ala 617 Try Asp Thr Gly Thr Ile Ser 35 Glu Ala Ala Ser Cly Gly Phe Ile Met Gly Tyr Asp Thr Gly Thr Ile Ser 35 Glu Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr Pro Ser Asn Lys 50 Cla Gly Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr For Ser Asn Lys 50 Cla Gly Thr Phe Phe Gly Ala Lys Cys Ala Pro Phe Leu Asn Asp Thr	Gl	n Ala 290	Phe	Gln	Gln	Leu	Thr 295	Gly	Val	Asn	Phe	Ile 300	Phe	Tyr	Tyr	Gly
Ala Thr An lle Val An Val Gly Se Int lle Pro Gly lle Leu $\frac{1}{325}$ Met Glu Val Leu Gly Arg Arg An Met Leu Met Gly Gly Ala Thr Gly $\frac{1}{350}$ Met Ser Leu Ser Gln Leu Ile Val Ala Ile Val Gly Vat Ala Thr Ser $\frac{3}{350}$ and $\frac{1}{350}$ Val Leu Val Ala Phe Ser Cyr Ile $\frac{3}{370}$ Ner Lyr Ser Ser Gln Ser Val Leu Val Ala Phe Ser Cyr Ile $\frac{3}{370}$ Ner Lyr Ser Ser Gln Ser Val Leu Val Ala Phe Ser Cyr Ile $\frac{3}{370}$ Ner Lyr Ser Ser Gln Ser Val Leu Val Ala Phe Ser Cyr Ile $\frac{3}{370}$ Ner Arg Ala Phe Phe Ala Ala Thr Tr Gly Pro Cyr Ala Tr Val Val 400 Val Gly Glu Leu Phe Pro Leu Arg Thr Arg Ala Lyr Ser Val Ser Leu $\frac{4}{405}$ Ner Tr Ala Ser Arg Tr Leu Tr An Tr Gly Ile Ala Tyr Ala Thr $\frac{4}{420}$ Ner Val Arg Glu Arg Lyr Gly Arg Leu Gly Gly Ser Val Ser Leu $\frac{4}{415}$ Ner Tr Mat Arg Glu Arg Lyr Gly Arg Leu Gly Gly Arg Leu Marg Arg Arg Arg Ner Val Phe Phe Ala Arg Cyr Gly Arg Leu Gly Gly Arg Leu $\frac{4}{450}$ Ner Val Phe $\frac{1}{450}$ Ner Val Arg Glu Arg Lyr Gly Arg Leu Gly Gly Arg Leu $\frac{1}{450}$ Arg Cu Leu $\frac{4}{450}$ Ner Val Arg Glu Arg Lyr Gly Arg Leu Glu Glu Val Arg Glu Leu $\frac{1}{450}$ Arg Cu Leu $\frac{1}{450}$ Arg Cu Thr Lyr Gly Leu Ser Leu Glu Glu Nal Arg Glu Leu $\frac{1}{450}$ Ner Val $\frac{1}{50}$ Ner Val	Th 30	r Thr 5	Phe	Phe	Lys	Arg 310	Ala	Gly	Val	Asn	Gly 315	Phe	Thr	Ile	Ser	Leu 320
Met Glu Val Leu Glu Val Arg Arg Arg Arg Jate Met Glu Val Jate The Glu Jate Jate Glu Val Jate The Jate	Al	a Thr	Asn	Ile	Val 325	Asn	Val	Gly	Ser	Thr 330	Ile	Pro	Gly	Ile	Leu 335	Leu
Met Ser Leu Ser Gln Leu Ile Val Ala Pie Sie Cys Ile Glu Asn Asn Lys Ser Gln Ser Val Leu Val Ala Pie Ser Cys Ile Pie Ile Ala Pie Pie Ala Pie Tr Gly Pie Val Val Val Ser Val Va	Me	t Glu	Val	Leu 340	Gly	Arg	Arg	Asn	Met 345	Leu	Met	Gly	Gly	Ala 350	Thr	Gly
Glu Asn Asn Lys Ser Ser Gln Ser Val Leu Val Ala Phe Ser Cys Ile 370 370 Asn Lys Ser Ser Gln Ser Val Leu Val Ala Phe Ser Cys Ile 380 375 Glu Ala Phe Phe Ala Ala Thr Trp Gly Pro Cys Ala Trp Val Val 380 375 Cys Ala Cys Val Ser Val Ser Leu 400 405 Cys Thr Ala Ser Asn Trp Leu Trp Asn Trp Gly Ile Ala Tyr Ala Thr 420 410 Cys Thr Ala Ser Asn Trp Leu Trp Asn Trp Gly Ile Ala Tyr Ala Thr 420 440 Asn Val Phe Pro Leu Arg Thr Arg Ala Lys Ser Val Ser Val Phe 70 Tyr Met Val Asp Glu Asp Lys Gly Asn Leu Gly Ser Asn Val Phe 445 440 Cys Val Phe Phe Ala Trp Tyr 450 440 Cys Cys ID NO 5 510 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 510 510 SEQ ID NO 5 521 SEQ ID NO 5 521 SEQ ID NO 5 521 SEQ ID NO 5 521 SEQ TID NO 5 521 SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 1 Glu Lys Lys Ala Gly Ser Thr Ala Met Ala Ile Ile Val Gly Leu Phe 20 SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Cal Lys Arg Phe Val Asn Val Gly 1 Glu Lys Lys Ala Gly Ser Thr Ala Met Ala Ile Ile Val Gly Leu Phe 30 Ala Ala Ser Gly Gly Phe Ile Met Gly Tyr Asp Thr Gly Thr Ile Ser 40 40 40 40 40 40 40 40 40 40	Me	t Ser	Leu 355	Ser	Gln	Leu	Ile	Val 360	Ala	Ile	Val	Gly	Val 365	Ala	Thr	Ser
