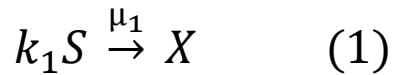# MODELING OF ALCOHOLIC BATCH FERMENTATION BY KLUYVEROMYCES MARXIANUS

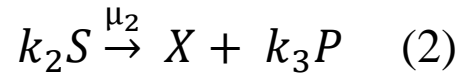*Ch. Assist. Dr Anastasiya Zlatkova*

Craiova, Romania
2024 October

Oxidative state

$$k_1 S \xrightarrow{\mu_1} X \qquad (1)$$

Fermentative state

$$k_2 S \xrightarrow{\mu_2} X + k_3 P \qquad (2)$$

Model

$$\frac{dX}{dt} = (\mu_1 + \mu_2)X \qquad (5)$$

$$\frac{dS}{dt} = (-k_1\mu_1 - k_2\mu_2)\,X \qquad (6)$$

$$\frac{dP}{dt} = k_3\mu_2 X \qquad (7)$$

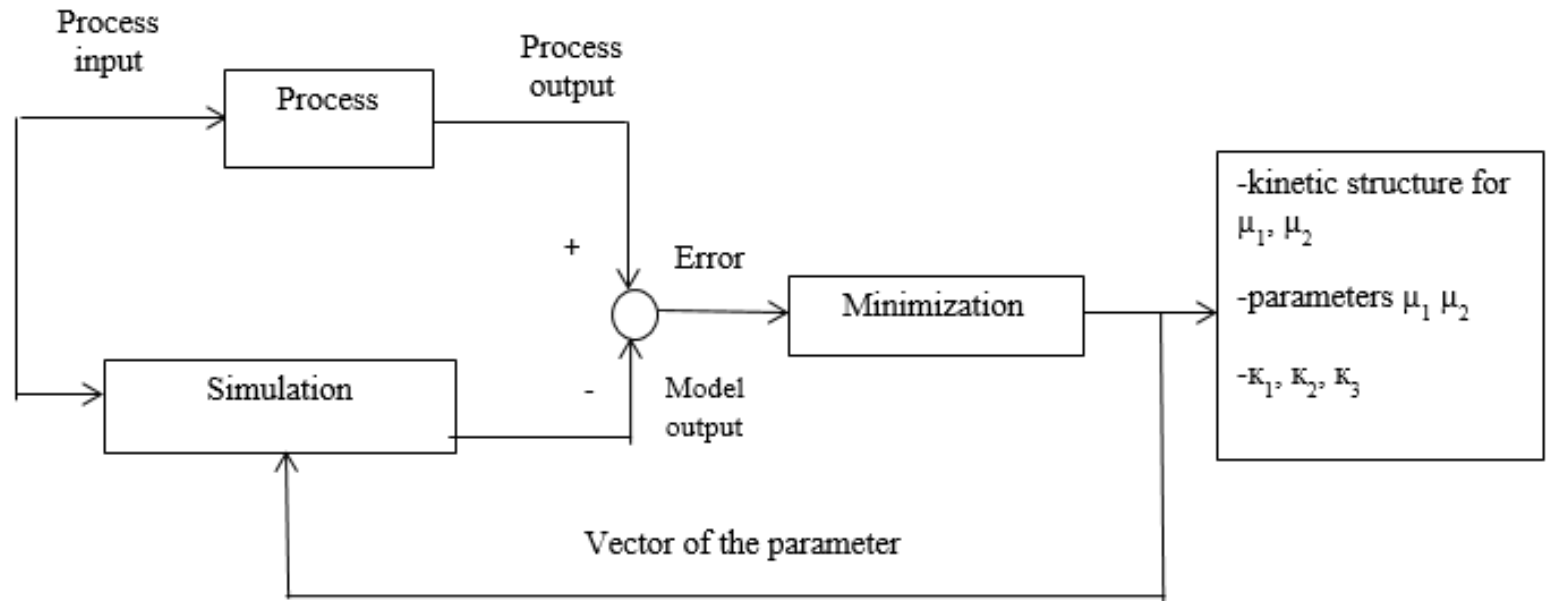$$\mu_1 = \frac{q_S}{k_1} \qquad (8) \qquad \mu_2 = \frac{q_S k_3}{k_2} \qquad (9)$$

Fig. 1 Methodology for derivation of best kinetic structure of the model

$$dif = \sum_{j=1}^{p}\left(\frac{P_{sim,j} - P_{exp,j}}{P_{exp,max}}\right)^2 + \sum_{j=1}^{p}\left(\frac{X_{sim,j} - X_{exp,j}}{X_{exp,max}}\right)^2 + \sum_{j=1}^{p}\left(\frac{S_{sim,j} - S_{exp,j}}{S_{exp,max}}\right)^2 \qquad (3)$$

