Article

Enhancing Biohydrogen Production: The Role of Iron-Based Nanoparticles in Continuous Lactate-Driven Dark Fermentation of Powdered Cheese Whey

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Supplementary data contain the following:

Table S1: Kinetic parameters obtained from the modified Gompertz model.
Table S2: Removals of COD_{total}, $COD_{soluble}$ and TOC in the batch fermentation assays.
Table S3: Comparison of H_2 productivities among operational phases (Kruskal-Wallis test).
Table S4. Comparison of H_2 productivities among operational phases (matrix with p values resulting from Dunn's post-hoc test).
Table S5. Comparison of H_2 productivities between operational phases III and IV (Wilcoxon t test for paired samples).
Tabla S6. Comparison of H_2 productivities between operational phases IV and V (Mann-Whitney U test for paired samples).
Table S7. Carbohydrate and soluble COD removal efficiencies and biomass concentration (VSS) increase (%) along the different operational phases.
Table S8. Comparison between the operation phases regarding effluent COD concentrations (Kruskal-Wallis test).
Table S9. Comparison of effluent COD concentrations among operational phases (matrix with p values resulting from Dunn's post-hoc test).
Table S10. Comparison of effluent VSS concentrations among operational phases (Kruskal-Wallis test).
Table S11. Comparison of lactate concentrations among operational phases (Kruskal-Wallis test).
Table S12. Comparison of lactate concentrations among operational phases (matrix with p values resulting from Dunn's post-hoc test).

Table S1. Kinetic parameters obtained from the modified Gompertz model.

Parameter	Unit	Value
P	NmL	1672.5
R_{max}	mL H_2/h	342.3
λ	h	5.7
R^2	-	0.995

Table S2. Removals of COD_{total}, $COD_{soluble}$ and TOC in the batch fermentation assays.

Parameter	% removal	Standard deviation
COD_{total}	11.4	4.0
$COD_{soluble}$	13.4	2.6
TOC	29.3	1.6

Table S3. Comparison of H_2 productivities among operational phases (Kruskal-Wallis test).

Parameter	Value
H (chi2)	25.1
Hc (tie corrected)	25.1
p-value	4.811E-05*

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)

Table S4. Comparison of H_2 productivities among operational phases (matrix with p values resulting from Dunn's post-hoc test).

	Phase I	Phase II	Phase III	Phase IV	Phase V
Phase I		0.00961*	0.6069	0.1199	0.02558*
Phase II	0.00961*		0.1003	0.5272	2.586E-06*
Phase III	0.6069	0.1003		0.3675	0.01925*
Phase IV	0.1199	0.5272	0.3675		0.0007453*
Phase V	0.02558*	2.586E-06*	0.01925*	0.0007453*	

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)

Table S5. Comparison of H_2 productivities between operational phases III and IV (Wilcoxon t test for paired samples).

Parameter	Value
W	43
p-value (Normal appr. Z: 1.5799)	0.11413
p-value (Monte Carlo)	0.13186
p-value (exact)	0.13086

Tabla S6. Comparison of H_2 productivities between operational phases IV and V (Mann-Whitney U test for paired samples).

Parameter	Value
Mann-Whitney U	3
p-value (Z: 4.1983)	2.6892E-05*
p-value (Monte Carlo)	0.0001*

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)

Table S7. Carbohydrate and soluble COD removal efficiencies and biomass concentration (VSS) increase (%) along the different operational phases.

Phase	Carbohydrates	Soluble COD	VSS
I	86.2 ± 4.7 %	34.3 ± 4.1 %	790.6 ± 426.1 %
II	71.6 ± 6.1 %	29.7 ± 4.1 %	572.2 ± 416.0 %
III	81.4 ± 3.8 %	35.9 ± 7.8 %	410.7 ± 330.9 %
IV	81.7 ± 4.1 %	43.1 ± 3.2 %	536.5 ± 270.1 %
V	84.8 ± 3.2 %	42.7 ± 5.4 %	552.9 ± 212.8 %

Table S8. Comparison between the operation phases regarding effluent COD concentrations (Kruskal-Wallis test).

Parameter	Value
H (chi2)	17.23
Hc (tie corrected)	17.24
p-value	0.001738*

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)

Table S9. Comparison of effluent COD concentrations among operational phases (matrix with p values resulting from Dunn's post-hoc test).

	Phase I	Phase II	Phase III	Phase IV	Phase V
Phase I		0.1918	0.8681	0.02908*	0.03369*
Phase II	0.1918		0.1412	0.0006971*	0.0008618*
Phase III	0.8681	0.1412		0.0425*	0.04884*
Phase IV	0.02908*	0.0006971*	0.0425*		0.9563
Phase V	0.03369*	0.0008618*	0.04884*	0.9563	

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)

Table S10. Comparison of effluent VSS concentrations among operational phases (Kruskal-Wallis test).

Parameter	Value
H (chi2)	4.158
Hc (tie corrected)	4.164
p-value	0.3843

Table S11. Comparison of lactate concentrations among operational phases (Kruskal-Wallis test).

Parameter	Value
H (chi2)	9.911
Hc (tie corrected)	9.911
p-value	0,04196*

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)

Table S12. Comparison of lactate concentrations among operational phases (matrix with p values resulting from Dunn's post-hoc test).

	Phase I	**Phase II**	**Phase III**	**Phase IV**	**Phase V**
Phase I		0.01698*	0.1039	0.0234*	0.8649
Phase II	0.01698*		0.5892	0.7071	0.04115*
Phase III	0.1039	0.5892		0.4386	0.1699
Phase IV	0.0234*	0.7071	0.4386		0.0444*
Phase V	0.8649	0.04115*	0.1699	0.0444*	

*There is a significant difference between the medians of the samples ($\alpha = 0.05$)