Phe Ile Ala Phe Phe Ala Ala Thr Try Gly Pro Cys Ala Try Val Val 400 Val Gly Glu Leu Phe Pro Leu Arg Thr Arg Ala Lys Ser Val Ser Leu 415 Cys Thr Ala Ser Asn Try Leu Try Asn Try Gly Ile Ala Tyr Ala Thr 420 Try Met Val Asp Glu Asp Lys Gly Asn Leu Gly Ser Asn Val Phe 455 Phe Ile Try Glu Thr Lyg Gly Leu Ser Leu Glu Gln Val Asp Glu Leu 475 Phe Ile Try Glu Thr Lyg Gly Leu Ser Leu Glu Gln Val Asp Glu Leu 475 Tyr Glu His Val Ser Lys Ala Try Lys Ser Lys Gly Phe Val Phe Val Pro Ser 495 Lys His Ser Phe Arg Glu Gln Val Asp Gln Gln Met Asp Ser Lys Thr 500 Clu Ala Ile Met Ser Glu Glu Ala Ser Val 505 Clu SEQ ID NO 5 C2110 SEQ ID NO 5 C2110 SEQ ID NO 5 C2110 SEQ ID NO 5 C2110 SEQ UD NO 5 C2120 FEATURE: C2200 FEATURE: C2200 FEATURE: C2200 FEATURE: C2200 FEATURE: C2200 FEATURE: C2000 SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly Is In Concentration Structure for the tash of the form form form form form form form form	Gl	u Asn 370	Asn	Lys	Ser	Ser	Gln 375	Ser	Val	Leu	Val	Ala 380	Phe	Ser	Суз	Ile
Val Gly Glu Leu Phe Pro Leu Arg Thr Arg Ala Lys Ser Val Ser LugCys Thr Ala Ser Asn Trp Leu Trp Asn Trp Gly Ile Ala Tyr Ala Thr 425Cys Thr Ala Ser Asn Trp Leu Trp Asn Trp Gly Ile Ala Tyr Ala Thr 425Pro Tyr Met Val Asp Glu Asp Lys Gly Asn Leu Gly Ser Asn Val Phe 455Phe Ile Trp Gly Gly Phe Asn Leu Ala Cys Val Phe Phe Ala Trp Tyr 465Phe Ile Tyr Glu Thr Lys Gly Leu Ser Leu Glu Gln Val Asp Glu Leu 475Cyr Glu His Val Ser Lys Ala Trp Lys Ser Lys Gly Phe Val Pro Ser 485Cys His Ser Phe Arg Glu Glu Ala Ser Val 500Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll Ala Ile Met Ser Glu Glu Ala Ser Val 515Cyll SeQUENCE: 5Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 200Met Gly Leu Glu Asp Asn Arg Met Gly Tyr Asp Thr Gly Thr Ile Ser 30Glu Ala Ala Ser Gly Gly Phe Ile Met Gly Tyr Asp Thr Gly Thr Ile Ser 30Gly Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr Pro Ser Asn Lys 60Gly Val Met Thr Ala App Glu Ser Ser Leu Tie Val Asp Chi Leu Ser 70Gly Val Met Thr Ala App Glu Ser Ser Leu Tie Val Asp Tie Ker 70Kala Ala Ser Phe Thr Ala App Glu Ser Ser Leu Ala Arg Tyr Asp Thr Gly Thr Ile Ser 60Kala Ala Ker Thr Met Asp Tyr Val Leu Ala Arg Tyr Asp Thr Gly Chi Asp Asp 60Kala Ker Thr Ala App Glu Ser Ser Leu Tie Val Asp Asp Asp Asp 60Kala Ker Thr Ala App Glu Ser Ser Leu T	Ph 38	e Ile 5	Ala	Phe	Phe	Ala 390	Ala	Thr	Trp	Gly	Pro 395	Cys	Ala	Trp	Val	Val 400
CysThrAlaSerAsnTrpLeuTrpAsnTrpGlyIleAlaTypAlaThrProTyrMetValAspGluAspLysGlyAsnLeuGlySerAsnValPheAtoTrpGlyGlyPheAsnLeuAlaCysValPheAlaTrpTyrTyrPheIleTyrGluThrLysGlyLeuSerLeuGluGluAspGluLeu465TyrGluThrLysGlyLeuSerLysGluAspGluLeu465TyrGluThrLysGlyAlaTrpLysSerLysGlyPheAlaTrpTyr465TyrGluThrLysGluSerLysGluAspGluLeu465TyrGluThrLysGluGluAspGluLeuAspGluLeu465TyrGluGluSerPheAspGluLeuAspSerLysAspSerLys61uLisSerPheAspAspGluLisLysAspGlyLis </td <td>Va</td> <td>l Gly</td> <td>Glu</td> <td>Leu</td> <td>Phe 405</td> <td>Pro</td> <td>Leu</td> <td>Arg</td> <td>Thr</td> <td>Arg 410</td> <td>Ala</td> <td>Lys</td> <td>Ser</td> <td>Val</td> <td>Ser 415</td> <td>Leu</td>	Va	l Gly	Glu	Leu	Phe 405	Pro	Leu	Arg	Thr	Arg 410	Ala	Lys	Ser	Val	Ser 415	Leu