General Dynamic Model

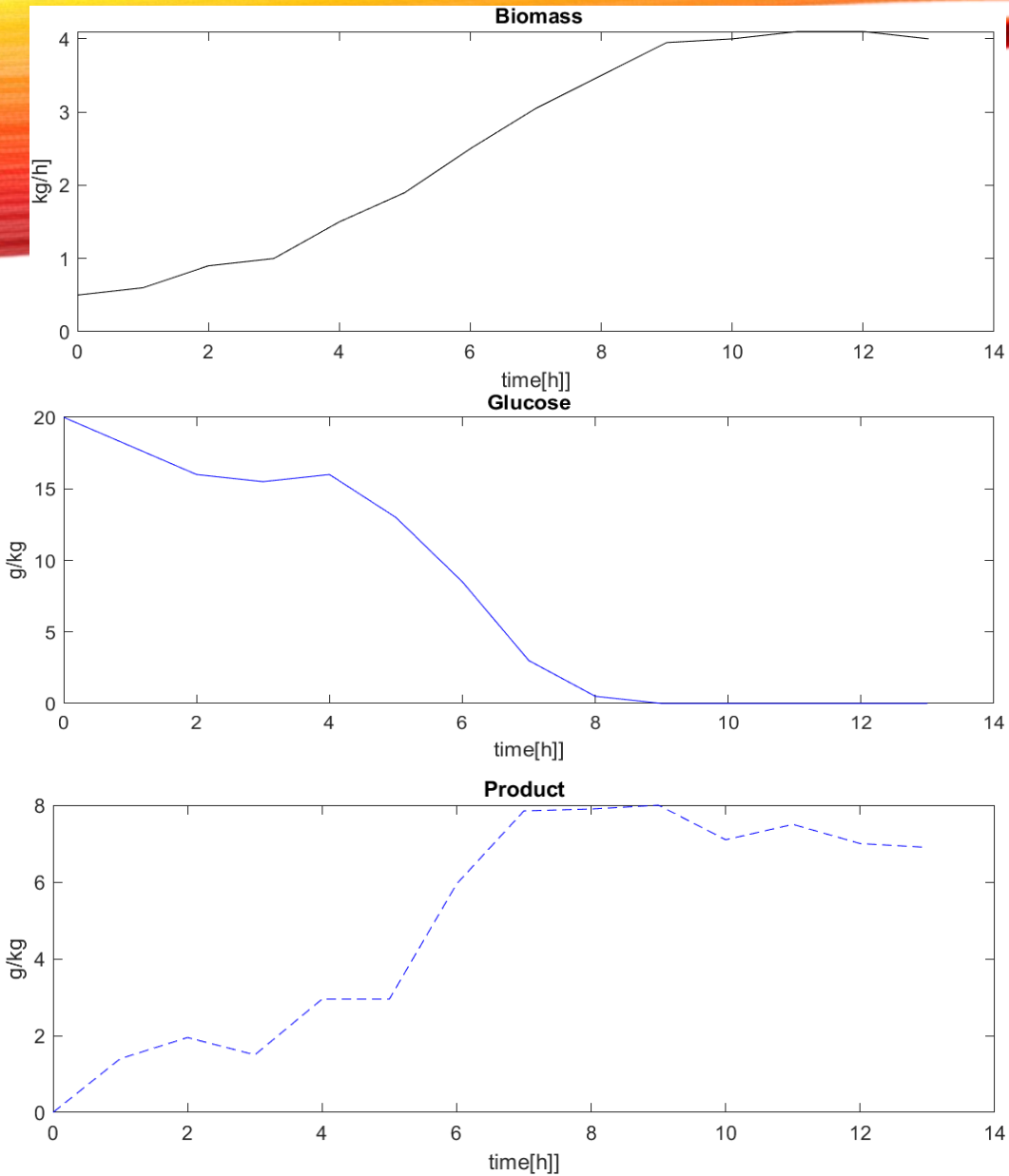$$\frac{d\xi}{dt} = K\varphi(t) - D\xi + F - Q \qquad (4)$$

Fig. 2 Concentrations of biomass, glucose and product

Different structures, describing glucose consumption rate

$$q_S = q_{S,max} \frac{S}{S+K_S} \qquad \text{Case 1}$$

$$q_S = q_{S,max} \frac{S}{S+K_S} \frac{K_{i,P}}{K_{i,P}+P} \qquad \text{Case 2}$$

$$q_S = q_{S,max} \frac{S}{S+K_S+\frac{K_S}{K_{i,P}}P^2} \qquad \text{Case 3}$$

$$q_S = q_{S,max} \left(\frac{S}{S+K_S}\right)\left(1 - \frac{P}{K_{i,P}}\right) \qquad \text{Case 4}$$

