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IN SITU LACTIC ACID REMOVAL FROM A CHARACTERISTIC FERMENTATION MEDIUM (YOGHURT) PREPARATION BY ITS RETENTION ONTO HYDROTALCITE-TYPE ANIONIC CLAY- STATISTICAL MODELLING

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INTRODUCTION

Anionic clays are natural or synthetic combinations of hydroxides with lamellar structure, having between layers spaces containing exchangeable anions and water molecules. Because hydrotalcites possess excellent properties, *e.g.*, low or no toxicity, good biocompatibility, the possibility of controlled release, there is a continuous interest in the discovery of new applications. Batch fermentation of milk inoculated with lactic acid bacteria was conducted in the presence of hydrotalcite-type anionic clay under static and ultrasonic conditons.

MATERIALS AND METHODS

For the synthesis of hydrotalcite-type anionic clay, coprecipitation method at low supersaturation and constant pH was selected, being the most frequently used method to prepare the anionic clays. A statistical analysis of the data based on a 2^3 factorial experiment was performed in order to express experimental and model-regressed process responses depending on fermentation temperature (t=38–43 °C), clay/milk ratio (R=1–7.5 g/L) and ultrasonic field (ν=0 and 35 kHz) factors. A mathematical model was selected to describe the fermentation process kinetics and its parameters were estimated based on experimental data.

RESULTS AND DISCUSSION

Final fermentation time, τf; minimum species concentration in the liquid phase in the presence of anionic clay, γLA,min; equilibrium (saturation) species concentration in the solid phase, sLA,eq; species mass transfer coefficient in the liquid fi lm, kLA; hourly yoghurt production, P; and yoghurt properties, i.e. dynamic viscosity, η; syneresis index, S; and viable LAB number, N, were selected as process- -dependent variables (responses). These variables can be linked to the process-independent variables (factors), namely ultrasound frequency, ν; operation temperature, t; and clay/milk ratio, R, with adequate regression equations.

Factor and response values for an experimental set consisting of favourable runs to obtain a high yoghurt quality at low cost are given in the Table 1.

Run	x_1	x_2	x_3	τ_f min	$\gamma_{LA,min}$ g/L	$s_{LA,eq}$ g/g	$k_{LA}\cdot 10^2$ cm/min	P g/h	η Pa·s	S %	$N\cdot 10^{-7}$ CFU/g
2	–1	–1	–1	250	4.696	0.225	0.47	33.65	0.140	31.49	1.31
3	–1	–1	1	260	4.005	0.194	0.20	32.77	0.145	28.24	1.42
6	–1	1	–1	240	4.923	0.243	0.49	37.96	0.142	29.81	1.42
7	–1	1	1	250	4.319	0.210	0.21	34.37	0.147	26.37	1.53
14	1	–1	–1	260	4.562	0.350	0.73	32.63	0.147	29.08	1.33
15	1	–1	1	270	3.893	0.220	0.23	31.80	0.152	26.34	1.45
18	1	1	–1	250	4.777	0.374	0.75	35.55	0.150	27.76	1.45
19	1	1	1	260	3.982	0.264	0.26	32.95	0.155	22.37	1.58

τ_f=final fermentation time; $\gamma_{LA,min}$=minimum lactic acid (LA) concentration in the liquid phase in the presence of anionic clay; $s_{LA,eq}$= equilibrium LA concentration in the solid phase; k_{LA}=mass transfer coefficient in the liquid film; P=hourly yoghurt production; η=yoghurt dynamic viscosity; S=syneresis index; N=viable LAB number

Values of dimensionless factors were calculated depending on those of natural factors with the following equations:

$$x_1 = \frac{\nu - 17.5}{17.5} \quad x_2 = \frac{t - 40.5}{2.5} \quad x_3 = \frac{R - 3}{2}$$

Processing the tabulated data based on characteristic procedure of a factorial experiment with 2 levels (*44*), the following regression equations were obtained:

$$\tau_f = 251.25 + 6.25x_1 - 8.75x_2 + 8.75x_3 + \\ +1.25x_1x_2 - 1.25x_1x_3 + 3.75x_2x_3 - 1.25x_1x_2x_3$$

$$\gamma_{LA,min} = 4.395 - 0.091x_1 + 0.106x_2 - 0.345x_3 - \\ -0.030x_1x_2 - 0.021x_1x_3 - 0.027x_1x_2x_3$$

$$s_{LA,eq} = 0.260 + 0.042x_1 + 0.013x_2 - 0.038x_3 - 0.022x_1x_3$$

$$k_{LA} = (0.418 + 0.075x_1 + 0.010x_2 - 0.193x_3 - 0.055x_1x_3)\cdot 10^{-2}$$

$$P = 33.960 - 0.728x_1 + 1.247x_2 - 0.988x_3 - \\ -0.230x_1x_2 + 0.130x_1x_3 - 0.560x_2x_3 + 0.118x_1x_2x_3$$

$$\eta = 0.147 + 0.004x_1 + 0.001x_2 + 0.003x_3$$

$$S = 27.683 - 1.295x_1 - 1.105x_2 - 1.852x_3 - \\ -0.217x_1x_2 - 0.180x_1x_3 - 0.355x_2x_3 - 0.308x_1x_2x_3$$

$$N = (1.436 + 0.016x_1 + 0.059x_2 + 0.059x_3)\cdot 10^7$$

CONCLUSIONS

A statistical analysis of the data based on a 2^3 factorial experiment was performed for the runs selected as favourable. Regression equations linking the process responses to their factors were established and commented.