

1    **Original Research Article**

2    Anti-ulcerogenic, antioxidant and mucogenic effects of L-cysteine in  
3    gastric tissue of wistar rats

4

5

6    **ABSTRACT**

7    **Aim:** to evaluate the effect of L-cysteine pretreatment on indomethacin induced ulceration in  
8    male wistar rats.

9    **Study design:** experimental animal study

10    **Place and Duration of study:** Department of Physiology (inflammation and Gastrointestinal  
11    secretion unit), College of Medicine, University of Ibadan, Nigeria, between January and July  
12    2017.

13    **Methodology:** Fifty male wistar rats were used for this study and were randomly divided into  
14    two study groups of thirty five (25) animals each. The first sub-group was used for the anti-  
15    ulcer studies; antioxidant enzymes (SOD and MDA), Nitric oxide (NO), mean ulcer score  
16    and gastric blood flow (GBF), while the second sub-group was used for the gastric mucus  
17    secretion study. Each sub group was divided into five groups with five animals per group as  
18    follows: ulcer control, L-cysteine (100 mg/kg, 300 mg/kg and 500 mg/kg), cimetidine (50  
19    mg/kg). Results were analyzed using ANOVA and reported as Mean  $\pm$  SEM. Values were  
20    considered significant at  $P \leq 0.05$ .

21    **Results:** The results of this study showed that L-cysteine (100mg, 300mg, and 500mg  
22    respectively) pretreatment significantly reduced mean ulcer score ( $9.5 \pm 1.9$ ;  $7.5 \pm 1.5$ ;  $4.5 \pm 0.9$ )  
23    and MDA level ( $7.2 \pm 0.23$ ;  $7.49 \pm 0.3$ ;  $6.54 \pm 0.55$ ), and increased SOD activity ( $10.69 \pm 0.1$ ;

10.12±0.29; 14.76±0.07) when compared with the mean ulcer score, MDA and SOD in the ulcer control group (39.5±7.9; 10.62±1.11; 5.02±0.74). Also, NO level (10.8±0.44; 10.37±0.18; 8.41±0.06), gastric mucus secretion (0.92±0.008; 0.94±0.001; 0.99±0.001) and GBF (2.08±0.02; 2.11±0.06; 2.11±0.01) were significantly ( $p<0.05$ ) higher in the L-cysteine pre-treated animals when compared with NO, mucus secretion and GBF in the ulcer control (7.86±0.09; 0.82±0.01).

**Conclusion:** This study shows that L-cysteine pre-treatment has anti-ulcer potential which might be mediated through increased antioxidant enzymes, increased mucus secretion and enhancing gastric blood flow. This will be of immense advantage in the treatment of peptic ulcer.

**Keywords:** L-cysteine, cimetidine, antioxidants, mucus secretion, anti-ulcer.

## 1. INTRODUCTION

Peptic ulcer, a common gastrointestinal disorder, is a multifactorial and complex disease that involves imbalance between gastric offensive factors (e.g. lipid peroxidation) and defensive mucosal factors e.g. antioxidant enzymes [1, 2]. However, diverse factors such as non-steroidal anti-inflammatory drugs (NSAIDs), stressful lifestyle, alcohol consumption, *Helicobacter pylori* (*H. pylori*) infection, smoking, and family history can contribute to its pathogenesis [3, 4]. The NSAIDs such as indomethacin are commonly prescribed drugs for the treatment of pain and inflammation in rheumatic disorders and osteoarthritis [5], but are associated with peptic ulcer as their major complications. The mechanisms underlying the pathogenesis of NSAIDs-induced ulcers are complex and multifactorial. It involves both prostaglandin-dependent (through Cyclooxygenase inhibition) and prostaglandin-independent mechanisms. The independent mechanisms include inflammatory, immunogenic, genetic, and stress response pathways [6].

48 In an attempt to protect the gastric mucosa from ulceration, enhance ulcer healing and  
49 prevent ulcer recurrence, pharmacological control of gastric acid secretion has long  
50 represented a desirable goal. Thus, there is an increasing need to develop more potent  
51 therapeutic agents for the treatment of peptic ulcer and several experimental studies have  
52 shown the effectiveness of some nutrients and food supplements in the management of peptic  
53 ulcer.