Table 1 Results for the errors with the different strains

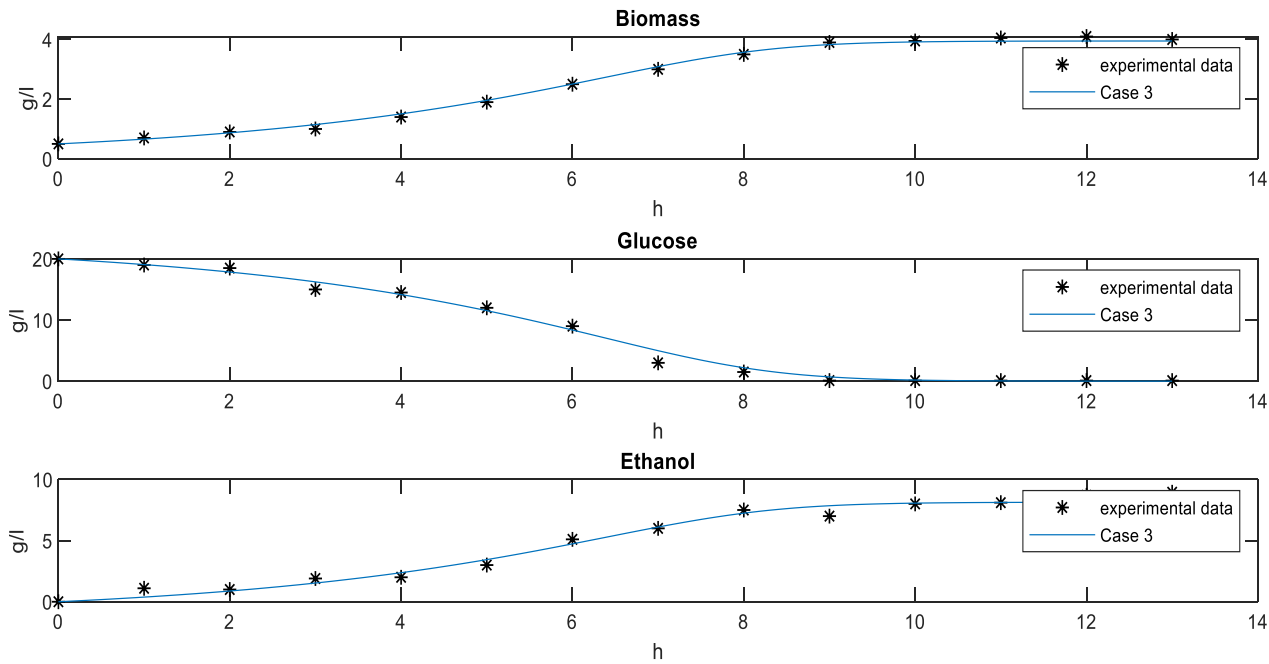| Strain	Best approximation structure	Error	Lowest approximation structure	Error
1	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}} P^2}$	0.8083	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.8449
2	$q_S = q_{S,max} \dfrac{S}{S + K_S}$	0.4480	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.4607
3	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}} P^2}$	0.3829	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.3964
4	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}} P^2}$	0.3946	$q_S = q_{S,max} \dfrac{S}{S + K_S}$	66.4209
5	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}} P^2}$	0.8881	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.9248

