Effect of Methanolic Extract of Ginger on Gastric pH and Serum Bicarbonate of Wistar Rats

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ABSTRACT
Ginger plant has a perennial, tuberous root or rhizome. The rhizome which is the horizontal stem from which the roots grow, is the main portion of ginger that is consumed as a spice in dried, preserved and green forms. The aim of this study was to determine the effect of methanolic extract of ginger on gastric pH and post-prandial serum bicarbonate in wistar rats. A total of 20 male rats weighing 180 to 250g were divided into four groups of 5 rats each; Group I served as control, Group II received 100mg/kg methanolic ginger extract, Group III received omeprazole (20mg/kg) and Group IV received a combination of omeprazole and methanolic ginger extract. After 45 minutes of administration of the extract, the pH of the gastric effluent increased significantly whereas the post-prandial serum bicarbonate concentration decreased significantly compared to control ($p<0.05$). Although Omeprazole caused marked reduction in gastric pH, co-administering with methanolic ginger extract prevented excessive reduction in gastric pH that occurred with the drug alone. In the determination of serum post-prandial bicarbonate level, the methanolic ginger extract group showed levels significantly lower than the control group while the Omeprazole and co-administration groups were significantly lower in comparison with extract group. Hence, the study concluded that methanolic ginger extract alone neutralized gastric acid secreted while in combination with Omeprazole, it acted as a buffer to stabilize the gastric pH.

Key words: *Ginger, Methanolic extract, Omeprazole*

BACKGROUND TO THE STUDY

Ginger (*Z. officinale Roscoe*), a member of *Zingiberaceae* family, is grown in tropical and subtropical regions for spice and medicinal purposes, since decades. With 53 genera and over 1200 species, the *Zingiberaceae* is the largest of the eight families of the order (Kress. 1990). It is a member of a plant family that includes highly valued premium spices like cardamom and turmeric. The plant has long history of cultivation in the Asian subcontinent, probably originating from South East Asia (Ravindran and Nirmal, 2005) and cultivated on a large scale in India, China. Bangladesh, Taiwan, Jamaica and Nigeria, from where it is exported to other countries of the world (Dedovet al., 2002). The plant is cultivated throughout the humid tropics where it was especially valued for its medicinal properties. Ginger continues to be a highly sought after commodity in Europe even after the fall of the Roman Empire, with Arab merchants controlling the trade in ginger and other spices for centuries.

Morphologically, ginger plant has a perennial, tuberous root, or rhizome having erect annual stem invested by smooth sheaths of leaves 2-3 feet in height. The rhizome, which is the horizontal stem from which the roots grow, is the main portion of ginger that is consumed as a spice in dried, preserved and green forms (Pandotra et al., 2013) and the rhizome is also known to have anti-diabetic, anti-hyperlipidemic and hepatic anti-cancer effects (Hamed et al., 2012; Bordia et al., 1997: Akimoto et al., 2015).

The nutritional composition of a powdered sample of ginger include carbohydrates, protein, fat, dietary fiber, iron, calcium, vitamin C and carotene (Kumari and Gupta. 2016) while its phytochemical profile reveals the presence of total polyphenols, flavonoids and anthocyanidins (Trinidad et al., 2012). Ginger contents of organic acids and their varieties are of great importance for its application in novel functional foods and there are five types of organic acids found in ginger rhizomes which include citric, malic, oxalic, succinic and tartaric acids (Yer et al., 2014).

Chemical analysis of the phytochemical composition of ginger shows that it contains terpenes including zingiberene, beta-bisabolene, alpha-farnesene, beta-sesquiphellandrene and alpha-curcumene and also phenolic compounds such as gingerol, paradols and shogaol (Grzanna et al., 2005). The bioactive compounds 6-gingerol, 6-shogaol, 8-gingerol and 10-gingerol have also been characterized in the dietary supplements of ginger as major components (Schwertner and Rios. 2007) and while Zingiberene and bisabolene contribute to its aroma, the volatile oils gingerols and shogaols, contribute to both its characteristic odor and pungent taste (Harold. 2004).

Ginger uses in food processing

Ginger also have important uses in food processing. The refreshing pleasant aroma, biting taste and carminative property of ginger makes it an indispensable food ingredient throughout the world. Fresh ginger is unique for its flowery flavor and spicy taste. Hygienic oleoresin and oil in convenient consumer-friendly packing and dispenser systems find a place in the culinary art of developed countries and the upper society strata of developing countries.