ProTyrMetValAspGluAspLayGlyAsnLeuGlySerAsnValPheHe11eTyrGlyGlyPheAsnLeuAlaCysValPhePheAlaTyrTyrPhe11eTyrGluThrLysGlyLeuSerLeuGluGluGluAspGluLeu465TyrGluHisValSerLysAlaTyrLysSerLysGlyPheValProSerTyrGluHisValSerLysAlaTyrLysSerLysGlyPheValProSerLysHisSerPheArgGluGluNalAspGluAspSerLysThrGluAla11eMetSerGluGluAlaSerValMetSerLysC210>SEQIDN05SerSerGluGluAspSerLysThrC210>SEQIDN05SerSerGluAspSerLysThrC210>SEQIDN05SerSerGluAspYasSerLysC210>SEQIDN0SerSerInLysAspYasNaYasYasC210>SEQIDN0	су	s Thr	Ala	Ser 420	Asn	Trp	Leu	Trp	Asn 425	Trp	Gly	Ile	Ala	Tyr 430	Ala	Thr
Phe IIe Trp Gly Gly Phe Asn Leu Ala Cys Val Phe Phe Ala Trp Tyr Phe IIe Tyr Glu Thr Lys Gly Leu Ser Leu Glu Gln Val Asp Glu Leu 465 I Glu His Val Ser Lys Ala Trp Lys Ser Lys Gly Phe Val Pro Ser 485 Van Asp Glu Gln Val Asp Gln Gln Met Asp Ser Lys Thr 505 Gln Gln Met Asp Ser Lys Thr 510 SEQ ID NO 5 2210> SEQ ID NO 5 2210> SEQ ID NO 5 2212> TYPE: PRT 2213> ORGANISM: Artificial sequence 2200> FEATURE: 2223> OTHER INFORMATION: Synthetic polypeptide 2400> SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 1 $\frac{1}{20}$ Seq Gly Gly Phe IIE Met Gly Tyr Asp Thr Gly Thr IIe Ser 400 $\frac{1}{20}$ Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr Pro Ser Asn Lys 61 $\frac{1}{20}$ Val Met Thr Met Asp Glu Ser Ser Leu IIe Val Ser IIe Leu Ser 25 $\frac{1}{20}$ Val Gly Thr Phe Phe Gly Ala Leu Cys Ala Pro Phe Leu Asn Asp Thr	Pr	o Tyr	Met 435	Val	Aap	Glu	Asp	Lys 440	Gly	Asn	Leu	Gly	Ser 445	Asn	Val	Phe
Phe lle Tyr Glu Thr Lys Gly Leu Ser Leu Glu Glu Nal Asp Glu Lys Ma Ser Lys Gly Phe Val Pro Ser $\frac{480}{490}$ Tyr Glu His Val Ser Lys Ala Trp Lys Ser Lys Gly Phe Val Pro Ser $\frac{490}{490}$ Lys His Ser Phe Arg Glu Glu Val Asp Glu Gln Met Asp Ser Lys Thr Glu Ala 11e Met Ser Glu Glu Ala Ser Val $\frac{2210}{515}$ SEQ ID NO 5 $\frac{2211}{223}$ DRGANISM: Artificial sequence $\frac{2220}{223}$ FEATURE: $\frac{2220}{223}$ ORGANISM: Artificial sequence $\frac{2200}{10}$ FEATURE: $\frac{2200}{2223}$ ORGANISM: Artificial sequence $\frac{2200}{10}$ FEATURE: $\frac{2200}{10}$ SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 15 Glu Lys Lys Ala Gly Ser Thr Ala Met Ala 11e 11e Val Gly Leu Phe $\frac{10}{30}$ Clu Phe Gly And Leu Ala Arg Tyr Pro Ser Asn Lys $\frac{10}{60}$ Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr Pro Ser Asn Lys $\frac{10}{60}$ Val Gly Thr Phe Phe Gly Ala Leu Cys Ala Pro Phe Leu Asn Asp Thr	Ph	e Ile 450	Trp	Gly	Gly	Phe	Asn 455	Leu	Ala	Сув	Val	Phe 460	Phe	Ala	Trp	Tyr
