OAT-BASED SNACK AS A VEHICLE OF THE PROBIOTIC BACTERIA *Bacillus coagulans* -BC4

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ABSTRACT

The aim of this study was to develop a probiotic breakfast cereal combining the benefits of oat flour with the probiotic microorganism *Bacillus coagulans*. To achieve this, the cereal formulation was optimized regarding the content of oat flour and other ingredients and the viability of *B. coagulans* BC4, after the cereal process by baking and microwaving. Product quality was evaluated in terms of probiotic viability and physical-chemical (moisture and water activity) parameters. The oat-based cereal was a suitable vehicle for the delivery of *B. coagulans* BC4 gulansspores in a potential probiotic snack product. The high viability and snack-like properties of dried cereal could make it an attractive vehicle for probiotics, but the water activity, reported still represents a big challenge for the survival of dried probiotics.

Keywords: Probiotic spores 1. Functional food 2. Oat 3. Thermal processing 4. Viability .5

1 INTRODUCTION

Many microorganisms from different groups have been used as probiotics in foods (Ex: *Lactobacillus*, *Bifidobacterium*, *Enterococcus*, *Bacillus*, *Streptococcus*) (Champagne et al., 2011). Probiotics are viable by definition, and the viability of probiotics is often considered to be a prerequisite for health benefits (Lahtinen, 2012). However, most probiotic bacteria lose viability during processing and storage due to exposure to high temperatures or other process conditions. Therefore, there is an interest in probiotic strains that can withstand drastic process conditions, such as high temperatures, without reducing viability until the moment of consumption.

Bacillus strains can form spores when the conditions of the environment in which they are found are unfavorable to their multiplication. However, when in favorable conditions (specific nutrients, pH, temperature, and humidity, among others) the spores germinate and can reproduce and multiply again (Majeed et al., 2021). This characteristic has been important in the development of bakeable foods such as bread and cookies, in which high temperatures are lethal to most microorganisms with probiotic properties. Thus, this study aimed to develop a probiotic breakfast cereal combining the benefits of oat flour with the probiotic microorganism *Bacillus coagulans* BC4.

2 MATERIAL & METHODS

Bacterial strain and cereal preparation

A suspension of *B. coagulans* BC4 (Sacco Cadorago, Italy) containing 10^{12} CFU.mL^{-1} spores (Lemma) was incorporated into an oat-based formulation composed of: oat (30g), cocoa (7g), and sugar (20g), and homogenized to obtain a final concentration of approximately 10^{10} CFU g^{-1}. After homogenization, the mass was shaped into a spherical form weighing 1g each. The cereal balls were processed by baking in an electric oven (6 L, 650 W, Mondial, model FR-09) at 180 °C; or in a microwave oven (21 L, 700 W, Panasonic, model NNST254W) according to the conditions established by the experimental design (Table 1 and 2). The effects of baking on *B. coagulans* BC4 viability were evaluated through a 2^2 design with triplicate runs of the central point to estimate the experimental error, composed of 2 independent variables, which were set at 2-levels each.

Viability assessment

The changes in viability of *B. coagulans* BC4 along the process-ing were monitored by viable cell counting. 25 g samples were homogenized into 225 mL peptone saline water (0.85% NaCl, 0.1% peptone) for 2 min, then 5-fold serial dilutions were plated in triplicate on TGY agar to determine the viable cell counts by the microdrop method. The plates were incubated at 37 °C, and the colonies were counted after 48h. All the viable cell counts were expressed as CFU.g^{-1}. Water activity was determined in duplicate at 25 °C, using a dew point water activity meter (AquaLab Series 3TE, Decagon Devices, Inc. USA). Moisture was determined in duplicate using a moisture balance (Marconi, ID50, Piracicaba, SP).

Statistical analysis

Results were expressed as mean±SD. Statistical analysis of the experimental data was carried out using the software. Statistica 14.0.0 (Statsoft). F-test and ANOVA analysis were used as significant criteria for the fitted models.

3 RESULTS & DISCUSSION

Besides *B. coagulans*' BC4 spore-forming capacity, baking and microwave processing affected its viability. The spores were more affected by the processing time since even spores are affected (although to a lower extent than vegetative cells) by higher temperatures. The bacteria viability was not significantly affected by water content, but only by the processing time (Fig. 1a). The highest viability (10.3 log CFU/g) was obtained at the following processing conditions: 20 min; 45% water.

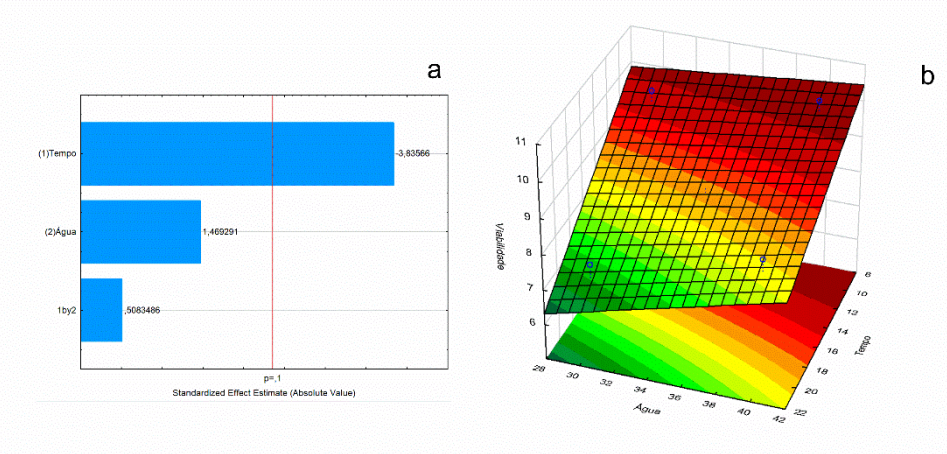

Figure 1 Pareto chart (a) and response surface (b) for the effect of baking on *B. coagulans* BC4 viability.

The oat-based snack was a suitable vehicle for the delivery of *B. coagulans* BC4 spores in a potential probiotic snack product. The high viability and snack-like properties of dried cereal could make it an attractive vehicle for probiotics, but the water activity reported (0.6) still represents a challenge for the survival of dried probiotics. It is considerably higher than the optimal aw range 0.07–0.2 found to improve the stability of probiotics in low aw food ingredients (Marcial-Coba et al., 2019). Probiotic products containing Bacillus strains are mainly found as dietary supplements. The oat-based snack developed offers a new and appealing way to provide large quantities of these spore-forming probiotics.

4 CONCLUSION

The oat-based snack is a suitable vehicle for the delivery of *B. coagulans* BC4 spores in a potential probiotic product.

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