Ginger preserve and candy are also in great demand for use in confectionery while chocolate manufacturers utilize the preserve for enrobing. It is also used in jams and marmalades. The syrup in which ginger is preserved is valued for pickle and sauce making. It is also used in the

production of gingerbread, biscuits, cakes, puddings, soups and pickles in western countries (Pruth, 1993). It is used too in the production of alcoholic beverages such as ginger beer, ginger ale, and ginger wine. Earlier, it was much favored for spicing wines and possets (Purseglove et al., 1981). In the east, fresh ginger chopped into small bits and in the ground form is very much used in vegetarian and non-vegetarian food preparation while it is also used in pickling, soft drink making, and confectionery and curry powder preparations.

Chinese cookery owes very much to the use of fresh ginger as ground paste. In India meat and fish dishes, it is indispensable in making these meals palatable and digestible. Buttermilk containing crushed fresh ginger, green chilies, salt and curry leaf serves as a delicious drink and appetizer of South India while Puliyingi, a curry meal prepared from finely chopped fresh ginger and ripe tamarind fruit extract, has a unique taste and is indispensable in social and festival feasts of the Malabar Coast.

Medicinal Uses

Ginger is an important plant with several medicinal, ethno medicinal, and nutritional attributes. Traditionally, in Indian, Chinese, and Tibetan system of medicines, ginger has being in use from ancient times for the treatment of catarrh, rheumatism, nervous diseases, gingivitis, toothache, asthma, stroke, constipation, diabetes, cough and cold, motion sickness, menstrual cramps, cancer, and many more (Shukla and Singh, 2007).

Ginger is so much used in traditional Indian (Ayurveda) and Chinese medicine (Sivarajan, Balachandran, 1994). In India, ginger has been used as medicine from the Vedic period and called 'maha aushadhi', which means the great medicine. In Ayurveda, ginger is recommended for use as a carminative, diaphoretic, antispasmodic, expectorant, peripheral circulatory stimulant, astringent, appetite stimulant, anti-inflammatory agent, diuretic and digestive aid (Warrier, 1989). It is also used by the Chinese to treat a variety of medical ailments such as stomach ache, cholera, nausea, heart diseases, toothache, respiratory disorders such as asthma and rheumatic diseases (Wagner and Hikino, 1965) while in the United states of America and Europe, its preparations are sold as nutraceuticals and also as over-the-counter medications for motion sickness, nausea and migraine (Plotto, 2011).

Regulation of Gastric Acid Secretion

The vital roles performed by the stomach such as storage, mixing and digestion of food substances are dependent on the rate of secretion of gastric juice, the integrity of the gastric mucosa as well as the presence of trefoil peptides (Wong et al., 1999). The mechanism of secretion of gastric acid in human stomach was not so well until the early 19th century when Prout showed that the hydrochloric acid is present in the gastric juice (Prout, 1824; Ghosh et al., 2011). The gastric juice is a thin watery acid digestive fluid composed mainly of 99% water, hydrochloric acid (HCI), pepsin, intrinsic factor, electrolytes (NaCl, KCI, Mg^2, SO_4^2, HPO_4^2) and mucus (Sembulingam & Sembulingam, 2012; Akwaras, Ibu, Onahinon & Eru, 2018).

The oxyntic gland parietal cells in the mucous membrane of the stomach is responsible for the secretion of HCI (Whitman & O'Neil. 2018) which has been found to be of great importance in digestive activities such as the activation of pepsin from pepsinogen, required for protein

digestion to take places; protection of the GIT from potentially infectious microorganisms that may have been ingested with food as well as preventing bacterial overgrowth in the stomach and small intestine duodenum; Hcl also causes solubilization of food as well as necessary for absorption iron and vitamin B12 (Mercer. Robinson & Stomach. 2008; Pohl et al., 2008: Canani & 2010: Ghosh et al., 2011: Holzer, 2011).

Studies have shown that ginger induces increased pancreatic and intestinal lipase secretions when given in animal diets (Patel and Srinivasan, 2000). Some active components of ginger have been reported to increase the muscular activity of the digestive tract, thus stimulating digestion and absorption while relieving constipation and flatulence (Wu et al., 1990, 2008). Ginger is also traditionally used in alleviating symptoms of nausea and vomiting and several controlled studies have reported that ginger is generally effective as an antiemetic (Quimby, 2007).

