SYMBIOTIC GROWTH OF A YEAST AND A BACTERIA
IN BATCH FERMENTORS

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SUMMARY
Single cell protein was produced from cassava starch by
symbiotic growth of the α-amylase producing bacteria Bacil-
lus subtilis and the yeast Candida utilis, which is accepted
as fodder. By batch fermentations it was shown, that the pH
fluctuation during the fermentation and the inoculum were ex-
tremely important parameters.

INTRODUCTION
Production of single cell protein from inexpensive starch
material represents an alternative method to avoid the threat-
tening protein deficiency in certain parts of the world. One
of the cheapest carbon sources available is cassava (maniok,
tapioca, manihot, yuca), a perennial bush having swollen
roots containing 25-30% starch. As the demands of this plant
to soil quality and climate are small, it is a widespread
crop. Fermentation of cassava starch by a mixed microbial
population consisting of the α-amylase producing bacteria B.
subtilis and the fodder yeast C. utilis - keeping the cell
mass of bacteria low - makes the conversion of starch into a
product containing more than 50% protein possible. In order
to perform this fermentation certain problems must be solved, as the temperature and pH optima for growth of, and α-amylase production by *B. subtilis* (for maximum enzyme activity) and for growth of *C. utilis* are quite different. Furthermore, it is necessary to minimize the yield of bacterial cell mass, as the RNA content of the protein product would otherwise be too high. In this paper experiments performed to fix the parameters of the mixed fermentation are described.

**MATERIALS AND METHODS**

**Microorganisms:** Bacillus subtilis NCIB 8646 and Candida utilis ATCC 9256 were maintained on nutrient agar slants at 3°C and were subcultured twice a month.

**Media:** A C-limited salt medium containing 2% prehydrolyzed cassava starch was used (Evans et al., 1970). The enzymatic hydrolysis was performed by addition of 23.5 kNU/kg DS "Bacterial amylase Novo 120L" to the starch suspension, followed by incubation at 70-75°C for 15 minutes.

**Cultural Conditions:** The microorganisms were grown in 5 litre batch fermentors (working volume 3.5 litres). The temperature was maintained at 32°C, the impeller speed was 700 r.p.m. and the aeration ½ vol/vol/min. pH was registered continuously but not adjusted to a fixed value.

**Analytical Procedures:** Cell growth was described by determining the dry weight of cells. Cells from 10 ml fermentation broth were washed twice by centrifugation and dried at 105°C for 20 hours. The numerical proportion of the bacteria and the yeast cells was determined by use of a "Thoma