

Manufacturing technology for a *Spirulina*-enriched mesophilic fermented milk

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INTRODUCTION

Spirulina (Arthrospira) platensis is a filamentous cyanobacterium that forms massive populations in tropical and subtropical waters characterized by high levels of carbonate and bicarbonate and pH values of up to 11. The dried biomass of *S. platensis* typically contains 3% to 7% moisture, 55% to 60% protein, 6% to 8% lipids, 12% to 20% carbohydrate, 7% to 10% ash, 8 to 10% fiber, 1 to 1.5% chlorophyll *a*, and a wide range of vitamins and other biologically active substances. Since the late 1970s, *S. platensis* has been marketed and consumed as a safe human food and has been approved for human nutrition by many governments and health agencies. The objectives of this research were: (1) to test the influence of a *S. platensis* biomass on growth and acid production of various *Lactococcus* and *Leuconostoc* strains in milk, (2) to develop a *Spirulina*-containing commercial cultured milk fermented with the mesophilic lactic acid bacteria (LAB) strains selected, and (3) to run storage trials to determine the effect of the *Spirulina* biomass on viability of starter organisms in the refrigerated product.

MATERIALS AND METHODS

Milk samples enriched with *S. platensis* at concentrations up to 0.8% (w/v) were inoculated at the rate of 1% (v/v) with the mesophilic LAB strains tested and then incubated at 30°C. The pH values and LAB counts of samples were measured at regular intervals. As part of the product development process, sensory tests were performed by untrained panelists to optimize the organoleptic properties of the final product, and then storage trials were carried out.

RESULTS

Used at the rate of 0.3% (w/v), the *Spirulina* biomass significantly stimulated ($P < 0.05$) several of the mesophilic LAB strains screened (Figure 1). A technology for production of a *Spirulina*-enriched functional fermented milk has been developed (Figure 2). According to the results of ranking tests done by sensory panelists, optimum organoleptic properties were achieved in the product formulation prepared with the mixed culture of *Lactococcus lactis* subsp. *lactis* NCAIM B.2128 and *Lc. lactis* subsp. *cremoris* ATCC 19257, and supplemented with sucrose at 10%, *S. platensis* biomass at 0.3%, and strawberry-kiwifruit flavor at 1.5%. During the first 2 weeks of refrigerated storage at 4°C, the *S. platensis* biomass significantly increased ($P < 0.05$) the viability of lactococci in the functional fermented milk developed (Table 1).

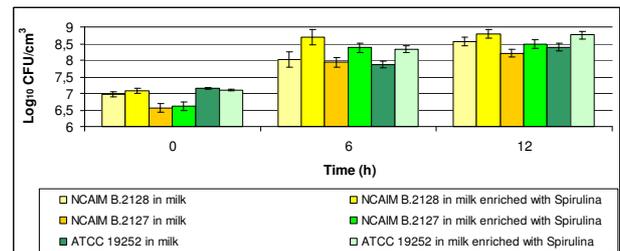


Figure 1: Changes in viable cell counts of *Lactococcus lactis* subsp. *lactis* NCAIM B.2128, *Lactococcus lactis* subsp. *lactis* var. *diacetyllactis* NCAIM B.2127, and *Lactococcus lactis* subsp. *cremoris* ATCC 19257 during fermentation in milk and in *Spirulina*-enriched milk (whiskers indicate 95% confidence intervals of means; n = 6)

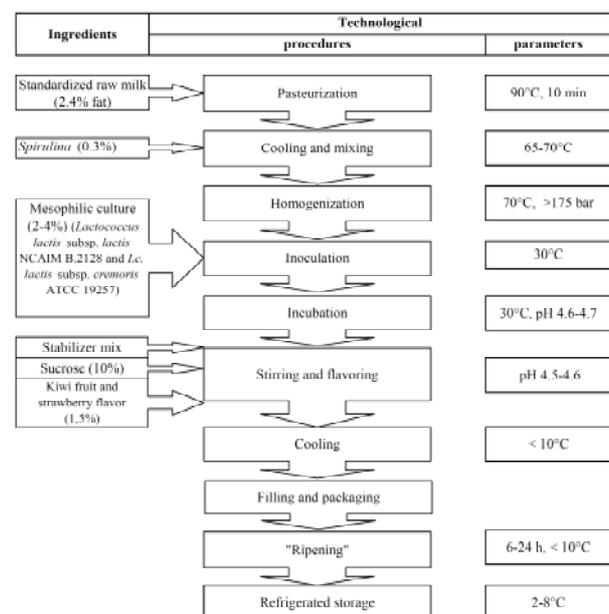


Figure 2: Technology of manufacture for the novel *Spirulina*-enriched functional fermented milk

Table 1: Viability of lactococci in *Spirulina*-enriched and control fermented milks during storage at 4°C

Storage time (day)	Lactococcus count (Log ₁₀ CFU/cm ³)*		Lactococcus survival (%)**	
	Control	<i>Spirulina</i> -enriched	Control	<i>Spirulina</i> -enriched
0	8.53 ± 0.05 ^a	8.65 ± 0.07 ^b	100.00	100.00
7	8.66 ± 0.17 ^a	8.92 ± 0.18 ^b	133.78	186.00
14	8.49 ± 0.17 ^a	8.79 ± 0.23 ^b	91.21	137.03
21	8.47 ± 0.05 ^a	8.65 ± 0.16 ^a	86.78	100.92
28	8.39 ± 0.10 ^a	8.26 ± 0.17 ^a	71.83	40.72
35	7.57 ± 0.11 ^a	7.57 ± 0.12 ^a	11.05	8.34
42	7.44 ± 0.07 ^a	7.43 ± 0.05 ^a	8.06	6.09

* Values are means ± SD, based on 6 observations (three samples × two replicates); ^{a,b} means within a row without a common superscript differ ($P < 0.05$). ** Values are means calculated from *Lactococcus* count (Log₁₀ CFU/cm³) means.