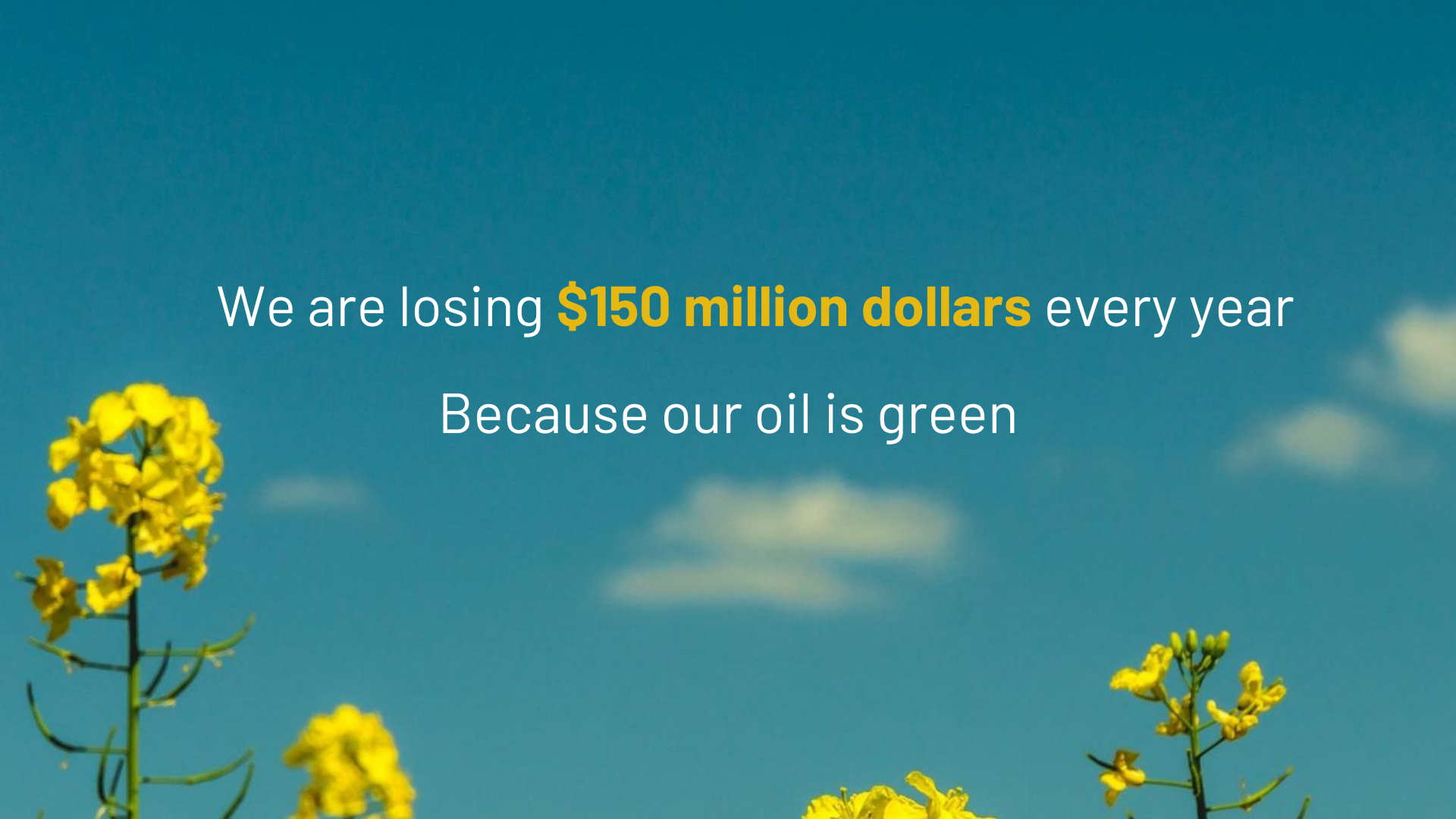
iGEM 2019 Calgary

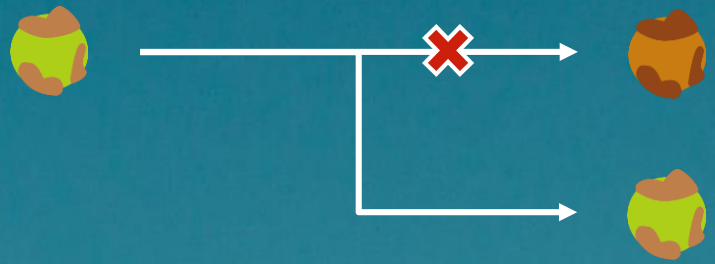
yOIL

An all-encompassing solution to the green seed problem


Canada is the world's largest producer and exporter of canola oil


We are losing **$150 million dollars** every year
Because our oil is green

The Green Seed Problem



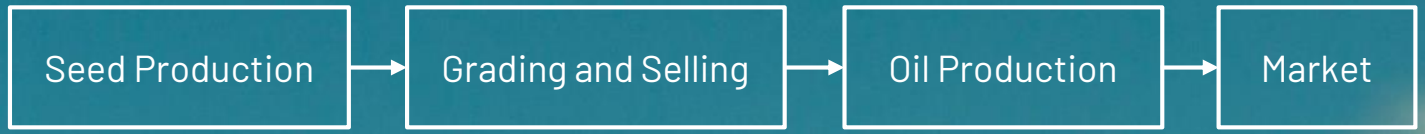
Chlorophyll in Oil

- Faster Spoilage
- Bitter Taste
- Lower Smoke Point

yOIL

An all-encompassing solution to the green seed problem

The Green Seed Problem



The Green Seed Problem

Oil Production

Oil Producers

Extra Processing: Acid Activated Clay

Green oil

Clay method

Oil Production

Up to 20% of Oil Lost

Negative Environmental Consequences

"Clay is the most **expensive** input cost"

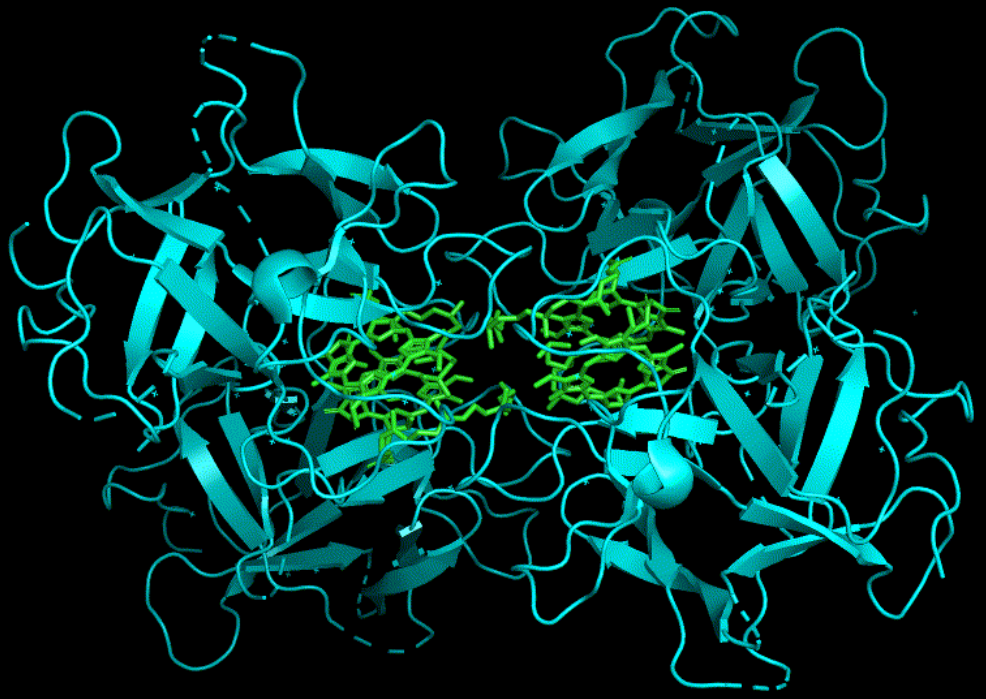
-Dallas Gade
Project Manager, Richardson Oilseed


Synthetic biology can improve green oil processing

Our Solution

6GIX: Water Soluble Chlorophyll Binding Protein

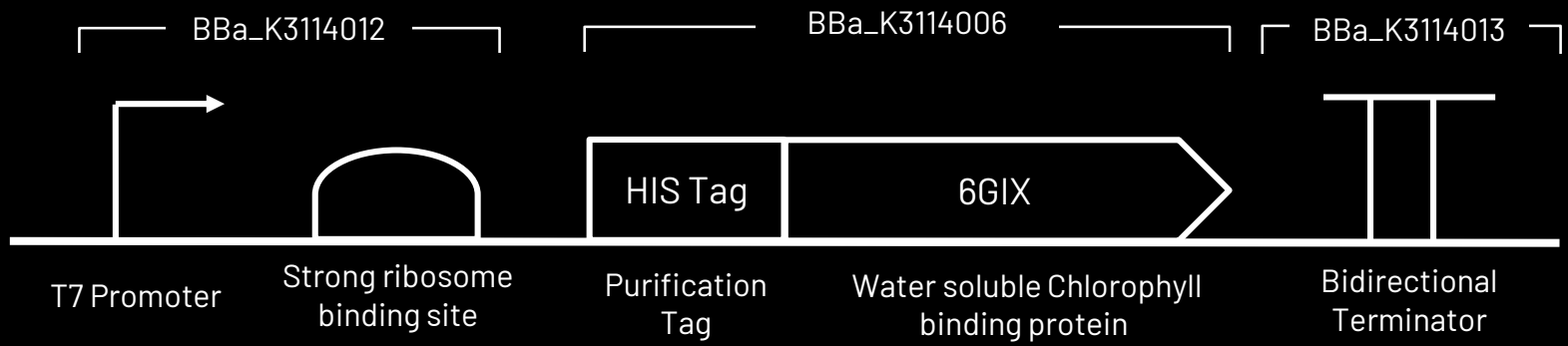
1) Binds four chlorophyll molecules
2) Protein-chlorophyll complex removed
3) Pure yellow oil



Bednarczyk and Noy, 2016

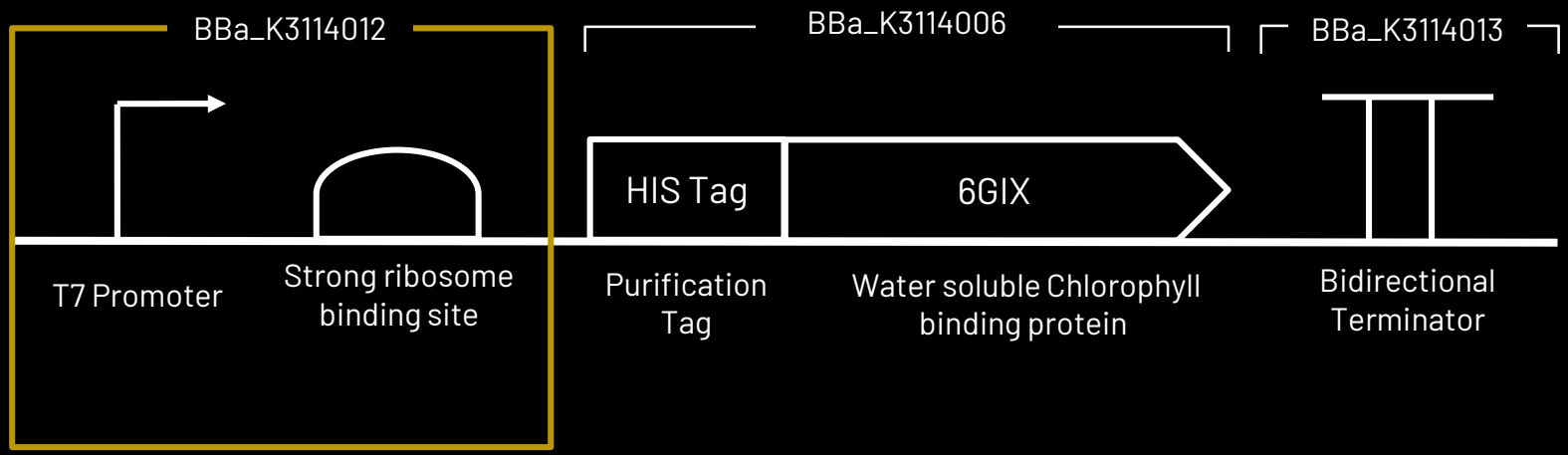
10.2210/pdb6GIX/pdb

Synbio for Green Seed Processing

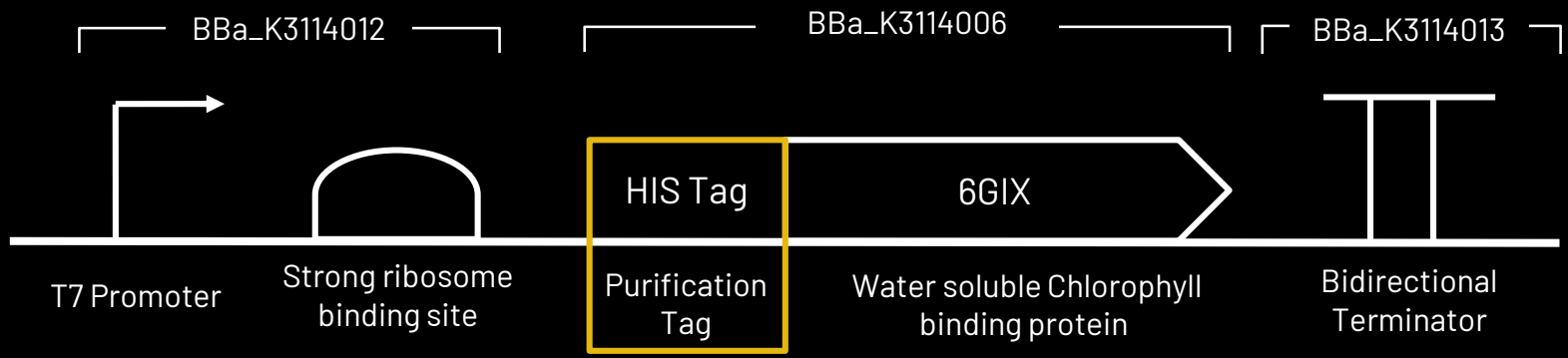


BBa_K3114015 allows golden gate cloning
(Improved BBa_K1467400)

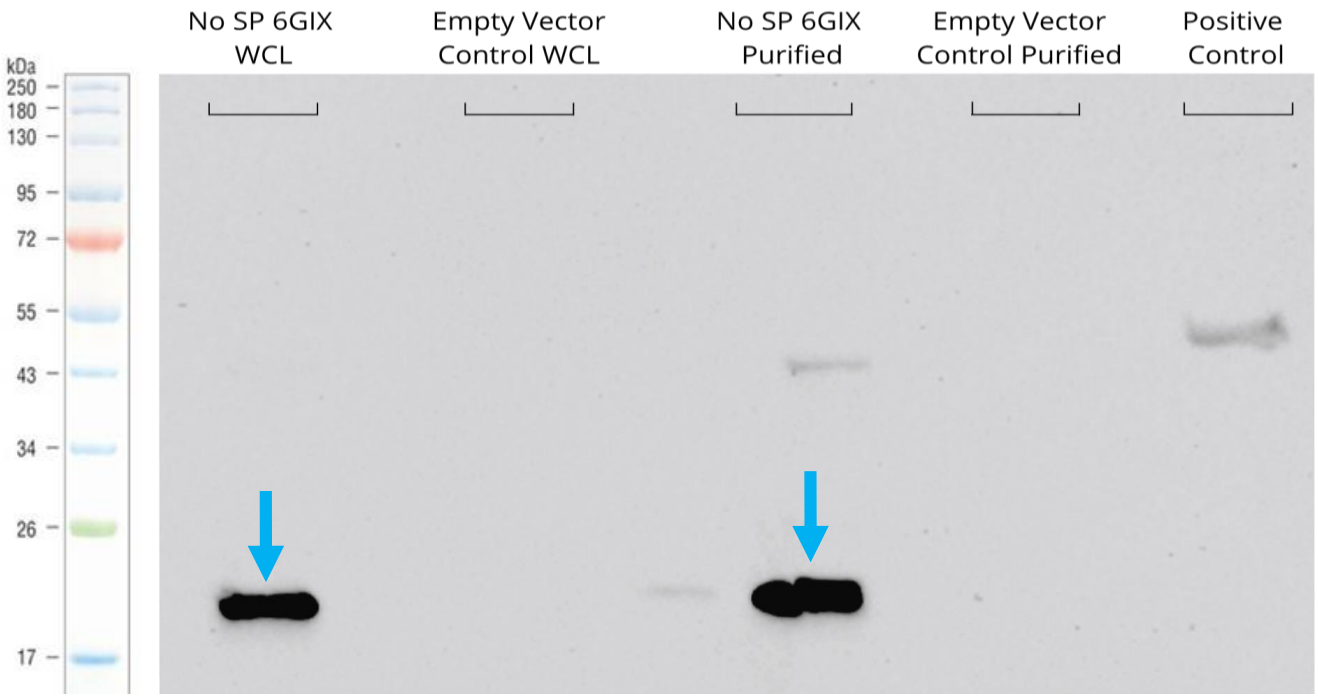
Synbio for Green Seed Processing



Synbio for Green Seed Processing



Purification of 6GIX



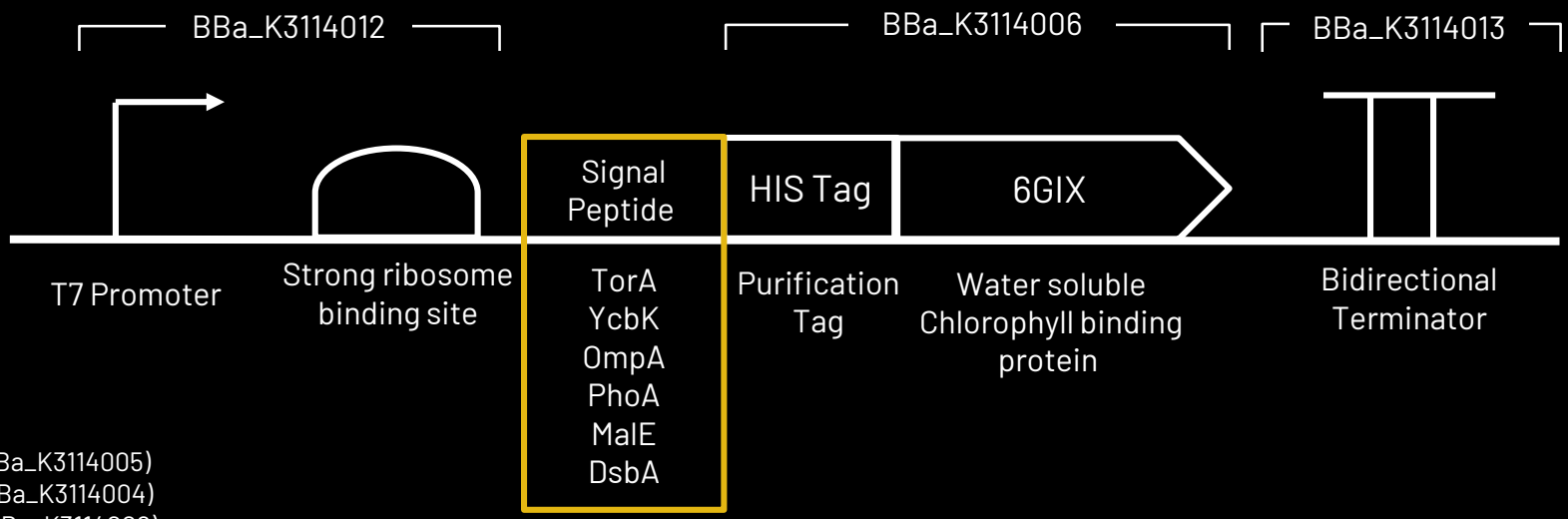
We SUCCESSFULLY expressed and purified 6GIX from the Cell Lysate

How can we **minimize costs** spent on purification?

Dr. Raymond Turner

University of Calgary
Biochemistry Faculty
Professor

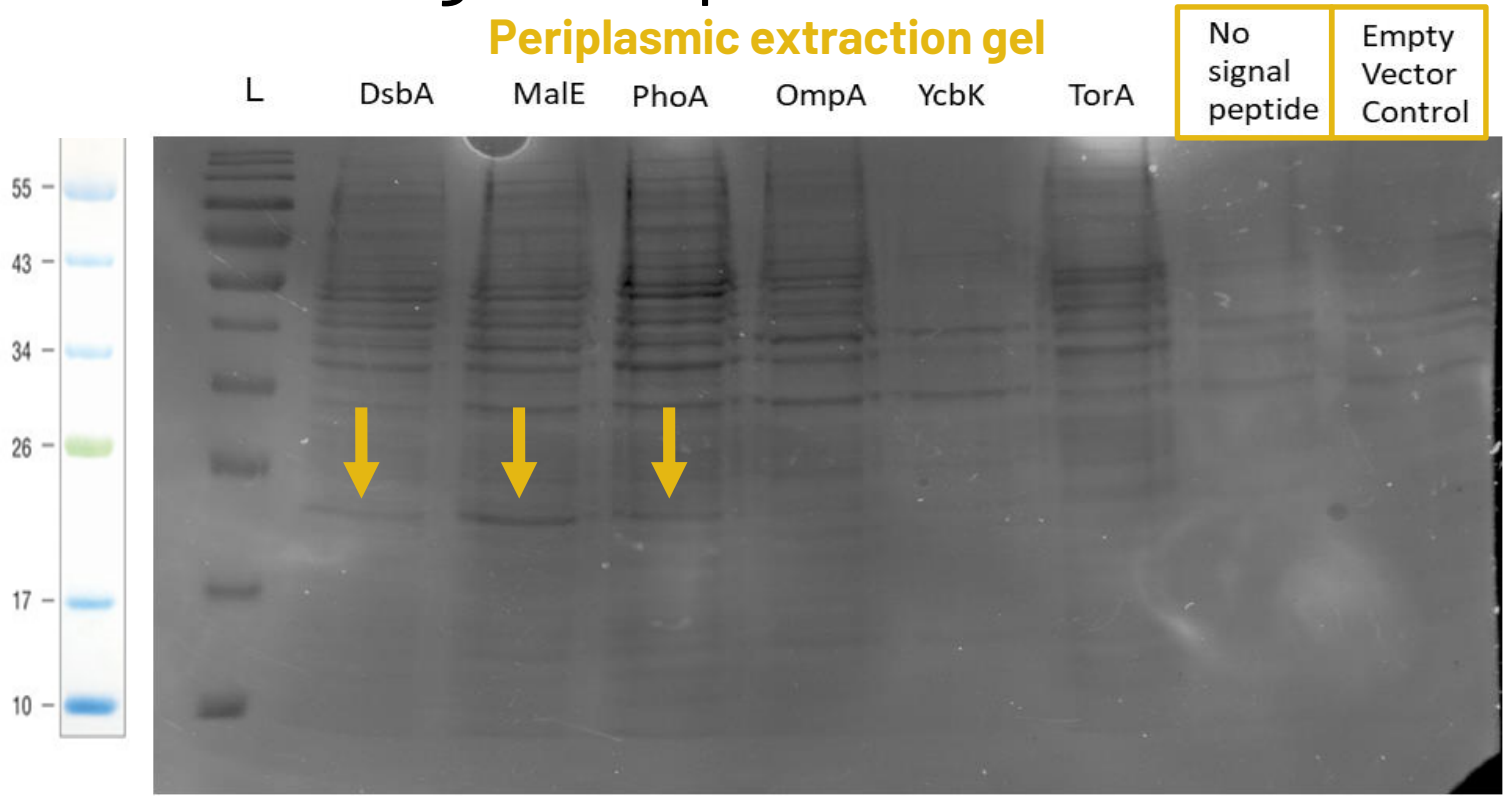
Synbio for Green Seed Processing



TorA: (BBa_K3114005)
YcbK: (BBa_K3114004)
OmpA: (BBa_K3114002)
PhoA: (BBa_K3114003)
MalE: (BBa_3114001)
DsbA: (BBa_K3114000)

