STUDIES ON THE ALIMENTARY FLORA OF PIG

V. INFLUENCE OF STARVATION ON THE MICROBIAL FLORA

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One of the roles of the alimentary flora of animals is to prevent the animals from intestinal infection with pathogenic bacteria. According to many investigators, growth of Shigella or Salmonella was inhibited in the intestine by some components of the normal intestinal flora. Formal et al. and Miller and Bohnhoff have reported that animals increased in susceptibility to intestinal infection with pathogens when they had been starved. This indicates that the intestinal infection may be concerned with disturbances in the intestinal flora. It is of value from such a point of view to study the influence of starvation on the alimentary flora of the pig. In addition, experimental starvation would throw light on a relationship between anorexia and the abnormal alimentary flora in pigs infected with hog cholera. It was demonstrated in rats by Yusa that lactobacilli and bifidobacteria decreased in number, coliforms, enterococci, and bacteroides increased inversely in number. Porter and Rettger have obtained similar results from rats. Smith reported that lactobacilli and yeasts were reduced greatly in number in the stomach and intestine of rats starved for 24 hours, and that anaerobic streptococci were principal inhabitants of the gizzard and small intestine in fowls starved for the same period. The present paper deals with the alimentary flora of pigs deprived of feed or of feed and water.

MATERIALS AND METHODS

As shown in Table 1, six adult pigs were used. Microorganisms were counted in the contents of various parts of the alimentary tract in them. Four pigs (Nos. 1 to 4) were reared on the concrete floor in stalls and given a little water during a period of fasting for 24 hours. Two pigs (Nos. 5 and 6) were reared in individual cages and denied from both feed and water for 72 hours. No alimentary tract changed in volume in the former 4 pigs (Nos. 1 to 4), whereas the stomach and the large intestine contracted markedly in the latter two pigs (Nos. 5 and 6). In addition, pig No. 5 was infected with Ascaris suilla. The fermented-Chlorella diet which was given to two pigs Nos. 3 and 4, had not sufficiently been fermented owing to the winter season. The media and methods used for cultivation were based on those reported by Mitsuoka et al.

RESULTS AND DISCUSSION

The results obtained are illustrated in Figs. 1 to 3, which deal with individual cases. In pigs starved for 24 hours, lactobacilli were found to have markedly decreased in number in the stomach and anterior jejunum, as compared with those in the healthy

Table 1. Segments of Alimentary Tract Subjected to Experiments

<table>
<thead>
<tr>
<th>Pig No.</th>
<th>Breed(1)</th>
<th>Sex</th>
<th>Age (months)</th>
<th>Diet(2)</th>
<th>Starvation period (hours)</th>
<th>Segment tested(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>YL</td>
<td>♂</td>
<td>8</td>
<td>CD</td>
<td>24</td>
<td>○ ○ ○ ○ ○ ○</td>
</tr>
<tr>
<td>2</td>
<td>YL</td>
<td>♂</td>
<td>8</td>
<td>CD</td>
<td>24</td>
<td>○ ○ ○ ○</td>
</tr>
<tr>
<td>3</td>
<td>YL</td>
<td>♂</td>
<td>7</td>
<td>FCD</td>
<td>24</td>
<td>○ ○ ○ ○ ○</td>
</tr>
<tr>
<td>4</td>
<td>YL</td>
<td>♂</td>
<td>7</td>
<td>FCD</td>
<td>24</td>
<td>○ ○ ○ ○</td>
</tr>
<tr>
<td>5</td>
<td>YL</td>
<td>♀</td>
<td>7</td>
<td>CD</td>
<td>72</td>
<td>○ ○ ○ ○ ○</td>
</tr>
<tr>
<td>6</td>
<td>YL</td>
<td>♀</td>
<td>6</td>
<td>CD</td>
<td>72</td>
<td>○ ○ ○ ○ ○</td>
</tr>
</tbody>
</table>

1) YL: Yorkshire x Landrace.
2) CD: Commercial diet.
   FCD: Fermented-Chlorella diet; two pigs, Nos. 3 and 4, had been fed this diet since about 3 months of age.

Pigs reported previously(9). The log count of them was less than 4.0 in these organs. Lactobacilli decreased further in number in the ileum and cecum of pig No. 5 and in the ileum of pig No. 6 when these two pigs had been starved for 72 hours. Their log counts were not more than 2.3 for the stomach to the ileum and 4.3 for the cecum of pig No. 5. They were 4.6 to 4.8 for the stomach to the ileum of pig No. 6. Those pigs fed the fermented-Chlorella diet harbored smaller numbers of lactobacilli in the large intestine than the other pigs.

Bifidobacteria were found in the same way as lactobacilli. They were present in small numbers or absent in the stomach and anterior jejunum. They were found normal in numbers in the lower parts (the ileum and the large intestine) of the alimentary tract.

Fig. 1. Alimentary Flora of Pigs Fed a Commercial Diet and Starved for 24 Hours

![Diagram of Alimentary Flora](chart.png)
Fig. 2. Alimentary Flora of Pigs Fed a Fermented-Chlorella Diet and Starved for 24 Hours

Fig. 3. Alimentary Flora of Pigs Fed a Commercial Diet and Starved for 72 Hours
tract of all the pigs, except pig No. 1.