Ginger has also been found to stimulate bile secretion, intestinal lipase, trypsin, chymotrypsin, amylase, sucrose and maltase activities in rats with 6- and 10-gingerols being chiefly responsible for this activity. (Patel and Srinivasan, 2000). These findings support the traditional use of ginger as a digestive stimulant hence this study was undertaken to throw more light on the potential role methanolic extract of ginger has on the secretion of gastric acid which implies the determination of the volume and concentration in a given time (the secretory rate) or in response to a given stimulus (the secretory output) as a way of developing a natural therapy for the treatment and possibly prevent the occurrence of gastric ulcer, resulting from excess gastric acid secretion. It will also take into consideration, the bicarbonate level of the gastric contents in view of tackling the stated abnormality.

STATEMENT OF PROBLEM

The highly acidic and proteolytic properties of the gastric juice gives it the ability to exert serious luminal challenge on the wall of the stomach, a condition known as ulcer (Hunt et al., 2015). The etiology of gastro-duodenal ulcers is influenced by several destructive and protective factors which includes: mucosal barrier, cellular regeneration, parietal cell mass, mucus secretion, secretion of acid-pepsin, blood flow and several endogenous protective agents like nitric oxide, prostaglandins and epidemics growth factors, though it can also be caused by non-steroidal anti-inflammatory drugs (NSAIDs) e.g. aspirin and bacterial infection due to infestation of Helicobacter pylori (Repetto and Llesuy, 2002). Hence, gastric ulcer treatment is often directed towards either reducing the aggressive factors, or strengthening of the defense system of the gastric gland mucosa (Jain et al., 2007) via the application of simple conventional antacids, to the use of more complex and effective anti-secretory drugs; such as proton pump inhibitors (PPIs) and type-2 histamine receptor antagonists (H2-Ras) (Sheen & Triadafilopoulos, 2011) and also antibiotics used to treat the H. pylori infections (Malfertheiner, 2015).

However, these synthetic therapeutic agents usually come with several adverse side effects such as: increased susceptibility to pneumonia, deficiencies of iron and vitamin B12, hypersensitivity, gynecomastia, arrhythmia, impotence, bone fractures, hematopoietic changes, hypergastrinemia and gastric cancer (Fathihahetal.,2005), all of which has become a major concern. For instance prolonged use of irreversible proton pump inhibitors brings about acid suppression thus upsetting the normal linings of the gastric mucosa, leading to achlorohydria (an absent or reduced gastric

output state) and predisposes the gastric mucosa to enteric infections like gastroenteritis, Clostridium difficile, typhoid, cholera and dysentery (Laheij et al., 2004; Dial et al., Jain et al., 2007) the above cascade of adverse effects which individuals have to go through in the cause of treatment of their condition, which may serve as contributory factor to why they will likely not follow through with their treatment regimen. The discovery of a natural plant that would effectively work without these adverse side effects or which can help in managing this phenomenon thereby became essential and necessary.

AIM AND OBJECTIVES OF THE STUDY

Aim

The aim of the study is to evaluate the effect of administration of methanolic extract of ginger on gastric pH and post-prandial serum bicarbonate in male wistar rats.

Objectives of the Study

1. To determine the effects of methanolic extract of ginger on gastric pH.
2. To determine the effect of administration of methanolic extract of ginger on post-prandial serum bicarbonate concentration
3. To evaluate the effect of co-administration of methanolic extract of ginger and omeprazole on gastric $_{P}$H and post-prandial serum bicarbonate concentration.

SIGNIFICANCE OF THE STUDY

There is a lot to the therapeutic potential of this nutraceutical substance ginger, which has been in use since antiquity in traditional human medicine in a great number of societies. These potentials are yet to be fully discovered hence the gross underutilization of this plant. Peptic ulcers constitute one of the major diseases of the GIT which results in pain and suffering of millions of people in the world today. Hence, on obtaining result which shows significance in reduction of gastric acid secretion by ginger, this study will stand to be beneficial as follows;
1. The present study would be useful to the dietician in preparing food menu for patients with peptic ulcer disease.

2. It will serve as a template for pharmaceutical industries for the production of an effective ulcer medication devoid of severe adverse effects.

3. It will add to the existing body of knowledge on gastric acid secretion and acid-base balance.

4. It will also serve as a reference for future studies in this area.

MATERIALS AND METHOD

ANIMAL ETHICS

All Procedures involving the use of animals in this study strictly followed the guiding principles for research involving animals, as recommended by the declaration of research ethics committee of the University of Port Harcourt, Rivers State. The guiding principles in the care and use of animals of the university was in conformity with International acceptable standards.