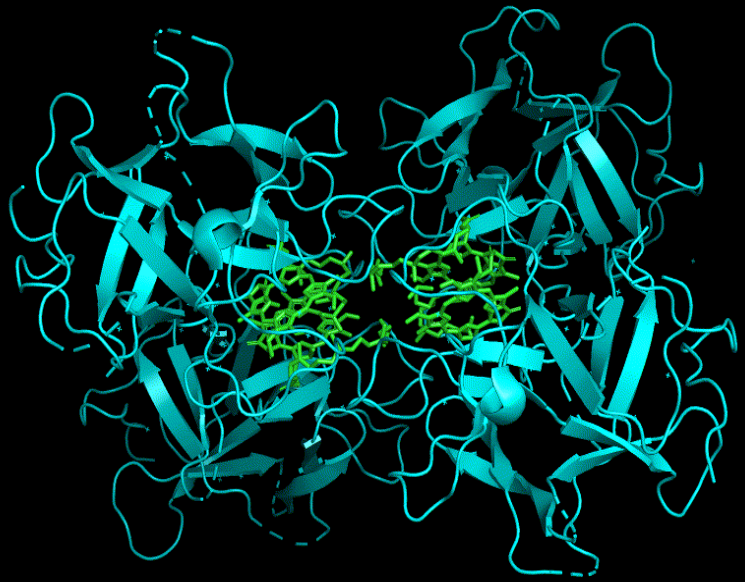
Signal Peptide Results

Periplasmic extraction gel



PhoA, MalE, and DsbA signal peptides SECRETE 6GIX into periplasm

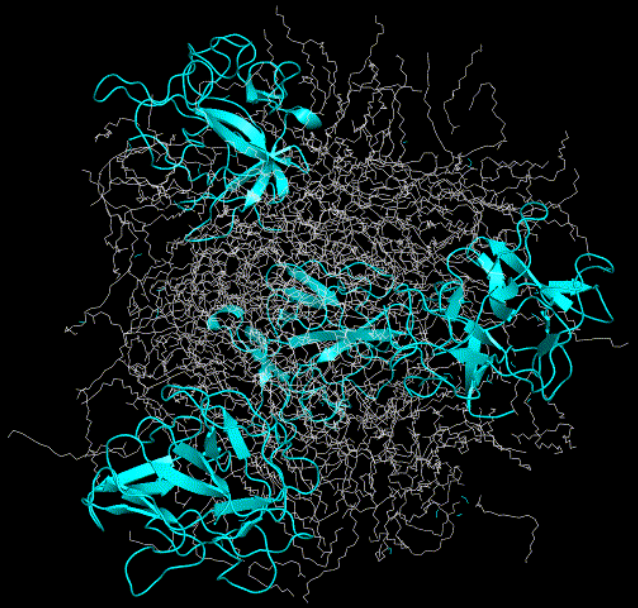
Hydrophobic Effect



6GIX normal structure

Hydrophobic Effect

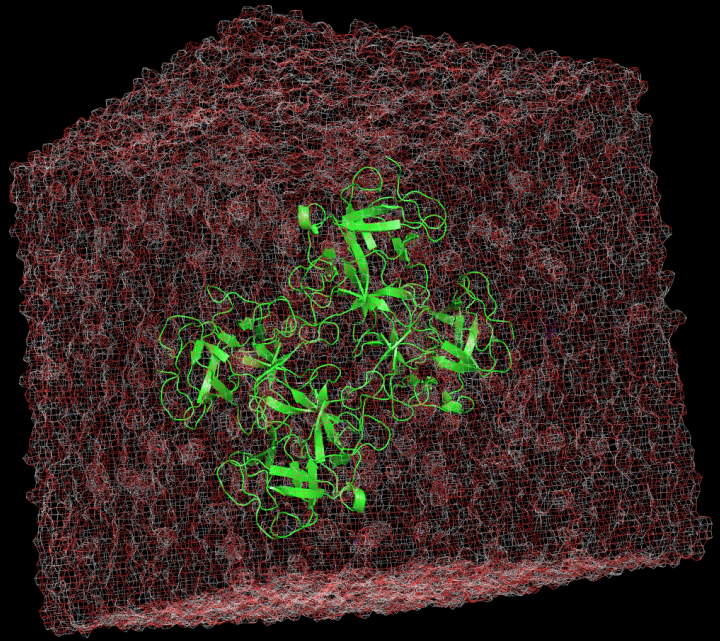
Water soluble proteins don't work in oil!!!!!!



6GIX denatured structure

Our Solution

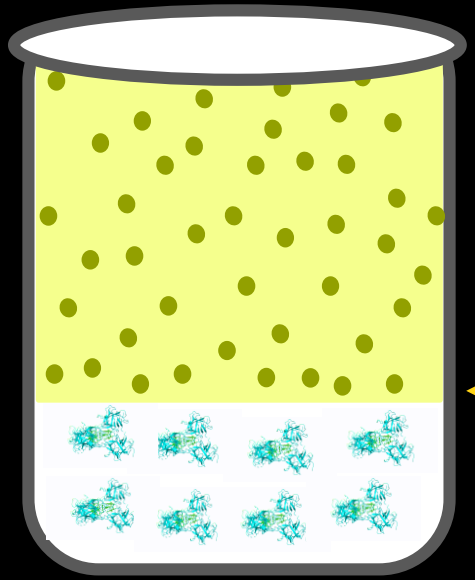
6GIX in Aqueous Phase



6GIX in water droplet

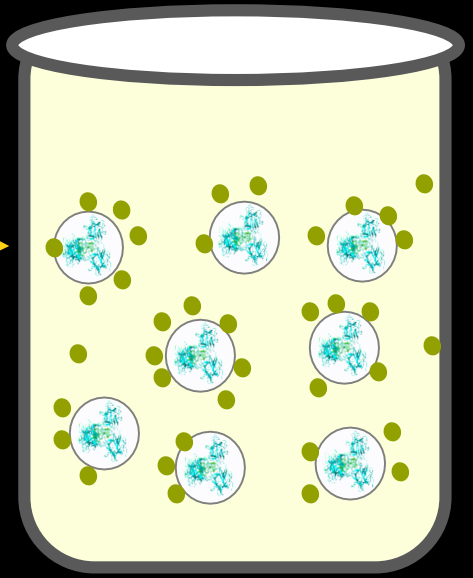
Our Solution

Oil-in-Water Emulsion



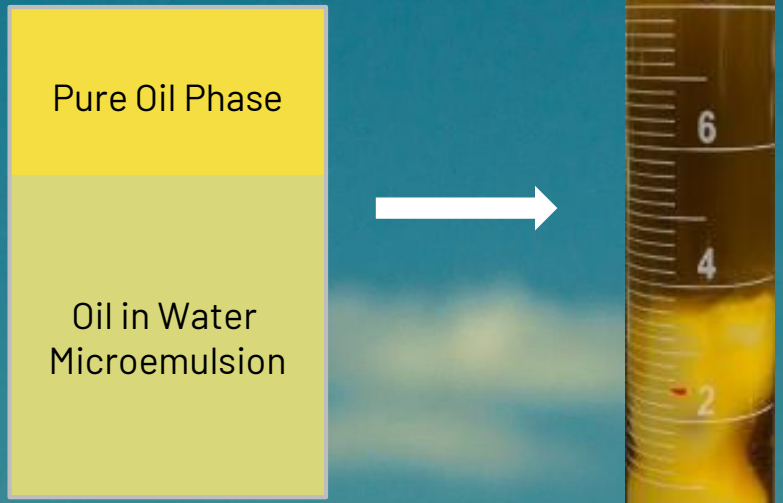
Contact between protein and chlorophyll

Increased surface area between oil and water



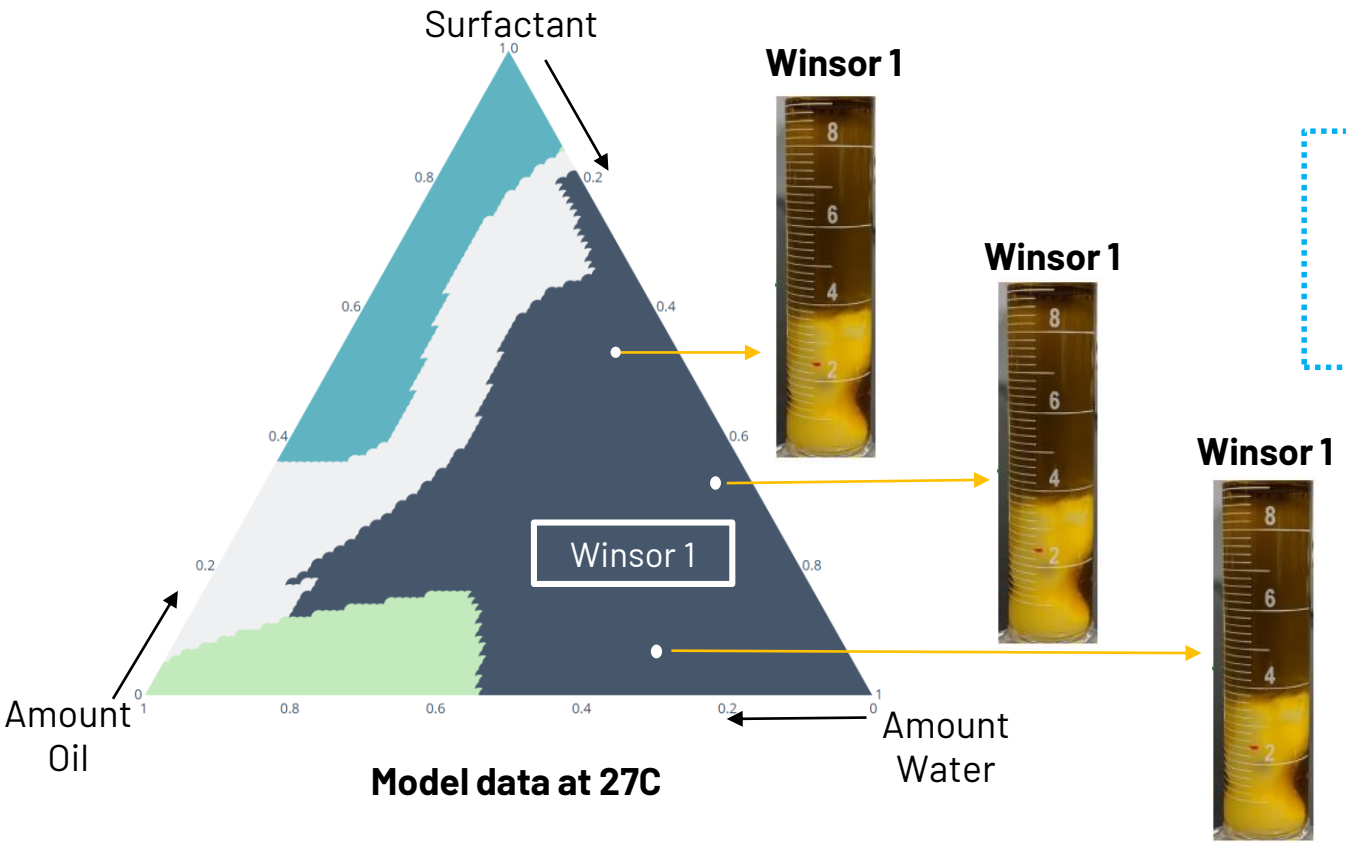
Emulsion Types

Different combinations of phases give different emulsions



Winsor 1

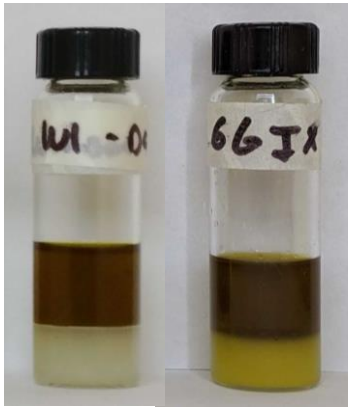
Phase Diagram Models



Proof of Concept:
BSA Experiments

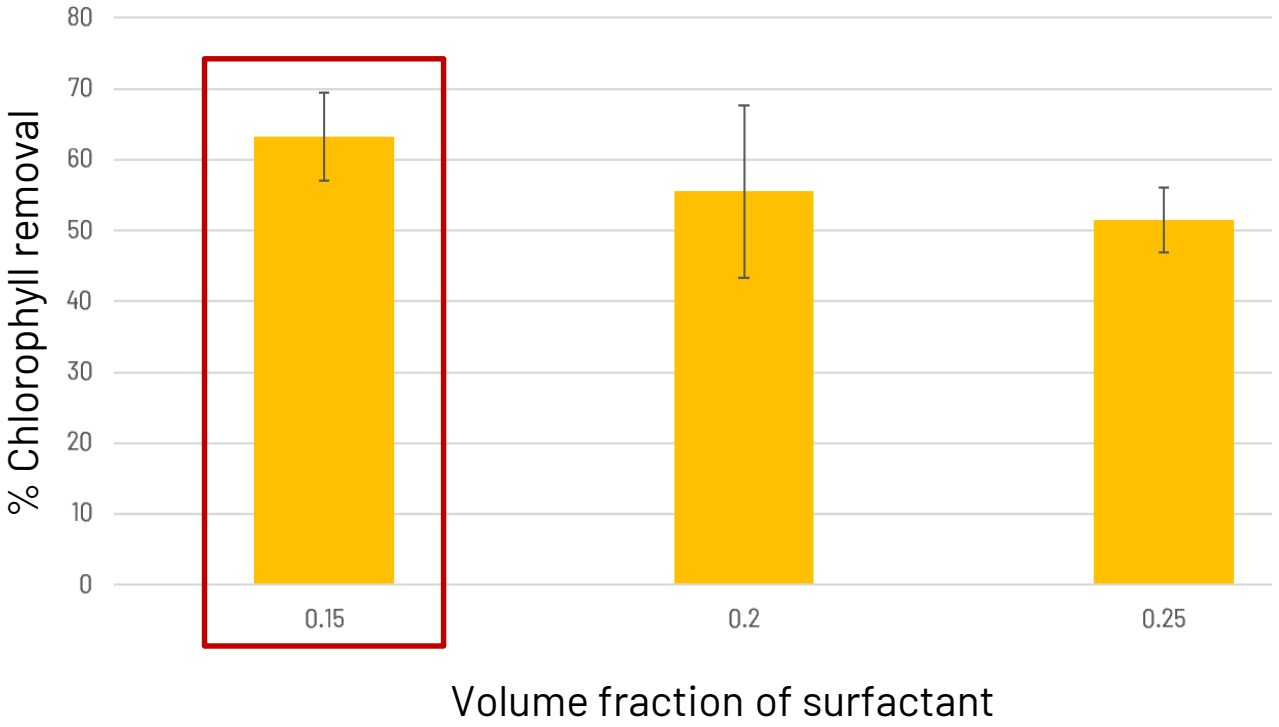
6GIX Emulsion Results

Three different emulsion compositions



No protein Emulsion

6GIX Emulsion

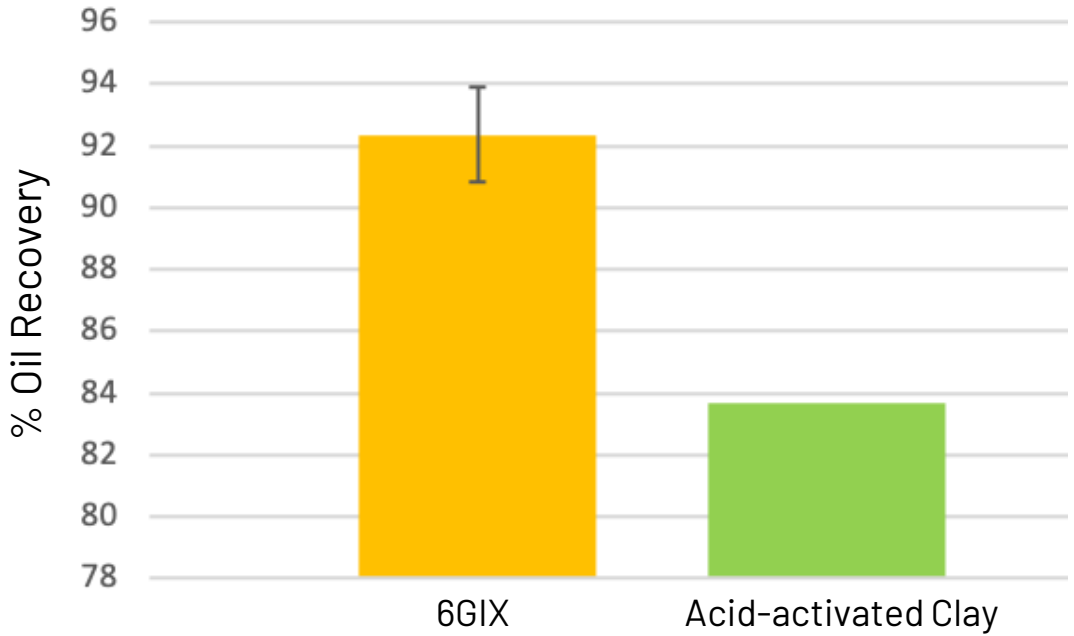


6GIX Concentration= ~5uM

Oil Recovery

How much oil is lost through processing

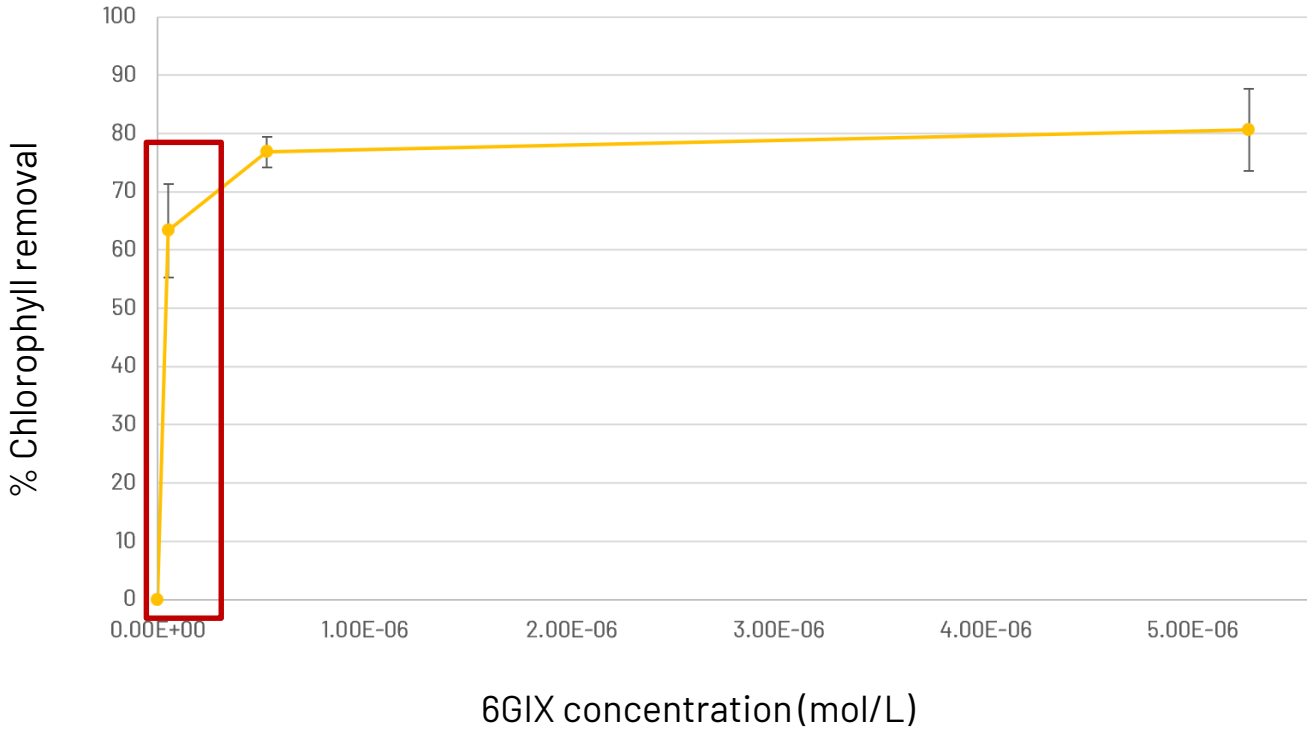
6GIX
Emulsion



6GIX Emulsions Results

Protein concentration vs. Chlorophyll removal

Aqueous phase with 6GIX



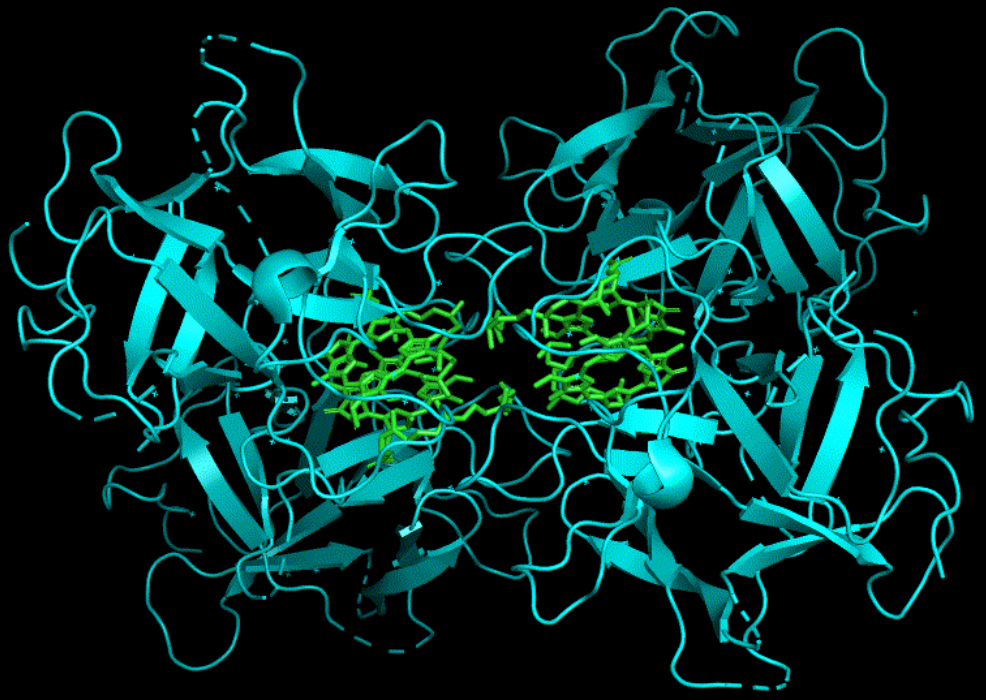
6GIX Instability

How to improve function and stability

12 amino acids cause variance

Denaturing at interface

iGAM – Genetic algorithm and PCA



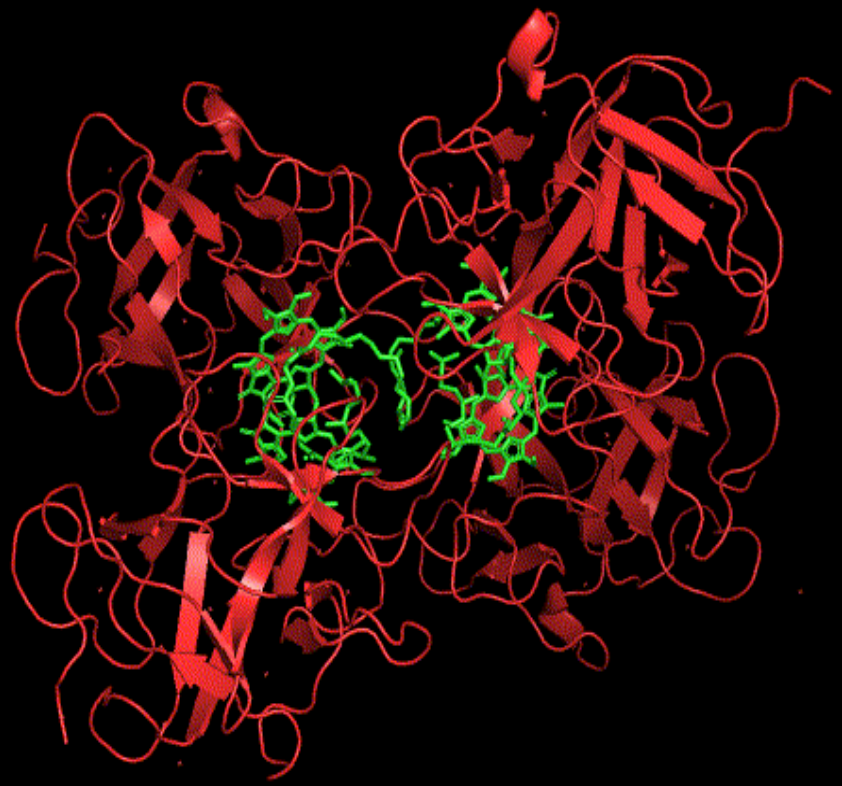
MODGIX

Modified 6GIX Protein

Modified for enhanced Chlorophyll Binding

Designed for stability

- Higher binding potential
- Less stabilizing agents required



Accomplishments

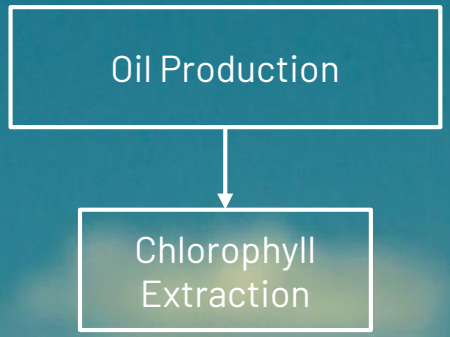
- ✓ Produce 6GIX
- ✓ Secrete 6GIX
- ✓ Purify 6GIX

→ Produce 6GIX on industrial level

- ✓ Determine best emulsion compositions
- ✓ Prove 6GIX's function in purifying green oil

→ Optimize for industry

Canola Oil Industry Pipeline



Canola Oil Industry Pipeline

Craig Shand

Ward Toma

John Mayko

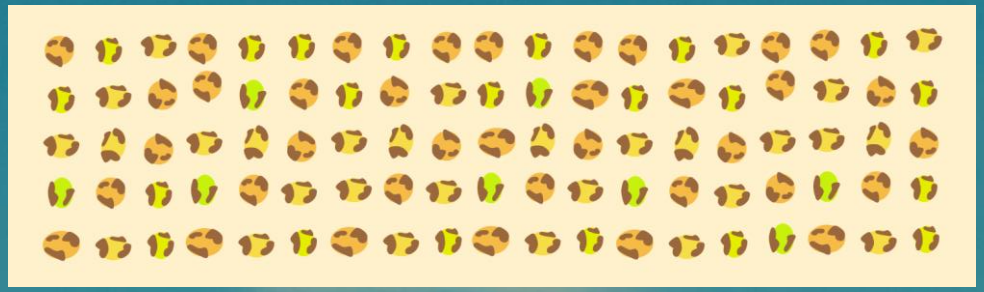
“Green is the difference between **profit** and **loss.”**

-Craig Shand

Co-Owner/Operator, Shand Farms Ltd.

