Infection is among the most important factors in delaying and preventing the healing of wounds and ulcers. It has recently been stated that “all of the topical antimicrobials employed to control wound/burn infection impeded wound healing”. Maltodextrin is a natural product obtained by hydrolysis of starch. Chemically, it is a D-glucose polysaccharide polymer with an average molecular weight ranging around 3000 Daltons. It contains small amounts of sugars (glucose and maltose) and large amounts of higher molecular weight polysaccharides. Clinical trials show that the topical application of Maltodextrin controls odor causing bacteria and eliminates infection in wounds and ulcers, promoting the growth of highly vascularized granulation tissue, illustrating the antibacterial and wound healing characteristics of Maltodextrin NF (2, 3, 4 & 5).

**Experimental:** It was decided to test in-vitro the antibacterial properties of Maltodextrin in view of the excellent clinical results. Control and experimental Erlenmeyer flasks were filled with appropriate growth medium (TSB) and sterilized. To the experimental flasks Maltodextrin NF powder was added in 10, 20, 30, 50, and 70% concentrations, w/v. All the flasks were inoculated with ATCC registered strains of pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli and Streptococcus fecalis. Bacterial growth over time was measured by the increase in the turbidity of the medium using a Coleman-Hitachi spectrophotometer. Bacterial growth inhibition was manifested by decrease in the turbidity of the medium.

**Results:** For all of the bacteria tested, growth was inhibited in-vitro by Maltodextrin NF. A 20% solution of Maltodextrin NF in TSB medium resulted in more than 50% inhibition whereas a 70% solution totally inhibited bacterial growth.

**Electron Microscopy:** Bacteria exposed to a 20% Maltodextrin NF solution for 6 hours at 37 degree centigrade, showed the following structural changes: 1) Plasmolysis, 2) swelling and stripping of bacterial membrane and 3) formulation of membrane pores generated porins, membrane proteins that are believed to be specifically activated by a Maltose-Maltodextrin complex of Maltodextrin NF (6&7). Any of the above changes may be conducive to bacterial death (bacteriocidal effect).

**Conclusion:** Maltodextrin NF is bacteriostatic to aerobic and anaerobic, gram positive and gram negative bacteria in-vitro.
REFERENCES:


THE CHEMOTACTIC ACTIVITY OF MALTODEXTRIN N.F. ON POLYMORPHONUCLEAR LEUKOCYTES

A Comparative In-Vitro Study using the Boyden Chamber

Anthony N. Silvetti, MD

It is well known that simple sugars such as glucose and other monosaccharides exert chemotactic activity towards leukocytes, in particular polymorphonuclear leukocytes (PMN).

It has been observed in hundreds of clinical cases of chronic and infected human wounds/ulcers that following the application of Maltodextrin NF, the infection and purulence began to decrease immediately and disappeared almost completely within 2 - 4 days. It is believed that this control of local infection and purulence may be due in part to the action of the patient’s own leukocytes that are attracted to the infected wound/ulcer site by the chemotactic properties of Maltodextrin NF, and proceed to phagocyte and kill bacteria present therein.

Maltodextrin NF is a natural medium molecular weight D-Glucose polysaccharide consisting of a mixture of mono, di, tri, tetra, hexa, hepta, and higher polysaccharides and is obtained by gentle acid and enzymatic digestion of plant starches.

In order to test this hypothesis, several in-vitro and in-vivo experiments were carried out to determine if Maltodextrin NF is indeed chemotactic to leukocytes (polymorphonuclear leukocytes, lymphocytes, and monocytes) and if its chemotactic action is stronger than other substances.
MATERIALS AND METHODS

Maltodextrin, NF  A pure maltodextrin powder, with a Dextrose Equivalence (D.E.) of 10 - 12 and an average molecular weight of 3000 Daltons was used. It was sterilized by gamma radiation and preserved in tight aluminum foil packets.

Guinea-Pigs  White Guinea-pigs, NMRI stock, weight 400 grams were used. In order to harvest the necessary Polymorphonuclear cells (PMN), several Guinea-pigs were injected intraperitoneally with sterile mineral oil under strict aseptic conditions. This produced in 48 - 72 hours a large harvest of intraperitoneal PMN leukocytes suspended in intraperitoneal fluid. This fluid was carefully collected and stored for the experiments.

BOYDEN CHAMBER FOR CHEMOTACTIC EXPERIMENTS  
This experimental chamber was divided into 2 compartments by a Micropore Filter, whose pores are small enough to allow passage of simple molecules and macromolecules but not cells such as PMN cells and other leukocytes. During the chemotaxis experiments, the PMN cells from the Guinea-pig are placed in one compartment and the chemical substance being tested in the other, for variable times, in an incubator at 37 degrees C.