Table 2 Results for the errors with the different strains

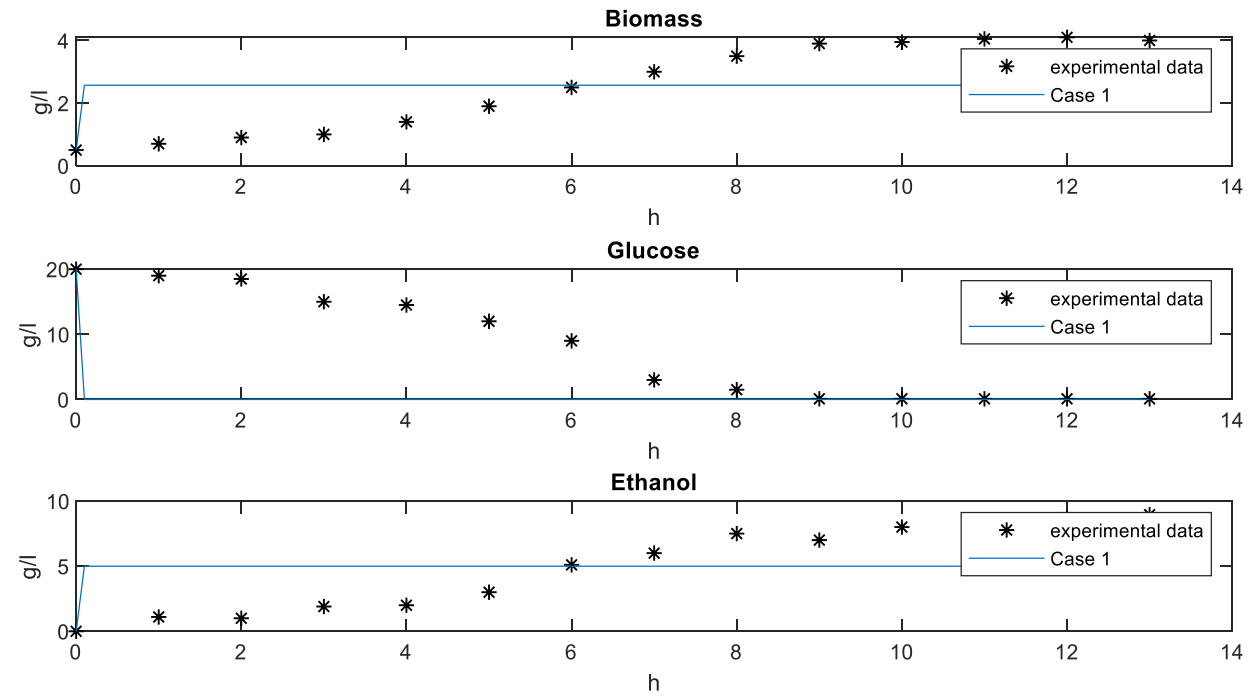| Strain	Best approximation structure	Error	Lowest approximation structure	Error
6	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}}P^2}$	0.7809	$q_S = q_{S,max} \left(\dfrac{S}{S+K_S}\right)\left(1 - \dfrac{P}{K_{i,P}}\right)$	0.8219
7	$q_S = q_{S,max} \dfrac{S}{S + K_S}\dfrac{K_{i,P}}{K_{i,P} + P}$	0.6004	$q_S = q_{S,max} \left(\dfrac{S}{S+K_S}\right)\left(1 - \dfrac{P}{K_{i,P}}\right)$	0.6061
8	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}}P^2}$	0.5177	$q_S = q_{S,max} \dfrac{S}{S + K_S}\dfrac{K_{i,P}}{K_{i,P} + P}$	0.5405
9	$q_S = q_{S,max} \dfrac{S}{S + K_S}\dfrac{K_{i,P}}{K_{i,P} + P}$	1.2312	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}}P^2}$	1.3480
10	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}}P^2}$	0.9018	$q_S = q_{S,max} \dfrac{S}{S+K_S}$	1.4884
11	$q_S = q_{S,max} \dfrac{S}{S + K_S}\dfrac{K_{i,P}}{K_{i,P} + P}$	0.4385	$q_S = q_{S,max} \dfrac{S}{S + K_S + \dfrac{K_S}{K_{i,P}}P^2}$	0.4633

Table 3 Results for the errors with the different strains

Strain	Best approximation structure	Error	Lowest approximation structure	Error
12	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.3100	$q_S = q_{S,max} \dfrac{S}{S+K_S}$	0.3823
13	$q_S = q_{S,max} \dfrac{S}{S + K_S + \frac{K_S}{K_{i,P}} P^2}$	0.6705	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.7283
14	$q_S = q_{S,max} \dfrac{S}{S + K_S + \frac{K_S}{K_{i,P}} P^2}$	0.7067	$q_S = q_{S,max} \left(\dfrac{S}{S+K_S} \right) \left(1 - \dfrac{P}{K_{i,P}} \right)$	26.9551
15	$q_S = q_{S,max} \dfrac{S}{S + K_S + \frac{K_S}{K_{i,P}} P^2}$	0.9057	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	0.9638
16	$q_S = q_{S,max} \dfrac{S}{S+K_S}$	2.2638	$q_S = q_{S,max} \left(\dfrac{S}{S+K_S} \right) \left(1 - \dfrac{P}{K_{i,P}} \right)$	93.6400
17	$q_S = q_{S,max} \dfrac{S}{S + K_S} \dfrac{K_{i,P}}{K_{i,P} + P}$	2.2380	$q_S = q_{S,max} \dfrac{S}{S + K_S + \frac{K_S}{K_{i,P}} P^2}$	2.4716