Current Grading System

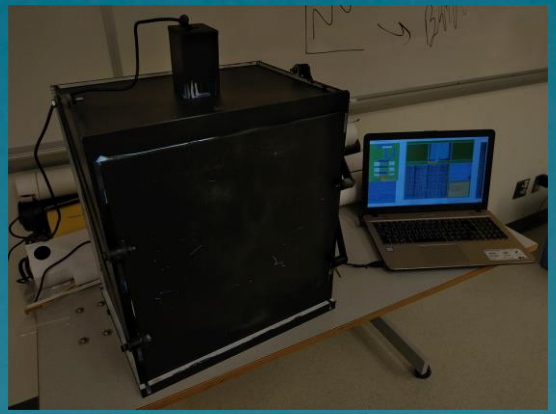
Seed Sample Assessed Against Colour Guide

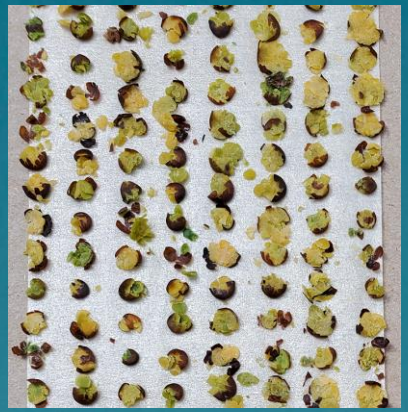


Canadian Grain Commission

VITERRA

Mean Green Machine





Canadian Grain Commission

Consistent Lighting

Accurate Capture

Colour Determination Algorithm

Can we empower farmers with the ability to produce **better quality seeds**?

Angela Brackenreed
Agronomist

Autumn Barnes
Agronomist

Sunny Days

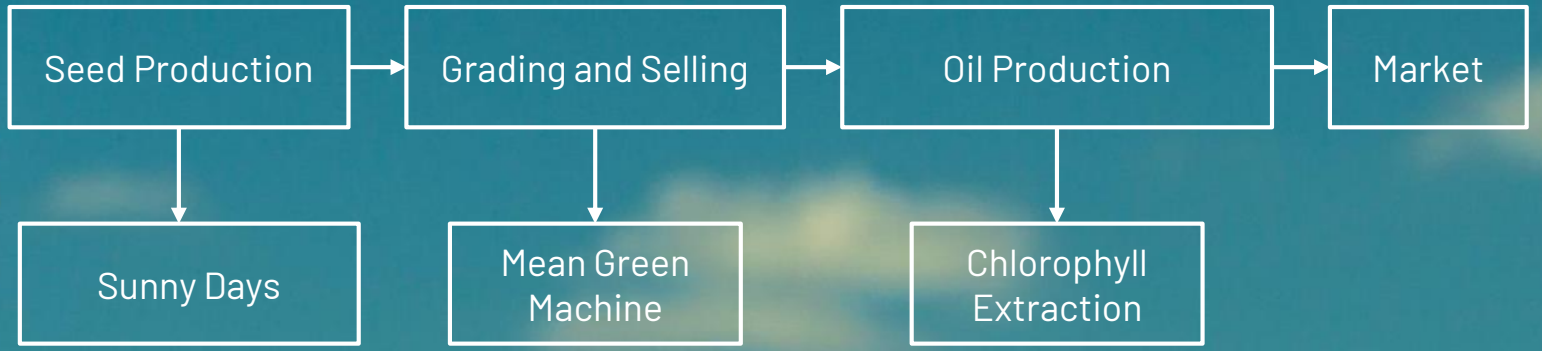
A **Precise Predictive Algorithm** to **Inform Effective Agronomy**

Within 2.5 degrees on average

Prediction 5 months in advance

Informed Management

Canola Oil Industry Pipeline



Check out our poster and wiki!

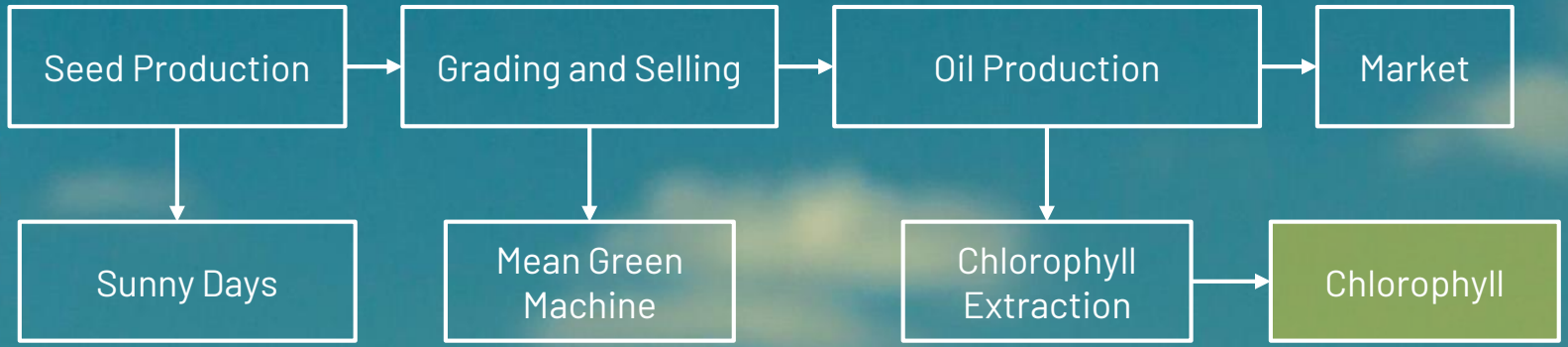


canolaPALOOZA




Green seed is a financial problem.

Canola Oil Industry Pipeline

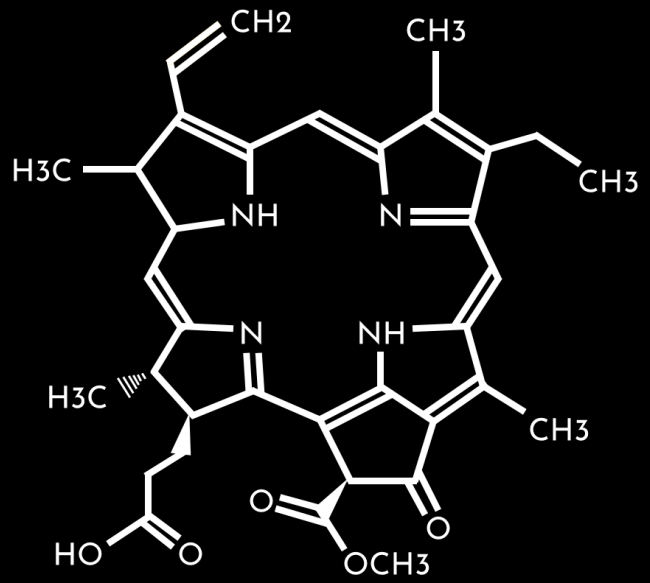


"Byproducts are valuable if they **offset** production costs"

- Dallas Gade

General Manager, Richardson Oilseed

Pheophorbide a



High value

Research: cancer & anti-fungal treatment

Canola suffers from fungal diseases

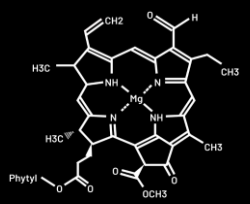
Sclerotinia

"Anybody growing canola in Alberta will have to deal with [fungus]."

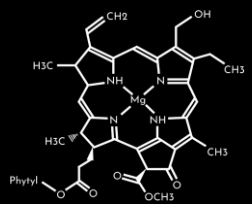
John Mayko

Farmer, The Alberta Canola Producers Commission

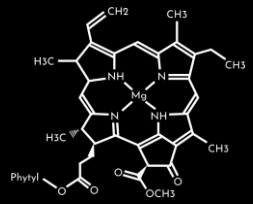
Chlorophyll to Pheophorbide: Steps



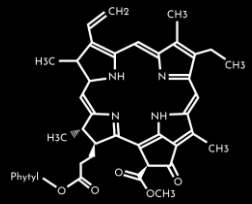
Chlorophyll b



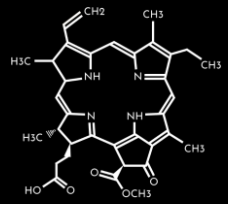
7 HCA



Chlorophyll a



Pheophytin a



Pheophorbide a

Chlorophyll b Reductase (CBR)

7-hydroxymethyl chlorophyll a reductase (7-HCAR)

Stage One

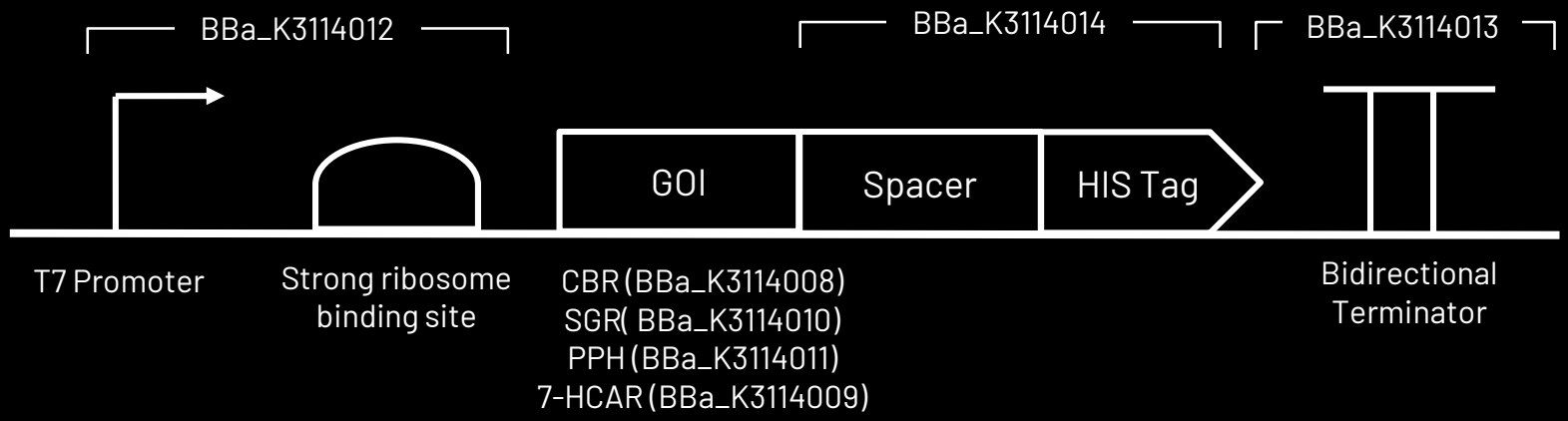
Magnesium Dechelatase (SGR)

Pheophytinase (PPH)

Stage Two

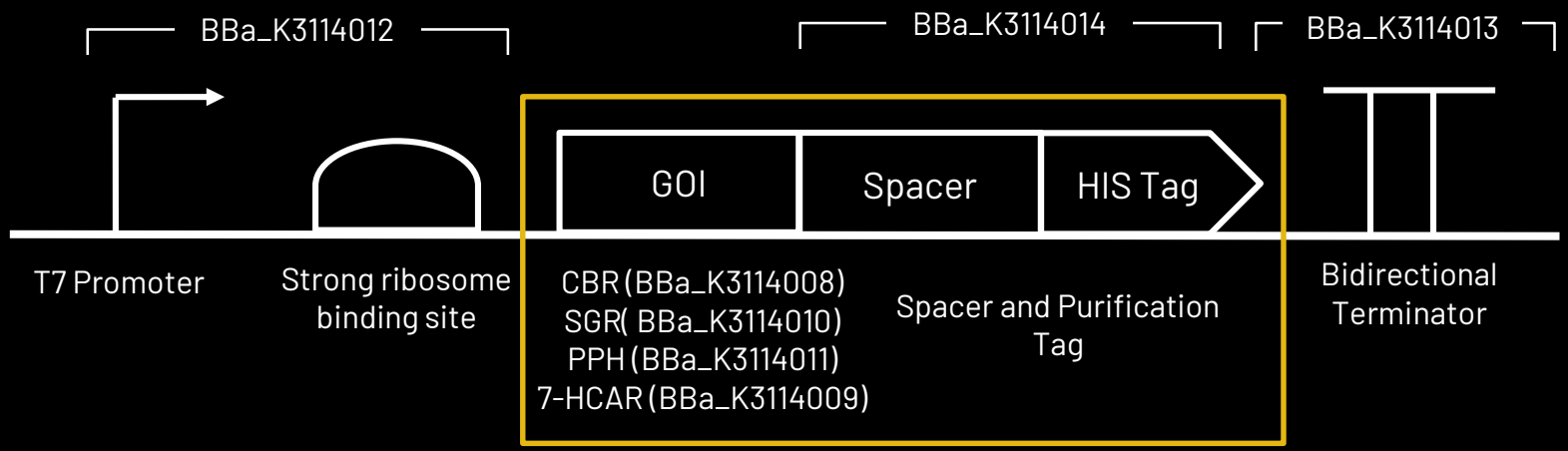
Synbio for Green Seed

Chlorophyll Degradation Proteins



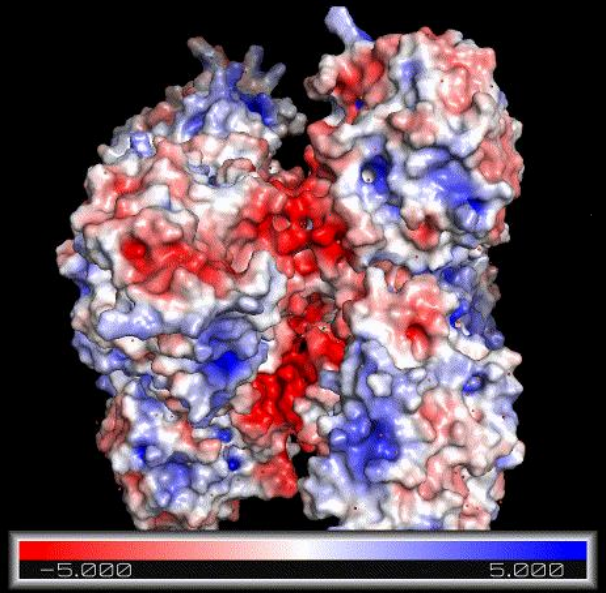
Synbio for Green Seed

Chlorophyll Degradation Proteins



Synbio for Green Seed

Protein-Spacer-His Tag

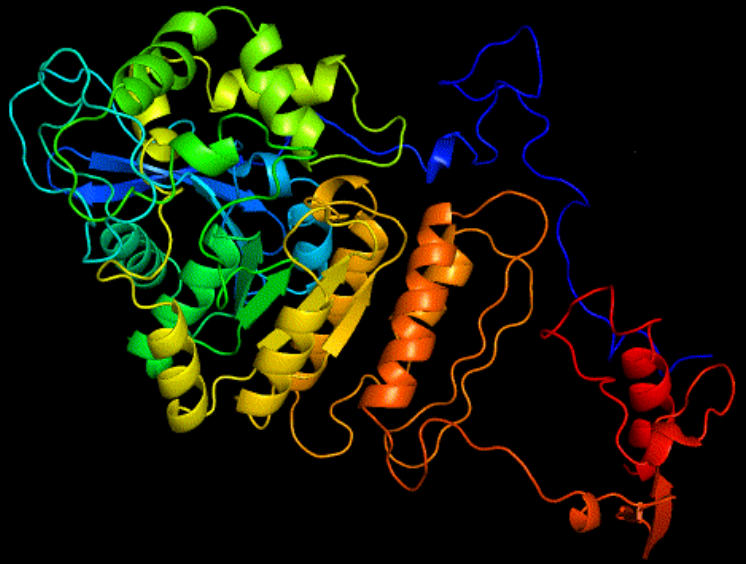


7-HCAR

(Meguro et al., 2011)

Synbio for Green Seed

Protein-Spacer-His Tag

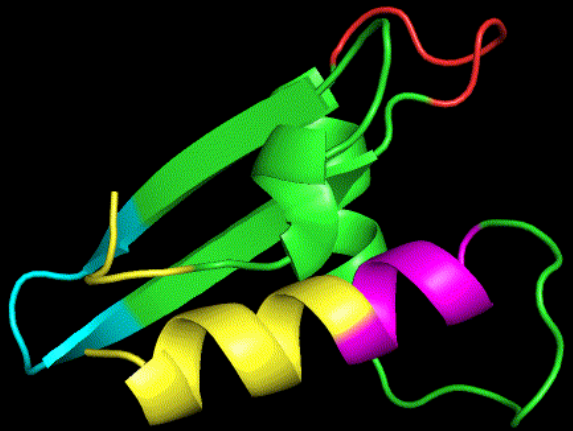


(Guyer, Salinger, Krügel,
& Hörtensteiner, 2017)

PPH (Predictive Homology Model)

ICARUS Universal Spacer

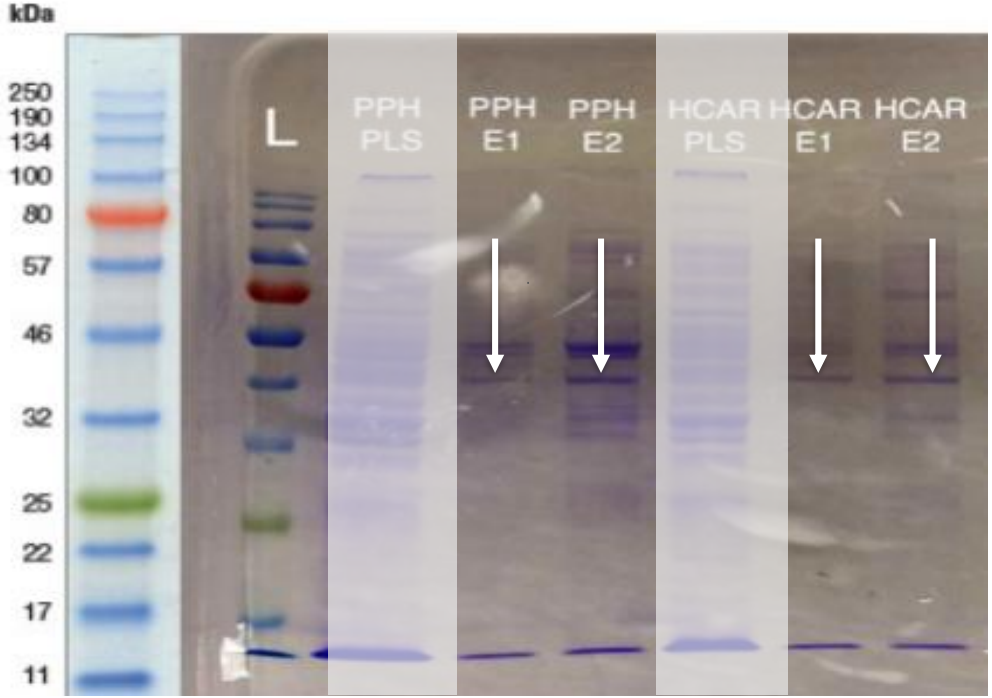
BBa_K3114014



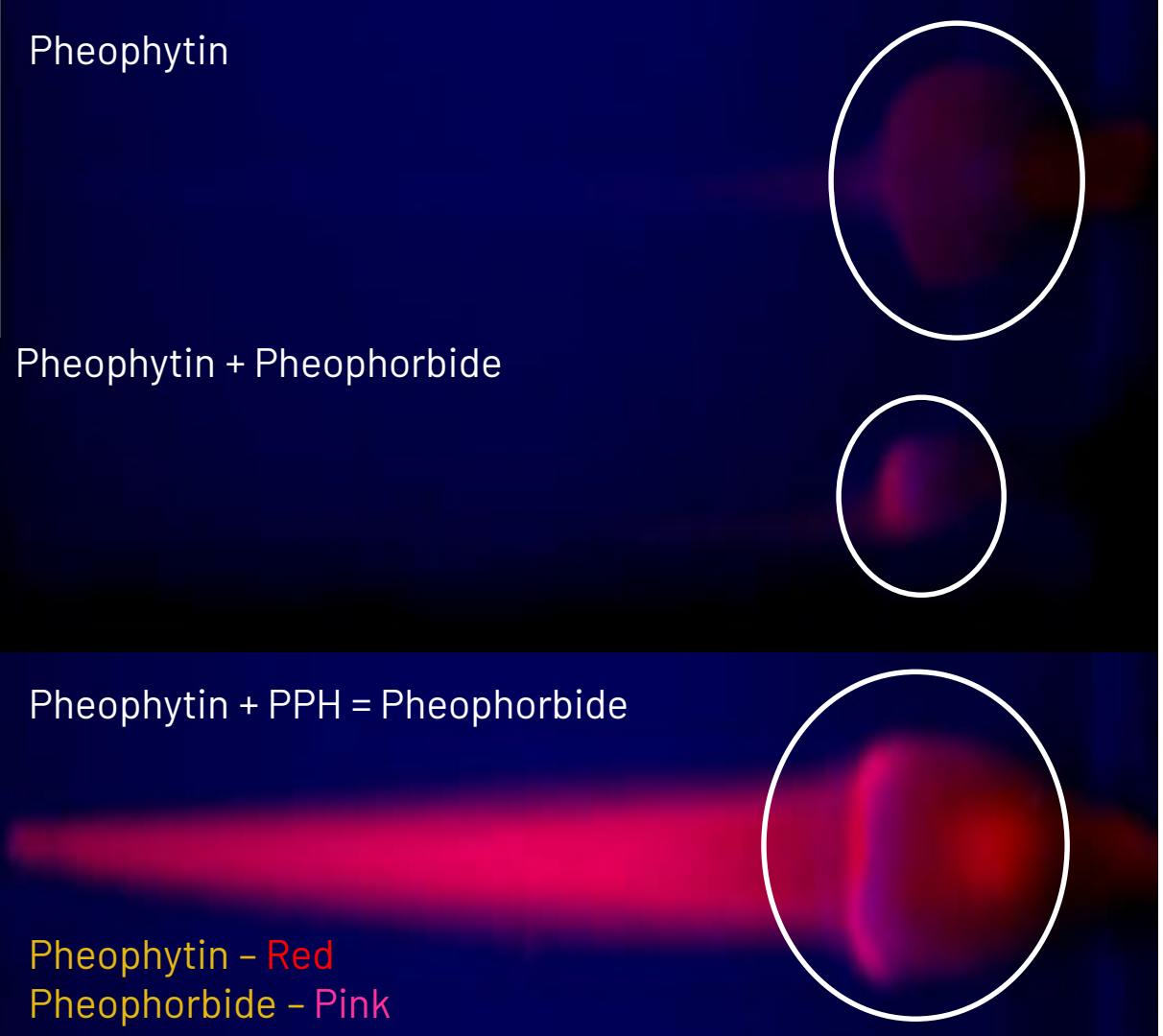
ICARUS (Predictive Homology Model)

Protein Purification

Protein-Spacer-His Tag



Both HCAR and PPH SUCCESSFULLY purified.