MATERIALS AND SUBSTANCES TESTED FOR CHEMOTACTIC ACTION
1. Maltodextrin NF powder (Described above). Used in 10% and 30% solutions.
2. Chemokinesis control (Chemotaxis control). A standard for chemokinesis or chemotaxis activity.
4. RPMI - 1640. Roswell Park Memorial Institute tissue culture medium, containing basic nutrients including amino acids.
5. Sucrose (Table sugar - in a 10% dilution). Used for centuries in the treatment of wounds and ulcers.
RESULTS

The following are the results observed:

<table>
<thead>
<tr>
<th>Material Tested</th>
<th># cells attracted</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPMI - 1640</td>
<td>4 cells/field</td>
</tr>
<tr>
<td>10% Sucrose</td>
<td>5 cells/field</td>
</tr>
<tr>
<td>Chemokinesis control</td>
<td>10 cells/field</td>
</tr>
<tr>
<td>N-f-met-leu-phe polypeptide</td>
<td>60 cells/field</td>
</tr>
<tr>
<td>10% Maltodextrin, NF</td>
<td>9 cells/field</td>
</tr>
<tr>
<td>30% Maltodextrin, NF</td>
<td>185 cells/field</td>
</tr>
</tbody>
</table>

CONCLUSIONS

It was shown that the 30% solution of Maltodextrin NF attracted an average of 185 cells per field. It is therefore established that this 30% solution is the most active chemotactic substance tested in these experiments.

In the in-vivo treatment of patients with deep, full-thickness skin wounds/ulcers, Maltodextrin NF powder (full strength) has been used. Originally, the concentration of the powder when first applied to the wound/ulcer is 100%. As the powder draws some of the wound/ulcer fluid, its concentration will decrease slightly, to a 95 - 97% range. In these clinical cases, the chemotactic activity of the Maltodextrin NF powder was much higher than that of the 30% dilution used for this experiment.

The outstanding infection control and cleansing effect on necrotic, infected tissue of wounds/ulcers in the clinical setting may be explained by the active phagocytic effects of the chemotactically attracted Polymorphonuclear cells and other leukocytes.
Maltodextrin NF powder is a mixture of monosaccharides (Glucose) and several polysaccharides with increasing molecular weights. This polysaccharide mixture is obtained by gentle and controlled acid and enzymatic digestion of plant starches. The average molecular weight of the Maltodextrin powder used in these studies is 3,000 Daltons.

In experimental in-vitro studies using the Boyden Chamber, it has been demonstrated that Maltodextrin is highly chemotactic to Polymorphonuclear cells (PMNs). As a matter of fact, Maltodextrin in a 30% solution is the most active chemotactic solution tested in these studies.

The wound healing enhancing effect of Maltodextrin could be explained by the large number of PMN cells that contain known specific growth factors as well as bacteriostatic and bacteriocidal factors, resulting in overall increased phagocytic activity. (Phagocytosis against tissue debris, purulent exudate and bacteria).

In 1962, Dr. Robert Chambers, a New York University Biologist known for the development of the Chambers micro cell manipulator, demonstrated that starches, glycogen, and sugars such as sucrose, maltose, lactose, fructose, and glucose in 2 to 5% Tryode solution exerted a positive chemotactic effect on Polymorphonuclear leukocytes (PMNs). Specifically, starch solutions incubated with animal serum (containing Serum Amylases) for several hours were highly chemotactic to PMN leukocytes. This reaction was due to the partial breakdown of the starch molecules by amylases present in the serum.

These products of starch breakdown are similar to Maltodextrin NF molecules, also obtained by enzymatic breakdown of starch. Hence, Maltodextrin NF is highly chemotactic to PMN leukocytes, and the presence of Maltodextrin NF at the wound site should assist in the wound healing process.
IN-VITRO TESTS

In this article, Dr. Grotendorst states, “During chemotaxis, cells respond to a chemical factor (chemoattractant) and move in the direction of an increasing concentration of that factor. The best characterized chemotactic response of mammalian cells is the directed migration of phagocytic cells, primarily macrophages and polymorphonuclear neutrophils, to sites of infection or trauma. Phagocytic cells recognize factors secreted by the infecting organism as well as those generated in the traumatized areas and migrate toward their source. However, chemotaxis is not limited to phagocytic cells and has been observed in other cell types, including fibroblasts, smooth muscle cells, and endothelial cells” and “our understanding of chemotaxis is based largely on in-vitro systems used to assess the migrating responses of cells. The Boyden Chamber is the most commonly used.”

Therefore, the Boyden Chamber assay was used to compare the chemotactic effects of Maltodextrin NF in-vitro versus other compounds/solutions. (See attached report: “The Chemotactic Activity of Maltodextrin NF on Polymorphonuclear Leukocytes”)