Streptococci were present in small numbers or absent in the upper parts (the stomach and the anterior jejunum) of the gut in all the pigs examine, except the anterior jejunum of pig No. 1. They were present in large numbers in the ileum, cecum, and rectum of three pigs, Nos. 1 to 3, but in smaller numbers in the cecum of pig No. 4 and in the lower parts of the gut of the 2 pigs starved for 72 hours. The number of streptococci in the cecum of pig No. 4 fed the fermented-Chlorella diet agrees with the previous data, but the streptococcal flora in the large intestine of pig No. 3 fed the same diet is contradictory.

Bacteroides were absent or scanty in the upper parts of the gut in all the pigs examined, except the anterior jejunum of pig No. 5. They were found in large numbers in the ileum of those pigs. These results were different from the previous data. Bacteroides were found in higher concentrations in the cecum and the colon or rectum of four pigs Nos. 1, 2, 5, and 6, but in much lower concentrations in the large intestine than in the ileum of two pigs, Nos. 3 and 4, which had been fed the fermented-Chlorella diet. These results indicate that the fermented-Chlorella diet may suppress the proliferation of bacteroides.

Escherichia coli was absent or scanty in the stomach and anterior jejunum of four pigs, Nos. 1 to 4. It was present in moderate or large numbers in the same segments of pigs No. 5 and No. 6. The abnormally high level in number of E. coli organisms in the anterior jejunum of pig No. 5 may be associated with Ascaris suilla parasitism. E. coli organisms were predominant in the ileum in all the pigs, particularly in Nos. 5 and 6 in which they numbered 9.3 and 9.5, respectively. A marked decrease in number of these organisms was found in the large intestine of 2 pigs fed the fermented-Chlorella diet. These results lend support to the view that the diet has effects on the alimentary flora.

Catenabacteria, which are Gram-positive, non-spore-forming anaerobic rods in chain forms, were frequently found in considerable numbers in the ileum and large intestine, but not at all in the upper parts of the gut.

Anaerobic streptococci, veillonellae, and clostridia were occasionally found principally in the ileum and large intestine.

Staphylococci and yeasts were constantly present in moderate or small numbers in all the pigs. The number of yeasts, however, was smaller in the pigs fed the fermented-Chlorella diet than those fed a commercial diet. This is contrary to the results reported previously. It may have been brought about by the unsufficient multiplication of yeasts in the diet owing to the winter season. Molds were very few, if any.

It is evident from the results of this experiment that fasting caused marked changes in the gut flora. Similar results have been obtained from starved rats by Porter and Retger, and Yuasa. Smith reported that anaerobic streptococci had appeared in the gizzard and small intestine of fowls after fasting for 24 hours. Such phenomenon was also reported by Shirasaka who demonstrated the appearance of Gram-positive, anaerobic coccobacilli in the gizzard and small intestine of starved fowls. The organisms which appeared in these starved fowls may prevent the fowls from invasion of pathogens and support the normal physiological function of the digestive tract. On the contrary, no organisms have emerged in the stomach and anterior jejunum, where lactobacilli and bifidobacteria decreased markedly in starved pigs. E. coli organisms and bacteroides, however, increased in the ileum of pigs by fasting. Noticeable changes in the flora may cause discomfort, giving little benefit to the host. Very high concentrations of E. coli organisms and bacteroides (8.0 and 6.8, respectively) were found in the anterior jejunum of a pig infected with Ascaris suilla. This suggests that the combination of round worm
infection and starvation may give rise to an abnormal flora in the anterior part of the small intestine. A similar abnormal flora was observed in some pigs infected with hog cholera\(^9\). It is speculated that an abnormal flora may be ready to be induced in the upper part of the small intestine of a pig by invasion of extrinsic agents when an abnormal ileal flora has been formed in the pig owing to starvation.

**SUMMARY**

Viable counts of various microorganisms were calculated in the contents of different parts of the alimentary tract in pigs deprived of feed for 24 hours, or of feed and water for 72 hours.

The principal results obtained are as follows.
1. Lactobacilli and bifidobacteria decreased markedly in number in the stomach and anterior jejunum of pigs starved for 24 hours and in the same parts and ileum of pigs starved for 72 hours.
2. Very large numbers of *Escherichia coli* organisms and bacteroides were found in the ileum of the starved pigs and in the anterior jejunum of a starved pig bearing infection with *Ascaris suilla*.
3. A fermented-Chlorella diet had some effects on the flora of the large intestine.

**REFERENCES**

豚の消化管内細菌叢に関する研究

V. 絶食時における細菌叢について

森下 芳 行・尾 形 学
東京大学農学部家畜微生物学教室
（昭和44年7月1日受付）

24時間および72時間絶食させた豚について、その消化管各部位（胃・上部空腸・回腸・盲腸・結腸・直腸）の細菌叢の検査を行なった。その結果は次のとおりである。

1. 24時間および72時間絶食によって、胃と上部空腸におけるLactobacillusおよびBifidobacteriumの著減が認められた。

2. 一方、Escherichia coliおよびBacteroidesの回腸における著増が認められた。また両菌種は、Ascaris suillaの寄生していた豚では、さらに上部空腸でも著増を示した。

3. クレラ発酵飼料給与の豚では、E. coli、BacteroidesおよびStreptococcusの菌数は、市販飼料給与の豚のそれらに比べて少なかった。