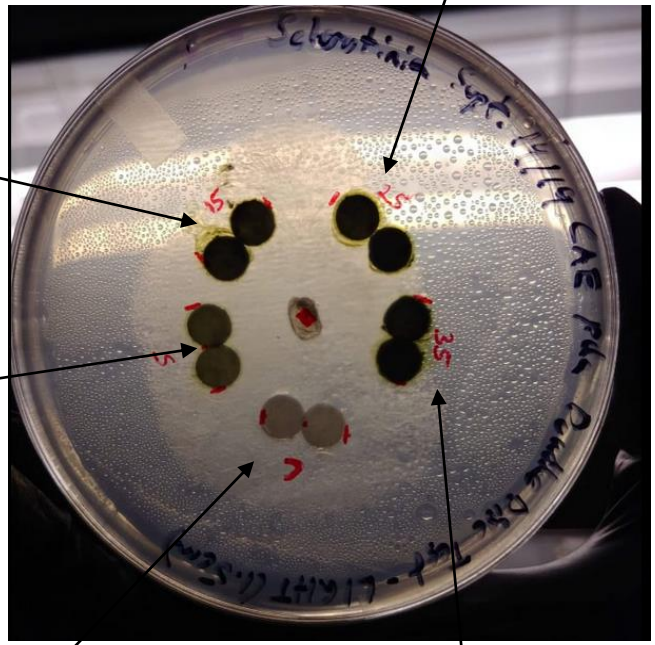
Thin Layer Chromatography

Showing PPH Function

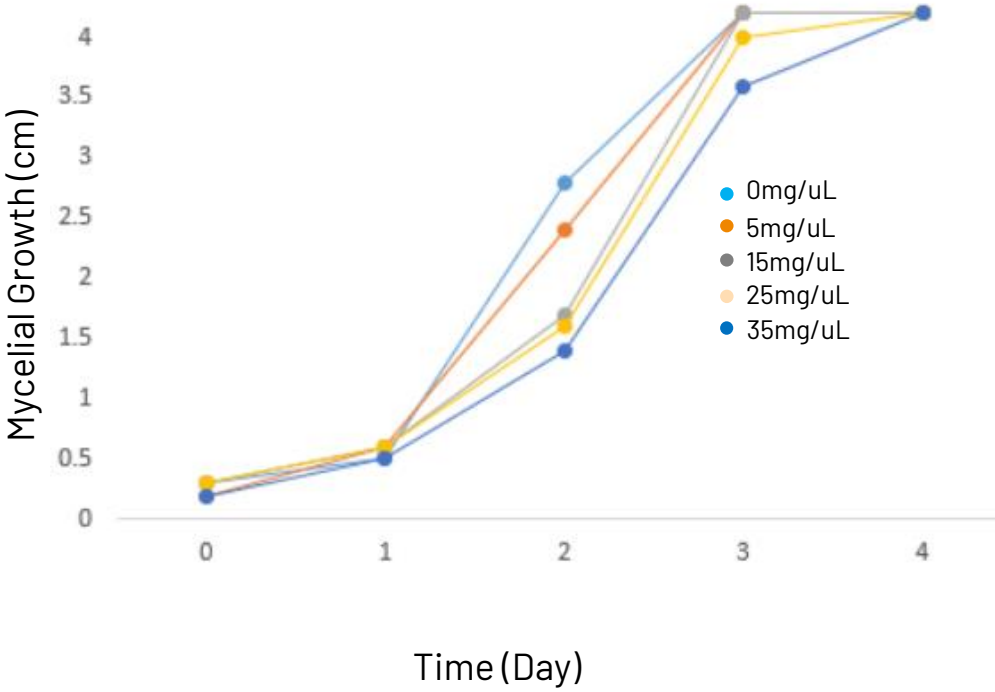
Pheophytinase (PPH) converts Pheophytin a into Pheophorbide

Pheophorbide Testing

Disc Test



Mycelial growth in pheophorbide a presence



Accomplishments

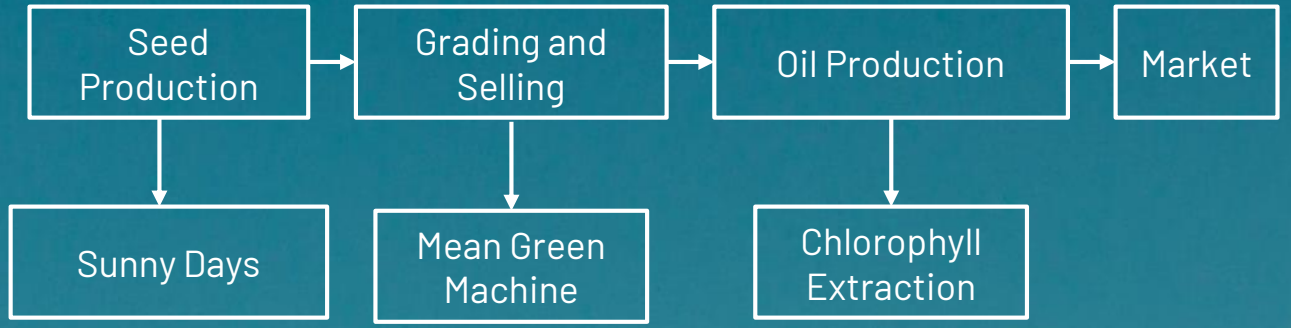
- Produced PPH and HCAR
- Purified PPH and HCAR with ICARUS

→ Produce chlorophyll degradation enzymes

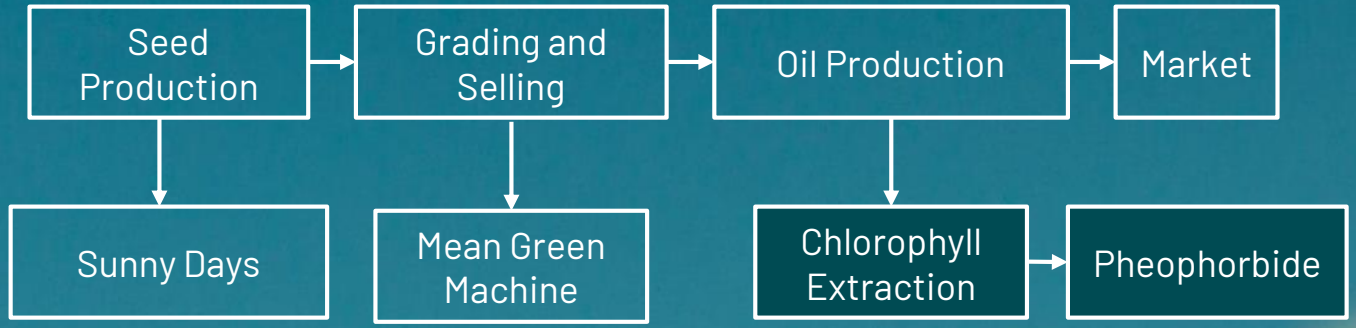
- Showed Pheophorbide Inhibited sclerotinia

→ Field test Pheophorbide

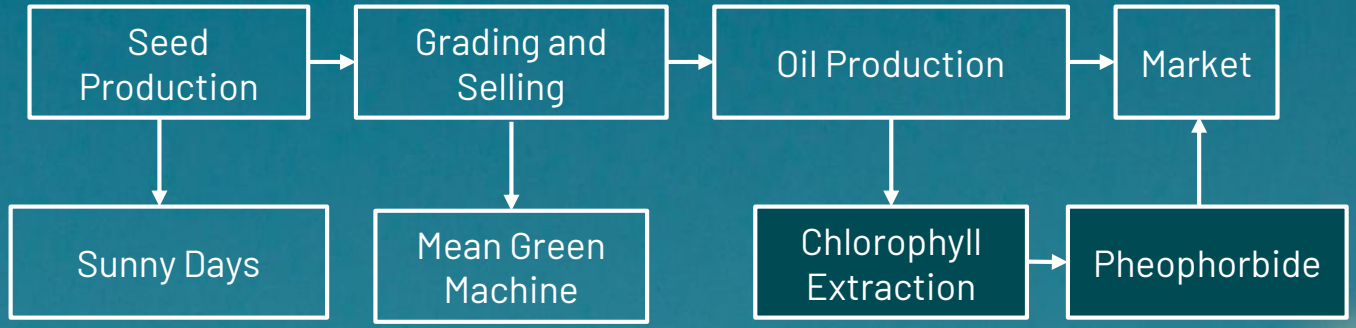
Canola Oil Industry Pipeline



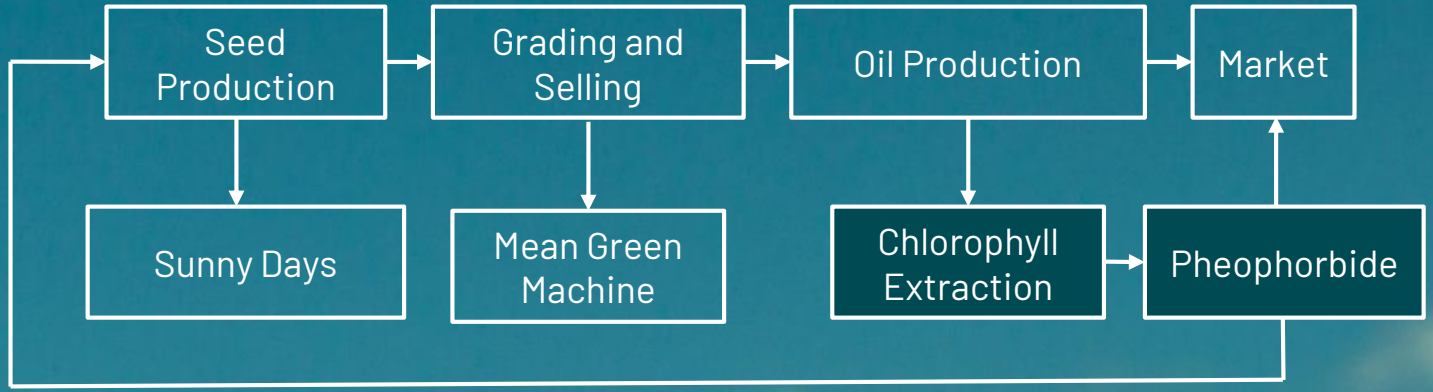
Canola Oil Industry Pipeline



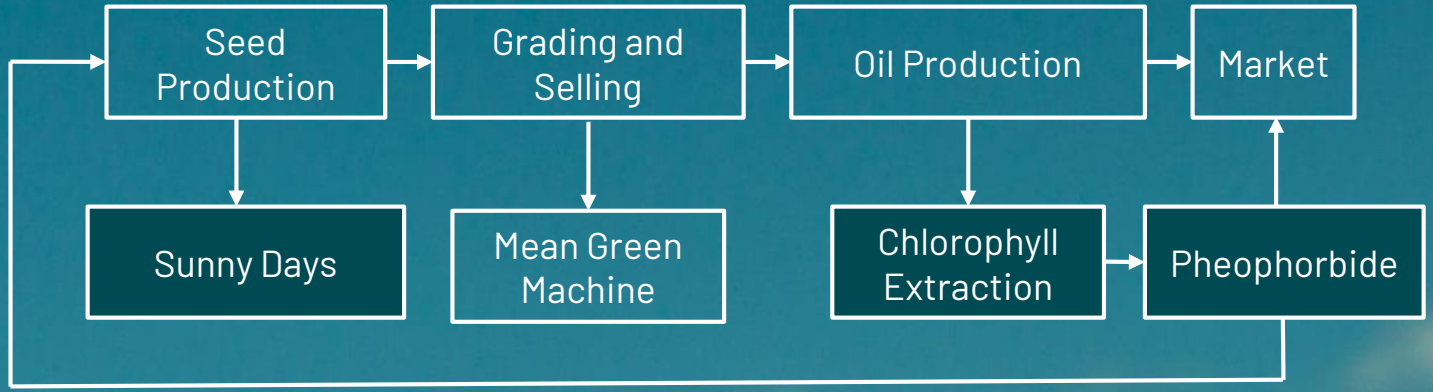
Canola Oil Industry Pipeline



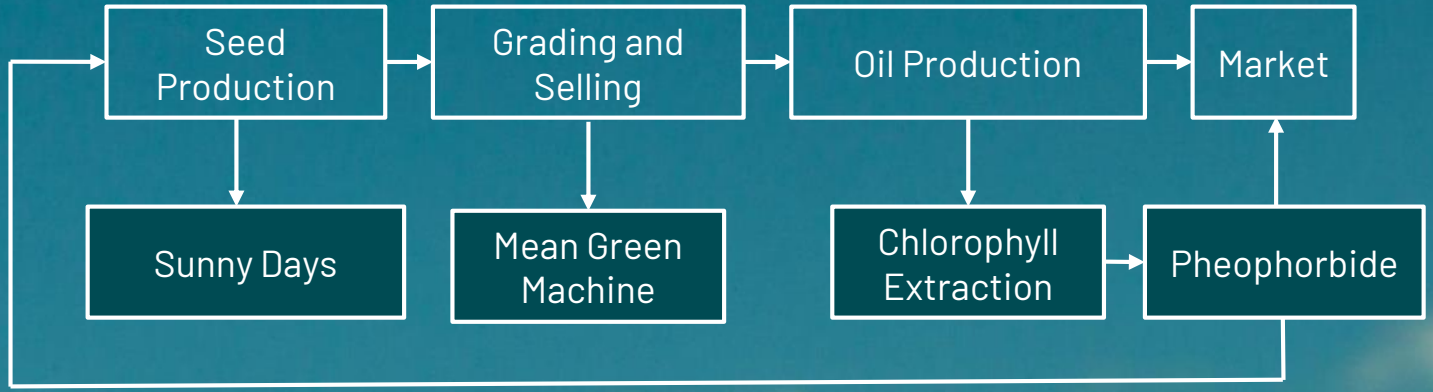
Canola Oil Industry Pipeline



Canola Oil Industry Pipeline



Canola Oil Industry Pipeline



Building Partnerships

IP Protection


28 New Parts
7 Models that Informed Project Design
37 Stakeholder Meetings
Unquantifiable Number of Hours in the Lab

yOIL

An all-encompassing solution to the green seed problem

- Sunny Days
- Standardized Grading
- Chlorophyll Extraction
- Pheophorbide

UNIVERSITY OF CALGARY
CUMMING SCHOOL OF MEDICINE
UNIVERSITY OF CALGARY
Vice President Research Office
SCHULICH School of Engineering
Mindfuel
geekStarter program and funders
UCalgary GivingDay
APRIL 25, 2019
ALBERTA INNOVATES
Shell Experiential Energy Learning Program
UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
UNIVERSITY OF CALGARY
PROVOST OFFICE

General Support:
David Bailey
Anita Ludwar
Patrick Wu
Dr. Gijs van Rooijen
Emily Hicks
Robert Mayall
Dr. Peter Facchini
Swapan Kakumanu
Dr. John Baker
Dr. Gavin Cameron
Deirdre Lobb

General Wet Lab Support:
Dr. Mary Reid
Dr. Vanina Zaremburg
Dr. Isabelle-Barette-Ng
Daniel Ziemianowicz
Margaret Redaud-Young
Dr. Dae-Kyun Ro

Chlorophyll Extraction:
Dr. Raymond Turner
Dr. Marie Elizabeth Fraser
Dr. Marcus Samuel
Dr. Ian Lewis
Dr. Gordon Chua
Dr. Joe Harrison

Emulsions:
Dr. Nashaat Nassar
Dr. Giovanniantonio Natale
Dr. Hector Siegler
Dr. Jianxun He
Dr. Kazi Sumon

Chlorophyll Repurposing:
Dr. Ronal Moore
Dr. Heather Addy
Fran Cusack
John Mayko
Dr. Kelly Turkington

HP:
Craig Shand
Randall Weselake
Dr. Veronique Barthet
Angela Brackenreed
Autumn Barnes
Pleasant Valley Oil Mills
Dallas Gade
Laurence Parslow
James Rae
Ward Toma
Dr. Brian Beres

Education and Outreach:
Alyssa Lam
John Pye
Bogusia Gierus
Erin Kelly

Dry Lab General:
Dr. Kartikeya Murari
Dr. David Anderson
Dr. Behrouz Far
Sean Mason
Dr. Usman Alim
Jeff Danielson
Dr. Thierry Chekouo
Dr. Lora Oehlerg
Dr. Laura De Castro

Entrepreneurship:
Elisa Park
Noren Howg
Erin Kulhawy

UNIVERSITY OF CALGARY
CUMMING SCHOOL OF MEDICINE

UNIVERSITY OF CALGARY
Vice President Research Office

SCHULICH School of Engineering

MindFuel
geekStarter program and funders

UCalgary GivingDay
APRIL 25, 2019
ALBERTA INNOVATES

Shell Experiential Energy Learning Program

UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

UNIVERSITY OF CALGARY
PROVOST OFFICE

yOIL

An all-encompassing solution to the green seed problem

- Sunny Days
- Standardized Grading
- Chlorophyll Extraction
- Pheophorbide

UNIVERSITY OF CALGARY
CUMMING SCHOOL OF MEDICINE

UNIVERSITY OF CALGARY
Vice President Research Office

SCHULICH School of Engineering
UNIVERSITY OF CALGARY

MindFuel
geekStarter program and funders

UCalgary GivingDay
APRIL 25, 2019
ALBERTA INNOVATES

Shell Experiential Energy Learning Program

UNIVERSITY OF CALGARY
FACULTY OF SCIENCE

UNIVERSITY OF CALGARY
PROVOST OFFICE

yOIL

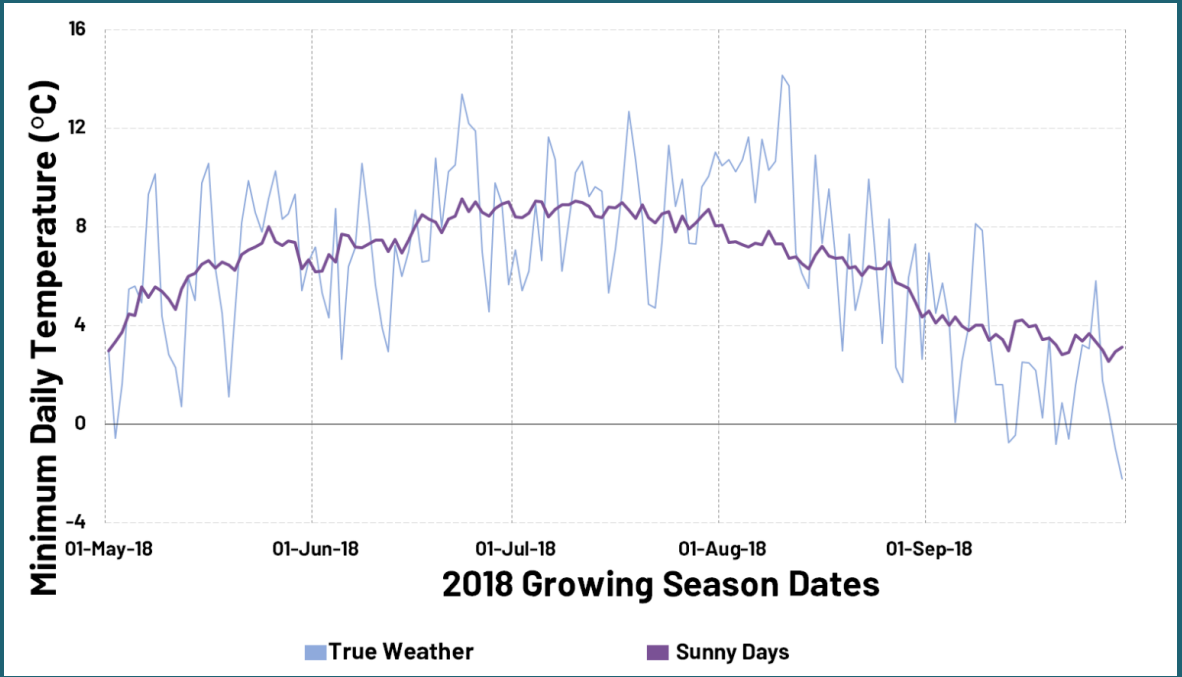
An all-encompassing solution to the green seed problem

- Sunny Days
- Standardized Grading
- Chlorophyll Extraction
- Pheophorbide

Sunny Days

Sunny Days

A Precise Predictive Algorithm to Inform Timing of Seeding



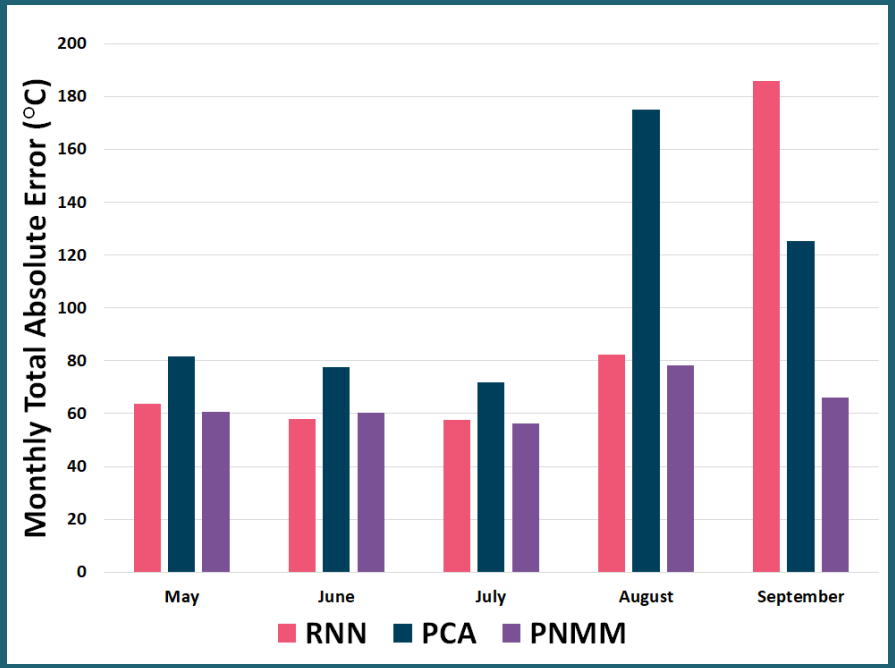
Prediction 5 months in advance

Within 2.1 degrees on average

In Peer Review at Alberta Academic Review

Sunny Days

A Precise Predictive Algorithm to Inform Timing of Seeding



Prediction 5 months in advance

Within 2.1 degrees on average

In Peer Review at Alberta Academic Review

Air temperature forecasts' accuracy of selected short-term and long-term numerical weather prediction models over Poland

Sebastian Kendzierski [1], *Bartosz Czernecki* [1], *Leszek Kolendowicz* [1] and *Adam Jaczewski* [2]

[1] Department of Climatology, Adam Mickiewicz University, Poznań, Poland

[2] Institute of Meteorology and Water Management – National Research Institute, Warszawa, Poland

Sunny Days

Comparison With Contemporary Methods

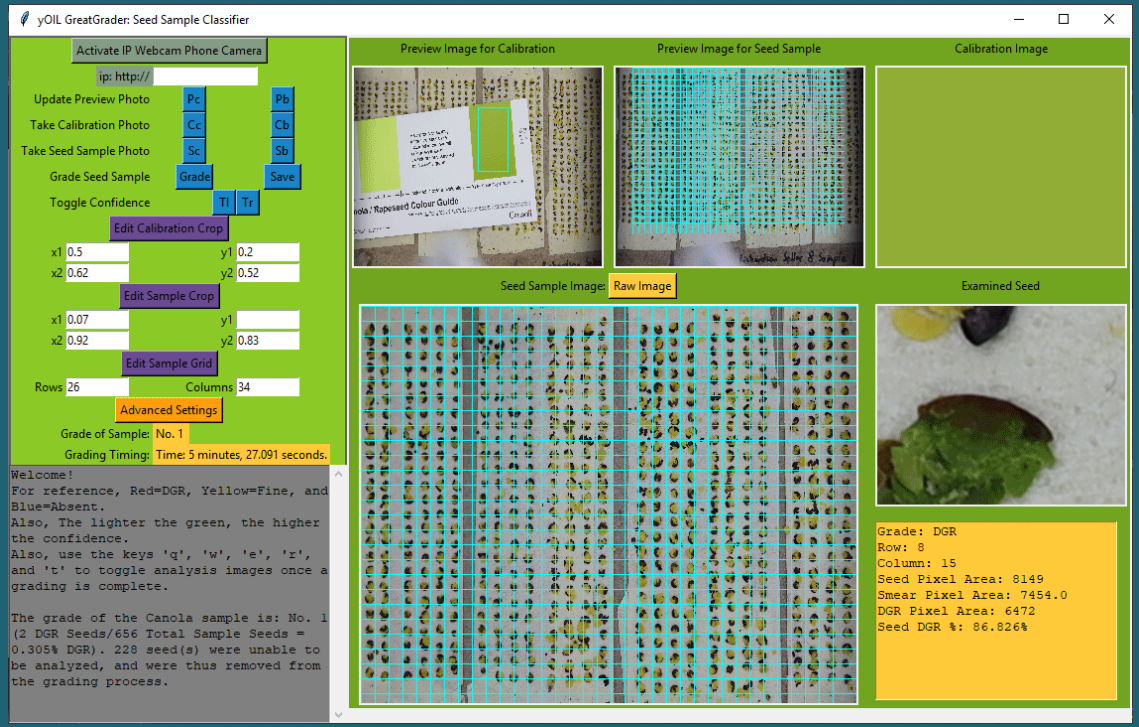
Sunny Days accomplished estimates for 180 days with a Mean Absolute Error of 2.109 C

Table 3. Statistical results of long-term forecast in different time horizons.

