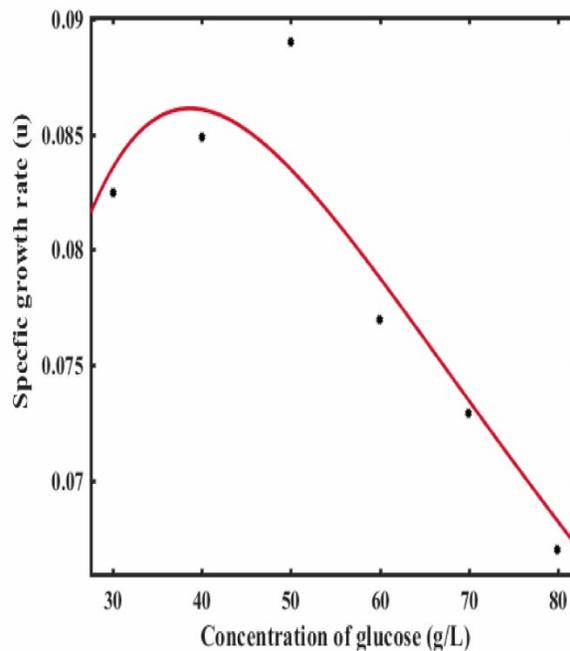
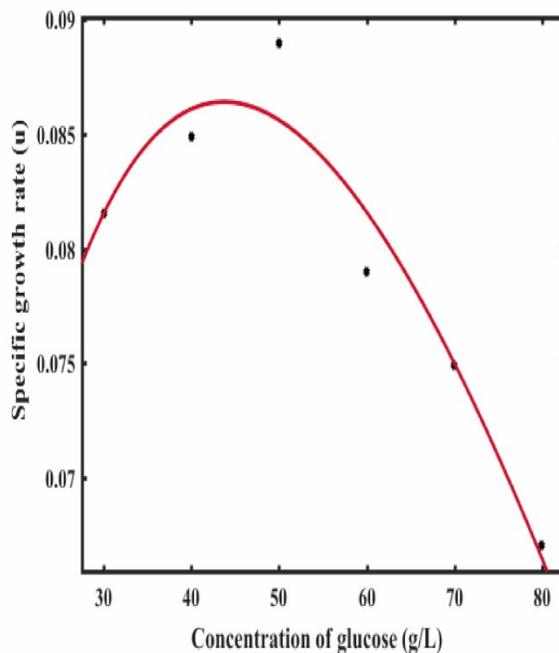


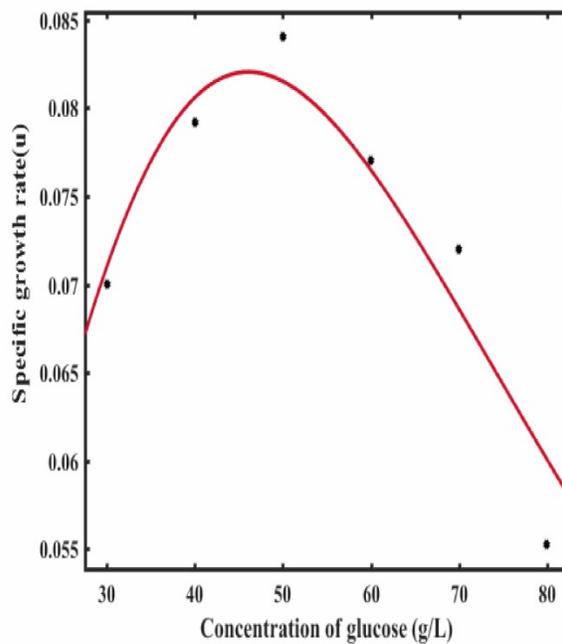
(A) Andrew model



(B) Haldane model



(C) Luong model



(D) Yano model

Figure.S1. Selected substrate inhibition models which fit the substrate inhibition studies

