

MediumFBA – A MATLAB Application for Integrated Medium Design and Flux Balance Analysis

MATLAB App

MediumFBA - Integrated Medium Design and Flux Balance Analysis for Genome-Scale Metabolic Models

1 - Select Models

Model Folder:

Model List:

Model	Number	Genes	Metabolites
Escherichia_coli_str_K_12_substr_MG1655	1	1190	1348
Haemophilus_influenzae_R2846	2	675	1084
Prevotella_melaninogenica_ATCC_25845	3	540	938
Pseudomonas_aeruginosa_NCGM2_S1	4	1234	1297

Panel 1 Status:

3 - Define Medium Design Constraints

Constrained Nutrient List:

Filter Constrained Nutrients:

Included Nutrient	Uptake Bound	Strains Transporter
Ornithine	-0.5000	1 2 3 4 5
Sodium	-1000	1 2 3 4
Water	-1000	1 2 3 4 5
Zinc	-1000	1 2 3 4 5
calcium(2+)	-1000	1 2 3 4 5
hydrogenphosphate	-1000	1 2 3 4 5
mannesium	-1000	1 2 3 4 5

Excluded Nutrient	Uptake Bound	Strains Transporter
NMN	0	1 2 4 5
Putrescine	0	1 2 3 4 5

Panel 3 Status:

5 - Refine Growth Medium

Refined Medium List:

Refined Nutrient List:

Filter Refined Nutrients:

Refined Nutrient	Uptake Bound	Strains Transporter
L-tryptophan	-0.5000	1 2 3 4
L-tyrosine	-0.5000	1 2 3 4 5
L-valine	-0.5000	1 2 3 4 5
Menaquinone 8	-1000	3 5
Mn2+	-1000	1 2 3 4 5
Nicotinate	-1000	1 2 3 4 5
O2	-1	1 2 3 4 5
Ornithine	-0.5000	1 2 3 4 5

Refined File:

Panel 5 Status:

2 - Define Core Medium

Medium Folder:

Core Medium List:

Core Nutrient List:

Filter Core Nutrients:

Core Nutrient	Uptake Bound	Strains Transporter
Cu2+	-1000	1 2 3 4 5
Fe2+	-1000	1 2 3 4 5
Fe3+	-1000	1 2 3 4 5
Glycine	-0.5000	1 2 3 4 5
L-alanine	-0.5000	1 2 3 4 5
L-argininium(1+)	-0.5000	1 2 3 4 5
L-phenylalanine	-0.5000	1 2 3 4 5

Core File:

Panel 2 Status:

4 - Design Growth Medium

LP Solver: Force Full Medium Design

Minimum Allowable Growth Rate:

Design Models:

Growth Nutrient	Strain 1	Strain 2	Strain 3	Strain 4	Strain 5
Growth rate	0.7038	0.4831	0.5801	0.6928	0.8181
Ammonium	4.2020	0.7757	2.8650	3.7919	3.1045
Chloride	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Co2+	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Cu2+	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
D-glucose	-5.0000	-4.6033	-5.0000	-5.0000	-5.0000

Growth File:

Panel 4 Status:

6 - Simulate Refined Medium

Simulation Name:

Simulation List:

Simulation Model:

Plot	Nutrient or Product	Strain 1	Strain 2	Strain 3	Strain 5
<input type="checkbox"/>	tetradecanoate (n-C14:0)	0	-0.0322	-0.0320	-0
<input type="checkbox"/>	uracil	-0.0875	-0.0445	-0.0442	-0
<input checked="" type="checkbox"/>	acetate	8.0110	5.0132	3.8147	6.
<input checked="" type="checkbox"/>	Produced biomass	0.2981	0.2148	0.2135	0.
<input checked="" type="checkbox"/>	carbon dioxide	0	2.0969	0.2784	10.
<input checked="" type="checkbox"/>	Formate	13.1831	5.6687	4.4715	0
<input type="checkbox"/>	glycolaldehyde	0	0	0.0020	0
<input type="checkbox"/>	Glycerol	0	0	0.0068	0

Panel 6 Status:

7 - Manage Case

Case Folder:

Results File:

State File:

Panel 7 Status:

1. Select metabolic models for strains of interest. The designed medium will ensure monoculture growth of all selected strains. Here we selected five bacteria commonly associated with cystic fibrosis airway infections.

1 - Select Models

Model Folder:

Model List:

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Pseudomonas_aeruginosa_NCGM2_S1	4	1234	1297

Panel 1 Status:

2. Define core nutrients contained in the desired medium. The core nutrients are common components included in a putative in vitro medium. Here we included common inorganic salt ions and all 20 amino acids.