STRAIN 4 – Comparison between best structure (A) and lowest approximation structure (B)
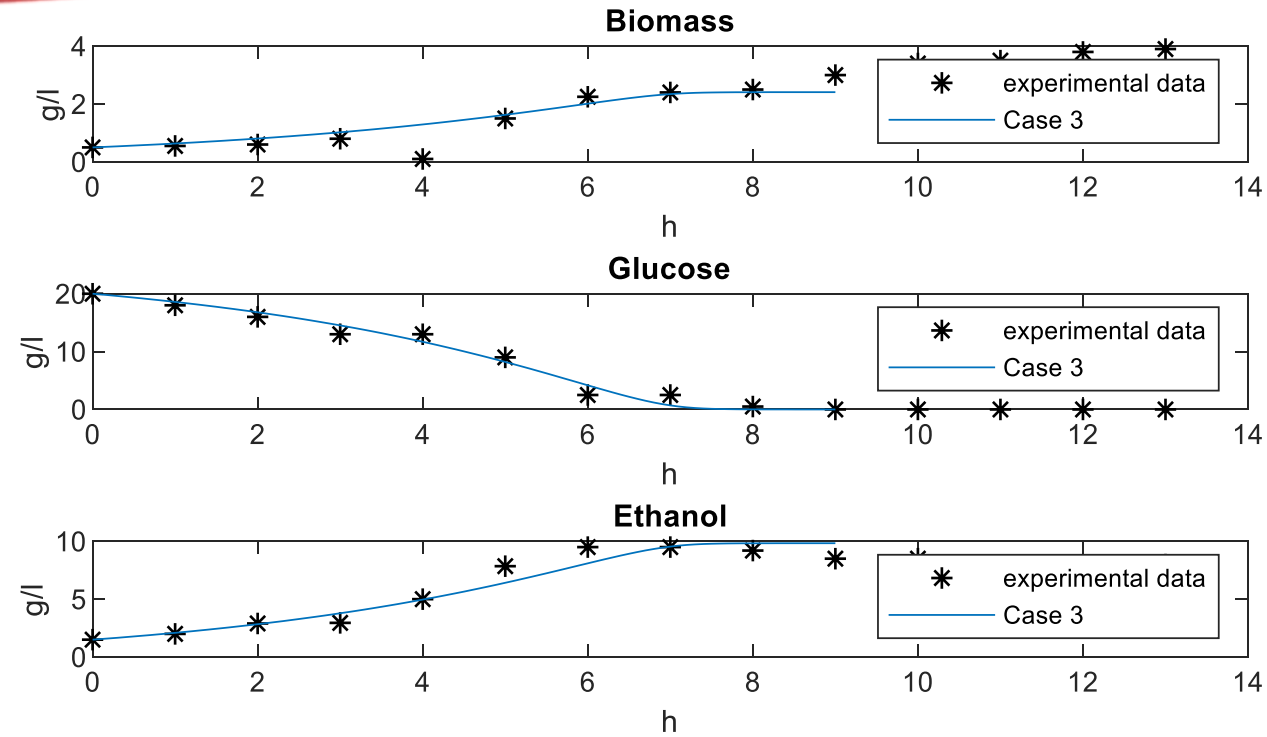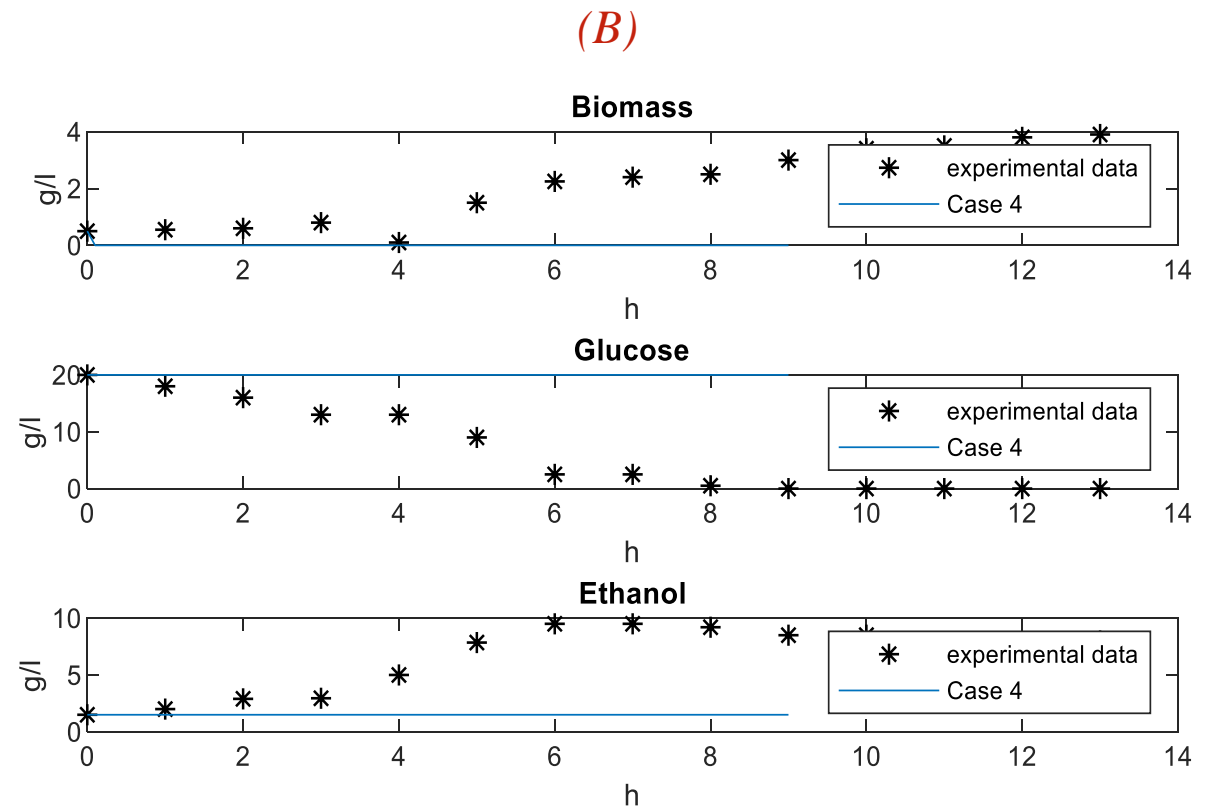