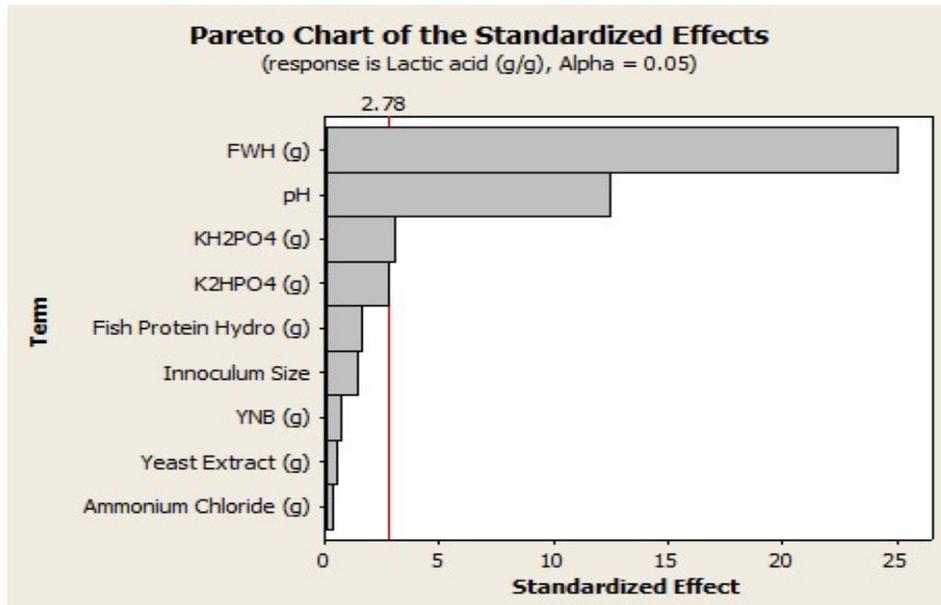


Figure.S2. Pareto chart of the standardized effects of parameters

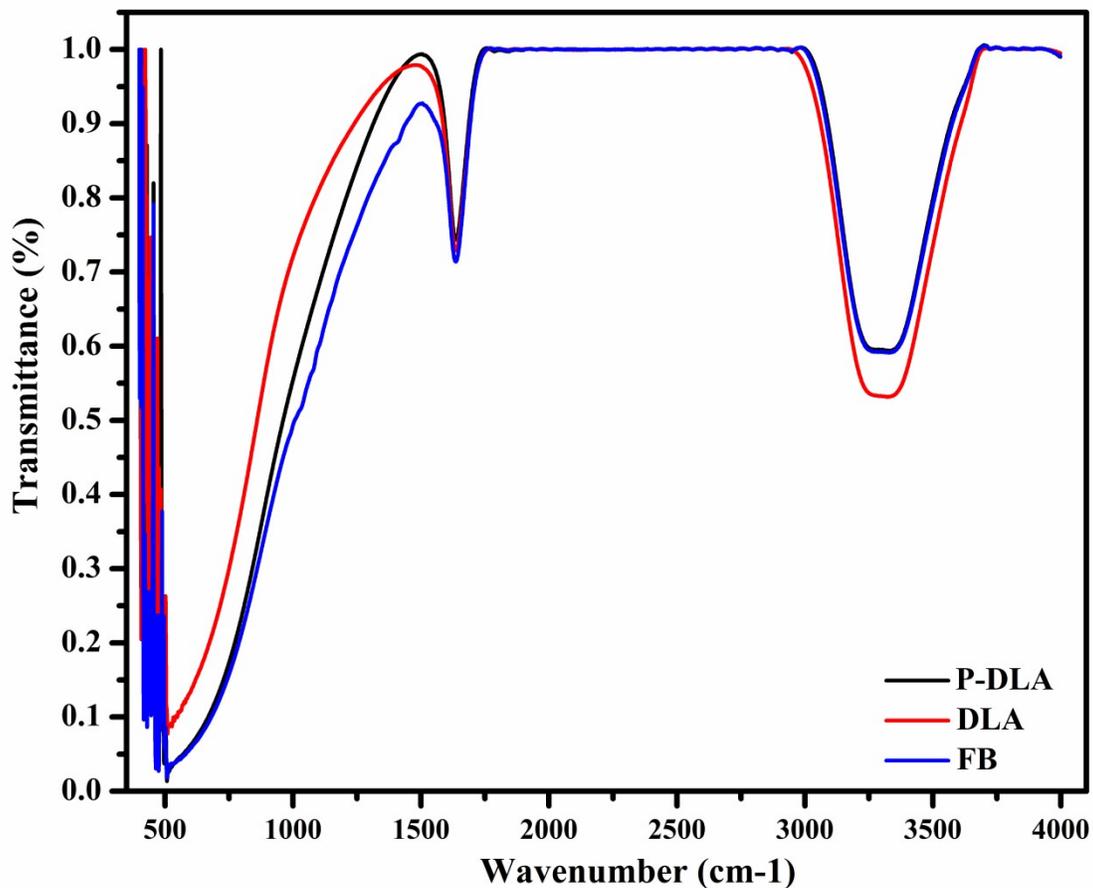


Figure S3: FTIR characterization of D-lactic acid Purified D-Lacticacid (P-DLA), D-Lacticacid (DLA) and (FB) Fermentation broth

Table.S1.Specific growth equation for substrate inhibition studies

Model	Equation	References
Monod model	$\mu = \frac{\mu_m \gamma_s}{K_s + \gamma_s}$	31
Aiba	$\mu = \frac{\mu_m \gamma_s}{K_s + \gamma_s} \exp\left(\frac{-\gamma_s}{K_I}\right)$	32
Andrew	$\mu = \frac{\mu_m \gamma_s}{(K_s + \gamma_s) \left(1 + \frac{\gamma_s}{K_I}\right)}$	33
Haldane	$\mu = \frac{\mu_m \gamma_s}{K_s + \gamma_s + \left(\frac{\gamma_s^*}{K_I}\right)}$	30

