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CONTINUOUS FERMENTATION OF APPLE JUICE BY IMMOBILIZED YEAST CELLS

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Summary: The sugar content of an apple juice was continuously converted into ethanol by Saccharomyces cerevisiae entrapped in Ca-alginate gel. The average values characterizing the process were: fermentation efficiency, 84.7±4.2 %, ethanol concentration in the mash, 38.9±1.9 $g \cdot l^{-1}$ and volumetric productivity, 6.3±0.5 $g \cdot l^{-1} \cdot h^{-1}$.

INTRODUCTION

Hungary is a traditional exporter of apples of good quality. A considerable quantity is processed in the canning industry. The surplus, owing to its oligosaccharide content, is suitable for the production of alcoholic beverages. Using immobilized yeast cells a continuous fermentation could be carried out. A similar process has been published by Rosario and Pamatong (1985) for the banana fruit pulp.

MATERIALS AND METHODS

Microorganism and culture medium. Commercial bakers' yeast was used. The cells were grown in a water bath shaker at 30°C in a culture medium containing 100 $g \cdot l^{-1}$ sucrose and different nutrients as

described by Wada et al. (1979). The pH was adjusted to 4.0. Cells were harvested by centrifugation at 2500 x g for 10 min.

Immobilization. The cells were suspended in a sterile sodium alginate solution (Protanal SF 120, Protan and Fragertun A.S., Drammen, Norway). The final cell density was $1-5 \cdot 10^6$ cells·ml^{-1}. Beads (Ø 4 mm) were formed by dripping the suspension through a syringe into sterile 1 % calcium chloride solution. The cells were grown in a water bath shaker at 30^{0}C for 24 h. The column reactor was then filled with alginate beads.

Fermentation. For continuous fermentation the apple pulp was extracted by centrifugation (2500 x g for 10 min). After sterilization (at 120^{0}C for 15 min) the juice was supplemented with a $CaCl_2$ solution up to a 5.0 g·l^{-1} concentration. The pH was not adjusted. The juice contained no supplement other than calcium chloride.

Analytical methods. The total sugar content was measured by the anthron reaction (Hanson and Phillips, 1981). The carbohydrate composition of the juice was analysed using quantitative thin-layer chromatography on Kieselgel 60 plates (Merck, Darmstadt F.R.G.) (Siegenthaler and Ritter, 1977).
Ethanol was determined by gas chromatography using a Chrom 4 type GC chromatograph (Laboratorni Pristroje Praha, Czechoslovakia) equipped with a flame ionization detector and a Porapak Q (80-100 mesh) column (250 cm long and 3 mm i.d.). Nitrogen was used as a carrier gas and methanol as an internal standard.

RESULTS AND DISCUSSION

An apple juice with 85.5 g·l^{-1} total sugar content was continuously converted into an ethanol containing mash using a column reactor filled with gel entrapped yeast cells. The reactor volume and the length/diameter ratio was 760 ml and 9.4 respectively. The total gel volume (260 ml) with a cell density of 10^9 cells·ml^{-1} gel was equally divided on to 7 perforated trays. The undiluted sterile apple juice (the main carbohydrate components were 50-50 % glucose and fructose), was passed through the reactor at a dilution rate (D) of 0.11 h^{-1} without aeration. The original pH of juice (3.7) was not

adjusted because it was found to be suitable for the achievment of maximum fermentation capacity in the case of immobilized yeast cells (in press). The temperature was maintained at 30°C. The progress curves of the fermentation are presented in Fig.1.

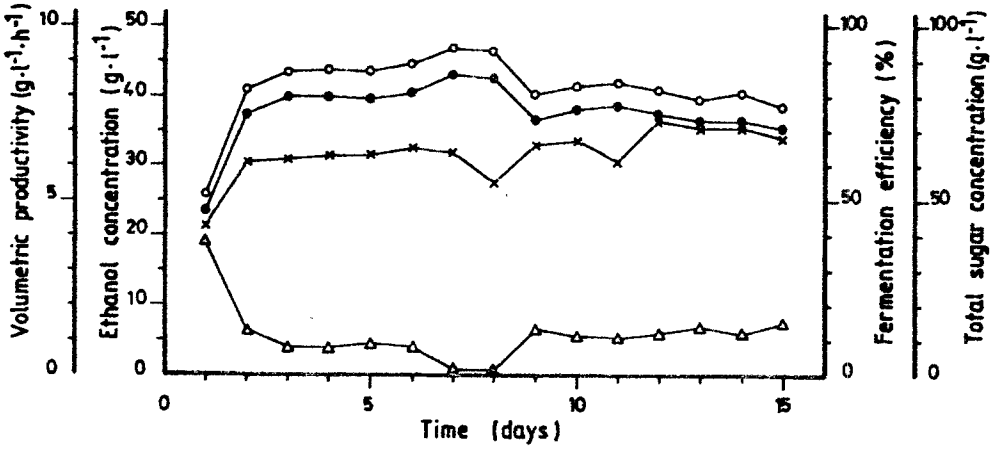

Fig. 1. Progress curves of the fermentation of apple juice. Fermentation efficiency, o; ethanol concentration, •; volumetric productivity, x and total sugar concentration, Δ.

The average values characterizing the process were found to be: fermentation efficiency, 84.7±4.2 %, ethanol concentration in the mesh, 38.9±1.9 $g \cdot l^{-1}$ and volumetric productivity, 6.3±0.5 $g \cdot l^{-1} \cdot h^{-1}$. During the continuous fermentation the structure of the alginate gel was not destroyed and the high conversion shows that the apple juice contained enough nutritive material to maintain the growth of yeast cells and the fermentation process without any supplementation.

The distillation of mash resulted in an apple brandy of good quality.

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