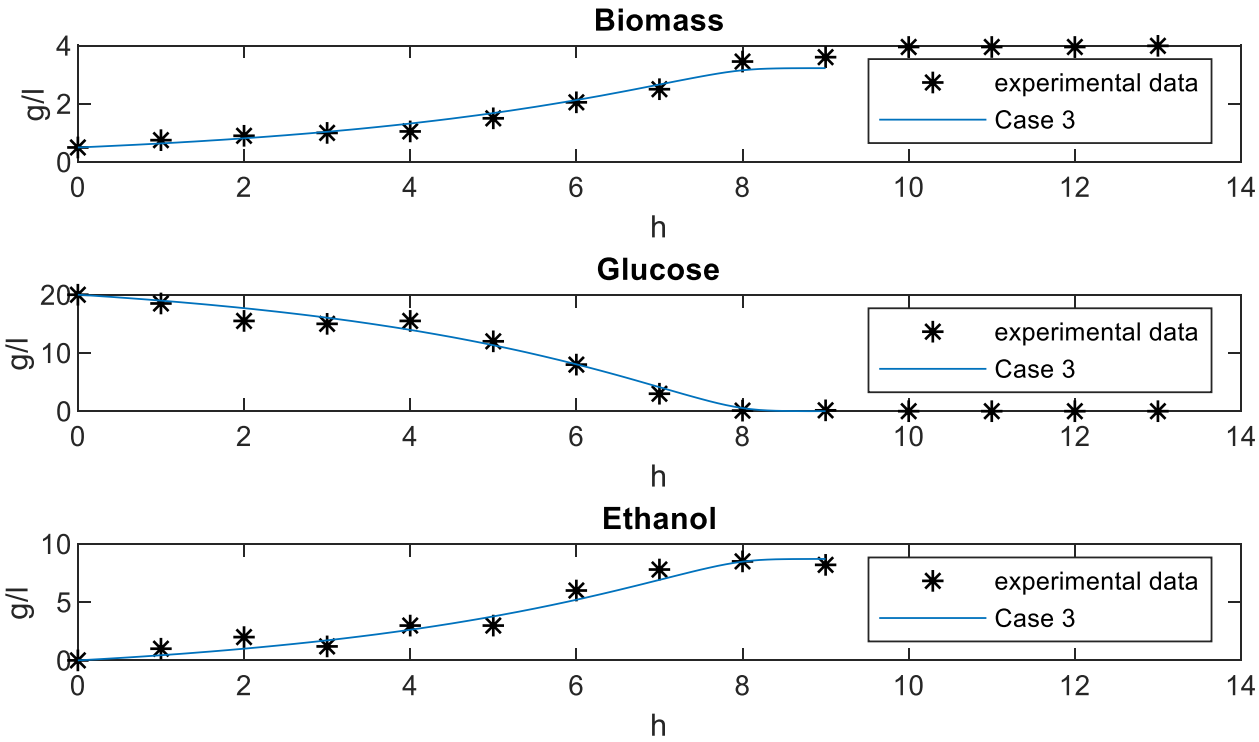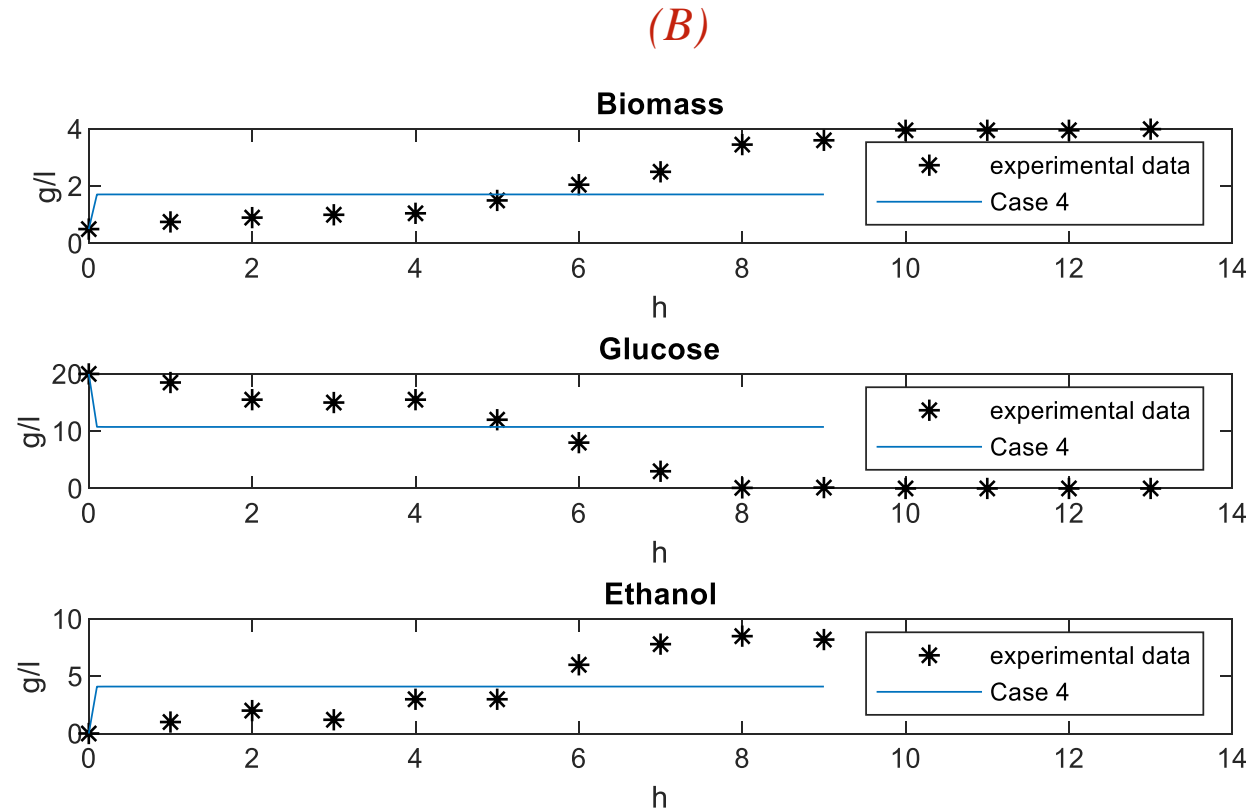