2 - Define Core Medium

Medium Folder:

Core Medium List:

Core Nutrient List:

Filter Core Nutrients:

Core Nutrient	Uptake Bound	Strains Transporter
Cu2+	-1000	1 2 3 4 5
Fe2+	-1000	1 2 3 4 5
Fe3+	-1000	1 2 3 4 5
Glycine	-0.5000	1 2 3 4 5
L-alanine	-0.5000	1 2 3 4 5
L-argininium(1+)	-0.5000	1 2 3 4 5
L-phenylalanine	-0.5000	1 2 3 4 5

Core File:

Panel 2 Status:

3 - Define Medium Design Constraints

Constrained Nutrient List:

Filter Constrained Nutrients:

Included Nutrient	Uptake Bound	Strains Transporter

Excluded Nutrient	Uptake Bound	Strains Transporter

Panel 3 Status:

4 - Design Growth Medium

LP Solver: Force Full Medium Design

Minimum Allowable Growth Rate:

Design Models:

Growth File:

Panel 4 Status:

7 - Manage Case

Case Folder:

Results File:

State File:

Panel 7 Status:

3. Impose constraints on the medium design solution. Nutrients can be included with specified uptake bounds or excluded entirely. Here we included glucose and oxygen and excluded unusual nutrients identified by the design algorithm so they can be replaced.

4. Design growth medium by ensuring monoculture growth of all strains. The minimum growth rate and full/partial medium design can be specified. Here the constraints were altered in an iterative manner to generate a desirable set of growth nutrients.

MATLAB App

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Model List:

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Pseudomonas_aeruginosa_NCGM2_S1	4	1234	1297

Panel 1 Status:

2 - Define Core Medium

Medium Folder:

Core Medium List:

Core Nutrient List:

Filter Core Nutrients:

Core Nutrient	Uptake Bound	Strains Transporter
Cu2+	-1000	1 2 3 4 5
Fe2+	-1000	1 2 3 4 5
Fe3+	-1000	1 2 3 4 5
Glycine	-0.5000	1 2 3 4 5
L-alanine	-0.5000	1 2 3 4 5
L-argininium(1+)	-0.5000	1 2 3 4 5
L-arginine	-0.5000	1 2 3 4 5

Core File:

Panel 2 Status:

7 - Manage Case

Case Folder:

Results File:

State File:

Panel 7 Status:

3 - Define Medium Design Constraints

Constrained Nutrient List:

Filter Constrained Nutrients:

Included Nutrient	Uptake Bound	Strains Transporter
Ornithine	-0.5000	1 2 3 4 5
Sodium	-1000	1 2 3 4
Water	-1000	1 2 3 4 5
Zinc	-1000	1 2 3 4 5
calcium(2+)	-1000	1 2 3 4 5
hydrogenphosphate	-1000	1 2 3 4 5
magnesium	-1000	1 2 3 4 5

Excluded Nutrient	Uptake Bound	Strains Transporter
NMN	0	1 2 4 5
Putrescine	0	1 2 3 4 5

Panel 3 Status:

4 - Design Growth Medium

LP Solver: Force Full Medium Design

Minimum Allowable Growth Rate:

Design Models:

Growth Nutrient	Strain 1	Strain 2	Strain 3	Strain 4	Strain 5
Growth rate	0.7038	0.4831	0.5801	0.6928	0.8181
Ammonium	4.2020	0.7757	2.8650	3.7919	3.1045
Chloride	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Co2+	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Cu2+	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
D-glucose	-5.0000	-4.6033	-5.0000	-5.0000	-5.0000

Growth File:

Panel 4 Status:

Core Nutrients Specified

Ammonium
Chloride
Co²⁺
Cu²⁺
Fe²⁺
Fe³⁺
Mn²⁺
Sodium
Water
Zinc
Calcium(2+)
Hydrogenphosphate
Magnesium
Potassium
Proton
Sulfate

Bounded Nutrients Included

Specified

Glucose
Oxygen
All 20 amino acids

Identified

L-cysteinylglycine
Ornithine
Uracil

Unbounded Nutrients Identified

(R)-Pantothenate
2-Demethylmenaquinone 8
4-hydroxybenzoate
Folate
Menaquinone 8
Nicotinate
Oxidized glutathione
Protoheme
Pyridoxine
Riboflavin
Siroheme
Spermidine
Thiamin
Ubiquinone-8
Meso-2,6-Diaminoheptanedioate
Octadecanoate (n-C18:0)
Tetradecanoate (n-C14:0)

Analysis for Genome-Scale Metabolic Models

3 - Define Medium Design Constraints

Unconstrained Nutrient List: Ornithine

For Constrained Nutrients:

Unconstrained Nutrient	Uptake Bound	Strains Transporter
Ornithine	-0.5000	1 2 3 4 5
Glucose	-1000	1 2 3 4
Glucose	-1000	1 2 3 4 5
Glucose	-1000	1 2 3 4 5
Glucose(2+)	-1000	1 2 3 4 5
Inorganic phosphate	-1000	1 2 3 4 5
Ammonium	-1000	1 2 3 4 5