54 L-cysteine is an essential amino acid that is ingested from diet to meet up the body's  
55 requirement and is majorly found in most dairy foods (e.g. milk, egg, meat and spices). L-  
56 cysteine contains sulfhydryl group and serve as a precursor of hydrogen sulphide [7].  
57 Hydrogen sulphide is a potent mediator of vascular smooth muscle relaxation, exhibit anti-  
58 inflammatory activities and contribute to gastric mucosal defense [8, 9]. It has also been  
59 shown to reduce the severity of NSAIDs and also protective in a number of models of acute  
60 gastric injury, but the mechanism underlying this action is unclear [10]. Therefore, the  
61 present study aimed at evaluating the mechanisms of action of this amino acid in the  
62 prevention of peptic ulcer.

## 63 **2.0 MATERIALS AND METHODS**

### 64 **2.1 DRUGS AND CHEMICALS USED**

65 Cimetidine, Ulcertret-20 (Swiss pharma pvt.Ltd. 3709, GIDC, Phase IV, Vatva, Ahmedabad-  
66 382 445, Gujarat, India. Indomethacin, Omecet (Medibios Laboratories PVT Limited. J-76,  
67 M.I.D.C, Tarapur, Taluka-Palghar Dist, Thane-401 506, India), L-cysteine, (Solgar, Inc. 600  
68 Willow Tree Road, Leonia, NJ 07605 U.S.A. Sodium thiopental (Abbot Laboratories),  
69 Trichloroacetic acid (TCA), Thiobarbituric acid (TBA), Ellman reagent (5', 5' dithio-bis-2-  
70 nitrobenzoic acid), Sodium azide, 1-2, 4-dinitrobenzene.

### 71 **2.2 Experimental Design**

72 Fifty adult male Wistar rats weighing 100-130 g were used for this study. The animals were  
73 obtained from Central Animal house, College of Medicine, University of Ibadan. The  
74 experimental animals were acclimatized for two weeks and were fed on rats' pellets and  
75 water given *ad libitum*. After the period of acclimatization, the experimental animals were  
76 divided into two groups each containing twenty-five animals and each group were subdivided  
77 into five groups containing five animals each and treated as follows; Group 1 (control) -  
78 normal rats that had access to clean water and rat pellets; Group 2- animals pre-treated with  
79 100 mg/kg body weight of L-cysteine; Group 3- animals pre-treated with 300 mg/kg body  
80 weight of L-cysteine; Group 4- animals- pre-treated with 500 mg/kg body weight of L-  
81 cysteine; group 5- animals pre-treated with 50 mg/kg body weight of cimetidine.  
82 The first sub-group was used for the anti-ulcer studies; antioxidant enzymes (SOD and  
83 MDA), Nitric oxide, Gastric blood flow and the mean ulcer score, while gastric mucus  
84 secretion study was performed with the second sub-group. All procedures used in this study  
85 conformed to the guidelines on the care and use of animals in research and teaching [11].

### 86 **2.3 Indomethacin Gastric Ulcer Induction**

87 Gastric ulcer was induced in the experimental animals using indomethacin at a dosage of 40  
88 mg/kg body weight in accordance with previously described method by [12]. Afterwards, the  
89 animals were sacrifice by cervical dislocation 4 hours after ulcer induction.

### 90 **2.4 Assessment of Ulcer Spots**

91 Macroscopic examination of the stomach was carried out and scored using the method  
92 described by [13] modified by [14]. Ulcer index was calculated using the formula.

93 
$$\text{Ulcer index} = \text{Mean Ulcer Score} \times \text{Number of animals in a group}/100$$

### 94 **2.5 Assay of Superoxide Dismutase (SOD)**

95 SOD activity was measured by assessing the inhibition of autoxidation of adrenaline at 30°C  
96 with the pH raised from 7.8-10.2 using the method described by [15].