Tyr Glu His Val Ser Lys Ala Trp Lys Ser Lys Gly Phe Val Pro Ser App Ser Clys His Ser Phe Arg Glu Gln Val Asp Gln Gln Met Asp Ser Lys Thr $\frac{500}{500}$ SeQ Glu Glu Ala Ser Glu Glu Ala Ser Val $\frac{510}{520}$ SEQ ID NO 5 (211> LENGTH: 496 (212> TYPE: PRT (213> ORGANISM: Artificial sequence (220> FEATURE: (223> OTHER INFORMATION: Synthetic polypeptide) (400> SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 15 Glu Lys Lys Ala Gly Ser Thr Ala Met Ala IIe IIe Val Gly Leu Phe 20 Ala Ala Ser Gly Gly Phe IIe Met Gly Tyr Asp Thr Gly Thr IIe Ser 40 $\frac{510}{50}$ Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr Pro Ser Asn Lys 60 $\frac{510}{50}$ Val Gly Thr Phe Phe Gly Ala Leu Cys Ala Pro Phe Leu Asn Asp Thr	Ph 46	e Ile 5	Tyr	Glu	Thr	Lys 470	Gly	Leu	Ser	Leu	Glu 475	Gln	Val	Asp	Glu	Leu 480
Lys His Ser Phe Arg Glu Gln Val Asp Gln Gln Met Asp Ser Lys Thr Glu Ala Ile Met Ser Glu Glu Ala Ser Val 515 SEQ ID NO 5 521> LENGTH: 496 212> TYPE: PRT 213> ORGANISM: Artificial sequence 220> FEATURE: 223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 10 10 10 10 10 10 10 10 10 10 10 10 10 1	ту	r Glu	His	Val	Ser 485	Lys	Ala	Trp	Lys	Ser 490	Lys	Gly	Phe	Val	Pro 495	Ser
Glu Ala lie Met Ser Glu Glu Ala Ser Val 5210> SEQ ID NO 5 5211> LENGTH: 496 5212> TYPE: PRT 5213> ORGANISM: Artificial sequence 5200> FEATURE: 5223> OTHER INFORMATION: Synthetic polypeptide 5400> SEQUENCE: 5 Met Gly Leu Glu Asp Asn Arg Met Val Lys Arg Phe Val Asn Val Gly 10 Glu Lys Lys Ala Gly Ser Thr Ala Met Ala Ile Ile Val Gly Leu Phe 20 Ala Ala Ser Gly Gly Phe Ile Met Gly Tyr Asp Thr Gly Thr Ile Ser 61y Val Met Thr Met Asp Tyr Val Leu Ala Arg Tyr Pho Ser Asn Lys 61s Ser Phe Thr Ala Asp Glu Ser Ser Leu Ile Val Ser Ile Leu Ser 70 Val Gly Thr Phe Phe Gly Ala Leu Cys Ala Pro Phe Leu Asn Asp Thr	гу	s His	Ser	Phe 500	Arg	Glu	Gln	Val	Asp 505	Gln	Gln	Met	Asp	Ser 510	Lys	Thr
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MetGlyLeuGluAspAspAspMetValLysArgPheValAspValGlyGluLysLysAlaGlySerThrAlaMetAlaIleIleValGlyGlyPheAlaAspSerGlyGlyGlySerThrAlaMetAlaIleValGlyThrIleSerAlaAspSerClySerGlySerSerGlyThrMetAspTyrValAspTyrAspAlaArgTyrThrSerAspAspSerSerFibThrAlaAspGlySerSerFibAspAspGlySerSerFibSerIleAspThrValGlyThrPheFibGlyAlaLeuCysAlaProPheLeuAspThrValGlyThrPheFibAlaLeuCysAlaProPheLeuAspThrValGlyThrPheFibAlaLeuCysAlaProPheLeuAspThrSerSerPheFibFibAlaLeuCysAlaProPheLeuAspThrSerSerFibFibFibAlaLeuCysAlaProPheLeuAspTh	< 4	00> S	EQUEI	NCE:	5											
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AlaAsSerGlyGlyPheIleMetGlyTyrAspThrAspGlyThrIleSerGlyValMetThrMetAspTyrValLeuAlaArgTyrProSerAsnLysGlySerPheThrAlaAspGluSerSerLeuAlaArgThrNeSerLysHisSerPheThrAlaAspGluSerSerLeuThrNeSerSerValGlyThrPhePheGlyAlaLeuCysAlaProPheLeu AsnAspThr	Gl	u Lys	Lys	Ala 20	Gly	Ser	Thr	Ala	Met 25	Ala	Ile	Ile	Val	Gly 30	Leu	Phe
Gly Val Met Thr Met Asp 50Tyr Val Leu Ala Arg 55Tyr Pro Ser Asn Lys 60His 65Ser Phe Thr Ala 70Asp 61Glu Ser Ser Leu 75Ile 75Val Ser Ile Leu 80Val Gly Thr Phe Phe Gly Ala Leu Cys Ala Pro Phe Leu Asn Asp Thr	Al	a Ala	Ser 35	Gly	Gly	Phe	Ile	Met 40	Gly	Tyr	Asp	Thr	Gly 45	Thr	Ile	Ser
His Ser Phe Thr Ala Asp Glu Ser Ser Leu Ile Val Ser Ile Leu Ser 65 70 75 80 Val Gly Thr Phe Phe Gly Ala Leu Cvs Ala Pro Phe Leu Asn Asp Thr	Gl	y Val 50	Met	Thr	Met	Aap	Tyr 55	Val	Leu	Ala	Arg	Tyr 60	Pro	Ser	Asn	Lys
Val Gly Thr Phe Phe Gly Ala Leu Cvs Ala Pro Phe Leu Asn Asp Thr	Ні 65	s Ser	Phe	Thr	Ala	Asp 70	Glu	Ser	Ser	Leu	Ile 75	Val	Ser	Ile	Leu	Ser 80
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143