Constrained Nutrient	Uptake Bound	Strains Transporter
Glucose	0	1 2 4 5
Glucose	0	1 2 3 4 5

Panel 3 Status:

4 - Design Growth Medium

LP Solver: gurobi Force Full Medium Design

Minimum Allowable Growth Rate:

Design Models: Escherichia_coli_str_K_12_substr_MG1655

Growth Nutrient	Strain 1	Strain 2	Strain 3	Strain 4	Strain 5
Growth rate	0.7038	0.4831	0.5801	0.6928	0.8181
Ammonium	4.2020	0.7757	2.8650	3.7919	3.1045
Urea	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Glucose	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Glucose	-0.0055	-0.0015	-0.0018	-0.0021	-0.0065
Glucose	-5.0000	-4.6033	-5.0000	-5.0000	-5.0000

Growth File:

Panel 4 Status:

In Silico Fermentation

5 - Refine Growth Medium

Refined Medium List:

Refined Nutrient List: O2

Filter Refined Nutrients:

Refined Nutrient	Uptake Bound	Strains Transporter
L-tryptophan	-0.5000	1 2 3 4
L-tyrosine	-0.5000	1 2 3 4 5
L-valine	-0.5000	1 2 3 4 5
Menaquinone 8	-1000	3 5
Mn2+	-1000	1 2 3 4 5
Nicotinate	-1000	1 2 3 4 5
O2	-1	1 2 3 4 5
Ornithine	-0.5000	1 2 3 4 5

Refined File:

Panel 5 Status:

6 - Simulate Refined Medium

Simulation Name: reduced_glucose_oxygen

Simulation List: reduced_glucose_oxygen

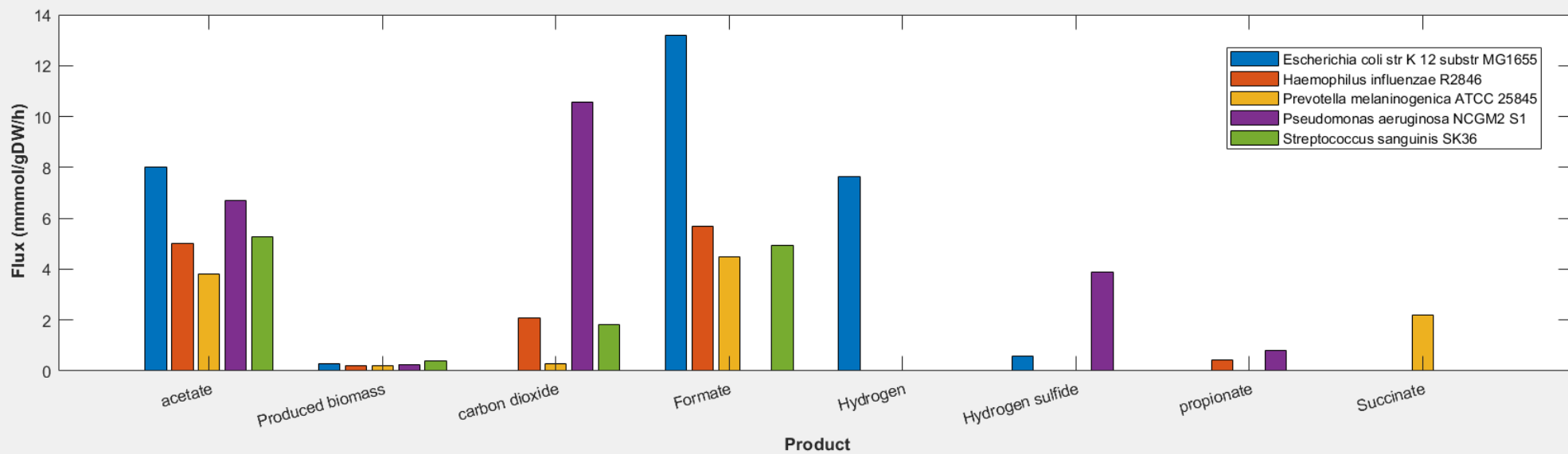
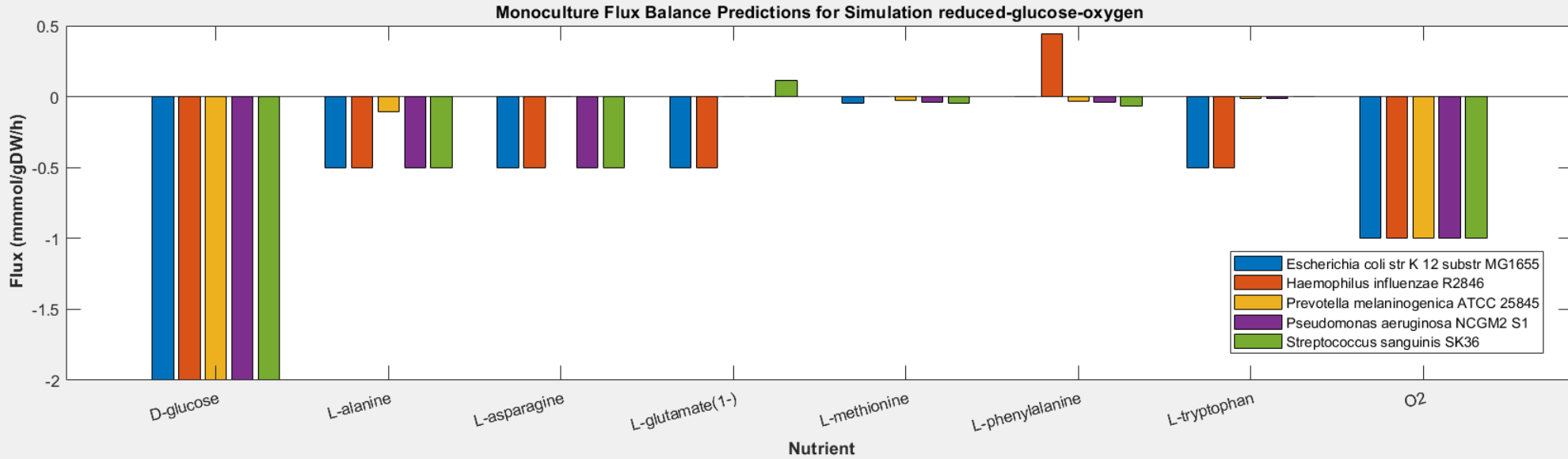
Simulation Model: Escherichia_coli_str_K_12_substr_MG1655