(A)

(B)

(A) *(B)*

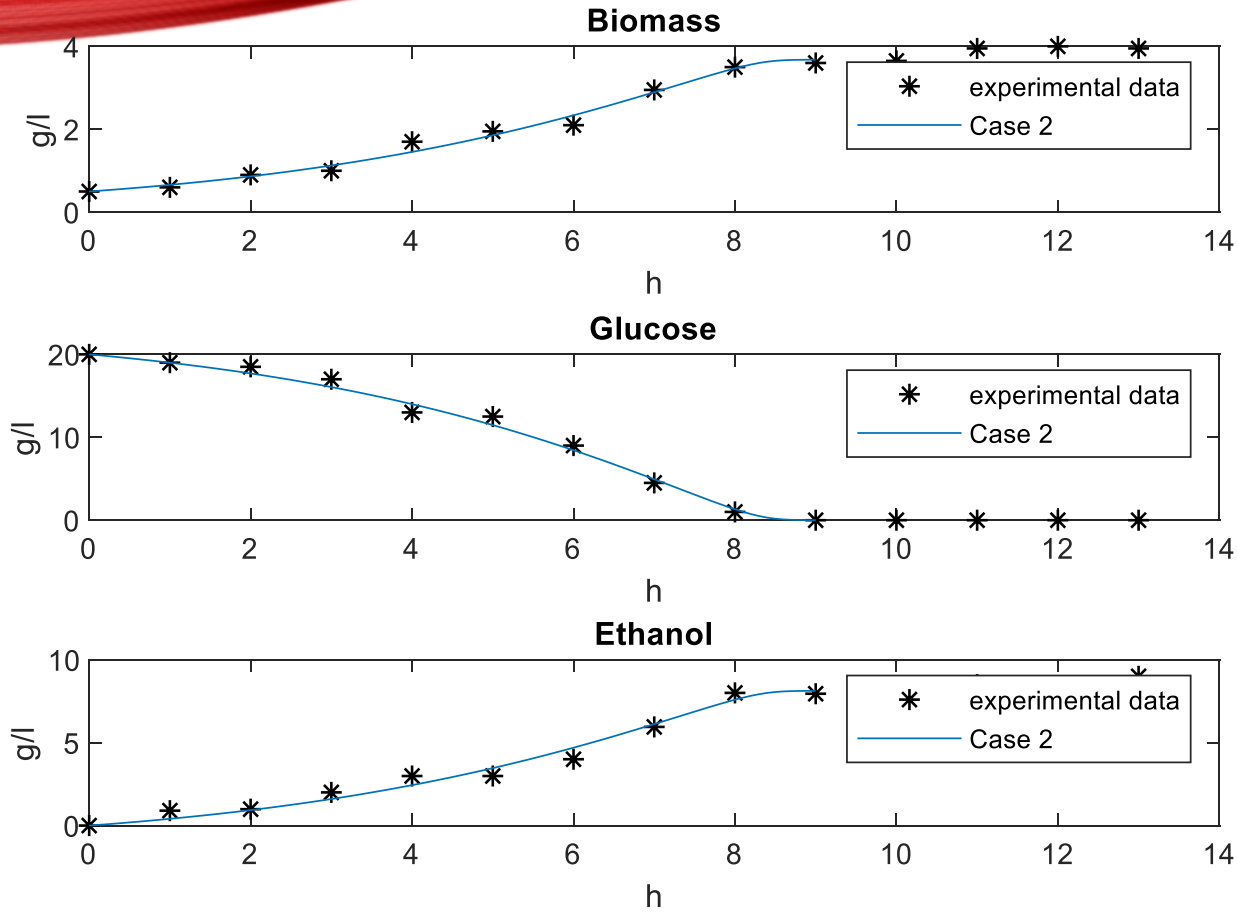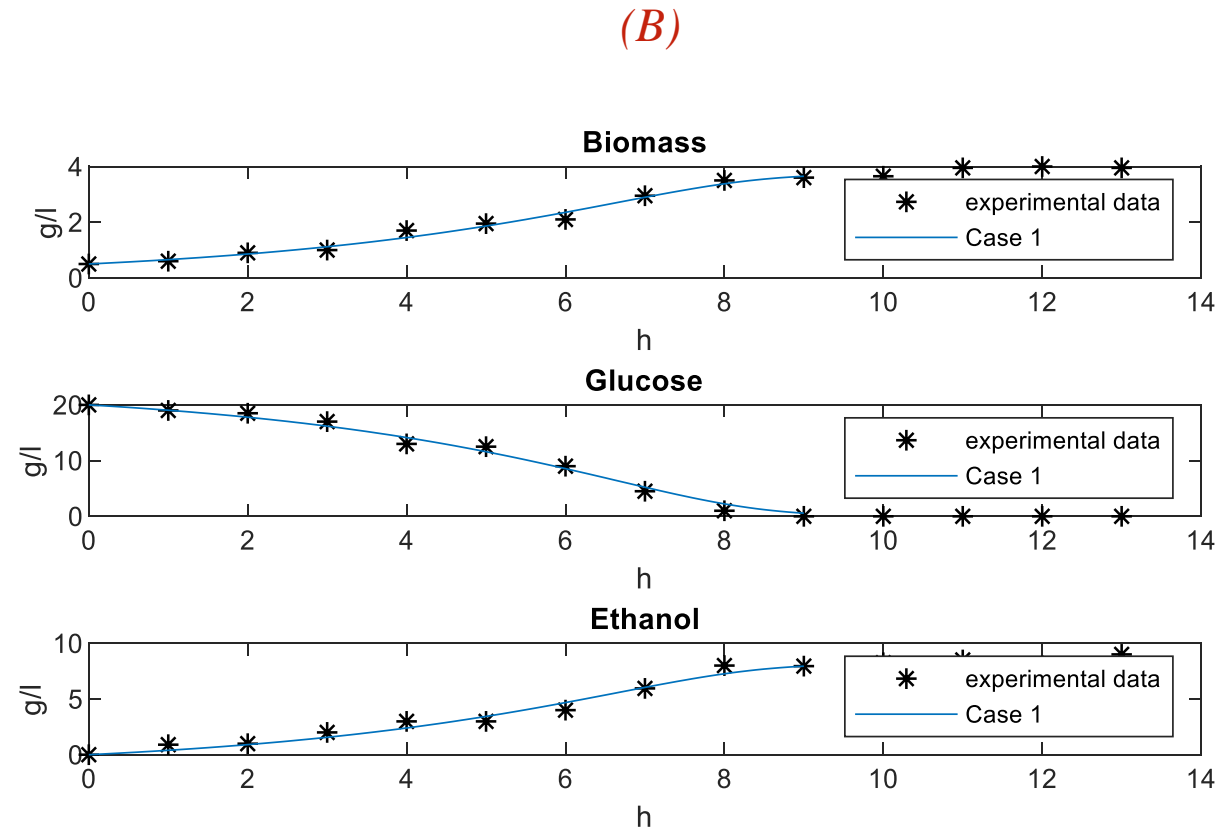STRAIN 14 – Comparison between best structure (A) and lowest approximation structure (B)

(B)

(A)

ACKNOWLEDGEMENTS

THANK YOU FOR YOUR ATTENTION