## 97 **2.6 Determination of Lipid Peroxidation**

98 MDA (marker for oxidative stress) assessment was done according to the method of [16].

99 MDA which is the unit for lipid peroxidation is calculated in units/mg protein, using the  
100 formula:

101 
$$\text{MDA (units/mg proteins)} = (\text{Absorbance} \times \text{Volume of mixture}) / (\text{E532nm} \times \text{Volume}$$
  
102 
$$\text{of sample} \times \text{mg protein}).$$

## 103 **2.7 Gastric Mucus Secretion Study**

104 This study was carried out using the spectrophotometry method described by [17]. The  
105 weight of dye was expressed over the weight of the stomach, to give the weight of mucus  
106 secreted.

107 Thus,

108 
$$\text{Gastric mucus secretion (mg/g tissue)} = \frac{\text{Weight of dye (mg)}}{\text{Weight of stomach (g)}}$$
  
109

## 110 **2.8 Determination on Nitric Oxide Levels**

111 Nitrite was determined as an oxidation product and indicator of NO synthesis as described by  
112 [18]. The method is based on the addition of Griess reagent to the sample which converts  
113 nitrite into deep purple azo chromophore. The colour intensity was measured using a UV-  
114 visible spectrophotometer. Nitrite level was expressed as mol/g tissue.

## 115 **2.9 DETERMINATION OF GASTRIC BLOOD FLOW**

116 Gastric blood flow was measured as a component of abdominal aortic blood flow. Abdominal  
117 aortic blood flow was measured by placing an ultrasonic Doppler flow probe  
118 (Transonic# 11RB) around the abdominal aorta between the diaphragms and celiac artery.

Flow rates were obtained with the Transonic T206 Blood Flow Meter (Transonic Instrument, Ithaca, NY).

Animals were fasted, but not deprived of water for 24 hours before the onset of the experiment. 1 hour before ulcer induction, the test substance were administered to their respective group after which indomethacin was given to induced ulcer in all groups except group 1 (control group). Animals were anesthetized with ketamine (1ml/kg) intraperitoneal. A midline laparotomy was performed to expose the abdominal aorta for the placement of probe. The intestine of the rats was deflected to the right to expose the abdominal aorta. Adjacent fats were removed for proper acoustical coupling. The recorded blood flow was expressed in ml/min.

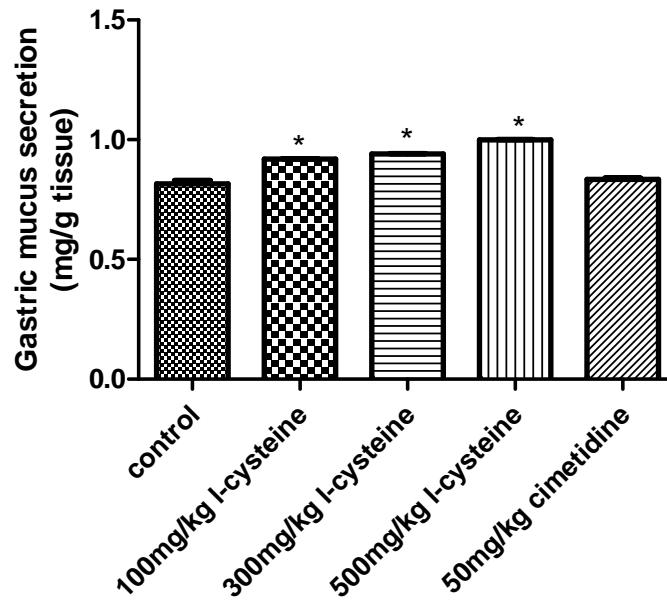
## **2.10 Statistical Analysis**

Data were expressed as Mean  $\pm$  Standard Error of Mean (SEM). Statistical analysis was performed with Graph Pad Prism 5.0. Comparison between mean were done using one way analysis of variance (ANOVA) and differences between means were considered statistically significant at  $P=0.05$ .

## **3. RESULTS**

### **3.1 Effect of L-cysteine Pre-treatment on Gastric Mucus Secretion**

Animals pre-treated with various doses of L-cysteine showed significant increase in gastric mucus secretion when compared with the ulcer control group. The groups treated with the standard drug; cimetidine and 500 mg/kg L-cysteine showed the highest secretion of gastric mucus. There was also a dose-dependent increase in gastric mucus secretion in the L-cysteine treated group as shown in Fig 1.