ANIMAL PROCUREMENT AND MANAGEMENT

Twenty (20) adult Wistar rats weighing 180-250g were purchased from the animal house of the department of Human Physiology, Faculty of Basic Medical Sciences. College of Health Sciences, University of Port Harcourt, Nigeria. The Wistar rats were kept and housed in clean cages lined with saw dust to acclimatize for two weeks with condition of the animal housing facility, with ambient environmental temperature of 26-28 C, and humidity of 60-70% and natural light dark cycle of twelve hours with free access to feed (Standard finisher diet Top feed, Nigeria) and normal tap water *ad libitum*.

PLANT COLLECTION AND PREPARATION OF EXTRACT

Fresh rhizomes of ginger were obtained from a fruit retail trader at Choba Market in Port-Harcourt. Rivers State Nigeria. The ginger rhizomes were thoroughly washed with clean water to remove dirt and unwanted particles, sliced into small pieces and air-dried for about 8 days on a clean white bag with constant turning over to avoid fungal growth. After the rhizomes was dried enough, it was blend into a powder form.

The methanolic extraction was prepared according to the method described by Sofowara (1984). About 25g of the powder form was macerated in 1000ml of methanol for 24 hours using mechanical agitation at temperature. The suspension was filtered using Whatman filter paper and dried in a water bath by using evaporating disk at 55^{o}C. The crude extract gotten was stored at 40'C in a refrigerator for subsequent usage.

EXTRACT DILUTION

The extract was then diluted with distilled water to obtain a dosage of 100mg/kg used for the study and the pH of the ginger extract also determined with the aid of a precise pH meter (Model 2211. Ilanna: Italy).

EXPERIMENTAL DESIGN

This experiment was aimed at investigating the possible effect of administration of methanolic extract of ginger on gastric pH and post-prandial serum bicarbonate in male wistar rats

The twenty (20) rats used for the study were divided into four (4) groups of five (5) animals each as:

Group I which served as the negative control and received distilled water

Group II received 100mg/kg methanolic extract of ginger

Group III which served as the Standard Group and received intra-muscular 20mg /kg body weight Omeprazole (Strides Shasun Ltd., Mumbai: India) (Sabiu et al., 2016) and

Group IV received a combination of 20mg/kg body weight Omeprazole before the administration of 100mg/kg methanolic extract of ginger.

DETERMINATION OF GASTRIC ACID SECRETION

The Gastric acid output analysis of the animal stomach was done after a 24 hour fast which was meant to ensure that the stomach content are emptied before commencement of the procedure.

The animals prior to the commencement of the procedure were anesthetized by intra-peritoneal injection of 25% Urethane (ethyl carbamate) at a dose 6 mg/kg BW.
The anesthetized rat was then pinned on the dissecting table before making an incision around the neck region to expose the trachea from where the tracheal cannula is inserted to ensure normal breathing throughout the duration of the procedure. An abdominal incision was then made through the linea alba to expose the stomach from where a semi-transection was made at the junction of the pylorus with the duodenum and a pyloric cannula inserted and tied properly to ensure collection of the gastric content into the beaker, thereby bypassing the duodenum. The animal was covered with clothing material to keep it relatively warm throughout the procedure to prevent hypothermia (Ajeigne et al., 2012).

An oro-esophageal tube was then inserted into the mouth for perfusion of pre-warmed distilled water to flush out the food debris in the stomach. This was done 10 minutes after the dissection to enable the animal stabilize. This procedure for lumen perfusion preparation and gastric acid secretion determination was based on that of Ghosh and Schild (1958) as modified by Lai (1964) and Amure and Ginsburg (1964).

After 15 minutes, the gastric content was washed out with 10 ml perfusion of the pre-warmed normal saline, and the fluid was collected via the pyloric cannula after passing through the stomach. The procedure was repeated at intervals of 15mins (i.e. 15. 30 and 45 minutes) for each rat. The pH of the gastric effluents was determined using a pH meter (Model 2211. Hanna: Italy).

DETERMINATION OF POST PRANDIAL BICARBONATE SECRETION
After collecting the last gastric effluents at 45mins, blood sample was collected from each rat into a lithium heparin bottle for analysis of the serum post-prandial bicarbonate concentration. This was done using the back titration method.

