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Research Article

Concocting a More Effective Antacid

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Abstract

Objective: The purpose of this experiment was to test the effectiveness of two commercial antacids against several acidic solutions and to determine if a newly concocted antacid that was comprised of both a metal hydroxide and a carbonate would be more effective than the current commercial antacids at neutralizing the pH of the solutions.

Methods: Six acidic products were chosen for this experiment: apple cider vinegar, lemon juice, orange juice, tomato juice, coffee, and jalapeno pepper juice. Hydrochloric acid was used as a baseline acid to test each antacid and then mixed with each one of the acidic products to produce "stomach contents". The antacids used in this experiment were calcium carbonate ($CaCO_3$), sodium hydroxide (NaOH), sodium bicarbonate ($NaHCO_3$), and a suspension containing both aluminum hydroxide ($Al(OH)_3$) and magnesium hydroxide ($Mg(OH)_2$). Each of the four antacids was individually added to test tubes containing the acidic products and the stomach contents. A "new antacid" was created by combining equal parts of $CaCO_3$ with NaOH. The effectiveness of this new antacid at neutralizing the pH of the acidic products and stomach contents was compared to the commercial antacids as well as $CaCO_3$ and NaOH individually.

Results: Sodium hydroxide was the most effective antacid followed in decreasing order by sodium bicarbonate, the "new antacid", calcium carbonate and the suspension containing aluminum and magnesium hydroxides.

Conclusions: The third most effective antacid was the "new antacid", which was a combination of sodium hydroxide and calcium carbonate. Based upon these results, further experimentation should be done to develop an antacid containing a metal hydroxide and a carbonate. Combining the individual alkaline materials into one product could result in a more effective antacid.

Keywords

Antacid; Heartburn; Acid; Alkaline; Calcium Carbonate; Stomach; Ph; Indigestion

Introduction

Antacids are medications used to treat heartburn. As the name implies, their mechanism is to neutralize acid [antacid = anti (against) + acid]. This is a biological acid-base reaction that reduces or neutralizes acid levels in the stomach. The stomach releases hydrochloric acid to digest food which can result in a pH as low as 1.50-2.00 in the stomach after eating. Acidic foods can aggravate the stomach lining. Antacids are used to neutralize the acid level of the stomach if a person experiences indigestion or heartburn. Antacids contain an alkaline reactant, usually sodium bicarbonate, calcium carbonate, or aluminum and/or magnesium hydroxides.

In this experiment, one commercial antacid was used that contains sodium bicarbonate, one that contains calcium carbonate, one that contains aluminum and magnesium hydroxides and a "new antacid" was created by combining calcium carbonate with sodium hydroxide. The results were compared to see how well the new antacid neutralizes pH compared with the over-the-counter antacids. The acidic components of the experiment were hydrochloric acid (HCl), several common acidic liquid foods and then a combination of HCl with each of the liquids to create a mixture of "stomach contents".

Acid-related gastrointestinal problems have been increasing in prevalence over the last several decades, with up to 60% of the population experiencing GERD symptoms at least once a year and 20-30% weekly [1]. Complaints of heartburn, indigestion, and nausea continue to rise across every population as physicians struggle to find safe long-term treatments that reduce gastrointestinal acidity [2]. Antacids that are currently available offer short-term relief of heartburn and other acid-related diagnoses but new treatments need to be developed that provide safe long-term relief. The focus of treatment has turned from antacids to proton pump inhibitors. "Since the introduction of proton pump inhibitors (PPI), clinical management of GORD has markedly changed, shifting the therapeutic challenge from mucosal healing to reduction of PPI-resistant symptoms" [3]. If GERD is not treated, a person can develop very serious illnesses such as asthma, esophagitis, and Barrett's esophagus which can all increase the likelihood of developing esophageal cancer [2].

Materials and Methods

Five antacids were used in this experiment: $CaCO_3$, NaOH, a commercial antacid containing sodium bicarbonate ($NaHCO_3$), and a commercial antacid that is a suspension containing both aluminum hydroxide ($Al(OH)_3$) and magnesium hydroxide ($Mg(OH)_2$). A combination of 8ml NaOH and 8ml $CaCO_3$ was made in a beaker and set aside. This was the "new antacid" to be used in the experiment.

The acidic products chosen were apple cider vinegar, lemon juice, orange juice, tomato juice, coffee, and jalapeno pepper juice. The jalapeno pepper juice was taken from a jar of Mezzetta Deli-Sliced Jalapeno Peppers (G.L. Mezzetta, Inc., 105 Mezzetta Court, American Canyon, CA, 94503). The vinegar, lemon juice, orange juice, and tomato juice were all Kroger brand products (The Kroger Co., 1014 Vine St., Cincinnati OH, 45202) and the coffee was original coffee from Dunkin Donuts (Dunkin Donuts, Canton MA). Hydrochloric acid was used as an acid to test against each antacid and then mixed with each of the acidic products to produce "stomach contents". These stomach contents were a 1:1 ratio of HCl and the acidic product. Distilled water (dH_2O) was used as a control. A volume of 4ml each of HCl, vinegar, lemon juice, orange juice, tomato juice, coffee, jalapeno pepper juice and dH_2O was pipetted into test tubes. The pH of each substance was measured using a digital pH meter purchased from Alibaba.com and the results were recorded. Four additional sets of test tubes with these contents were prepared. Next the "stomach

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contents" were prepared. To each test tube, 2ml of HCl and 2 ml of an acidic product were added. The tubes were capped and gently shaken before the pH was measured and recorded. Four additional sets of the stomach content tubes were prepared.

Into each one of the sets of test tubes, 1ml of an antacid was added to each tube and the pH was measured and recorded. This procedure was performed using five sets of test tubes containing the acidic products and five sets of test tubes containing the stomach contents. To the first set of test tubes, 1ml of the $NaHCO_3$ antacid was added, to the second set, 1ml of the antacid containing $Al(OH)_3$ and $Mg(OH)_2$ was added. One ml NaOH was added to the third set of test tubes, 1ml of $CaCO_3$ was added to the fourth set of test tubes and 1ml of the new antacid was added to the fifth set of test tubes.

Results

Sodium hydroxide was the most effective antacid followed in decreasing order by sodium bicarbonate, the "new antacid", calcium carbonate and the suspension containing aluminum and magnesium hydroxides as shown by the pH values in Tables 1 and 2 below.

The "new antacid" very closely followed the neutralization pattern of NaOH when added to the acidic products (Figure1). The "new antacid" followed the neutralization pattern of NaOH when added to the stomach contents but kept the pH within an acidic range (pH values of 1.82 to 3.87) even though the pH of the new antacid itself was 12.70. As seen below in Figure 2, the new antacid reduced the acidity of each of the products tested.

Table 1: The pH of the acidic contents with and without the antacids.

Antacid added	pH (antacid only)	HCl	Vinegar	Lemon Juice	Orange Juice	Tomato Juice	Coffee	Jalapeno Pepper Juice	dH_2O
pH (no antacid)		1.33	2.83	2.70	3.80	4.22	5.24	3.32	4.42
$NaHCO_3$	6.33	1.67	3.46	3.40	5.00	5.67	6.30	3.90	6.55
$Al(OH)_3$ + $Mg(OH)_2$	8.58	1.74	3.31	2.84	4.25	4.88	7.14	3.68	7.18
NaOH	12.83	1.60	3.65	3.04	4.07	4.81	11.49	3.62	12.14
$CaCO_3$	9.68	1.54	3.07	2.87	4.09	4.69	6.13	3.43	5.55
New Antacid	12.70	1.82	3.64	2.91	4.54	5.28	10.13	3.91	11.99

Table 2: The pH of the stomach contents with and without the antacids.

Antacid added	pH (antacid only)	HCl	Vinegar + HCl	Lemon Juice + HCl	Orange Juice + HCl	Tomato Juice + HCl	Coffee + HCl	Jalapeno Pepper Juice + HCl	dH_2O + HCl
pH (no antacid)		1.33	1.77	1.96	2.03	2.12	1.75	1.68	1.59
$NaHCO_3$	6.33	1.67	2.30	2.94	3.76	3.93	3.11	3.43	2.50
$Al(OH)_3$ + $Mg(OH)_2$	8.58	1.74	1.93	2.27	2.71	2.66	2.36	2.02	2.25
NaOH	12.83	1.60	2.65	2.67	4.15	4.51	4.15	3.34	2.35
$CaCO_3$	9.68	1.54	2.08	2.44	2.88	3.21	2.25	2.26	1.95
New Antacid	12.70	1.82	2.20	2.49	3.60	3.87	2.36	2.67	2.21

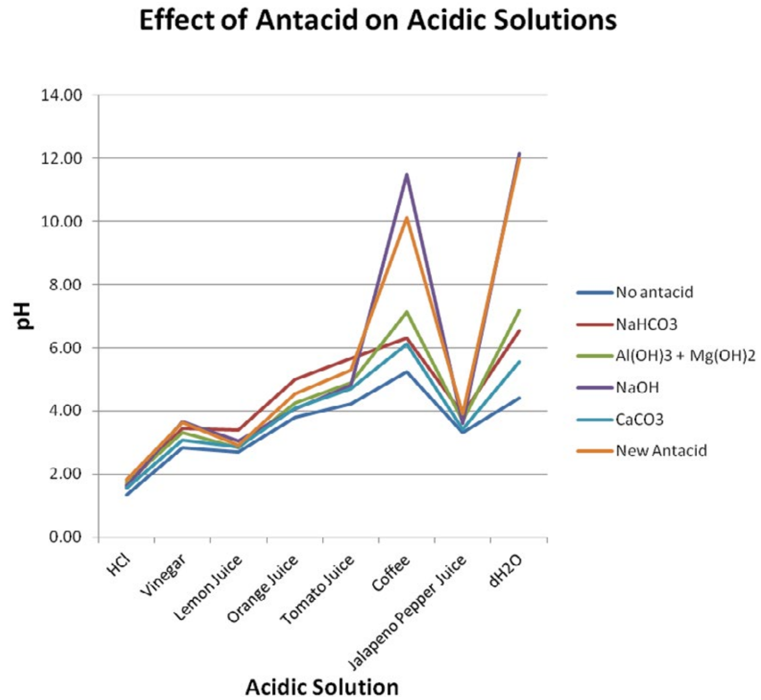

Figure 1: The effect of antacids on acidic solutions.

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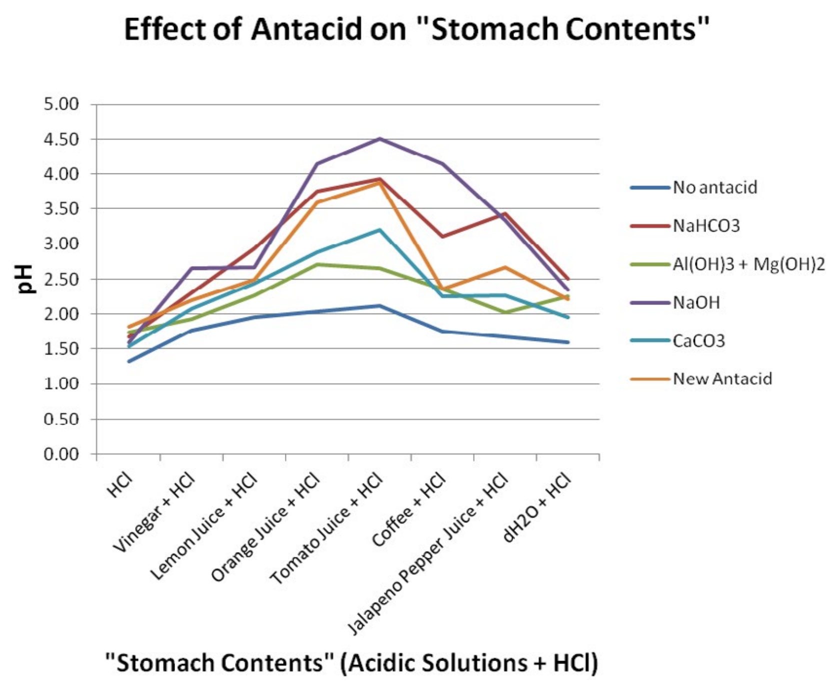

Figure 2: The effect of antacids on stomach contents.

Discussion

Sodium hydroxide tested as the most effective antacid but it is too caustic to be used in the digestive tract. Sodium bicarbonate tested to be the second most effective antacid and is available as a commercial antacid. The third most effective antacid was the "new antacid", which was a combination of sodium hydroxide and calcium carbonate. Based upon these results, further experimentation should be done to develop an antacid containing a carbonate and a metal hydroxide. While reducing the symptoms associated with acidity in the gastrointestinal tract, it is important to maintain an overall acidic environment to promote proper digestion and mineral absorption. Combining the individual alkaline materials into one product could result in a more effective antacid. When $NaHCO_3$, $Mg(OH)_2$, and $Al(OH)_3$ are added to HCl, the reactions each produce a salt and water and in addition, the $NaHCO_3$ produces a gas. The $NaHCO_3$ reaction is much faster than that of the Mg and Al hydroxides. The gas produced by the $NaHCO_3$ can be an unpleasant side effect but the reaction is quicker and will provide more rapid relief to symptoms. An ideal treatment to reduce the acidity in the stomach would contain both a carbonate and a metal hydroxide that, when reacted with the stomach acid, will produce a fast-acting as well as a long-acting result. The carbonate component reacts quicker while the metal hydroxide component reacts slower but the effects last longer.

Given the prevalence of heartburn and other acid-related digestive problems, more effective antacid products are needed. Negative side effects related to long-term use of proton pump inhibitors (PPIs) show that these medications, while effective, are not ideal for long-term treatment of reducing stomach acid [4]. PPIs are often overprescribed [5] and if more effective antacids were available, the overuse and long-term side effects of PPIs could be avoided. PPIs have been associated with negative side effects such as hypomagnesemia, hypocalcemia, hypoparathyroidism, chronic kidney disease, and end-stage renal disease [4,5]. New medications need to be developed that will provide safer long-term outcomes for the reduction of gastrointestinal acidity and a product that combines the mechanism of products already on the market, such as I have suggested with this combination of carbonate and metal hydroxides, could provide an ideal treatment.

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