Eriocheir sinensis Optimal Nutritional Requirements Prediction Base on Genome-scale Metabolic Network

（Registration Number: 16829873）

Tong Hao[1], Yifei Gou[1], Lingxuan Zhao[1], Jingjing Li[2], Jinsheng Sun[1]*

[1] Tianjin Key Laboratory of Animal and Plant Resistance / College of Life Sciences, Tianjin Normal University, Tianjin, China

[2] Tianjin Fisheries Research Institute, Tianjin, China

* Correspondence: Jinsheng Sun, skysjs@tjnu.edu.cn

Abstract

Objectives： *Eriocheir sinensis* is an important economic variety of artificial large-scale breeding because of its delicious, nutritious and high economic value. This work aims to construct a genome-scale metabolic network (GSMN) of *E. sinensis* and use it to predict the optimal nutritional requirements for the growth of *E. sinensis*. The results can provide reference for the improvement of crab feeds.

Methods: Based on the multi-organ transcriptome data, a GSMN of *E. sinensis* was constructed combined with KEGG database, literature and experimental data. Flux balance analysis was used to predict the optimal nutritional requirements. Based on the predictions, suggestions were proposed to improve the feed proportioning of *E. sinensis*.

Results/findings: The GSMN contains 4665 unigenes, 2062 reactions and 1893 metabolites. The simulation results showed that arginine, methionine, histidine and phenylalanine have more active metabolism in *E. sinensis*. It is suggested that the amount of these essential amino acids should be appropriately higher than other amino acids in feed to ensure the amino acid metabolism of *E. sinensis*. Based on the simulation of lipids, the amount of linoleic acid, EPA and DHA should be increased in feed to ensure the essential fatty acids for the growth of *E. sinensis*. In addition, the amount of zinc and selenium in feed should be properly increased to ensure the basic metabolism and growth demand of *E. sinensis*.

Conclusions: This paper predicted the optimal nutritional requirements of *E. sinensis* with a GSMN and provides suggestions for crab feed proportion, which is of great significance to improve the yield and cultivation of *E. sinensis*.

