MAGNETIC STUDY ON YEAST CELLS

YOSHIHIKO SUGIURA and SHOZO KOGA

Institute of Applied Microbiology, University of Tokyo, Tokyo

Received January 20, 1964

In a recent article Szent-Györgyi (1) suggested on the basis of his triplet hypothesis that the aerobically respiring cells would be expected to show a slightly paramagnetic susceptibility as compared with the diamagnetic values given by resting or dead cells.

In an earlier paper in 1936, Bauer and Raskin (2) reported that the diamagnetic susceptibility of yeast cells and some bacteria (E. coli and B. proteus) increased by 4% upon death of the organisms. This value has been quoted in several articles (Blois, 3; Selwood, 4) as the only experimental data on cellular susceptibility so far obtained.

Therefore, it seemed of interest to check at this time the validity of the observed figure in possible relation to Szent-Györgyi’s suggestion.

MATERIALS AND METHODS

Baker’s yeast cells (Saccharomyces cerevisiae) obtained from Oriental Kobo Co., Ltd. were used in suspension. After washing the cells several times with distilled water to remove the culture medium, samples were prepared as follows:

Sample 1: suspension of intact resting cells.

Sample 2: suspension of cells heated at 70° for 3 min: After this treatment, all the cells were found dead as judged by colony formation, methylene blue decoloration and eosine stainability test.

Sample 3: suspension of metabolizing cells prepared from sample 1 by passing oxygen gas for 30 min at 30° in the presence of glucose at an initial concentration of 2%.

Acetate buffer solutions of pH 5.0 were used as a common medium for all samples.

Magnetic susceptibility of the suspensions was measured by Gouy’s technique (3) as shown in Fig. 1. A cylindrical glass tube containing a sample to be measured was suspended between the poles of an electromagnet with a gap of 3 cm, thereby making the direction of the magnetic field perpendicular to the axis of the tube of 1 cm² cross section and 15 cm length. The strength of the applied magnetic field was 7,000 oersteds in region of maximum intensity where the bottom part of a sample tube was placed. The magnetic force exerted on the sample was measured with a semi-microbalance by using a fine suspending wire of phosphor bronze. The
effect of glass tube used was calibrated by using carefully distilled water and an aqueous solution of nickelous chloride. The temperature was 24° ±1°.

The estimated errors were within ±0.3% in our experiments, while ±0.7% in Bauer's work.

The volume fraction of cells in suspension was calculated from the mean diameter and the number of cells per unit volume measured under the microscope, respectively.

RESULTS AND DISCUSSIONS

The observed results are shown in Fig. 2, in which the value of magnetic susceptibility per unit volume are plotted against cell volume fractions. The magnetic susceptibility was found to depend linearly on the volume fraction. The figure also shows that, contrary to our expectations, the differences among the samples in the susceptibility are not beyond the limit of experimental errors, although dead cells appear to be slightly more diamagnetic than the others. No attention was paid in this experiment to the amount of dissolved oxygen, since the susceptibility-change due to the existence of this paramagnetic molecule did not exceed 0.2% in magnitude.

Thus, our magnetic measurements on yeast cells have failed to reveal a remarkable increase in diamagnetic susceptibility upon death of cells as reported in Bauer's paper.
Descriptions of the experimental procedure in the literature cited above was too brief to permit any definite speculation for the reason of this disagreement. Nevertheless, a susceptibility change amounting to 4% (BAUER and RASKIN, 2) appears to be erroneous or at least to be exceptional by large value.

As for SZENT-GYÖRGYI’S suggestion, the authors could neither confirm nor disprove it from the present experiment. He proposed the existence of triplet states in living cells as possible cause of susceptibility changes, however, there may be at least two other effects to be considered. One is attributable to the presence of paramagnetic atoms such as iron which is a constituent element in the prosthetic group of the cytochrome oxidase and related enzymes normally contained in aerobically grown baker’s yeast. A second effect is attributed to free radicals which are considered to participate in various metabolic processes in living cells (Blois et al. 5).

Therefore, even if a change in magnetic properties upon death is detected by some other method, it will probably be difficult to conclude that the change is attributable to the SZENT-GYÖRGYI effect mentioned above.

**SUMMARY**

(1) Magnetic susceptibility was measured of intact resting, metabolizing and heat-treated yeast cells in suspension.

The accuracy of measurement was ±0.3%.

(2) A susceptibility change of 4% as obtained by BAUER and RASKIN upon death of the cells was not observed.

(3) The remarkable change in susceptibility given by BAUER and RASKIN seems to be erroneous.
The authors are indebted to Miss K. NUNOMURA for her technical assistance.

REFERENCES