Procedure:

. 200ul of the blood sample were added to the test-tube

. 200ul of distilled water was added to it

. 1 ml of 0.01N HCI were added

. 2 drops of phenol red indicator was also added

. Then, the test-tube together with its content was shaken

. The test-tube was titrated with a 0.01N NaoH until the first colour change

. The value of the titer was recorded

Calculation:

Bicarbonate concentration = $\frac{1-titre}{2} \times 100$

STATISTICAL ANALYSIS OF RESULTS

The statistical analysis was done using Statistical Package for Social Science (SPSS) version 23. Data were represented in tables and chart. Continuous variables were represented as mean and standard error of mean (i.e. mean + SEM). Comparison of means was done using ANOVA test and differences considered significant at $P < 0.05$.

RESULTS

PRESENTATION OF DATA

The data obtained from the study were presented as follows;

1. pH OF GASTRIC EFFLUENT

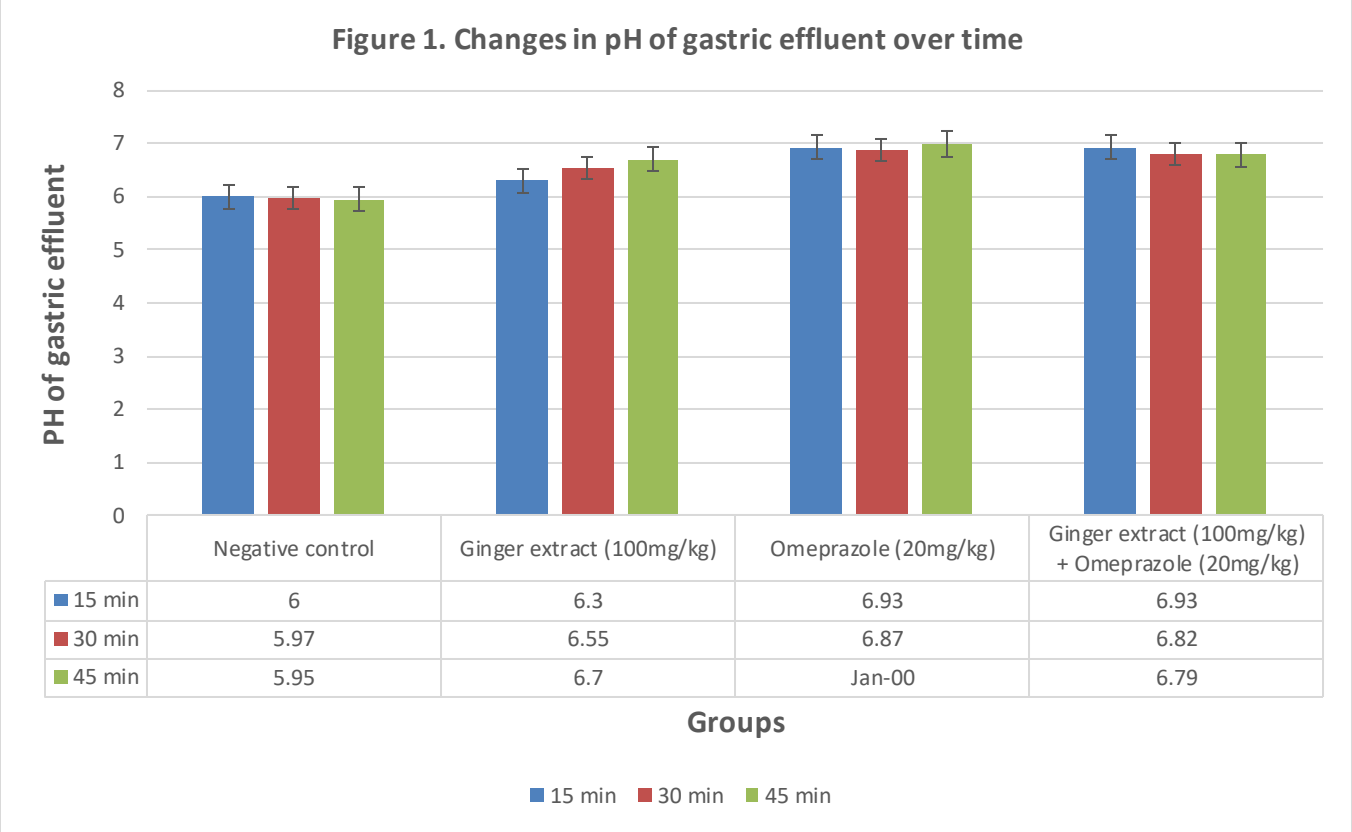
Table 1: pH of gastric effluent result

TIME INTERVAL (min)	Negative Control group	Ginger Extract 100mg/kg	Omeprazole 20mg/kg BW (Standard)	Omeprazole 20mg/kg BW + Ginger 100mg/kg
15	6.00 ± 0.02	6.30 ± 0.17 [c]	6.93 ± 0.09	6.93 ± 0.09[a]
30	5.97 ± 0.01	6.55 ± 0.02 [a c]	6.87 ± 0.00	6.82 ± 0.08[a]
45	5.95 ± 0.00	6.70 ± 0.09 [a c]	6.99 ± 0.01	6.79 ± 0.07[a]