Moser	$\mu = \frac{\mu_m \gamma_s^n}{K_s + \gamma_s^n}$	34
Edward	$\mu = \mu_m \gamma_s \left[\exp\left(\frac{-\gamma_s}{K_I}\right) - \exp\left(\frac{-\gamma_s}{K_I}\right) \right]$	35
Webb	$\mu = \frac{\mu_m \gamma_s \left(1 + \frac{\gamma_s}{K}\right)}{K_s + \gamma_s + \left(\frac{\gamma_s^2}{K_I}\right)}$	36
Luong	$\mu = \frac{\mu_m \gamma_s}{(K_s + \gamma_s)} \left[1 - \frac{\gamma_s}{\gamma_s^*} \right]^n$	37
Yano	$\mu = \frac{\mu_m \gamma_s}{\left(K_s + \gamma_s + \frac{\gamma_s^2}{K_I} \left(1 + \left(\frac{\gamma_s}{K_I}\right)\right)\right)}$	38
Han-levenspiel	$r = k \left[\left(1 - \frac{\gamma_s}{\gamma_s^*}\right)^n \right] \frac{\gamma_s C}{\gamma_s + K_M \left[\left(1 - \frac{\gamma_s}{\gamma_s^*}\right)^m \right]}$	39
Verhulst	$\mu = \mu_{max} \left[1 - \frac{X}{X_m} \right]$	40
Teissier	$\mu = \mu_m \left(1 - e^{-\frac{s}{k_s}} \right)$	41

Table.S2. Parameters for Placket-Burman design with maximum and minimum value

Variable Code	Variable Name	Minimum value (-1)	Maximum value (+1)
A	Food waste hydrolysate (FWH) (g/L)	30	60
B	Yeast Extract (g/L)	15	20
C	Fish Protein Hydrolysate (FPH) (g/L)	10	15
D	YNB (g/L)	1	3
E	Ammonium Chloride (g/L)	1	3
F	Inoculum Size	0.5	2.0
G	K ₂ HPO ₄ (g/L)	2	6
H	KH ₂ PO ₄ (g/L)	2	6
I	pH	6	9

Table.S3. Parameters for Central composite design with maximum and minimum value

Variable Code	Variables	Minimum value (-1)	Maximum value (+1)
A	Food waste hydrolysate (g/L)	20	60
B	KH ₂ PO ₄ (g/L)	2	6
C	pH	7	10

Table.S4. Analysis of Variance for Plackett-Burman design for D-Lactic acid

Source	DF	SS	MS	F Value	P Value
Model	9	0.54	0.54	89.25	0.000
Residual error	4	0.10	0.10		
Lack of fit	5	0.0023	0.0023	6.56	0.132
Pure Error	2	0.0035	0.0035		
Total	14	0.59			

Table.S5. Analysis of Variance for CCD optimization for DLA

Source	DF	SS	MS	F Value	P Value
Model	9	1.093	1.093	44.08	0.000
Residual error	10	0.027	0.027		
Lack of fit	5	0.024	0.024	6.84	0.027
Pure Error	2	0.0035	0.0035		
Total	19	1.120			

Table.S6.Fish waste composition

Parameter	Unit	Value
Protein	(g/100g) (%)	80
Nitrogen (N)	(g/100g) (%)	13
Phosphorous (P)	(g/100g) (%)	1
Potassium (K)	(g/100g) (%)	1.5
pH		6.5
Total organic carbon	(g/100g) (%)	45
C:N ratio	(g/100g) (%)	4:1
Sodium	(g/100g) (%)	1.4
Calcium	(g/100g) (%)	0.1

Scale up studies consideration for bioreactor studies

Considerations

Total volume: 3.7L

Working volume: 2L

Impeller speed: 200rpm

Impeller diameter: 0.05 to 0.075 m

Power (W) = $N_p \rho N^3 D^5$

P falls under 7-15W

N_p -5 for Rushton turbines

Constant P/V and Constant tip Speed

Table S7. Comparative effects of shake flask and scale up with bioreactor studies

Parameter	Shake flask	2L Bioreactor (Biojenik Engineering)
Mixing	Orbital Non-homogenous	Rushton impeller
Oxygen Supply	Poor uncontrolled	Precise microaerobic controller
Heat removal	Passive	Active cooling Jacket
Shear stress	Low	Moderate
K_{LA} Control	Very Low	High and Tunable

Table S8. Scale up parameters for bioreactor studies

Parameter	Values
Power input	5-6 W/L
Tip Speed (V_{tip}) m/s	0.68 (m/s)
Volumetric oxygen transfer rate (K_{LA}) h^{-1}	60-100 h^{-1}
Mixing time (t_m)	6-8 seconds
Heat generation (Q)	1.3 W