MODEL	*t* (hs)	*ME*	*MAE*	*RMSE*	*MSE*	*BIAS*	*r*
GFS	0–48	–0.09	1.63	2.24	5.00	0.97	0.94
	49–96	–0.07	1.91	2.56	6.53	0.96	0.95
	97–144	–0.17	2.38	3.17	10.02	0.93	0.93
	145–192	–0.23	2.93	3.87	14.94	0.90	0.93
	193–240	–0.25	3.52	4.60	21.85	0.86	0.92
HIRLAM	0–48	0.11	1.53	2.06	4.25	0.97	0.98
	49–96	0.09	1.82	2.42	5.84	0.96	0.98
	97–144	–0.04	2.31	3.07	9.42	0.94	0.97
	145–192	–0.18	2.97	3.92	15.34	0.90	0.95
	193–240	–0.15	3.40	4.46	19.91	0.87	0.94

Standardized Seed Grading

GreatGrader



A software tool for standardizing seed grading:

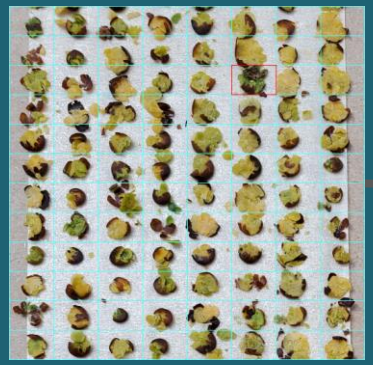
- Calibrate the system using a colour chip
- Take a seed sample picture
- Crop and divide seeds
- Grade
- Examine individual seeds
- See confidence

GitHub links:

Python Script Version: https://github.com/iGEMCalgary/DGRClassification

Standalone Version for Windows 10 64-bit: https://github.com/iGEMCalgary/GreatGrader

GreatGrader Grading Process

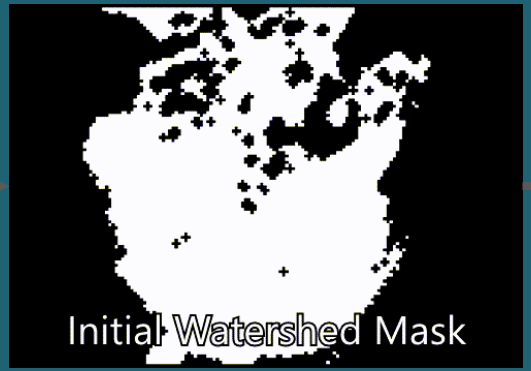


1) Seed Sample

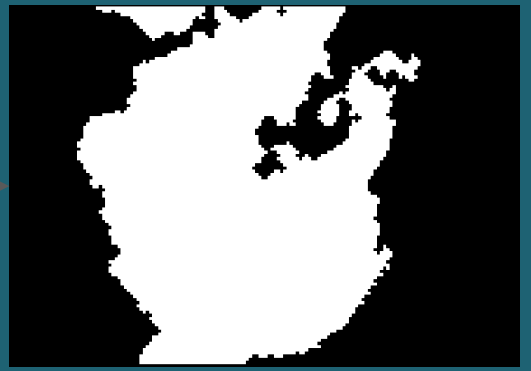
2) Individual Seed

3) Watershed Marking

4) Watershed Mask

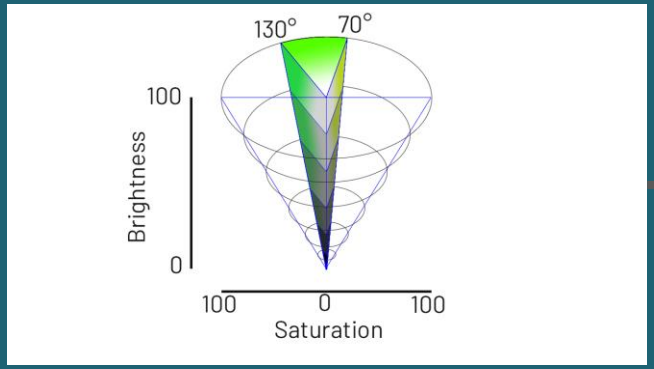


5) Modified Flood Fill

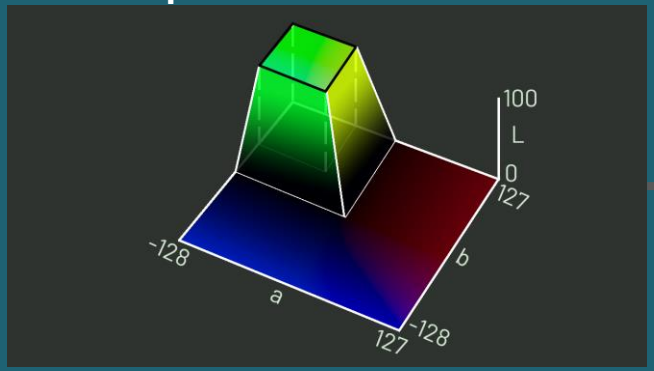


6) Final Seed Mask

GreatGrader Grading Process

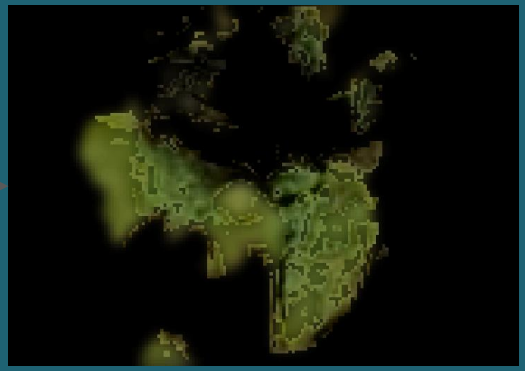


HSV colour space distance calculations used



Lab colour space distance calculations used

7) Smear Parse

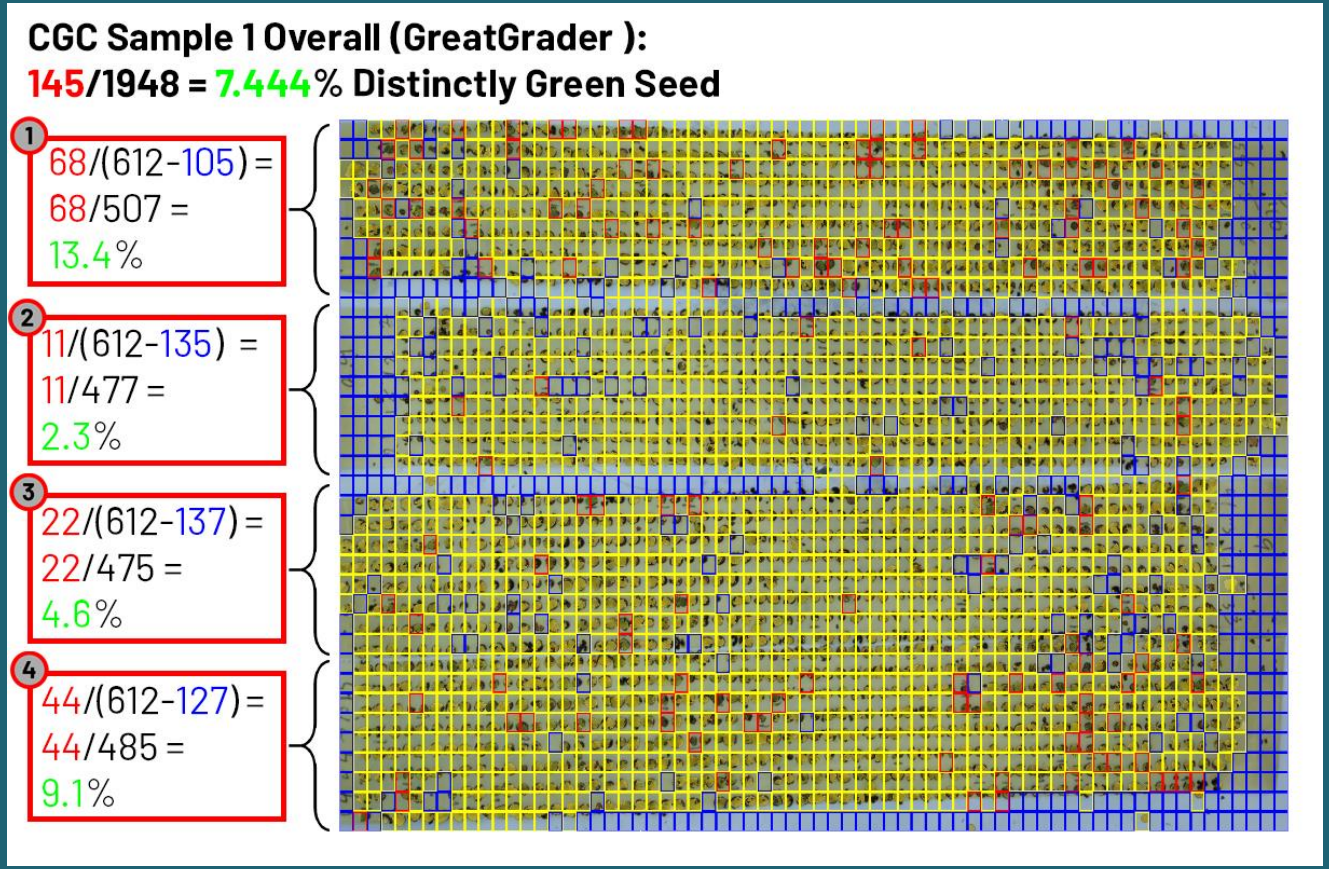


8) DGR pixel grading

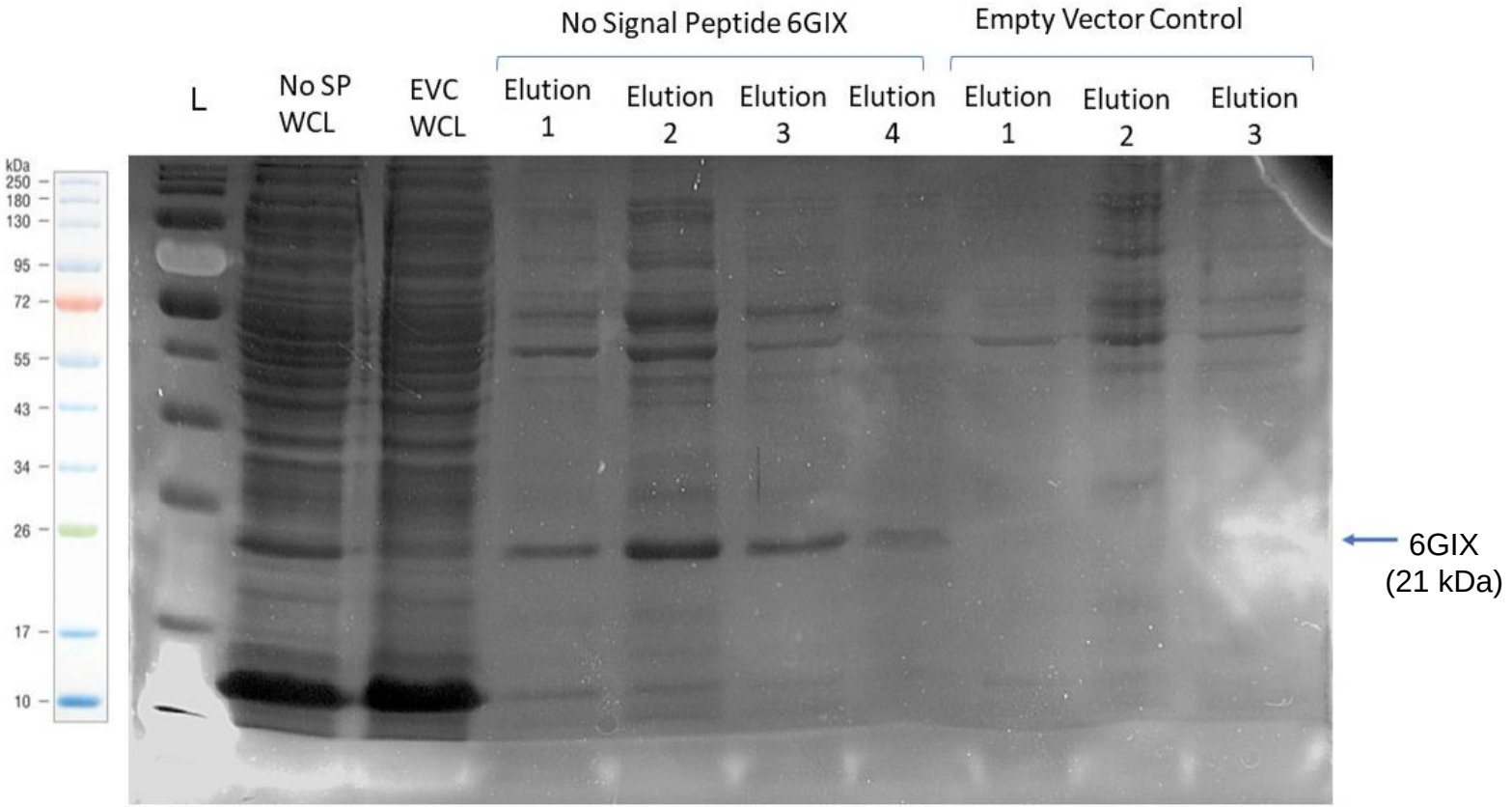
GreatGrader Performance

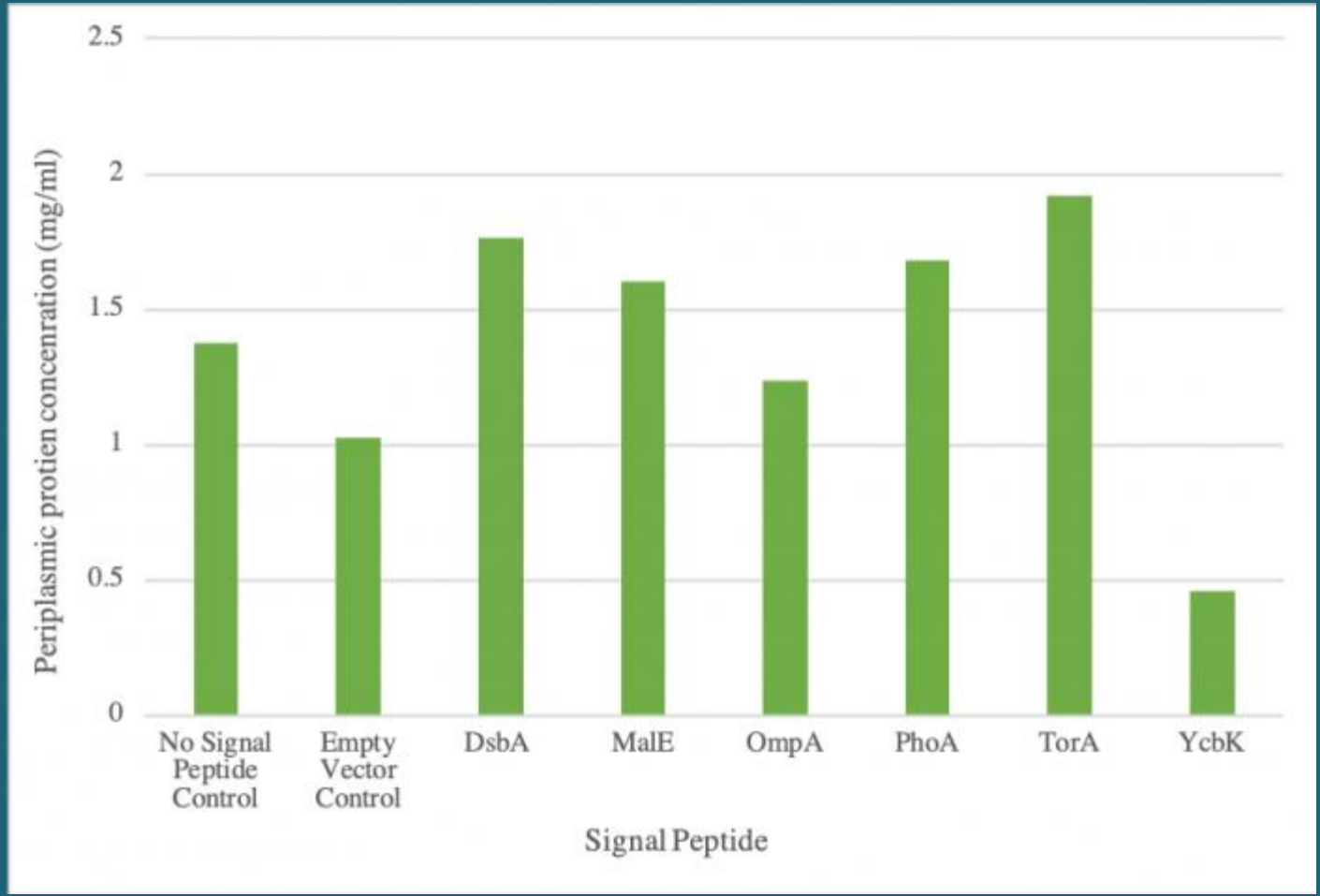
Sample	Human Grading DGR%	MGM & GG DGR%	Absolute Error (DGR%)	Time to Grade (seconds)
CGC #1	6.400%	7.444%	1.044%	164.287
CGC #2	7.000%	7.739%	0.739%	189.261
Grainger	4.143%	5.734%	1.591%	289.408
Richardson	0.308%	0.305%	0.003%	267.353

GreatGrader Performance

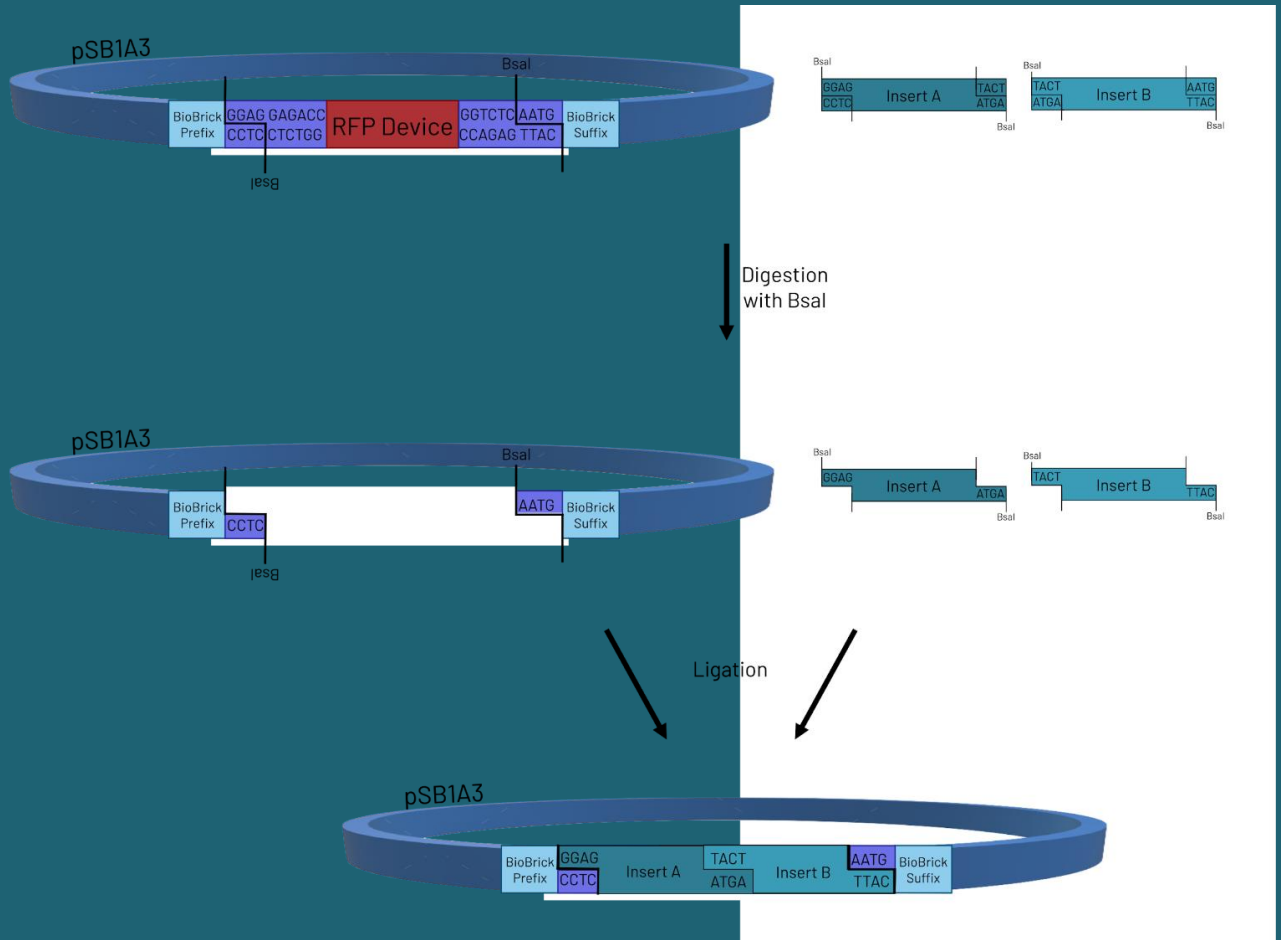


6GIX Production

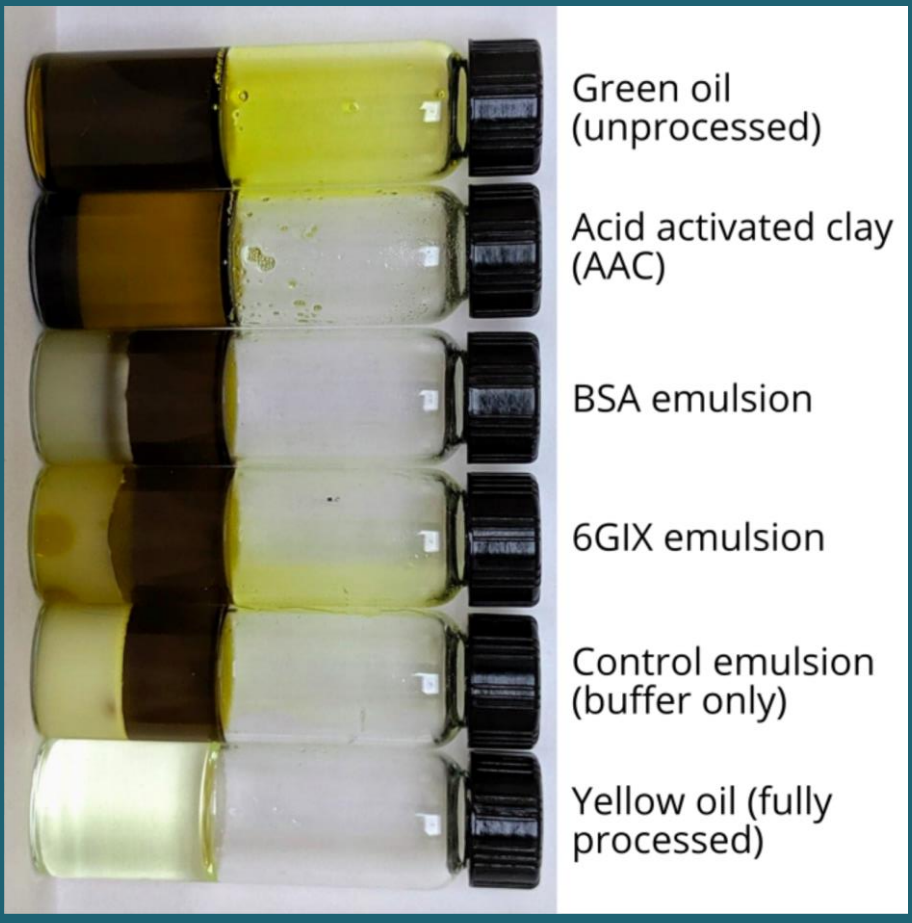

No Signal Peptide 6GIX
Empty Vector Control
L
No SP WCL
EVC WCL
Elution 1
Elution 2
Elution 3
Elution 4
Elution 1
Elution 2
Elution 3
kDa
250
180
130
95
72
55
43
34
26
17
10
6GIX (21 kDa)