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Thr Val Val Ala Thr Leu Gly Phe Ser Leu Phe Gly Tyr Asp Gln Gly

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Leu Val Ile Leu Phe Ala Ser Leu Gly Gly Leu Leu Phe Gly Tyr Asp

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20 25 30 Gln Gly Val Ile Ser Gly Ile Val Thr Met Glu Ser Phe Gly Ala Lys 35 40 45 Phe Pro Arg Ile Phe Met 50 <210> SEQ ID NO 78 <211> LENGTH: 54 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 78 Ser Lys Gly Asn Ile Ile Thr Val Met Ser Lys Asp Pro Leu Val Phe 1 5 10 15 Cys Ile Ile Ala Phe Ala Ser Ile Gly Gly Leu Leu Phe Gly Tyr Asp 25 20 30 Gln Gly Val Ile Ser Gly Ile Val Thr Met Glu Ser Phe Ala Ala Lys 35 40 45 Phe Pro Arg Ile Phe Ser 50 <210> SEO ID NO 79 <211> LENGTH: 57 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 79 Pro Ile Glu Ile Pro Lys Lys Pro Met Ser Glu Tyr Val Thr Val Ser 1 5 10 15 Leu Leu Cys Leu Cys Val Ala Phe Gly Gly Phe Met Phe Gly Trp Asp 20 25 30 Thr Gly Thr Ile Ser Gly Phe Val Val Gln Thr Asp Phe Leu Arg Arg 35 40 45 Phe Gly Met Lys His Lys Asp Gly Thr 50 55 <210> SEQ ID NO 80 <211> LENGTH: 58 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 80 Glu Val Val Pro Glu Lys Pro Ala Ser Ala Tyr Ala Thr Val Ser 5 10 15 1 Ile Met Cys Leu Cys Met Ala Phe Gly Gly Phe Met Ser Gly Trp Asp 20 25 30 Thr Gly Thr Ile Ser Gly Phe Val Asn Gln Thr Asp Phe Leu Arg Arg 40 45 35 Phe Gly Asn Tyr Ser His Ser Lys Asn Thr 50 55 <210> SEQ ID NO 81 <211> LENGTH: 57

