ON GAS PRODUCTION BY FECAL BACTERIA GROWN ON SUGAR BOUILLON.

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The ingenious and helpful studies by Professor Theobald Smith of pure cultures of bacteria grown in fermentation tubes suggested to us that something might be learned of the physiological attributes of the mixed bacteria of the human feces when these are grown in health or disease in the anaerobic portion of fermentation tubes. We desire to record here briefly the results of observations on the gas production by mixed fecal bacteria introduced (in a water-suspension designed to secure representative bacteria) into fermentation tubes containing sugar-peptone solutions. The observations on gas production were recorded at the end of about forty-eight hours' sojourn in the incubator at 37° C., and are given in terms of the height of the columns of gas in millimeters. Four sugar-peptone media were used.

The basis of the media was a bouillon medium to which were added different sugars in a concentration sufficient to give in each instance a concentration of two per cent. The sugars used were dextrose, a levulose-dextrose mixture (Schering's diabetin) lactose, and saccharose. Nearly uniform results in gas production were obtained in duplicate series when care was taken to insure a uniform distribution of the inoculated fecal bacteria.

The gas production by the mixed, unisolated fecal bacteria of normal individuals was found to be influenced somewhat by dietetic conditions and age. Presumably healthy, breast-fed children showed a smaller gas production than children who were bottle-fed or than children or adults on mixed diet. In the present communication reference will be made mainly to the gas production by the fecal bacteria of normal and pathological adults and of children who are no longer infants...

The average gas production noted in sixteen observations on the fecal bacteria of normal individuals was 103.65 mm. for the
four tubes. The largest gas production among these was 138, 137, and 129 mm., the smallest, 65, 69, and 72 mm. As a rule, the largest gas production was in the lactose-peptone tube, the smallest, in the saccharose tube. The averages of gas production for the different individual tubes are as follows:

<table>
<thead>
<tr>
<th>Sugar</th>
<th>Gas Production (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dextrose</td>
<td>26.75</td>
</tr>
<tr>
<td>Levulose-dextrose</td>
<td>27.5</td>
</tr>
<tr>
<td>Lactose</td>
<td>29.9</td>
</tr>
<tr>
<td>Saccharose</td>
<td>19.5</td>
</tr>
</tbody>
</table>

The gas formed under the conditions that have been described was in some instances subjected to the absorption test by a caustic potash solution. The proportion of gas absorbed varied somewhat in the different sugar-peptone tubes. It may be said that, as a rule, from about one-quarter to one-tenth of the total gas (representing carbon dioxide) was absorbed. The proportion of carbon dioxide production was about the same in the cases where gas formation was inhibited.

Some observations have been made on the gas production by pure cultures of bacteria normally inhabiting the gastro-enteric tract. For example, one strain of B. coli communis gave 90 mm. of gas in the four tubes, while another strain gave 92 mm. B. lactis aerogenes gave 76 mm. All these values are somewhat below those obtained by growing the mixed fecal bacteria from presumably normal persons. Greater gas production was noted where B. coli was grown with B. aerogenes capsulatus.

The fact which we desire to bring forward in this communication is that there are pathological conditions in which the production of gas by the mixed fecal bacteria is distinctly less than is usual for normal persons. The feces from a number of persons showing the evidences of excessive intestinal putrefaction (putrefactive products in the feces or derivatives of putrefactive products in the urine) have been studied with respect to their gas production. It was found that a somewhat diminished gas production is a not infrequent accompaniment of various digestive disorders. A pronounced reduction in gas formation is less common, and when persistent is apparently associated with graver clinical manifestations.

Thus in a man of thirty-two years, suffering from pernicious anæmia, the gas production in the four tubes was only 30 mm.

1 The anaerobic portion of the tubes used by us is about 9.5 cm. in length.
This was soon after entering the hospital. About a week later, during a diarrhoeal period the gas production rose to 100 mm. but declined again later to 60 mm.