n 5: All results present in mean + SEM ($p<0.05$),

a is significantly different from group 1

c is significantly different from group 3



2. POST-PRANDIAL SERUM BICARBONATE CONCENTRATIONS

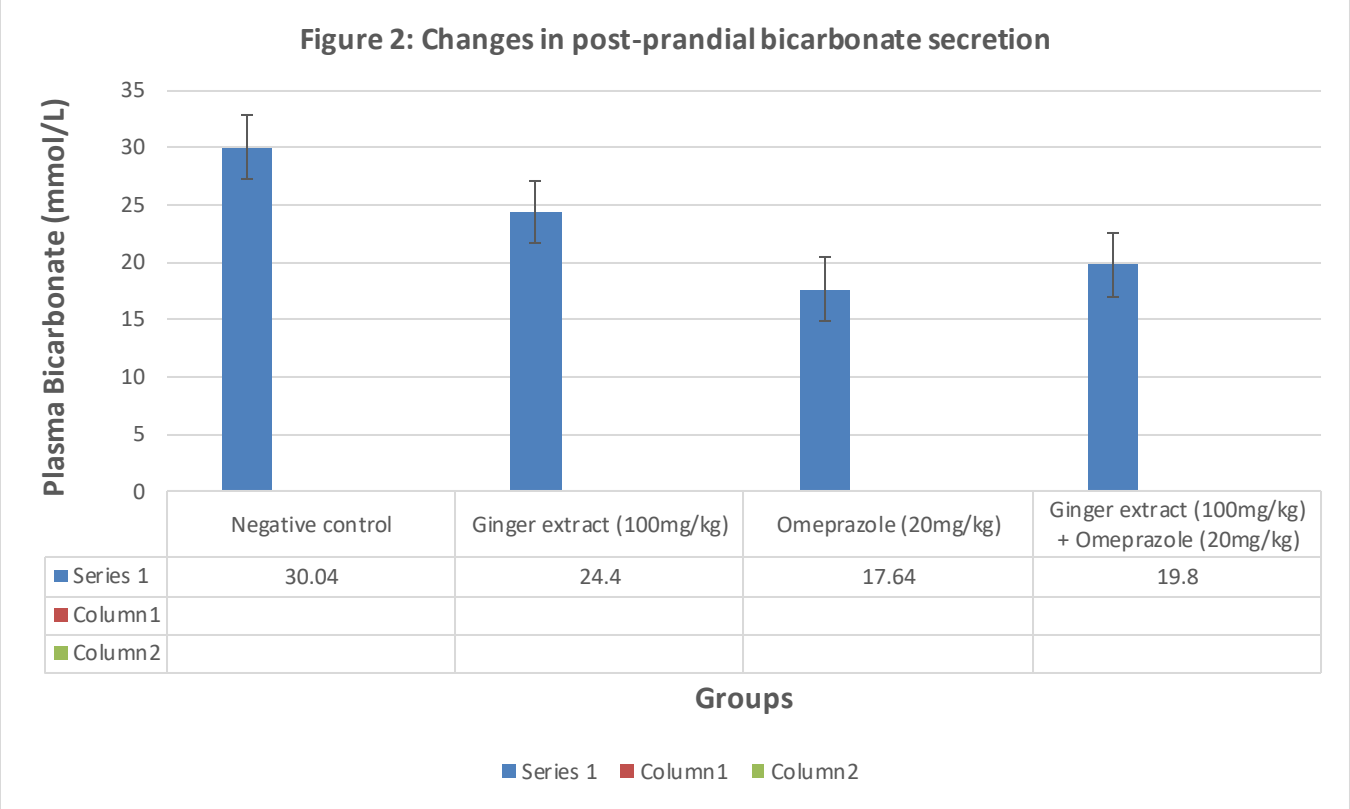
Table 2: Post-prandial serum bicarbonate concentration

Groups	Bicarbonate concentration (mMol/L)	Relative change (%)
Negative Control	30.04 ± 0.09	0
100mg/kg Ginger	24.40 ± 0.68 [a,c]	- 21
Omeprazole (20mg/kg)	17.64 ± 0.13	- 52
Ginger extract (100mg/kg) + Omeprazole (20mg/kg)	19.80 ± 1.32[a,c]	- 41

n 5: All results present in mean + SEM ($p<0.05$).