<212> TYPE: PRT <213> ORGANISM: Artificial sequence

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Phe Gly Gln Lys Asn Asp Lys Gly Thr 50 55 <210> SEQ ID NO 85 <211> LENGTH: 57 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 85 Asn Ala Glu Leu Pro Ala Lys Pro Ile Ala Ala Tyr Trp Thr Val Ile 1 5 10 Cys Leu Cys Leu Met Ile Ala Phe Gly Gly Phe Val Phe Gly Trp Asp 25 20 30 Thr Gly Thr Ile Ser Gly Phe Val Asn Gln Thr Asp Phe Lys Arg Arg 35 40 45 Phe Gly Gln Met Lys Ser Asp Gly Thr 50 55 <210> SEQ ID NO 86 <211> LENGTH: 57 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 86 Ser Leu Asp Ile Pro Tyr Lys Pro Ile Ile Ala Tyr Trp Thr Val Met 1 5 10 15 Gly Leu Cys Leu Met Ile Ala Phe Gly Gly Phe Ile Phe Gly Trp Asp 20 25 30 Thr Gly Thr Ile Ser Gly Phe Ile Asn Gln Thr Asp Phe Lys Arg Arg 35 40 45 Phe Gly Glu Leu Gln Arg Asp Gly Ser 50 55 <210> SEQ ID NO 87 <211> LENGTH: 57 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 87 Gln Val Asp Ala Pro Gln Lys Gly Phe Lys Asp Tyr Ile Val Ile Ser 10 1 5 15 Ile Phe Cys Phe Met Val Ala Phe Gly Gly Phe Val Phe Gly Phe Asp 20 25 30 Thr Gly Thr Ile Ser Gly Phe Val Asn Met Ser Asp Phe Lys Asp Arg 35 40 45 Phe Gly Gln His His Ala Asp Gly Thr 50 55 <210> SEQ ID NO 88 <211> LENGTH: 58 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 88

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<212> TYPE: PRT

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<400> SEQUENCE: 99

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<210> SEQ ID NO 100 <211> LENGTH: 41 <212> TYPE: PRT

<400> SEQUENCE: 100

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<220> FEATURE:

<210> SEQ ID NO 101 <211> LENGTH: 52 <212> TYPE: PRT

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<220> FEATURE:

