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Buenos Aires - Argentina - June 4-8, 2023
BUENOS AIRES 2023
JUNE 4 - 8
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Experimental and theoretical growth of the probiotic bacteria *Lactobacillus rhamnosus* in whey permeate

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The main problem to produce probiotics in adequate amounts for industrial applications is the high cost of the formulated growth media. In this sense, whey permeate is an economical "by-product" of the cheese-making process, rich in lactose. Also, the optimisation of fermentation processes and their subsequent industrial large scaling requires the development of kinetic models to understand and predict the behaviour of the specific strain.
The aim of this work was to study experimentally and theoretically the fermentation of whey permeate using an isolated strain of the species *Lactobacillus rhamnosus*.
Lactobacillus rhamnosus was isolated in our laboratory from whey samples from Córdoba (Argentina).
For the formulation of the fermentation medium, a whey permeate solution with an initial lactose concentration of 53 g/L supplemented with yeast extract (20 g/L), tryptone (10 g/L) and Tween 80 (1 g/L) was prepared. Batch fermentation was performed in a 1 L bioreactor at atmospheric pressure, constant temperature (37ºC), pH (6) and agitation (200 rpm). Ammonium hydroxide was employed as neutralizing agent. The bioreactor was inoculated (12.5% v/v) with a 24h-old seed culture. The fermentation was performed for 14 h and monitored every hour for biomass, lactose and lactic acid measurements by viable cell counts, Fehling-Causse-Bonnans titration, and the spectroscopic Fe^{+3} lactate complex method, respectively.The measurement are showed in Figure 1.

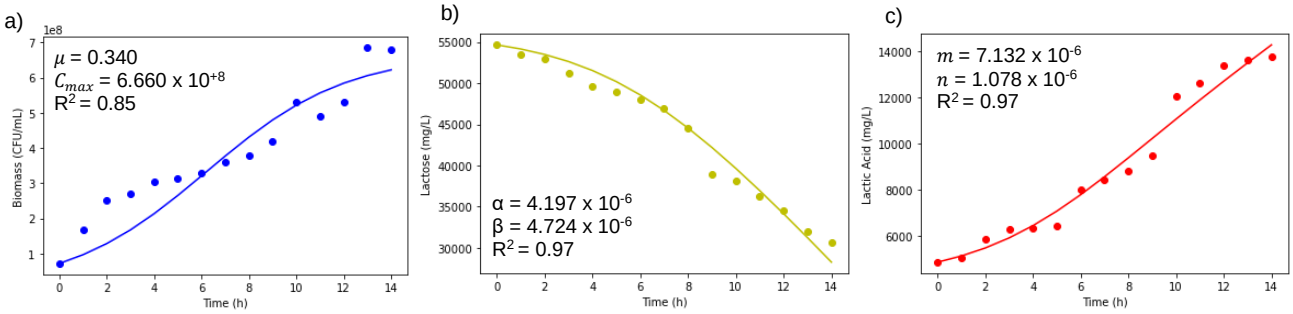

Figure 1- Model (—) and experimental (●) measurements. a) biomass concentration b) lactose utilisation; c) lactic acid formation.
μ = initial specific growth rate (h^{-1}), C_{max} = maximum attainable biomass concentration (CFU/mL), α = empirical constant for growth-associated substrate consumption [mgL/L $(CFU/mL)^{-1}$], β = empirical constant for non-growth associated substrate consumption [mgL/L $(CFU/mL)^{-1}$ h^{-1}], m = empirical constant for growth-associated product formation [mgLA/L $(CFU/mL)^{-1}$] y n = empirical constant for non-growth-associated product formation [mgLA/L $(CFU/mL)^{-1}$ h^{-1}]

The fermentation model involves the rate equations of biomass growth (logistic equation), product formation (Luedeking–Piret) and substrate utilization (modified Luedeking–Piret) [1]. The computer program was written in Python3. The differential equations were solved with an integration routine appropriate for non-stiff systems. Kinetic parameters were adjusted to fit the measurements. Simulation results and the adjusted kinetic parameters are shown in Figure 1.
Final viable cell count was $6.8x10^8$ CFU ml^{-1}. The model predictions appropriately reproduce the experimental data.
In future works, the fermentation model will be employed for the optimization of biomass production from the isolated strain of *Lactobacillus rhamnosus*.

References

1. Roy, D., Leduy, A., Goulet, J. (1987). Kinetics of Growth and Lactic Acid Production from Whey Permeate by *Lactobacillus helveticus. The Canadian Journal of Chemical Engineering,* 65, 597-603.