Model Construction

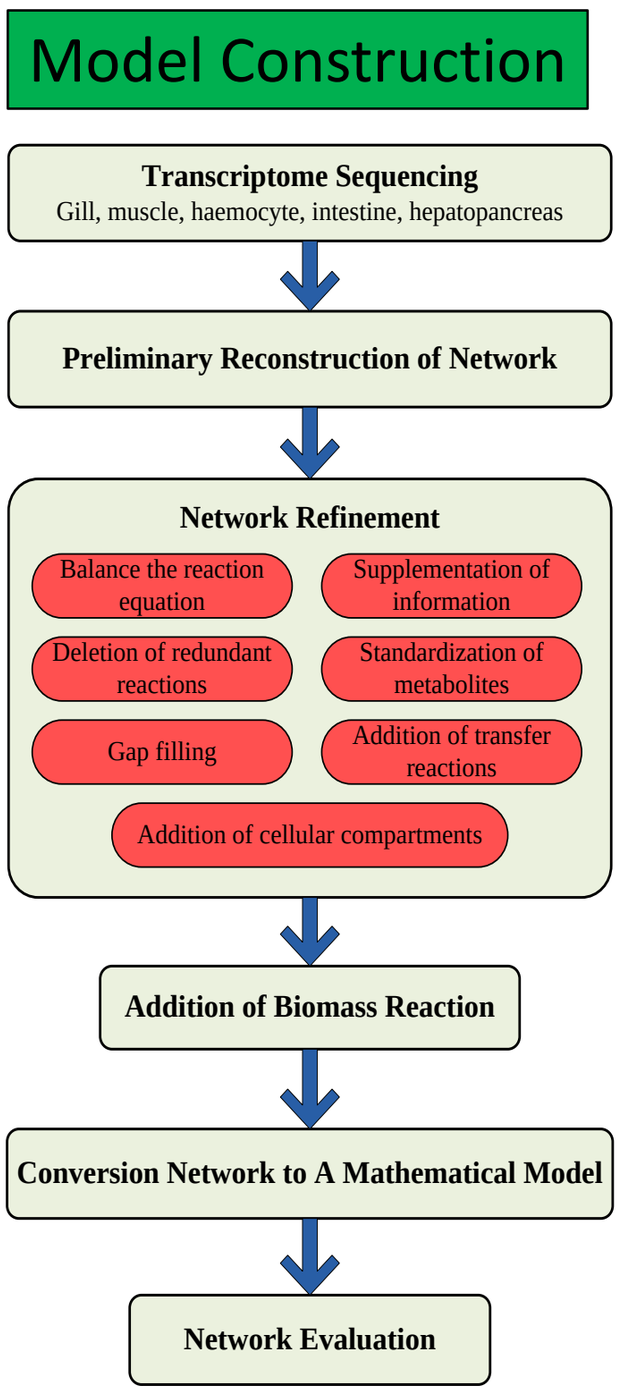

Table 1. Features of *E.sinensis* GSMN

Item	Count
Unigenes	**4,665**
Reactions	**2,060**
metabolic reactions	**1,897**
transport reactions	**81**
exchange reactions	**81**
Biomass reaction	**1**
Metabolites	**1,893**
cytosol metabolites	**1,810**
extracellular metabolites	**83**
Gene-reaction relationship	**1,685**
Pathways	**113**
Subsystems	**12**