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<213> ORGANISM: Artificial sequence <223> OTHER INFORMATION: Synthetic polypeptide Ile Ile Asn Arg Gly Glu Lys Pro Glu Gly Ser Ala Phe Met Ala Ala 10 15 Phe Val Ala Val Phe Val Ala Phe Gly Gly Ile Leu Phe Gly Tyr Asp 25 30 Thr Gly Thr Ile Ser Gly Val Met Ala Met Pro Phe Val Lys Lys Thr 40 45 <213> ORGANISM: Artificial sequence <223> OTHER INFORMATION: Synthetic polypeptide Met Ala Ile Ile Val Ala Val Phe Val Ala Phe Gly Gly Leu Leu Tyr 10 15 Gly Tyr Asp Thr Gly Thr Ile Ala Gly Ile Met Thr Met Gly Tyr Val 25 30 Lys Phe His Phe Thr Asp Phe Gly Lys 40 <213> ORGANISM: Artificial sequence <223> OTHER INFORMATION: Synthetic polypeptide Tyr Tyr Lys Lys Met Gln Gln Lys Ser Ser Ser Ser Ser Ala Ile Thr 10 15 Val Gly Leu Val Ala Ala Val Gly Gly Phe Leu Tyr Gly Tyr Asp Thr 25 30

Gly Leu Ile Asn Asp Ile Met Phe Met Thr Tyr Val Lys Asp Asn Phe 40 35

Pro Ala Asn Gly 50

<210> SEQ ID NO 102 <211> LENGTH: 54 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 102 Met Asn Thr Gln Tyr Asn Ser Ser Tyr Ile Phe Ser Ile Thr Leu Val 15 1 5 10 Ala Thr Leu Gly Gly Leu Leu Phe Gly Tyr Asp Thr Ala Val Ile Ser 20 25 30 Gly Thr Val Glu Ser Leu His Thr Val Phe Val Ala Pro Gln Asn Leu 35 40 45 Ser Glu Ser Ala Ala Asn

50

<210> SEQ ID NO 103 <211> LENGTH: 50 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 103 Arg Ser Ile Gly Pro Leu Ile Pro Arg Asn Lys His Leu Phe Tyr Gly 1 5 10 15 Ser Val Leu Met Ser Ile Val His Pro Thr Ile Met Gly Tyr Asp 20 25 Ser Met Met Val Gly Ser Ile Leu Asn Leu Asp Ala Tyr Val Asn Tyr 35 40 Phe His 50 <210> SEQ ID NO 104 <211> LENGTH: 57 <212> TYPE: PRT <213> ORGANISM: Artificial sequence <220> FEATURE: <223> OTHER INFORMATION: Synthetic polypeptide <400> SEQUENCE: 104 Lys Ser Met Thr Leu Lys Gln Ala Leu Leu Lys Tyr Pro
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Gly Gly Leu Val Tyr Gly 1 5

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What is claimed is:

1. A recombinant xylose transporter protein comprising a xylose transporter motif sequence and at least one glucose mitigation mutation; wherein said xylose transporter motif sequence corresponds to amino acid residue positions 36, 5 37, 38, 39, 40, and 41 of SEQ ID NO: 1, and wherein the xylose transporter motif comprises the sequence -G-G/F- $X^1-X^2-X^3-G$ -;

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wherein,

X¹ is D, C, G, H, I, L, or F;

 X^2 is A, D, C, E, G, H, or I; and

X³ is N, C, Q, F, G, L, M, S, T, or P;

and further wherein said glucose mitigation mutation is at a position corresponding to N326, T170, I171, K155, N225, S354, A361, L407, and/or N446 of SEQ ID NO: 1 wherein the xylose transporter protein is at least 95% identical to the ¹⁵ sequence of SEQ ID NO: 1 and has xylose transporter protein activity.

2. The recombinant xylose transporter protein of claim **1**, wherein said xylose transporter motif sequence is G-G-F-I-M-G- (SEQ ID NO:107), -G-F-F-I-M-G- (SEQ ID NO:108), 20 -G-G-F-I-S-G- (SEQ ID NO:109), or -G-F-F-I-S-G- (SEQ ID NO: 110).

3. The recombinant xylose transporter protein of claim **1**, wherein said glucose mitigation mutation is a N326H mutation.

4. The recombinant xylose transporter protein of claim **1**, wherein said glucose mitigation mutation is a N326S mutation.

5. The recombinant xylose transporter protein of claim **1** further comprising an amino acid deletion.

6. The recombinant xylose transporter protein of claim 5, wherein said deletion is within a protein domain corresponding to residue 497-522 of SEQ ID NO: 1.

7. A recombinant yeast cell comprising a recombinant xylose transporter protein of claim 1.

8. The recombinant yeast cell of claim 7, wherein the growth rate of said recombinant yeast cell in a xylose-glucose growth media is at least about 50% of the growth rate of said recombinant yeast cell in a xylose growth media.

9. A nucleic acid encoding the recombinant xylose transporter protein of claim **1**.

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