Plot	Nutrient or Product	Strain 1	Strain 2	Strain 3	Strain 5
<input type="checkbox"/>	tetradecanoate (n-C14:0)	0	-0.0322	-0.0320	-0.0320
<input type="checkbox"/>	uracil	-0.0875	-0.0445	-0.0442	-0.0442
<input checked="" type="checkbox"/>	acetate	8.0110	5.0132	3.8147	6.0110
<input checked="" type="checkbox"/>	Produced biomass	0.2981	0.2148	0.2135	0.2981
<input checked="" type="checkbox"/>	carbon dioxide	0	2.0969	0.2784	1.0969
<input checked="" type="checkbox"/>	Formate	13.1831	5.6687	4.4715	13.1831
<input type="checkbox"/>	glycolaldehyde	0	0	0.0020	0.0020
<input type="checkbox"/>	Glycerol	0	0	0.0068	0.0068

Panel 6 Status:

5. Refine growth medium by changing uptake bounds of essential nutrients and adding non-essential nutrients. Multiple refined media can be formulated and simulated. Here we modify the designed medium by reducing glucose and oxygen uptakes.

6. Simulate monoculture growth for current refined medium. Multiple FBA solutions can be stored, plotted and later recalled. Here we simulate and plot selected fluxes for reduced glucose and oxygen uptakes.



7. Manage case by saving FBA simulation results and saving App states for later loading. The saved results can be used outside the App for additional MATLAB analysis. Here we save the current results and App state containing FBA simulations for the designed growth medium and one refined medium.

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Panel 1 Status:

2 - Define Core Medium

Medium Folder:

Core Medium List:

Core Nutrient List:

Filter Core Nutrients:

Core Nutrient	Uptake Bound	Strains Transporter
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Fe2+	-1000	1 2 3 4 5
Fe3+	-1000	1 2 3 4 5
Glycine	-0.5000	1 2 3 4 5
L-alanine	-0.5000	1 2 3 4 5
L-argininium(1+)	-0.5000	1 2 3 4 5
L-lysine	-0.5000	1 2 3 4 5

Core File:

Panel 2 Status:

3 - Define Medium Design Constraints

Constrained Nutrient List:

Filter Constrained Nutrients:

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Sodium	-1000	1 2 3 4
Water	-1000	1 2 3 4 5
Zinc	-1000	1 2 3 4 5
calcium(2+)	-1000	1 2 3 4 5
hydrogenphosphate	-1000	1 2 3 4 5
magnesium	-1000	1 2 3 4 5

Excluded Nutrient	Uptake Bound	Strains Transporter
NMN	0	1 2 4 5
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Panel 3 Status:

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LP Solver: Force Full Medium Design

Minimum Allowable Growth Rate:

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D-glucose	-5.0000	-4.6033	-5.0000	-5.0000	-5.0000

Growth File:

Panel 4 Status:

7 - Manage Case

Case Folder:

Results File:

State File:

Panel 7 Status: