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A comparative study of the antacid effect of some commonly consumed foods for hyperacidity in an artificial stomach model

Vandana Panda*, Priyanka Shinde, Jyoti Deora, Pankaj Gupta

Department of Pharmacology & Toxicology, Prin. K. M. Kundnani College of Pharmacy, Jote Joy Building, Rambhau Salgaonkar Marg, Cuffe Parade, Colaba, Mumbai 400005, India

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ABSTRACT

Objectives: The incorporation of certain alkalinizing vegetables, fruits, milk and its products in the diet has been known to alleviate hyperacidity. These foods help to restore the natural gastric balance and function, curb acid reflux, aid digestion, reduce the burning sensation due to hyperacidity and soothe the inflamed mucosa of the stomach. The present study evaluates and compares the antacid effect of broccoli, kale, radish, cucumber, lemon juice, cold milk and curd in an artificial stomach model.

Design: The pH of the test samples and their neutralizing effect on artificial gastric acid was determined and compared with that of water, the active control sodium bicarbonate and a marketed antacid preparation ENO. A modified model of Vatier's artificial stomach was used to determine the duration of consistent neutralization of artificial gastric acid by the test samples. The neutralizing capacity of the test samples was determined *in vitro* using the classical titration method of Fordtran.

Results: All test samples except lemon showed significantly higher ($p < 0.05$ for cucumber and $p < 0.001$ for the rest) acid neutralizing effect than water. All test samples also exhibited a significantly ($p < 0.001$) higher duration of consistent neutralization and higher antacid capacity than water. Highest antacid activity was demonstrated by cold milk and broccoli which was comparable with ENO and sodium bicarbonate.

Conclusion: It may be concluded that the natural food ingredients used in this study exhibited significant antacid activity, justifying their use as essential dietary components to counter hyperacidity.

1. Introduction

Hyperacidity also called acid dyspepsia is a set of symptoms caused by an excessive formation of acid in the stomach. The symptoms include burning and pain in the chest and stomach, vomiting, loss of appetite, flatulence and heartburn. Sometimes, the problem aggravates and lead to other complications such as chronic indigestion, gastric ulcers, pain in muscular contraction, bloating and weight gain. Acidity is generally a consequence of several external factors like eating habits, anxiety and stress, smoking and alcohol consumption, lack of physical activity and irregularity in eating pattern. Prolonged usage of certain medications like nonsteroidal anti-inflammatory drugs also predisposes individuals to gastric acidity. Other predisposing factors for hyperacidity include bacterial infections, pregnancy, obesity, aging and fasting.[1] Hyperacidity problems can interfere with daily activities and reduce functionality, hence it should be treated timely.

The currently used drugs for treatment of hyperacidity include antacids (aluminum hydroxide and magnesium trisilicate) which neutralize gastric acid, acid blockers which reduce gastric acid secretion for a prolonged duration (ranitidine and famotidine), proton pump inhibitors (omeprazole and lansoprazole), tissue-lining protecting agents (sucralfate and misoprostol) and antibiotics for hyperacidity caused due to *Helicobacter pylori* infection.[2] These drugs are effective antacids but are associated with many adverse effects such as rebound acid secretion, diarrhea and constipation and are often expensive for the poor population. It is, thus, pertinent to use natural products from food/plant origin as potential antacid compounds which help to restore natural gastric balance and function.

The consumption of certain alkalinizing vegetables, fruits, milk and milk products has been known to alleviate hyperacidity.[3] Eating fresh fruits and vegetables which are rich in antioxidants supports the body to resist and heal diseases and infection. They are high in fiber and help in recovering from stomach ulcers and also prevent the occurrence of one. Therefore, natural foods have generated increasing interest for the treatment of acidity and ulcer disease.

Kale, broccoli and other cruciferous vegetables are alkaline vegetables that combat acidity. Kale (*Brassica oleracea var. sabellica*) is rich in sulfur, calcium, iron, and vitamin A, which help support the stomach

* Corresponding author at: Prin. K. M. Kundnani College of Pharmacy, Jote Joy Building, Rambhau Salgaonkar Marg, Cuffe Parade, Colaba, Mumbai, 400005, India.
E-mail address: dr.vandana.panda@gmail.com (V. Panda).

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and heal duodenal ulcers, thereby lowering the stomach's acid levels. The minerals found in kale can decrease the stomach's acid levels, which can help lower the amount of stomach acid available for escape. The glucosinolates and their derived isothyocyanates from kale are known to help in protecting the stomach lining from bacterial overgrowth of *Helicobacter pylori* and in preventing excessive clinging by this bacterium to the stomach wall.[4] Broccoli (*Brassica oleracea var. italica*) aids in digestion and reduces acid reflux.[5] Eaten steamed or raw, it is an alkaline and nutritious food.

Cucumber (*Cucumis sativus*) another popular vegetable against acidity has 96% water content. The high water content helps suppress acute symptoms of acid reflux by temporarily raising stomach pH and rinses out stomach acid that has refluxed into the esophagus.[6] It also helps in flushing out the toxins from the body.

Radish (*Raphus sativus*) is one of the many treatments commonly prescribed to reduce acidity and prevent heartburn.[7] Ayurvedic medicine considers that the benefits in treating acidity and heartburn come from the chlorine that radish contains to reduce the acidity in the blood and stomach. Radishes are high in fiber which helps speed up the transit of food through the digestive system and are also considered to have a soothing effect on the digestive system. One of the enzymes radishes contain is *diastase* which aids the digestion of starchy foods.

Obesity and weight gain can both contribute to the symptoms of acid reflux.[8] Lemon (*Citrus limon*) may aid in weight loss, which may help reduce the symptoms of acid reflux. If the acid reflux is caused by low stomach acid, drinking lemon water may be beneficial due to its potential alkalizing effects. It is known that diets rich in ascorbic acid, such as lemon juice, actually help protect the stomach from certain cancers and other damage. These findings were especially applicable to people with peptic ulcers. Although lemon juice is very acidic, small amounts mixed with water can have an alkalizing effect when it is digested. This can help neutralize the acid in stomach.

Milk and milk products have a high amount of calcium that helps it prevent acid build up and absorbs the excess acid produced, thereby reducing the symptoms of acidity.[9] The alkalinity of milk due to calcium also works to neutralize stomach acid. If the milk taken is cold, it also provides instant relief from the burning sensation felt during acid reflux. Another benefit of drinking milk is its high content of vitamins and minerals. However, consuming excess amounts of fat can stimulate acid production inside the stomach, so avoiding whole milk or consuming it in moderation is advisable.

Curd is a dairy product obtained by coagulation of milk. Apart from calcium, other nutrients present in curd are easily digestible. Additionally, curd also helps in absorbing nutrients from other foods consumed with it, promoting healthy digestion. It contains probiotics, useful bacteria that help digestion. A study reports that curd may cure infection caused by the bacteria *Helicobacter Pylori,* the most common cause of acidity due to stomach infection.[10]

Considering the above facts, the present study attempted to evaluate the antacid effect of kale, broccoli, cucumber, radish, lemon juice, cold milk and curd in an artificial stomach model. It also undertook to validate scientifically the traditional claims of these foods to alleviate hyperacidity.

2. Materials and methods

2.1. Chemicals and reagents

Pepsin (from porine gastric mucosa) and sodium chloride were purchased from Sigma Chemical Co., St Louis, MO, USA. Hydrochloric acid was obtained from Merck Ltd, Mumbai, India. Sodium bicarbonate (SB) was purchased from S.D. Fine Chemicals Ltd, Mumbai, India. All other chemicals were obtained from local sources and were of analytical grade. The marketed formulation 'ENO" of GlaxoSmithKline was purchased from the local pharmacy store.

2.2. Plant and food material

Fresh kale, broccoli, radish, cucumber and lemon were purchased from a farm on the outskirts of Mumbai, India. Cow's milk and fresh curd was purchased from a local dairy farm and used.

2.3. Instruments

Instruments used in the study consisted of a standard pH meter (Labindia), a magnetic stirrer with hot plate temperature controller (1MLH, REMI), an adjustable electrode stand and a peristaltic tubing pump (Electrolab PP201V).

2.4. Preparation of artificial gastric acid

Sodium chloride (2 g) and pepsin (3.2 mg, 3200–4500 U/mg protein) were dissolved in 500 mL distilled water. Hydrochloric acid (7 mL) and adequate water were added to make a 1000 mL solution. The pH of the solution was adjusted to 1.2

2.5. Preparation of test and standard solutions

Kale, broccoli, radish and cucumber (50 g, each) were washed, chopped and their juices were prepared separately in 100 mL of drinking water in a juicer. A lemon (50 g) was squeezed and the juice was added to 100 mL of drinking water. Cold milk (50 g) and curd (50 g) were blended separately with 100 mL of drinking water and used. SB was dissolved in distilled water to make a 5% w/v solution and used as the active control. The standard solution of ENO was prepared by adding a sachet containing 5 g of the dispersible granules to 250 mL of water. Aliquots of this solution were used immediately.

2.6. Determination of pH

The pH of the juices of kale, broccoli, radish, cucumber and lemon, diluted cold milk, curd blend, SB, ENO and water was determined at temperatures ranging from 25 to 37 °C.

2.7. Determination of the neutralizing effect on artificial gastric acid

Test solutions (90 mL) of kale, broccoli, radish, cucumber, lemon, cold milk, curd, SB, ENO and water (90 mL) were added separately to 100 mL of artificial gastric juice. The pH of each solution was determined to examine the neutralizing effect on artificial gastric juice. Six experiments were performed for each solution.

2.8. Determination of the neutralization capacity in vitro against artificial gastric juice using the titration method of Fordtran's model[11]

Test solution (90 mL) of kale, broccoli, radish, cucumber, lemon, milk, curd, SB, ENO and water was warmed to 37 °C and stirred continuously at 30 rpm to imitate the stomach movement. The test solution was titrated with artificial gastric juice to the end point of pH 3. The consumed volume (V) of the artificial gastric juice was measured for each test solution. The H^+ consumed by each test solution was calculated using the formula H^+ consumed (mmol) = 0.063096 × V (mL). Six experiments were performed for each test solution.

2.9. Determination of the duration of consistent neutralization on artificial gastric acid in the modified model of Vatier's artificial stomach[12]

Apparatus of the modified model of Vatier's artificial stomach (Fig. 1) was made up of three elements: a pH-recording system (R), stomach (S) and a peristaltic pump (P). The stomach was made up of three portions: S_1, S_2 and S_3. Each test solution (90 mL) was added to 100 mL of artificial gastric juice in S_1 (reservoir to mix test solutions