a significantly reduced compared to group 1

c is significant reduced compared to group 3



DISCUSSION

As earlier stated by Wong et al. (1999), the physiologic characteristics of the stomach relies mainly in the rate of secretion of gastric acid and other parameters such as; the thickness of the gastric mucosa and the presence of gastric trefoil peptides. This is in line with a more recent finding by Holzer (2015) which stated that increased concentration of HCI within the gastric lumen endangers the integrity of the gastric mucosa in the stomach and adjacent regions of the gastrointestinal tract. However, though the occurrence of this deleterious effect by HCI on the mucosa is kept at bay by the network of mucosal defense mechanisms (Holzer, 2007), it may be overwhelmed by constant secretion of gastric acid. This calls for the need for a therapeutic agent which will keep gastric acid secretion in check while ensuring that it is available at the right proportion to carry out its functional activities in the lumen of the gastric gland.

In this study, it was shown that intra-gastric administration of 100mg/kg methanolic ginger extract markedly increased the pH of the gastric effluent gradually reaching a maximum of 6.70 after 45mins. Results obtained from several other studies such as that of Omayone et al. (2016) have been able to demonstrate that increase in acidity (decrease in pH) of the stomach is brought about by stimulation of histamine. Also, Ganong (2005) stated that H^+ secretion from the parietal cells is an oxidant process which dissociates from H_20 before being pumped into the gastric lumen in exchange with K^+ as an active transport process where it binds with Cl^- to form HCl in the gastric lumen. Hence, to prevent gastric ulceration, the gastric mucosal protective agents must be reinforced to prevent it from being overcome by the causative agent (Potrich et al., 2010;

Mohamed et al., 2018). It could therefore be inferred from the result obtained, that ginger extract was able to act directly by blocking the stimulation of this receptor thereby preventing or reducing the secretion of gastric acid within the stomach lumen or acts indirectly as an antacid to neutralize any acid secreted by its administration or both ways. Al-Yahya et al., (1989) studied the cytoprotective and gastric antiulcer effect of ginger in albino rats and the results demonstrated that the extract in the dose 500mg/kg orally exerted highly significant cryoprotection and prevented occurrence of gastric ulcers induced by non-steroidal anti-inflammatory drugs. Also, when 100mg/kg ginger was used alone, the initial pH of gastric effluent (at 15mins) was slightly higher than that of the control but increased till the 45mins mark, meaning that ginger may have a slow onset of action in gastric acid secretion.

Omeprazole, which is a standard drug (proton pump inhibitor) used commonly for gastric acid inhibition on other hand, greatly decreased the gastric acid secretion when compared to results from both the negative control group and the 100mg/kg ginger group (Table 1). The results showed that omeprazole caused an initial sharp rise in the gastric pH within 15 minutes and continued to rise at 45 minutes (Table 1). This result was seen to be significantly higher ($P<0.05$) in comparison with those of the negative control and the 100mg/kg ginger at all-time interval (Table 1). This result is backed by the earlier findings stated in the study conducted by Andersen, Andrade and Wang (2003) on the effects of Omeprazole on inhibition of gastric acid secretion during digestion in the toad *Bufo marinu* which also showed that the administration of Omeprazole during digestion in toads successfully inhibited gastric acid secretion.

Co-administering omeprazole and 100mg/kg Ginger also showed an increase in gastric pH at 15mins till 45mins when compared to the control, an outcome which is similar to that caused by administration of omeprazole only (Table 1). However, this trend was gradually reversed from the 30mins mark as the pH of the gastric effluent was seen to be on the rise till 45mins, a trend which is suggestive of an anti-secretory effect on gastric acid (Table 1). Omeprazole according to Bhave, Bhatt and Hemavathi (2006) irreversibly inhibits gastric acid (proton) pump which is the final common pathway for acid secretion in response to all varieties of stimuli. However, the result obtained from co-administration of 100mg/kg Ginger and Omeprazole goes a long way to show that ginger could have a synergistic effect when combined with Omeprazole to bring about a rise in the gastric pH and as well, helps stabilize the effects of Omeprazole on gastric acid pump inhibition upon prolonged administration to bring about a pH level that is favorable for gastric functions. Though Omeprazole has a half-life of about 2-3 hours, this result also indicates that ginger may be able to affect the drug proton pump bond in record time, thereby averting the occurrence of achlorohydria and its possible consequences which causes the gastric mucosa to be predisposed to enteric infections like gastroenteritis, pneumonia, Clostridium difficile, typhoid, cholera, and dysentery, especially in individuals with chronic ulcers.

