Microbial Control in the Human Stomach

by

Irving J. Pflug, Ph.D.
Professor Emeritus,
University of Minnesota

February, 2019

Published by

Environmental Sterilization Laboratories, LLC
9937 E 800 S; Otterbein, Indiana 47970 USA

Irving J. Pflug:

Professor Emeritus - University of Minnesota
Department of Food Science and Nutrition

Teaching Microbiology and Engineering of Sterilization Processes, 1976 to 2015

NASA: Planetary Quarantine Advisory Panel, 1966 to 1985

Printed February, 2019

Printed in the United States of America.

Microbial Control in the Human Stomach

Irving J. Pflug, Ph.D.

In a normal healthy individual, microbial control is carried out automatically by natural forces.

Microorganisms proceeded on this earth before man and the animals. The ability to destroy pathogenic microorganisms in the stomach was of first importance since failure to destroy pathogens resulted in the loss of the man or animal. Therefore, nature developed stomach systems that produced a controlled environment for chemical processes, with digestive enzymes and hydrochloric acid (HCl), that control pathogenic microorganisms so the workings of our innards can proceed safely.

Actions That Take Place in the Stomach

The stomach is the work-horse of the human body, an automated biological reactor vessel, whose purpose is to prepare (digest) ingested food into a form that can be absorbed in the duodenum and the small intestines.

The stomach receives everything that enters the mouth: food, vegetative microorganisms, spore-forming microorganisms, viruses, fungi, miscellaneous biological material, and fluids. The size and contents of the meal determine the microbial load and the digestion time in the stomach.

As soon as food enters the stomach, the neurological system puts the whole digestive system into an automatic operation mode. The walls of a healthy stomach produce a highly acidic blend of enzymes, hydrochloric acid, and mucus with a pH of about 1.8. These chemicals are as strong and aggressive as car-battery acid. After the digestion process has progressed, the resulting food mass has a pH of 2.0 to 3.0.

In a wave action from the stomach walls, food particles are combined with the chemicals secreted from the stomach walls, then kneaded, mixed, and liquefied. What started as masticated food is now a thick, soupy mass called chyme. The chyme is continuously subjected to this strong hydrochloric acid and enzyme environment, breaking down all biological material into its component molecular parts. All microorganisms in the chyme will be subjected to the same low pH environment throughout the digestion cycle.

Microorganisms, entering the stomach with food, are acted on by the low pH and are carried along with the chyme which will later exit through the Pylorus Valve into the duodenum. The Pylorus Valve is located between the stomach and the duodenum; it opens slightly, a few times per minute, to allow the chyme to enter the duodenum.

Reactions in the stomach system produce several product gases which are discharged either back through the mouth or through the colon.

Microbial control of vegetative microorganisms, pathogenic and non-pathogenic, takes place in the stomach when the chyme pH is 2.0 to 3.0. At this pH, the amount of time in the stomach needed to no longer recover viable microorganisms is usually minutes for vegetative micro-organisms, whereas for resistant bacterial spores a reduction of 90% may require hours.

According to Rahn (1945), microorganisms subjected to heat and chemicals die as a result of adverse chemical reactions in the cell. This follows the Law of Mass Action.

The microbial inactivation rate will be a function of the *D*-value of each species of microorganisms as it follows the logarithmic order-of-death model (Rahn 1945); survival will be on a probabilistic basis.

The more time microorganisms are at a pH of 2.0 to 3.0, the greater will be the microbial-reduction effect. When microbial survival is small, survival is a probability effect.

In this discussion of microbial destruction in the stomach, we assume that the chyme moves through the stomach as a series of packets; each packet will see the same series of effects as it moves from the entrance of the stomach until the end of the stomach (the duodenum). Average transit time from the stomach through to the duodenum is two to five hours.

In my opinion, the chyme, as it leaves the stomach and enters the duodenum, is not microbiologically sterile, but all vegetative types of microorganisms will have been killed and the numbers of spore-forming organisms will have been reduced.

Microbial Control Can Be Diminished When pH is Higher

When through food, drugs and/or lifestyle changes, we have altered the natural operation of the stomach such that we allow the stomach chyme to reach a pH of 5.0 or higher, we will have microbial-control problems. If the stomach's acid-producing system is degraded to where the pH of the chyme reaches a pH of 5.0 or higher, the control of pathogenic vegetative microorganisms is greatly diminished.

Disease and Chemicals Can Adversely Affect the Stomach

The literature contains studies that suggest that increasing the stomach chyme pH to 4.0 or 5.0 will lead to unhealthy conditions in the gut. I will describe one route that could lead to a bad outcome.

The size and nature of the microbial load leaving the stomach, on its way to the duodenum, is a function of the pH of the chyme in the stomach; increasing the pH from 2.0 to 5.0 will affect the kind and numbers of microorganisms that survive into the duodenum and small intestines.

Bavishi and DuPont in their report, *Systematic review: the use of proton pump inhibitors and increased susceptibility to enteric infection*, reported that at therapeutic doses among healthy volunteers, studies evaluating the effect of proton pump inhibitors (PPIs) on 24-h intragastic pH found that omeprazole 40m mg OD caused a median 24-h intragastric pH of 4.9 after one week; pantoprazole 40 mg caused a mean 24-h intragastric pH of 4.0 after one week; lansoprazole 30 mg OD produced a mean 24-h intragastric pH of 4.5, etc. They reported that at therapeutic doses PPIs generally cause the gastric pH to be greater than 4.0.

The significance of the paragraph above is that, whereas in nature, microorganisms will die at pH 2.0 to 3.0, when the pH increases to 4.0 to 5.0, a fraction of the microorganisms may survive through to the small intestines, and surviving microorganisms may reproduce and even colonize in the nutrient rich small intestines.

The results of this study, pH levels in the chyme from 4.0 to 5.0, suggests to me that some microorganisms may survive in the chyme through to the small intestines to reproduce and even colonize in the nutrient rich small intestines. The result is uncontrolled, indiscriminate-seeding of microorganisms into the GI system.

My point is that PPIs may not be bad in themselves, but will cause an increase in the pH in the stomach that in turn allows microorganisms to survive into the duodenum and small intestines.

Literature Cited

Bavishi, C, & DuPont, H.L. (2011). Systematic review: the use of proton pump inhibitors and increased susceptibility to enteric infection. *Aliment Pharmacol Ther, 34*:1269-1281.

Pflug, Irving J. (2010). Microbiology and Engineering of Sterilization Processes, 14th Edition. Environmental Sterilization Laboratory, Otterbein, IN 47970.

Rahn, O. (1945). Injury and death of bacteria by chemical agents. Biodynamica Monograph No. 3. Biodynamica. (ed. Luyet, B. J.) Normandy, MO. 1945. Republished in Pflug, I. J., ed., Selected Papers on the Microbiology and Engineering of Sterilization Processes, 7th Edition. Environmental Sterilization Laboratory, Otterbein, IN 47970, 2014. 1 - 16.