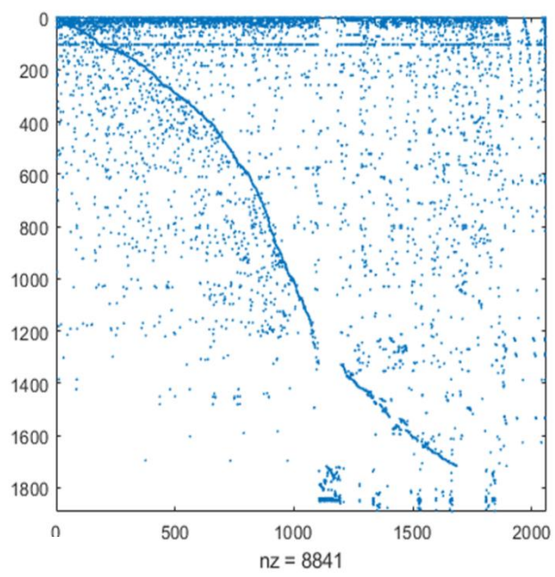

Figure 1. Visualization of stoichiometric matrix

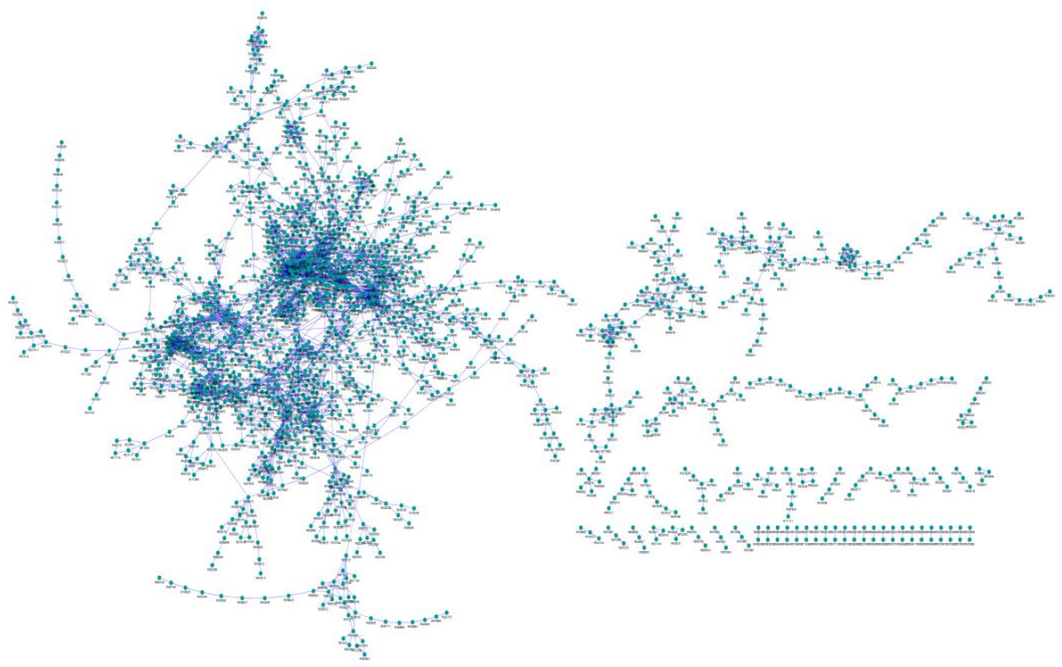

Figure 2. GSMN of *E. sinensis*

```
S: [1893×2062 double]
mets: {1893×1 cell}
b: [1893×1 double]
csense: [1893×1 char]
rxns: {2062×1 cell}
lb: [2062×1 double]
ub: [2062×1 double]
c: [2062×1 double]
osenseStr: 'max'
genes: {4665×1 cell}
rules: {2062×1 cell}
compNames: {2×1 cell}
comps: {2×1 cell}
metFormulas: {1893×1 cell}
metNames: {1893×1 cell}
grRules: {2062×1 cell}
rxnGeneMat: [2062×4665 double]
rxnConfidenceScores: [2062×1 double]
rxnNames: {2062×1 cell}
rxnECNumbers: {2062×1 cell}
subSystems: {2062×1 cell}
description: 'model2020a.xlsx'
```

Figure 3. Matrix of *E. sinensis* GSMN

Optimal Nutritional Requirements Prediction

Table 2. Requirements of Essential amino acid by *E. sinensis* in literature and simulation results

Essential amino acid	Demand in literature	Demand in $mmolgDW^{-1}h^{-1}$	simulation results	Deposition rate
Arginine	3.62g/100g feed	0.2078	0.07	34%
Lysine	2.34g/100g feed	0.1601	0.0664	53%
Methionine	1.12g/100g feed	0.0751	0.0249	29%
Leucine	2.36g/100g feed	0.1799	0.104	58%
Isoleucine	2.25g/100g feed	0.1715	0.0504	41%
Histidine	0.864%	0.0557	0.0293	33%
Phenylalanine	1.963%.	0.1188	0.0363	31%
Threonine	1.59%	0.1335	5	-
Tryptophan	0.182%	0.0089	0.0071	80%
Valine	1.504%	0.1284	0.0723	56%

- The amount of arginine, methionine, histidine and phenylalanine in the feed should be appropriately higher than other amino acids to fulfill the requirement of *E. sinensis*
- Addition of linoleic acid, EPA and DHA in feed should be considered to promote the growth of *E. sinensis*.
- The feed addition of zinc and selenium can be slightly increased

Table 3. Requirements of Essential fatty acids by *E. sinensis* in literature and simulation results

Essential fatty acids	Demand in literature	Demand in $mmolgDW^{-1}h^{-1}$	simulation results
linoleic acid	2.79%	0.0995	0.5835
linolenic acid	0.95%	0.0341	-4.567/0.0024
EPA	0.25%	0.0083	0.069
DHA	0.53%	0.0161	0.0314

Table 4. Requirements of mineral element s by *E. sinensis* in literature and simulation

Mineral elements	Mineral elements source	Demand in literature	Demand in $mmolgDW^{-1}h^{-1}$	simulation results
Calcium	Carbonate	2.9%	0.2897	0.0437
Magnesium	L-aspartate	3.76g/kg feed	0.0239	0.0233
Zinc	Methionine zinc	20mg/kg feed	0.0003	0.0005
Selenium	Yeast selenium	0.59mg/kg feed	0.000007	0.00001
Copper	sulphate	24.66mg/kg feed	0.0004	0.0003