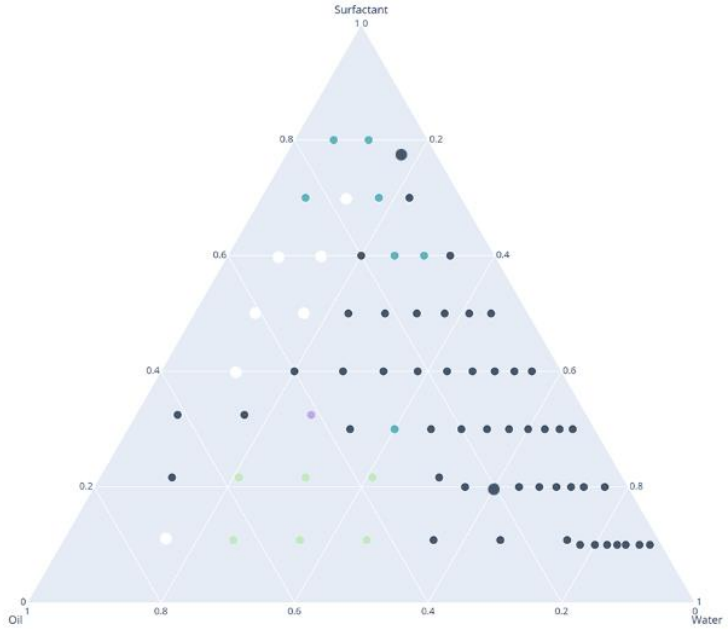

2.5
2
1.5
1
0.5
0
Periplasmic protien concenration (mg/ml)
No Signal Peptide Control
Empty Vector Control
DsbA
MalE
OmpA
PhoA
TorA
YcbK
Signal Peptide

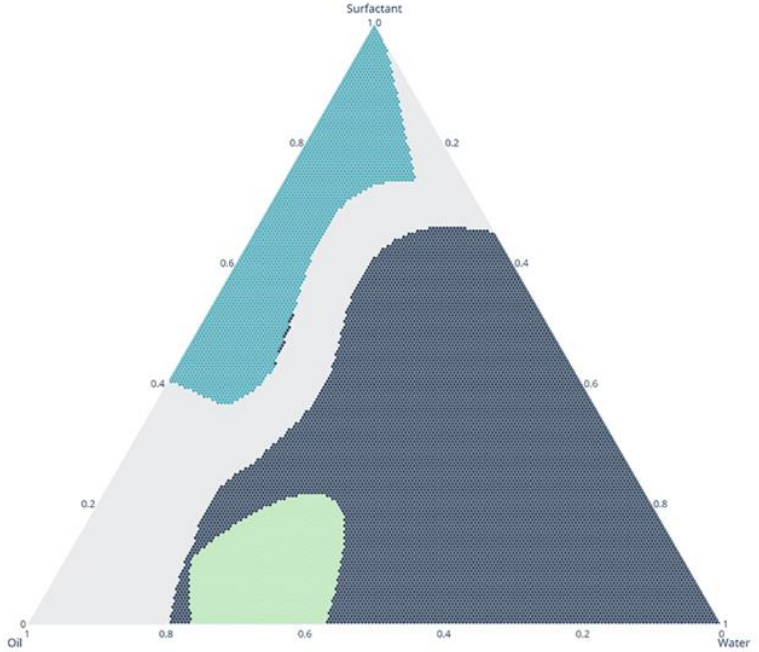
RFP Flipper Devices for Golden Gate Assembly



Emulsions


Green oil (unprocessed)
Acid activated clay (AAC)
BSA emulsion
6GIX emulsion
Control emulsion (buffer only)
Yellow oil (fully processed)



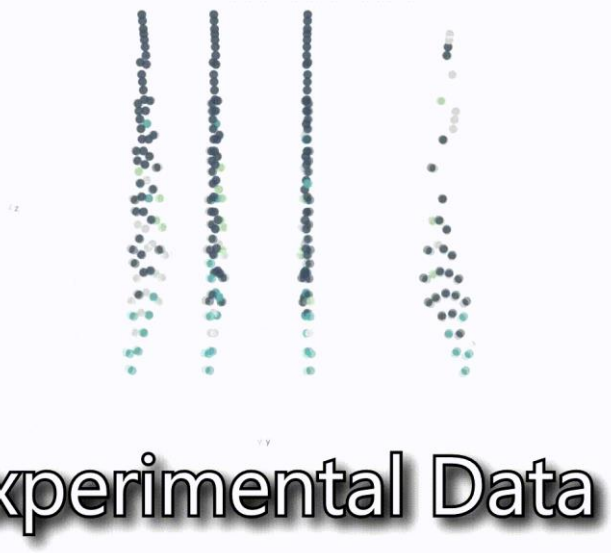


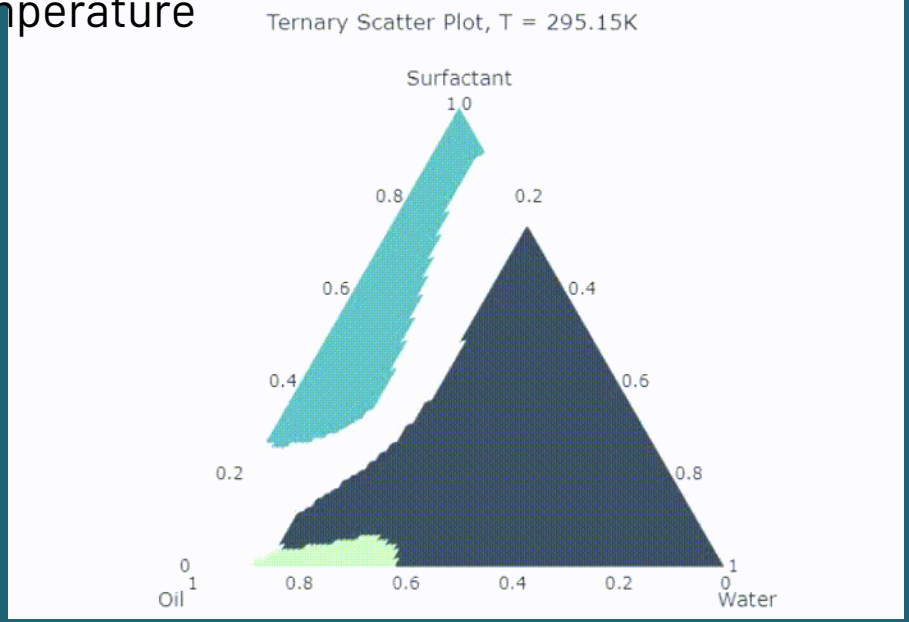
SVM

Collected Lab Data → Classification Model

Phase Modelling Process

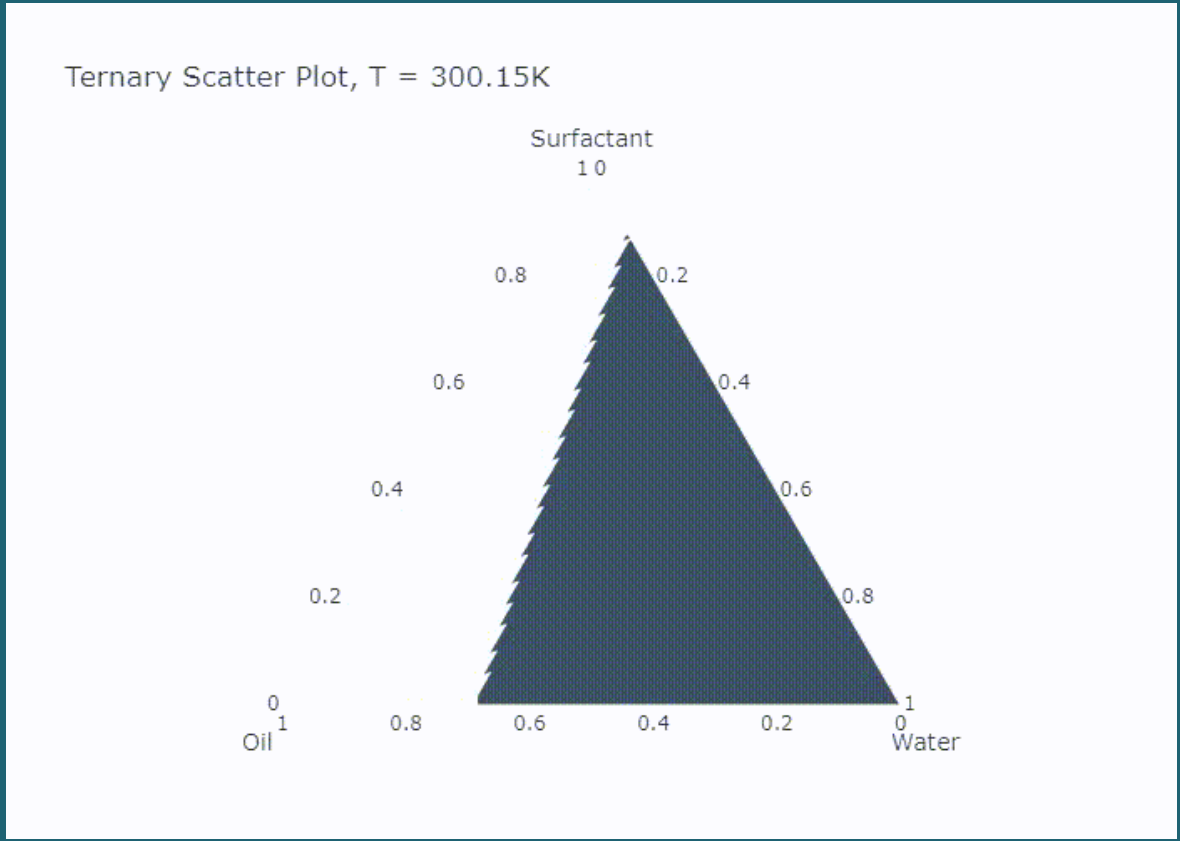
1. Experimental Data
2. SVM with RBF Kernel models phase data for the experimental temperatures
3. MLP models phase data for any temperature



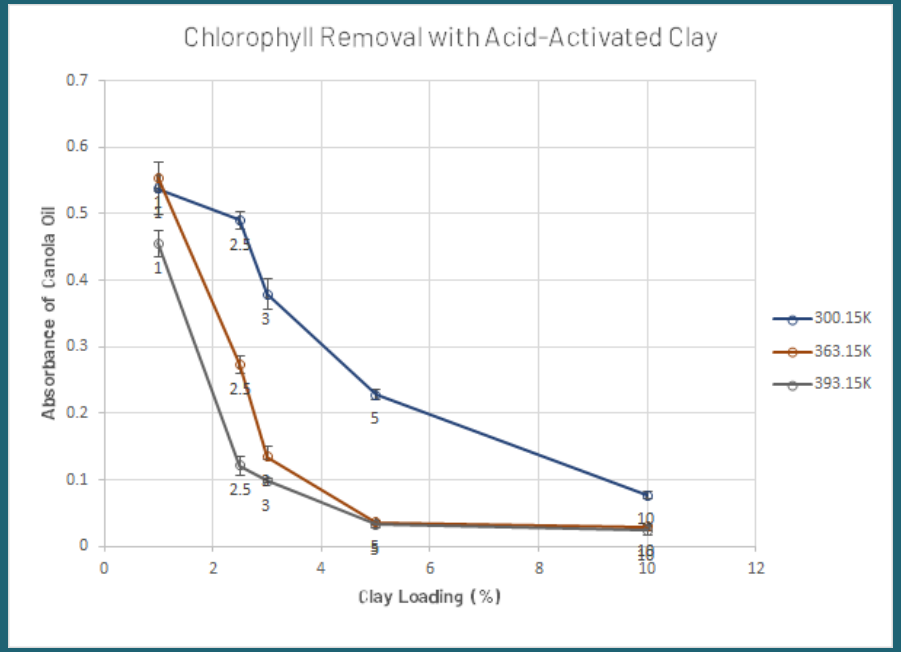


Validation using Confidence Map

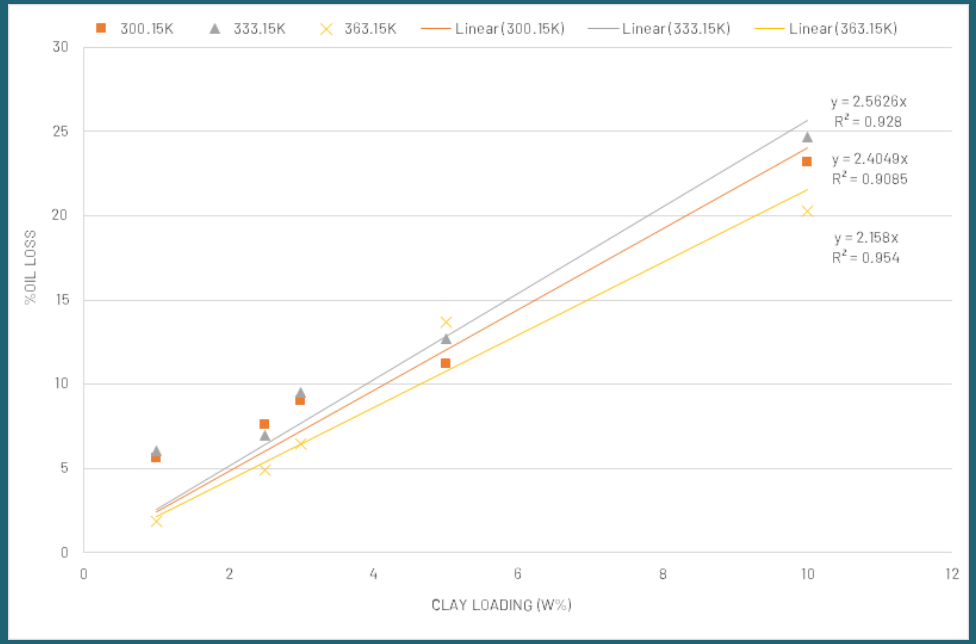
High confidence areas do **not change** in **predicted phase** for underfit to overfit models