Effect on Post-prandial Serum Bicarbonate Concentration

The serum post-prandial bicarbonate concentration was analyzed to get clarification on the particular mechanism of action employed by 100mg/kg ginger in increasing the gastric pH as seen in the result obtained. This is because measurement of the post-prandial bicarbonate concentration gives one another route (indirect method) of determining gastric acid secretion since proton pump actively transports one molecule of bicarbonate into the plasma for every

molecule of Hydrogen ion pumped into the gastric effluent. Hence, Flemstron and Garner (1982) stated that the level of plasma bicarbonate is directly proportional to the level of gastric acidity after a meal. The results from the analysis based on the relative percentage change of the various groups to that of the negative control as seen in Table 2, showed that administration of 100mg/kg Ginger caused a 21% reduction in the 45 minutes post-prandial serum bicarbonate concentration. That of omeprazole alone was 52% while combination of omeprazole and ginger showed only 41% reduction in the 45 minutes post-prandial serum bicarbonate concentration, relative to the negative control. A suitable explanation for the above observed phenomenon comes from the assertion made by Flemstrom and Garner (1982) that bicarbonate secretion requires the presence of acid or lowered pH in the lumen to be secreted, hence, 100mg/kg Ginger could have only neutralized the already secreted acid due to the high serum post-prandial bicarbonate concentration, while omeprazole eliminated the secretion of acid in the gastric lumen by blocking the proton pump, thereby leading to a decrease in the bicarbonate secretion.

Also from the work of Andersen, Andrade and Wang (2003) which illustrated the effect of inhibition gastric acid secretion on arterial acid-base status during digestion in the toad *Bufo marinus*, it was observed that digestion affects acid base status because of the net transfer of HCI from the blood to the stomach lumen which leads to an increase in serum $HCO3^-$ levels in both extra-and intracellular compartments, hence the ability of Omeprazole to inhibit gastric acid secretion, which in turn inhibits secretion of serum bicarbonate. This shows that administration of omeprazole alone can cause severe reduction in plasma bicarbonate leading to metabolic acidosis and its consequences but its co-administration with 100mg/kg Ginger showed a marked increase in the level of post-prandial serum bicarbonate concentration when compared to that observed in administration of omeprazole alone (Figure 2). Hence 100mg/kg Ginger acts as a buffer in omeprazole stimulated gastric acid inhibition that helps avert the problems associated with low levels of serum bicarbonate concentration such as; fatigue, confusion, tachypnea and so on.

CONCLUSION

Secretion of gastric acid by the parietal cells of the stomach is very important for some physiological functions, especially in the area of digestion of proteins as well as destruction of various unwanted micro-organisms (Martinsen et al., 2005). However, its increased secretion and acidity of the gastric gland can lead to excoriation of the gastric wall and the digestion of the gastric muscles by pepsin, resulting in formation of gastric ulcers (Goel & Bhattacharga, 1991) while the continuous inhibition of its secretion will result in successful breeding of bacteria in the stomach and possible indigestion of proteins as a result of inactivation of pepsin and other adverse effects. Hence, this study probed into the effects of methanolic ginger extract in eliciting or inhibiting gastric acid secretion as well as its effects on co-administration with omeprazole (a known proton pump inhibitor). The result showed that upon administration, methanolic ginger extract controlled both acid output in the gastric lumen and the postprandial serum bicarbonate concentration, thereby suggesting a possible moderating effect of ginger on the activity of the proton pump. Though ginger may have a slow onset of action in reducing gastric acid secretion the study showed that it acted as an antacid in neutralizing the already secreted acid due to the high serum post prandial bicarbonate concentration. Also, upon co-administration with

omeprazole, Ginger acted more as a buffer to help stabilize the effects of omeprazole on gastric acid pump inhibition.

RECOMMENDATION

From the result of this study, we recommend that patients who are on prolonged omeprazole administration should be encouraged to also take ginger as this will help eliminate the possible side effects from the prolonged administration of the proton pump inhibitors.

CONTRIBUTION TO KNOWLEDGE

This study has been able to bring to the limelight that ginger alone acts as an antacid by neutralizing gastric acid secreted while when co-administered with omeprazole, it acts as a buffer to stabilize the gastric pH.

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