In another patient with pernicious anæmia, the feces from a diarrhoeal stool gave 155 mm. of gas; some weeks later a formed stool gave bacteria which produced 45 mm. of gas. In a third patient with the same disease, a diarrhoeal stool gave 95 mm. of gas, but later the fecal bacteria from a formed stool gave 70 mm. only.

In another patient with pernicious anæmia, the semi-solid stool contained bacteria which gave 80 mm. of gas. As the patient improved, under the influence of rest and care in diet, the gas production increased to 90 mm. and later, coincidentally with further improvement, to 112 mm. Another patient with pernicious anæmia, a child of one year, gave on one occasion 35 mm. of gas, on another 38 mm.

Very low gas production was repeatedly observed in a severe case of diabetes on the verge of coma.

The smallest gas production has been noted in bottle-fed children suffering from marasmus. In several instances the fecal bacteria from such children have failed to make a volume of gas measurable by ordinary methods. In one highly anemic child in a marantic state the gas production amounted to 18 mm. when the first observation was made. After a week in bed, on a carefully chosen diet, the gas production was 105 mm. One week later it was 120 mm., and two weeks later 96 mm. The increase in gas production coincided with a striking improvement in nutrition and in the blood picture.

A marked fall in gas production has been noted during fever in a case where previous to the rise in temperature the gas production was large.

The explanation of the phenomena recorded here is not yet clear, but it appears likely that it is attributable at least in some instances to an interference with the normal gas-producing properties of organisms of the B. coli communis group. One may think of the gas-forming kinds of bacteria as actually dying out to a large extent in the lower bowel, or one may imagine them

Our observations on bottle-fed children are not sufficiently numerous to enable us confidently to give the normal gas production for them. It appears to vary from 50 to 100 mm.
Gas Production by Fecal Bacteria

to be simply inhibited in their growth by the presence of bacteria which are limited gas-producers. The view that the gas-makers of the upper bowel are replaced in the lower bowel very largely by organisms with other physiological character is substantiated in a noteworthy manner by the results of studies with the gram stain. Bacteria of the B. coli group are gram negative, and where we have preponderantly gram-negative stools containing, B. coli in large numbers one would expect an average gas production by fecal bacteria grown on sugar bouillon. This has been actually the case. On the other hand, gram-positive feces containing bacteria of the B. coli type are small gas-producers. A special instance of a physiological flora which is able to make little gas and is gram-positive is that of the breast-fed infant in which B. coli has not become established and in which B. bifidus (Tissier) and B. acidophilis (Moro) are dominant. In adults and in children on cow’s milk a gram-positive stool is usually not physiological, and in such cases it may be that small gas production is partly dependent on the inhibiting action of some pseudo-parasitic organism or combination of organisms.

We have repeatedly observed a change in the fecal flora from a gram-positive to a gram-negative character and with this change an increase in gas production. In an autopsy on a child dead of pneumonia, the following conditions were observed with respect to gas production. Bacteria from the stomach gave 40 mm. of gas; bacteria from the duodenum, 94 mm. of gas; cultures from the jejunum gave 78 mm. of gas, and the same amount was obtained from the cultures from the ileum; and finally bacteria from the rectum gave only 22 mm. of gas.1 In the rectum the bacteria were gram-positive; above the rectum, mainly gram-negative.

We have not yet been able to reproduce experimentally the impaired gas formation by combining with the colon bacillus some organism capable of inhibiting its gas-producing qualities. A definite association between gas production by the fecal bacteria under anaerobic conditions of growth and special conditions of intestinal putrefaction has not been established.

1 This observation harmonizes with the fact that the diarrheal flora of the human intestinal contents generally give more gas than the bacteria derived from formed movements from the same individual.
We believe that further studies of the phenomena here described will prove to be of biological interest and of value in clinical investigations of intestinal disorders.

Note.—A great increase in gas production was noticed in a monkey which developed diarrhoea after feeding with cabbage. This observation is in accord with what we have noticed in connection with human diarrhoea.
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