Acid-Activated Clay Performance
Chlorophyll Removal and Oil Loss

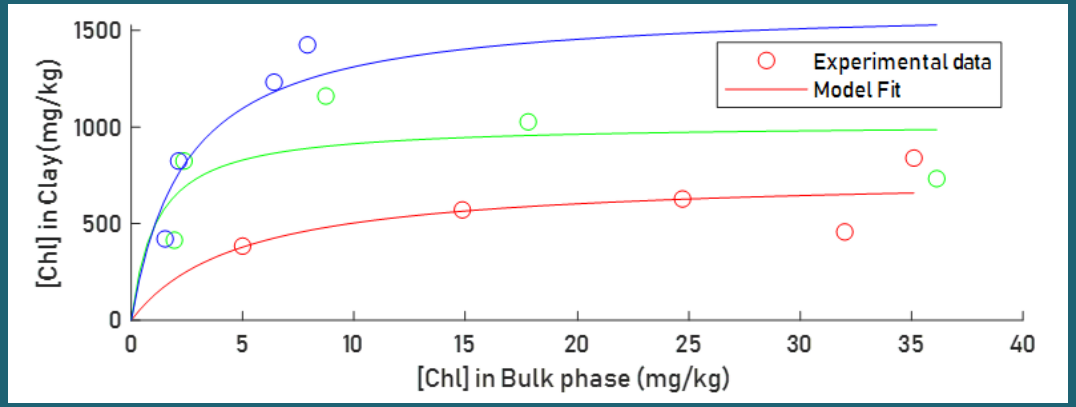


Chlorophyll Removal Experimental Results



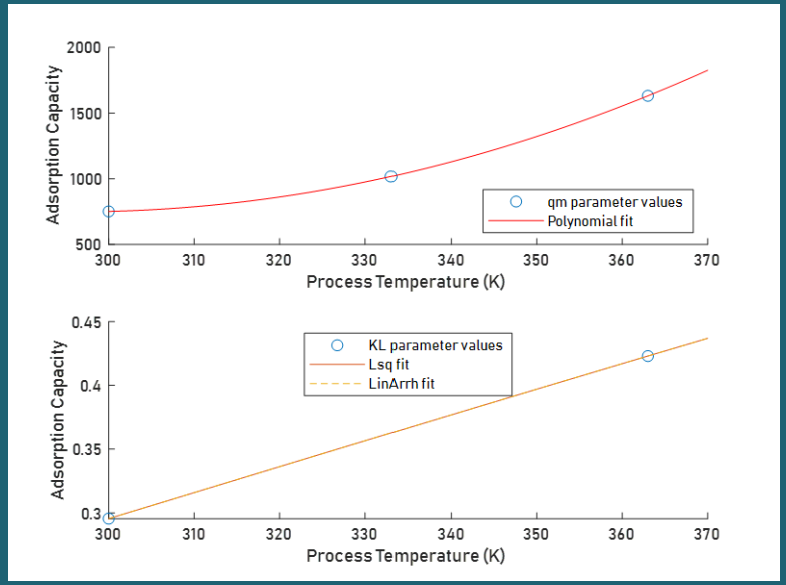
Oil Loss Experimental Results

Acid-Activated Clay Performance
Chlorophyll Removal and Oil Loss



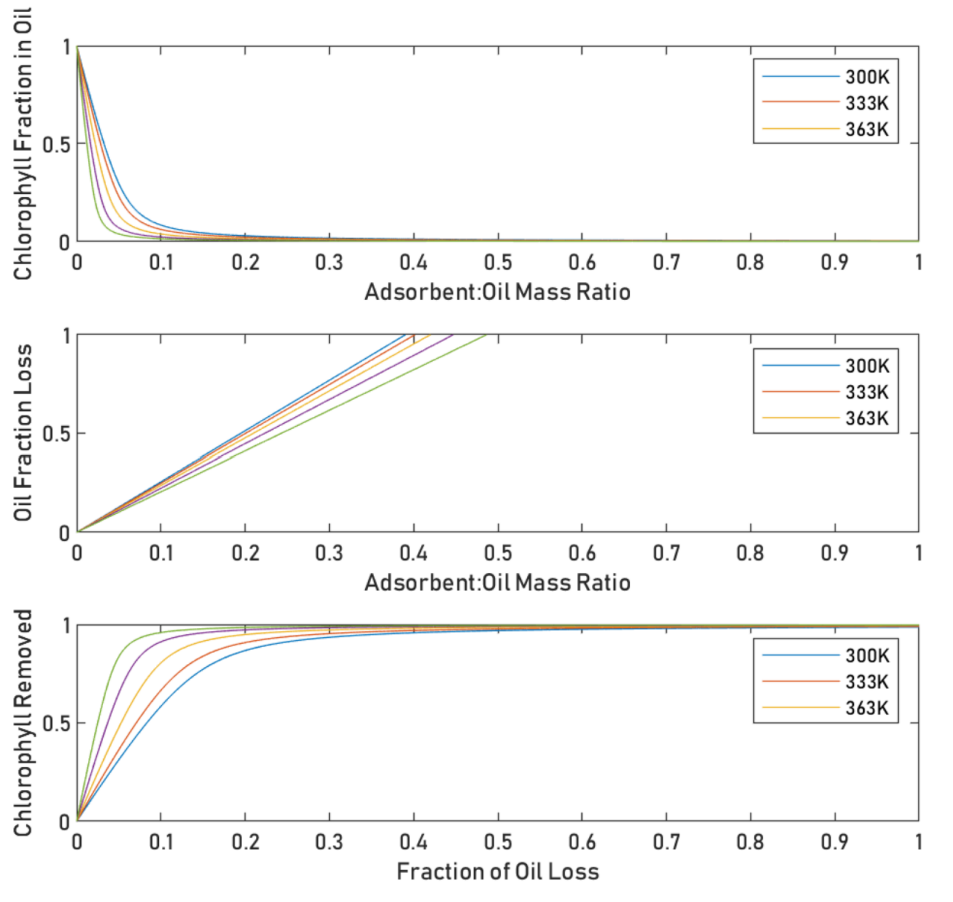
Langmuir Isotherm Model Fitting

R =

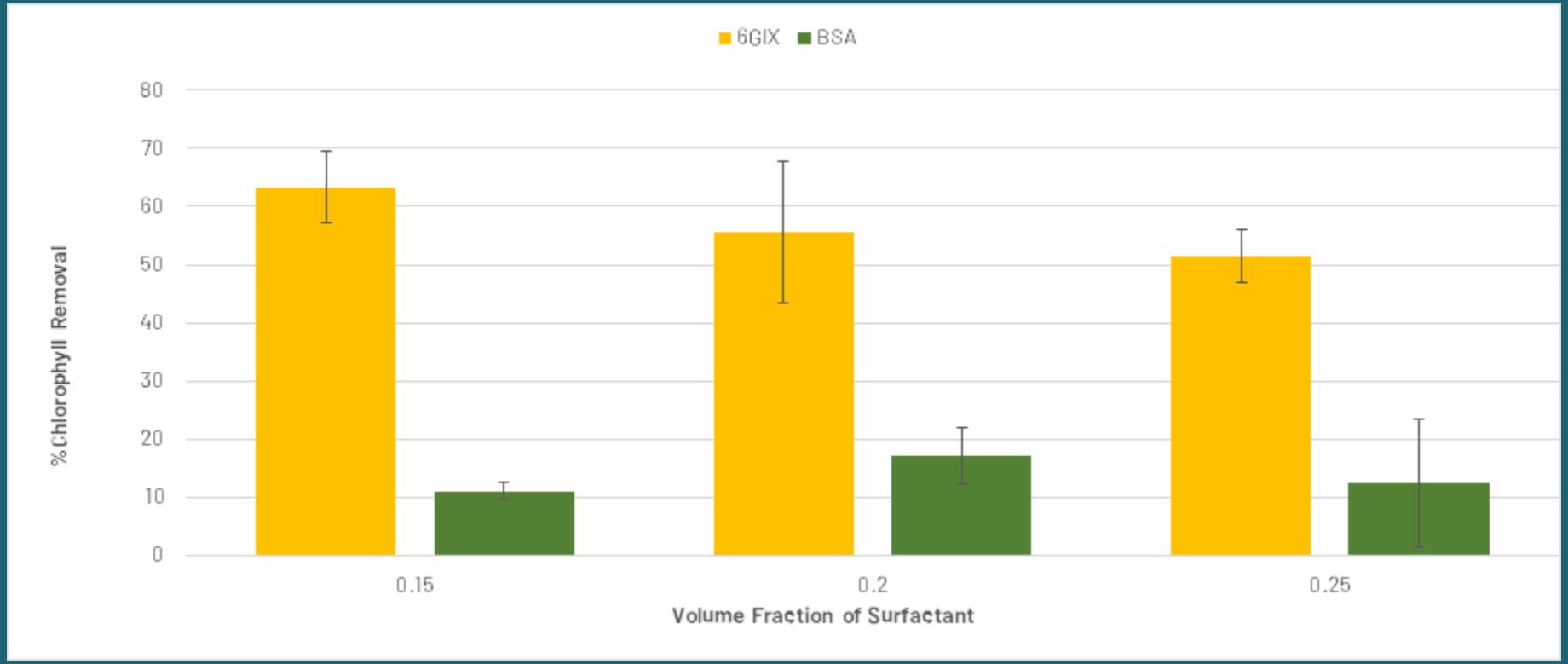


Temperature Dependance Fitting

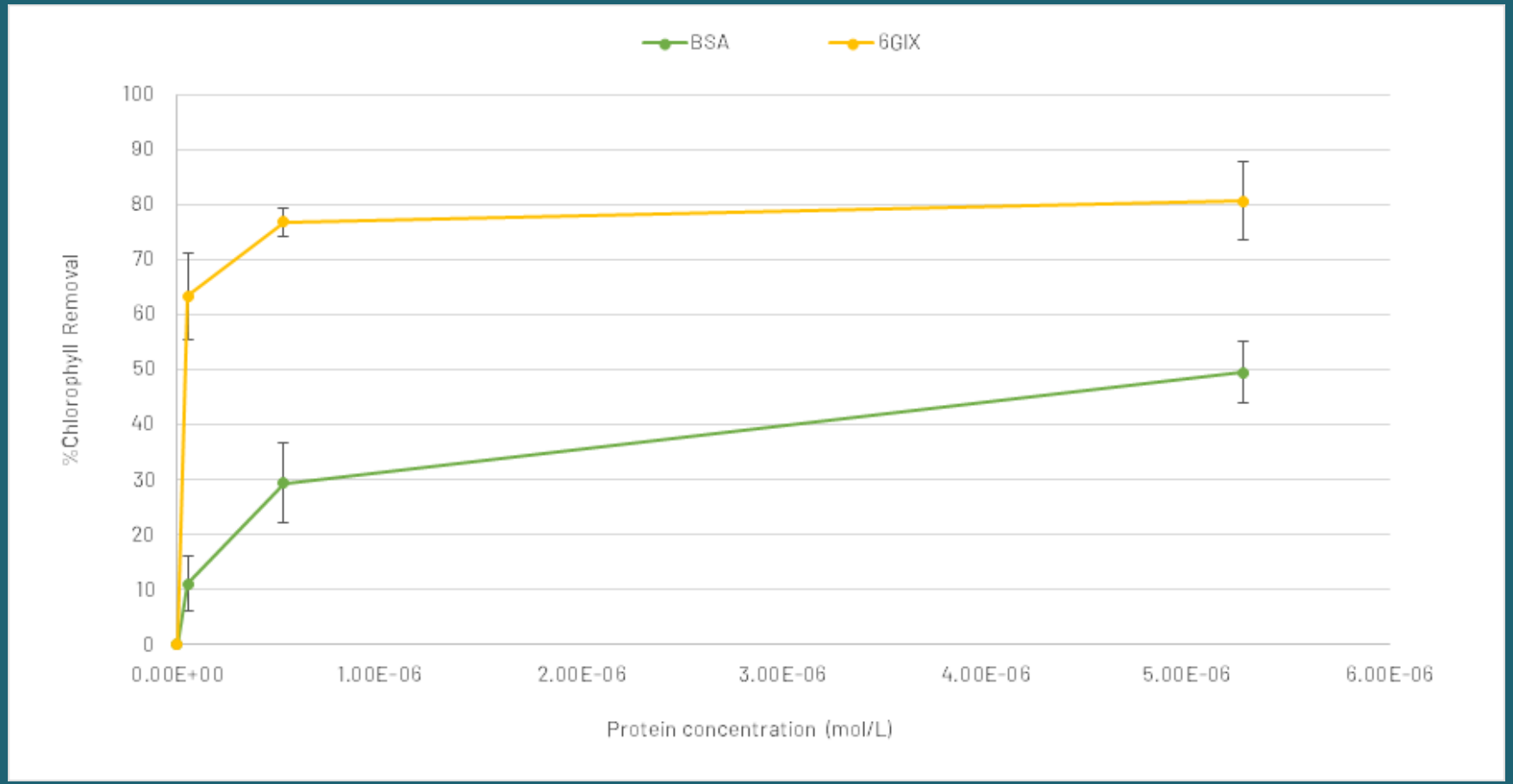
Acid Activated Clay Performance Model



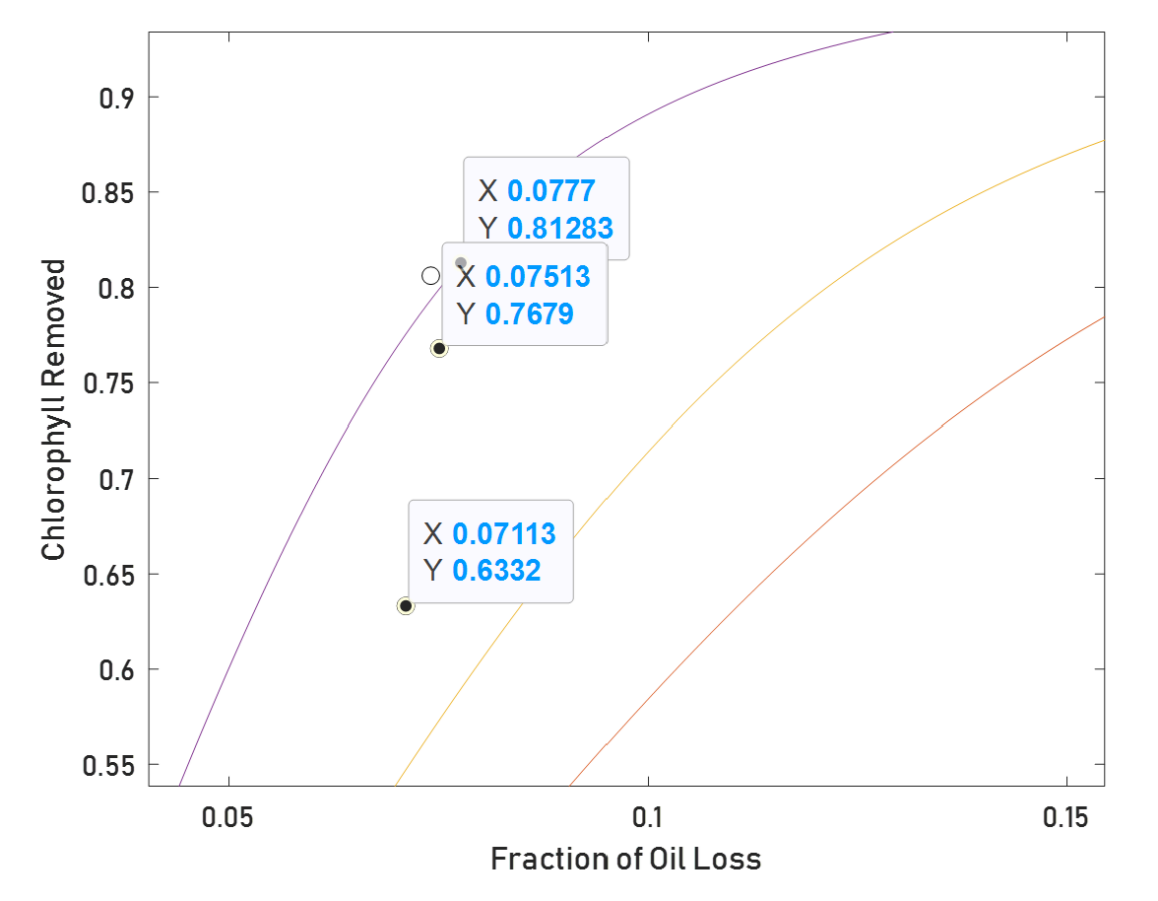
Surfactant Composition Experiments



Emulsified-Protein Chlorophyll Removal

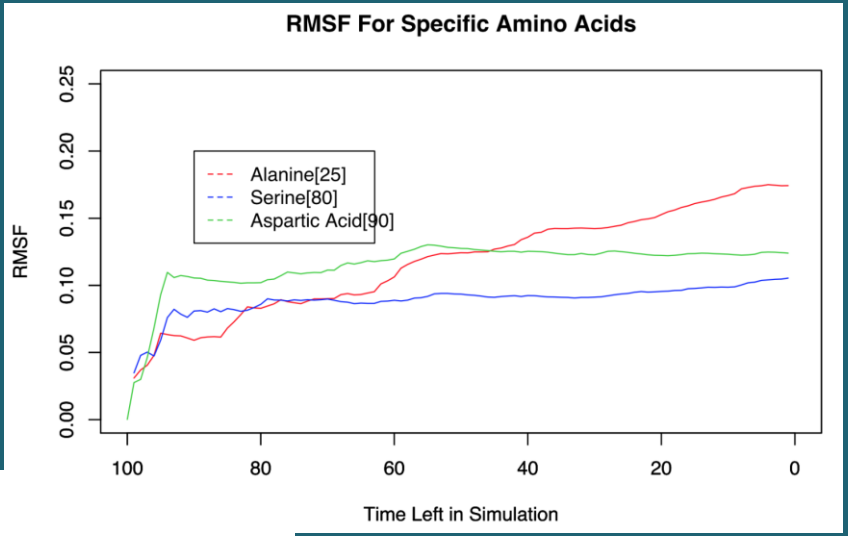


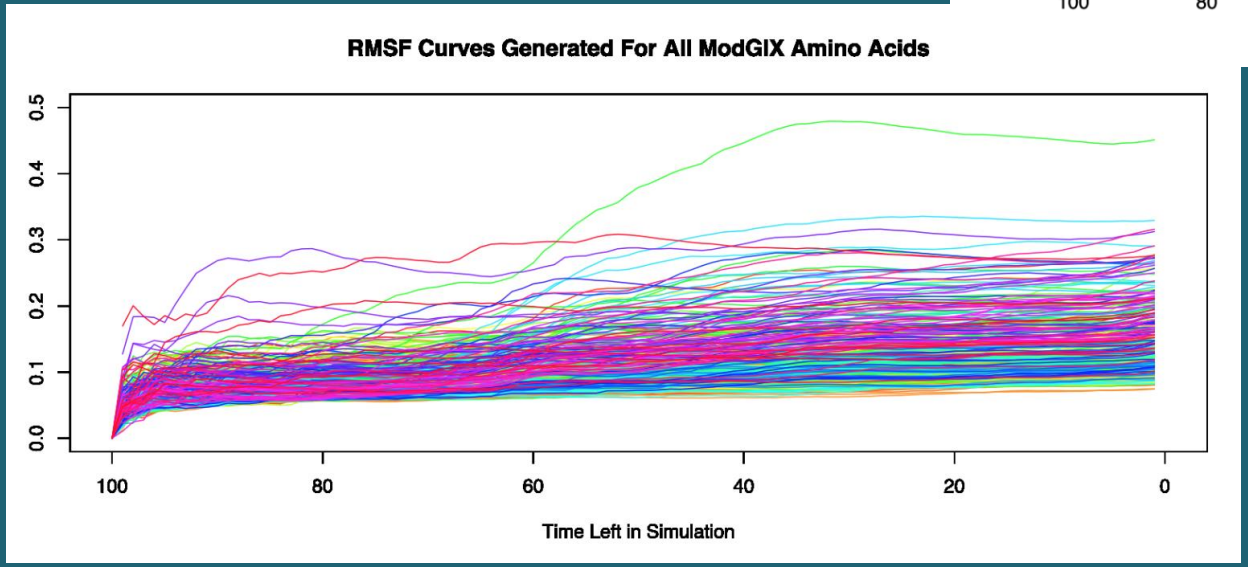
Performance Comparison



MODGIX

Measurement





Pheophorbide Production

CHLOROPHYLL REPURPOSING ACHIEVEMENTS

1. Universal spacer (ICARUS) for large proteins with a binding pocket that has strong electrostatic interactions

First to:

2. Test pheophorbide a on *Sclerotinia sclerotiorum*
3. Test pheophorbide a on *Pestalotiopsis microspora*
4. Execute pheophorbide a disc test
5. Purify Pheophytinase
6. Submit these proteins to the registry, characterized.

TO BE

1. Pheophorbide minimum inhibitory concentration

1. First in-vitro system to degrade chlorophyll a and b → pheophorbide a enzymatically

1. Quantitative characterization of pheophytinase

Chlorophyll Repurposing Achievements

1. Recombinant PPH converted pheophytin into pheophorbide, our desired product, not seen in prior literature.

ICARUS

1. ICARUS, a novel contribution, functionally allowed for purification of HCAR and PPH using a 6xHis-tag, despite problematic electrostatic interactions

Anti-Fungal

1. The harmful canola pathogen S. sclerotiorum's mycelium was inhibited by pheophorbide a treatment, not seen in prior literature
2. Comparative analysis of P. microspora suggests pheophorbide a specificity toward S. sclerotiorum inhibition

TO BE

1. Pheophorbide minimum inhibitory concentration

1. First in-vitro system to degrade chlorophyll a and b → pheophorbide a enzymatically

1. Quantitative characterization of pheophytinase

PHEOPHYTINASE PURIFICATION

Journal of Experimental Botany, Vol. 69, No. 4 pp. 879–889, 2018
doi:10.1093/jxb/erx326 Advance Access publication 23 September 2017
This paper is available online free of all access charges (see http://jxb.oxfordjournals.org/open_access.html for further details)

RESEARCH PAPER

Catalytic and structural properties of pheophytinase, the phytol esterase involved in chlorophyll breakdown

Luzia Guyer, Kathrin Salinger, Undine Krügel and Stefan Hörtensteiner*

Institute of Plant and Microbial Biology, University of Zurich, Zollikerstrasse 107, CH-8008 Zurich, Switzerland

* Correspondence: shorten@botinst.uzh.ch

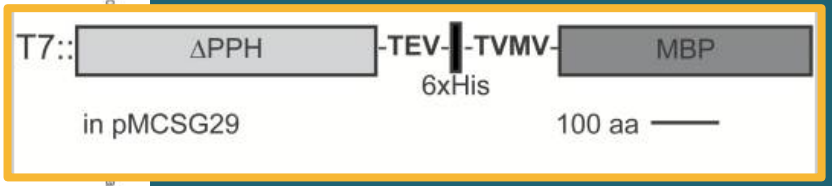
Received 14 July 2017; Editorial decision 21 August 2017; Accepted 21 August 2017

Editor: Christine Foyer, Leeds University, UK

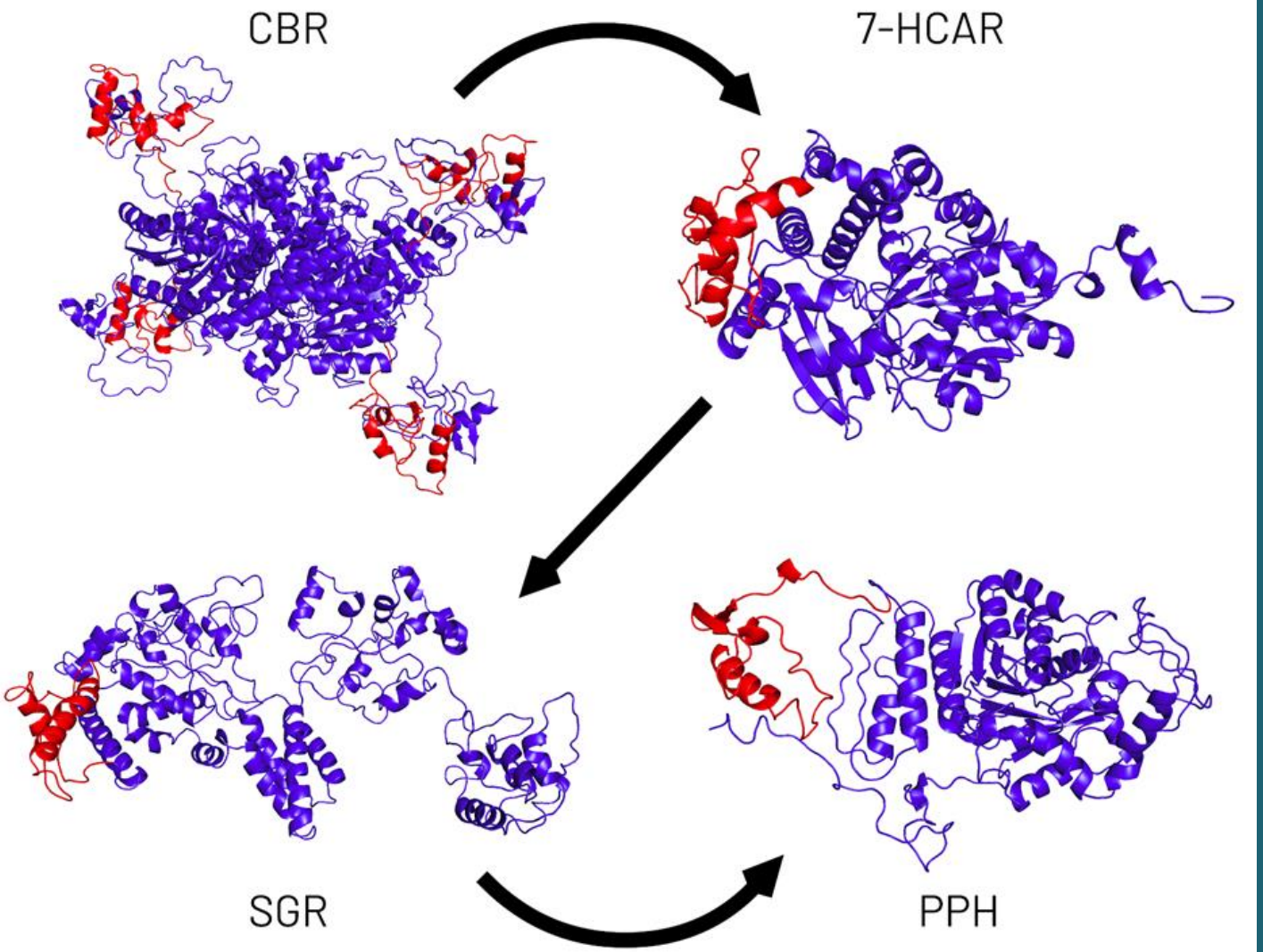
Abstract

During leaf senescence and fruit ripening, chlorophyll is degraded in a multistep pathway into linear tetrapyrroles called phyllobilins. A key feature of chlorophyll breakdown is the removal of the hydrophobic phytol chain that renders phyllobilins water soluble, an important prerequisite for their ultimate storage in the vacuole of senescent cells. Chlorophyllases had been considered for more than a century to catalyze dephytylation *in vivo*; however, this was recently refuted. Instead, pheophytinase was discovered as a genuine *in vivo* phytol hydrolase. While chlorophyllase acts rather unspecifically towards different porphyrin substrates, pheophytinase was shown to specifically dephytylate pheophytin, namely Mg-free chlorophyll. The aim of this work was to elucidate in detail the biochemical and structural properties of pheophytinase. By testing different porphyrin substrates with recombinant pheophytinase from *Arabidopsis thaliana* we show that pheophytinase has high specificity for the acid moiety of the ester bond, namely the porphyrin ring, while the nature of the alcohol, namely the phytol chain in pheophytin, is irrelevant. *In silico* modelling of the 3-dimensional structure of pheophytinase and subsequent analysis of site-directed pheophytinase mutant forms allowed the identification of the serine, histidine, and aspartic acid residues that compose the catalytic triad, a classical feature of serine-type hydrolases to which both pheophytinase and chlorophyllase belong. Based on substantial structural differences in the models of Arabidopsis pheophytinase and chlorophyllase 1, we discuss potential differences in the catalytic properties of these two phytol hydrolases.

Despite intensive attempts to purify and crystallize recombinant PPH, we were unsuccessful. Instead, we modelled the 3D structure of PPH based on publicly available structures of other α/β fold hydrolases. This model (Fig. 5) allowed the identifica-



Guyer et al. 2017


CBR
7-HCAR
SGR
PPH

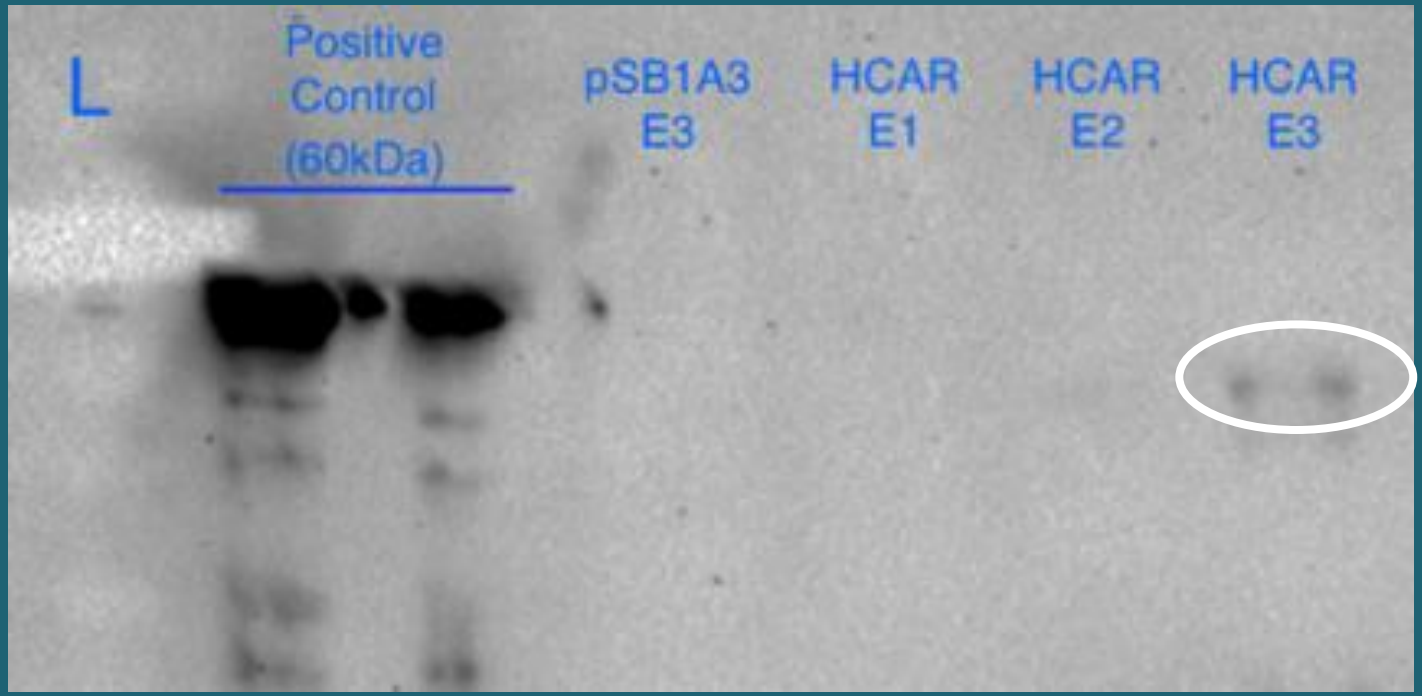
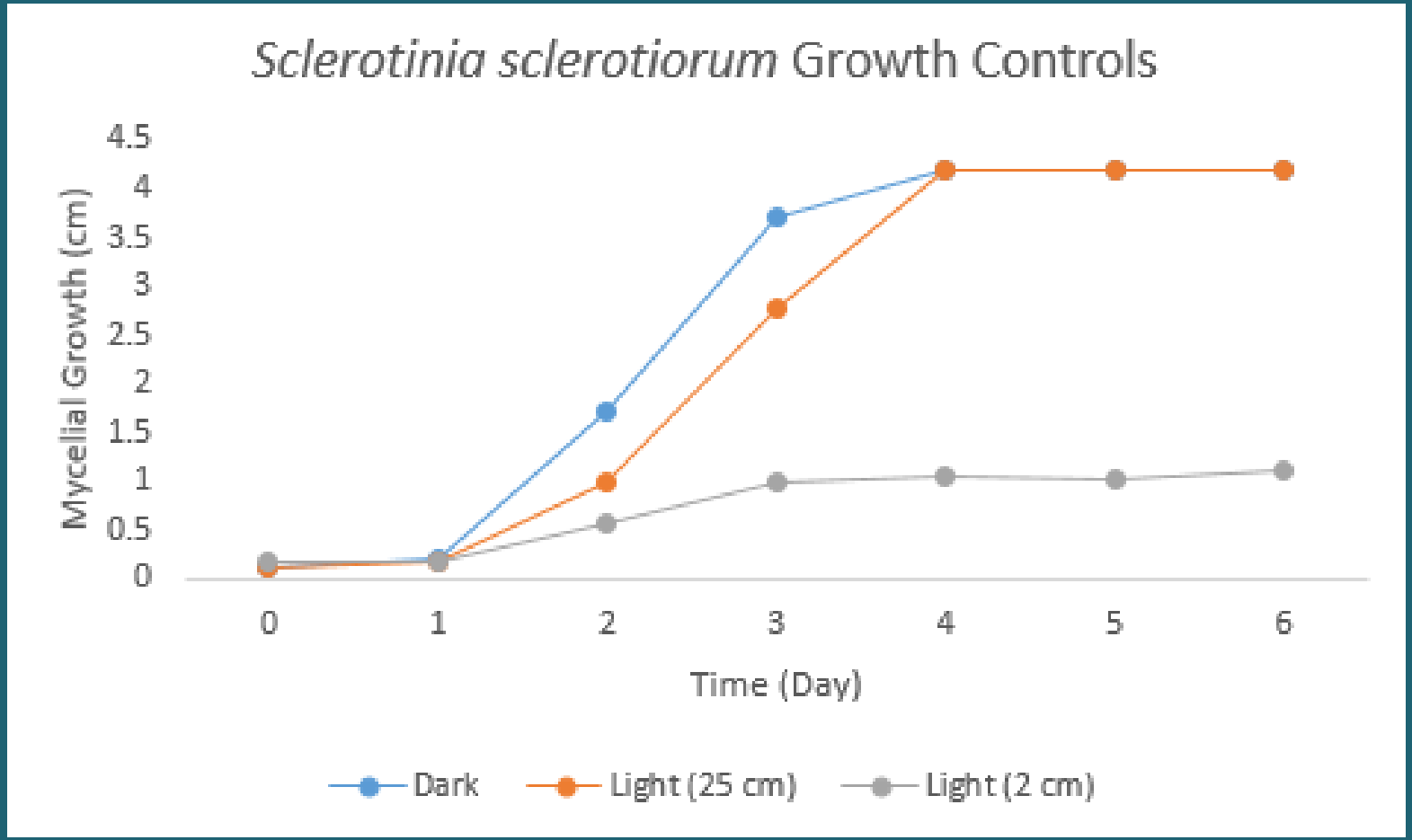
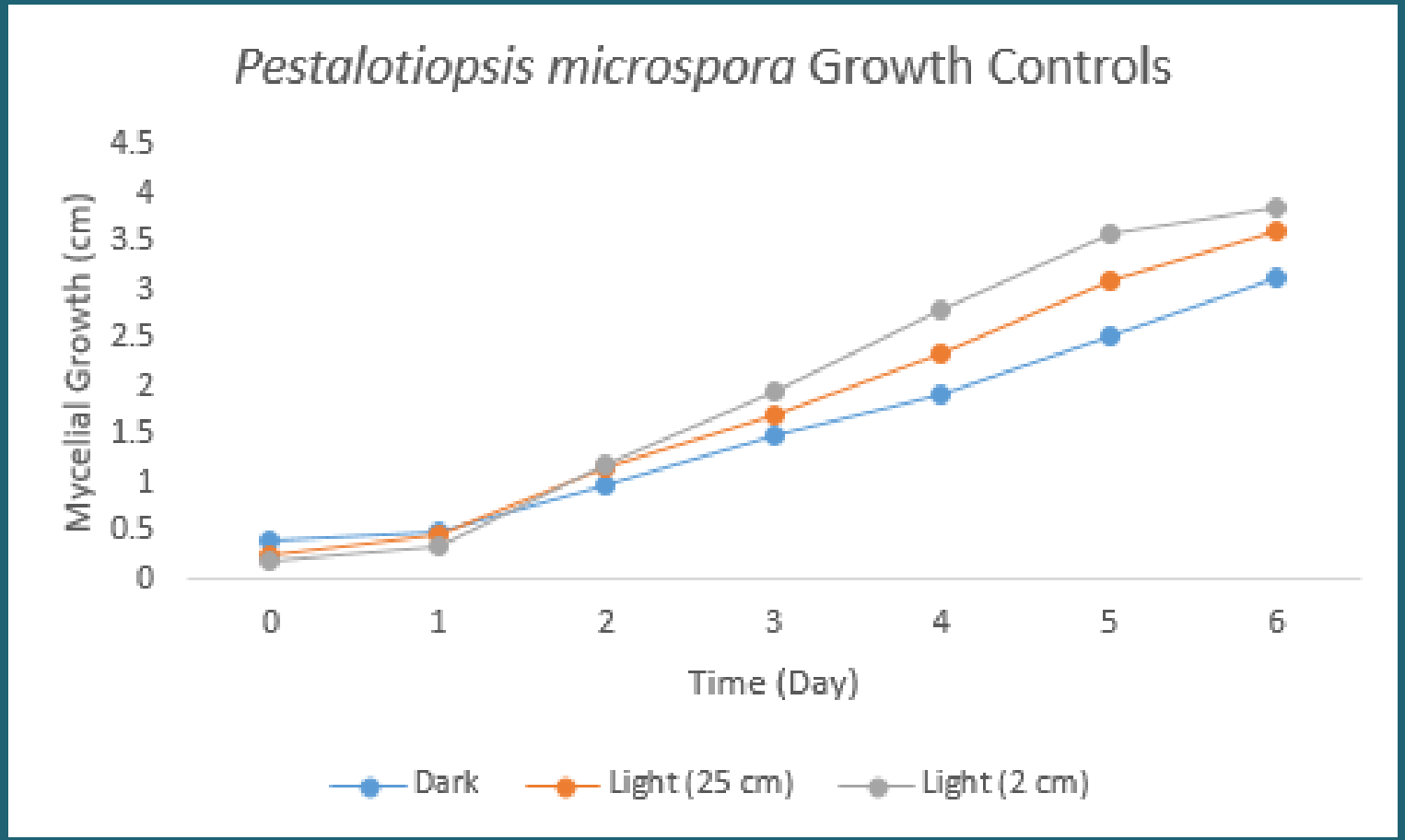
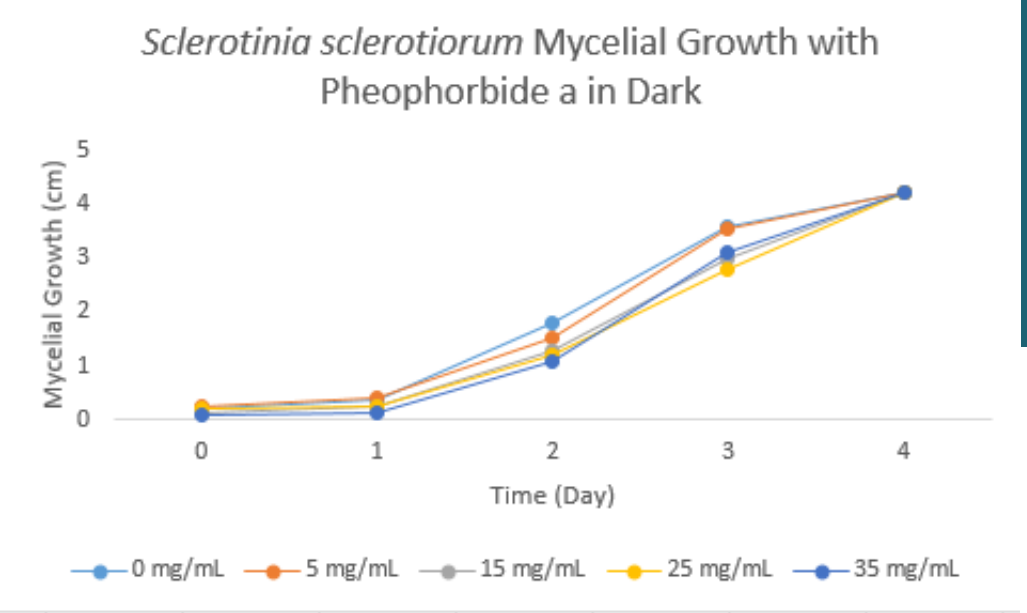
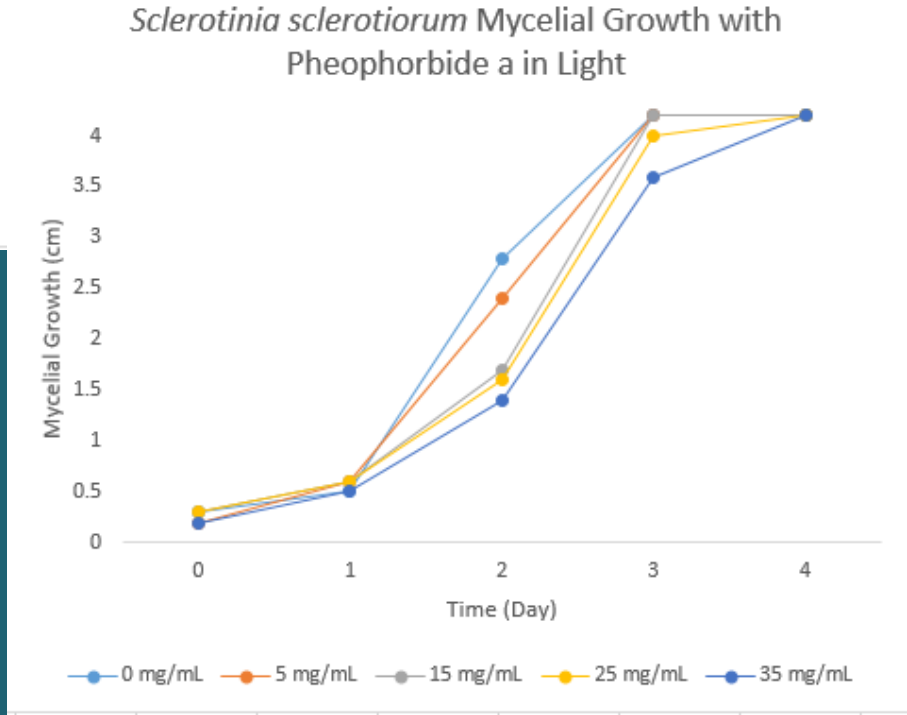


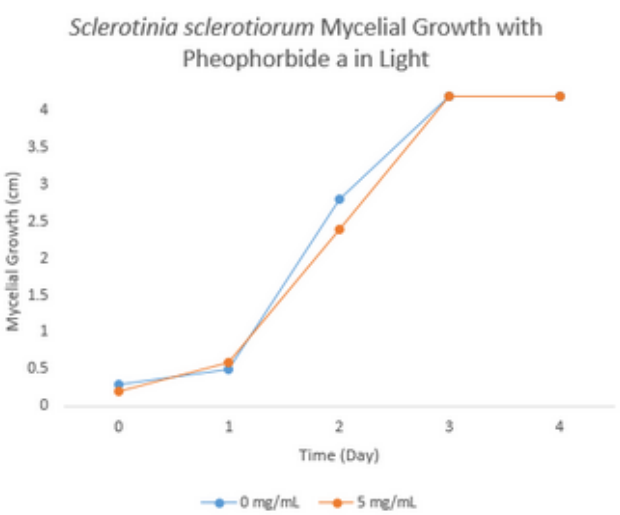
Figure 6. **Western Blot HCAR Purification Confirmation.** 10% SDS-PAGE was run and transferred to a PVDF membrane. An "anti-his-tag MAb" primary antibody was used with an "anti-mouse IgG conjugated with HRP" secondary antibody. ECL was used to visualise. Lanes from left to right on the SDS-PAGE were ladder (Color Prestained Protein Standard, Broad Range (11–245 kDa) (NEB)), ~60 kDa protein (positive control) in two lanes, pSB1A3 (plasmid control in BL21) - elution fraction 3, HCAR - elution fraction 1, HCAR - elution fraction 2, HCAR - elution fraction 3. HCAR is 58 kDa.

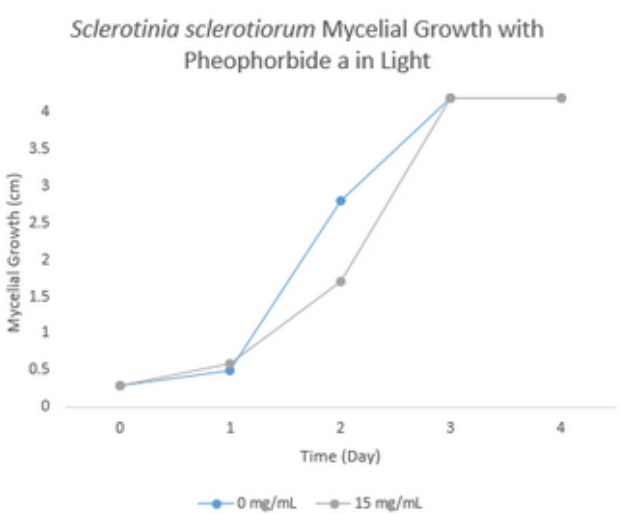

Sclerotinia sclerotiorum Growth Controls
Mycelial Growth (cm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Time (Day)
Dark
Light (25 cm)
Light (2 cm)

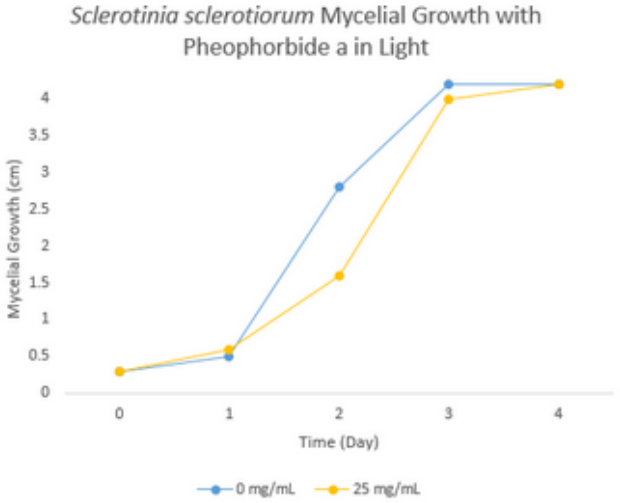

Pestalotiopsis microspora Growth Controls
Mycelial Growth (cm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Time (Day)
Dark
Light (25 cm)
Light (2 cm)

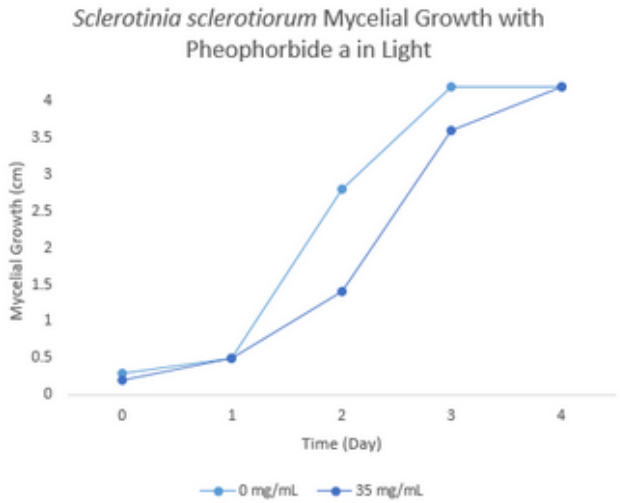

Sclerotinia sclerotiorum Mycelial Growth with Pheophorbide a in Dark
Mycelial Growth (cm)
0
1
2
3
4
5
0
1
2
3
4
Time (Day)
0 mg/mL
5 mg/mL
15 mg/mL
25 mg/mL
35 mg/mL


Sclerotinia sclerotiorum Mycelial Growth with Pheophorbide a in Light
Mycelial Growth (cm)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
1
2
3
4
Time (Day)
0 mg/mL
5 mg/mL
15 mg/mL
25 mg/mL
35 mg/mL

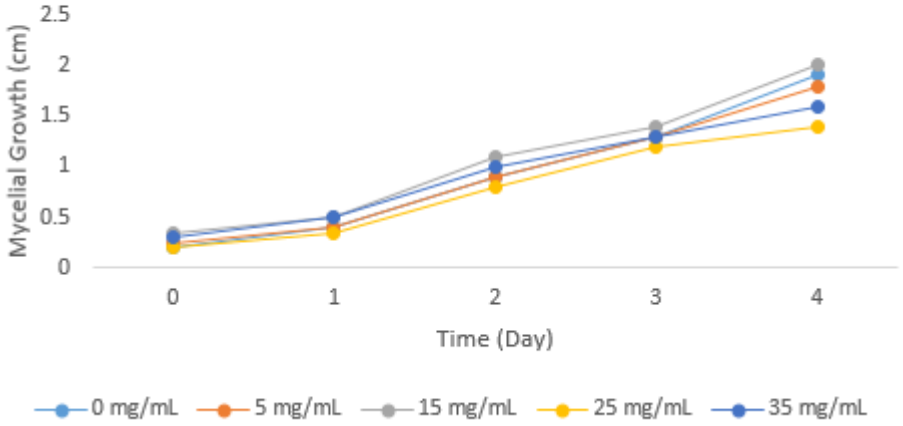

Sclerotinia sclerotiorum Mycelial Growth with Pheophorbide a in Light
Mycelial Growth (cm)
Time (Day)
0 mg/mL
5 mg/mL

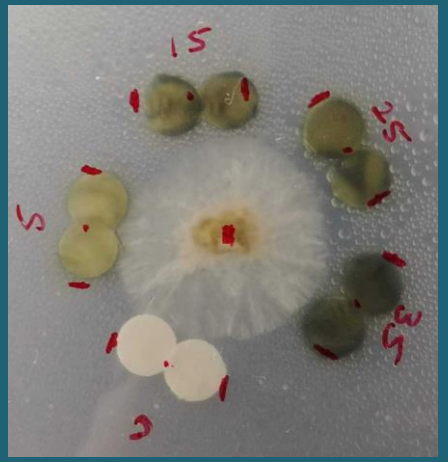

Sclerotinia sclerotiorum Mycelial Growth with Pheophorbide a in Light
Mycelial Growth (cm)
Time (Day)
0 mg/mL
15 mg/mL


Sclerotinia sclerotiorum Mycelial Growth with Pheophorbide a in Light
Mycelial Growth (cm)
Time (Day)
0 mg/mL
25 mg/mL

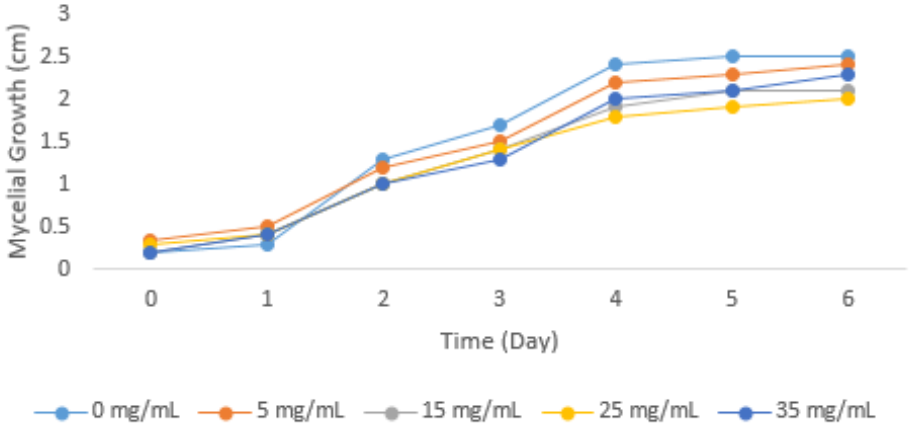

Sclerotinia sclerotiorum Mycelial Growth with Pheophorbide a in Light
Mycelial Growth (cm)
Time (Day)
0 mg/mL
35 mg/mL

Pestalotiopsis microspora Mycelial Growth with Pheophorbide a in Dark





Pestalotiopsis microspora Mycelial Growth with Pheophorbide a in Light



Education & Outreach

In the Community

iGEM Calgary and The Biological Students' Association Present

THE GOOD, THE BAD, AND THE BIOLOGICAL

Wednesday, September 25, 2019
5PM — 7PM @ The Hunter Hub in MacHall
(Food and refreshments will be provided)

A discussion on why we need to innovate with controversial biotechnology and how we can stop it from destroying us.

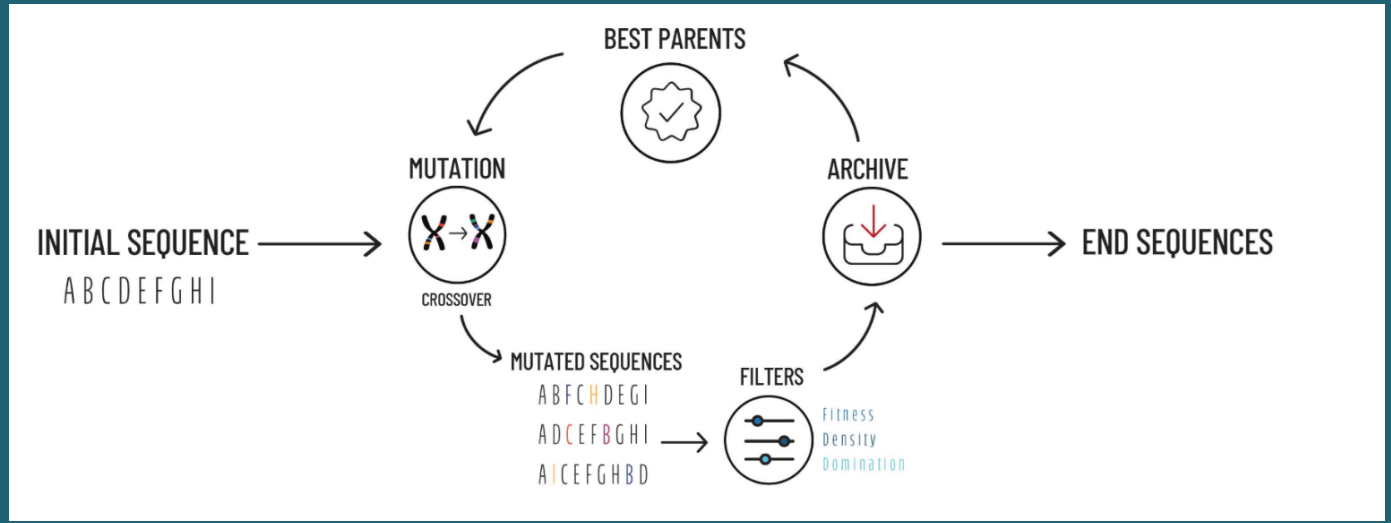
Education and Outreach

MDSC 507: Introduction to Synthetic Biology
Lab Skills Workshop (Lethbridge)
Webber Academy (1 and 2)
Canmore Mindfuel Event
CanolaPALOOZA
Faculty Talk
JulyGEM
Telus SPARK
Pacific Northwest Meetup
Philosophical Discussion
Bacteria Night

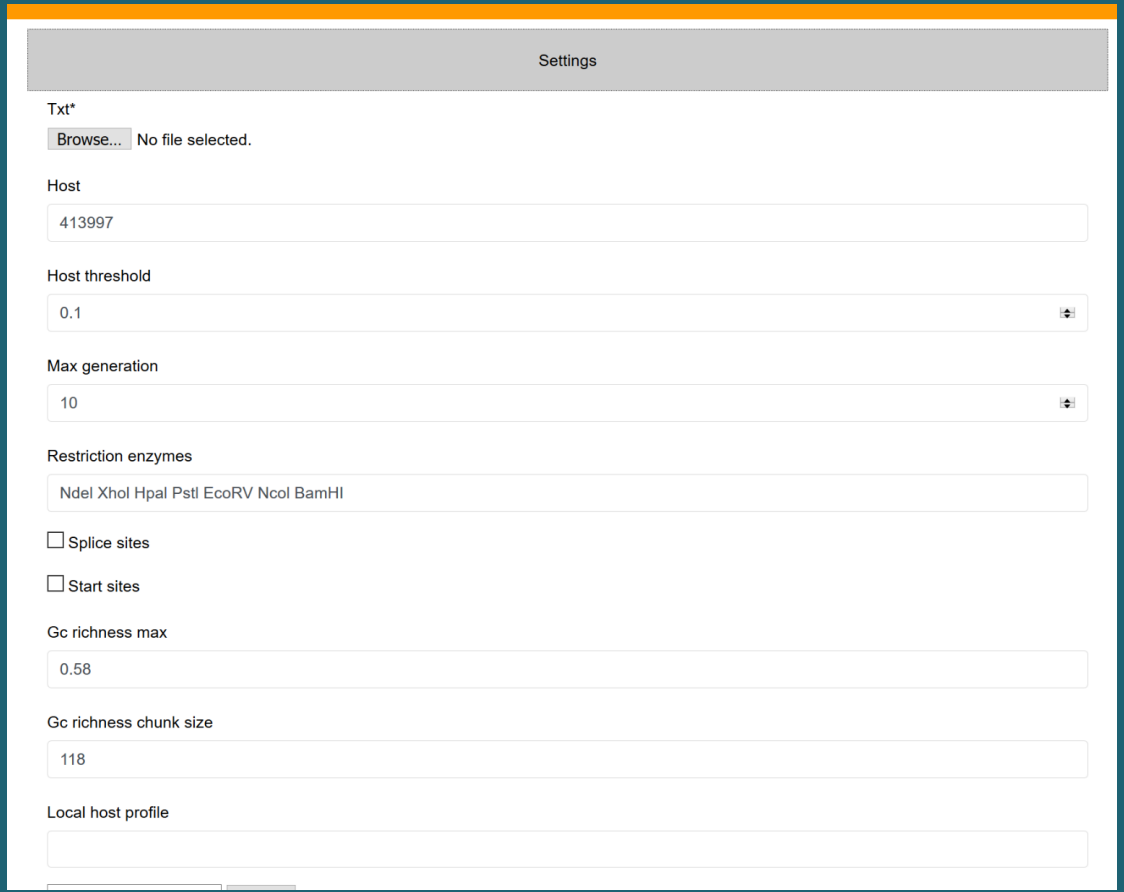
Functionality

Based on the work of Brian Weitzner/codon-harmony

repeats,
gc-richness,
and hairpins.



Interface


Settings
Txt*
Browse...
No file selected.
Host
413997
Host threshold
0.1
Max generation
10
Restriction enzymes
NdeI XhoI HpaI PstI EcoRV NcoI BamHI
Splice sites
Start sites
Gc richness max
0.58
Gc richness chunk size
118
Local host profile