141

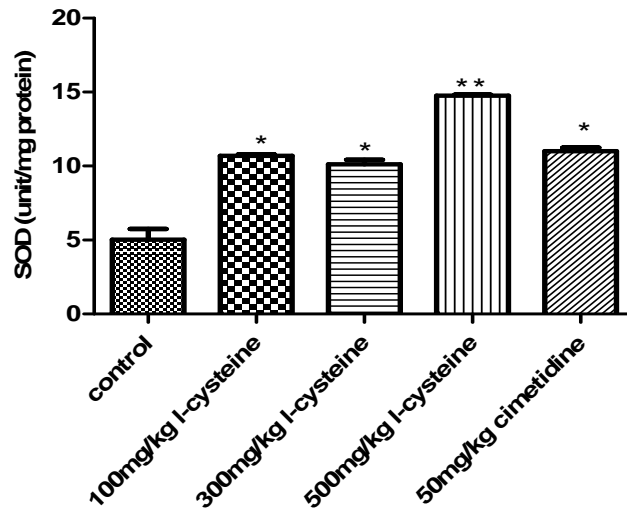
142 Figure 1: Effect of Cysteine on mucus secretion in Indomethacin induced ulceration in rats.

143 \* $p < 0.05$ , \*\*  $p < 0.005$ , \*\*\*  $p < 0.0005$  when compared with ulcer control.

### 144 3.2 Effect of L-cysteine Pre-treatment on Antioxidant Enzymes

#### 145 3.2.1 Superoxide Dismutase

146 The levels of superoxide dismutase obtained from this study are presented in Fig. 2. There  
 147 was a significant increase in super oxide dismutase levels in all the L-cysteine and cimetidine  
 148 pre-treated animals when compared with the control.

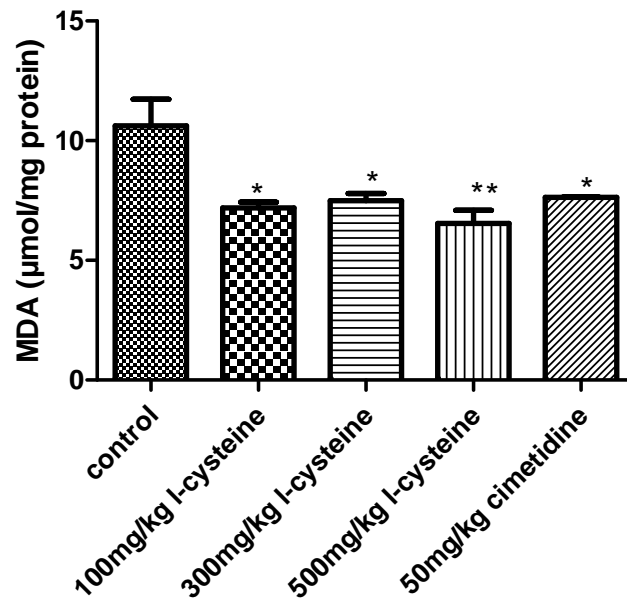


149

150 Figure 2: Effect of L-cysteine on Superoxide Dismutase (SOD) in Indomethacin-induced  
 151 ulceration in rats. \*  $p < 0.05$ , \*\*  $p < 0.005$ , when compared with ulcer control.

### 152 3.2.2 Lipid Peroxidation

153 Figure (3) shows gastric mucosal malondialdehyde (MDA) levels recorded in L-cysteine pre-  
 154 treated animals. All the pre-treated animals showed significant decrease in lipid peroxidation  
 155 when compared to the animals in the ulcer control group.



156



Figure 3: Effect of Cysteine on Malondialdehyde (MDA) in Indomethacin induced ulceration

\* $p < 0.05$ , \*\* $p < 0.005$  when compared with ulcer control.

### 3.3 Effect of L-cysteine on Gastric Nitric Oxide Level

The results obtained from the nitric oxide study are presented in Figure (4). In this study, pre-treatment with L-cysteine caused a significant increase in nitric oxide concentration similar with the standard drug cimetidine.

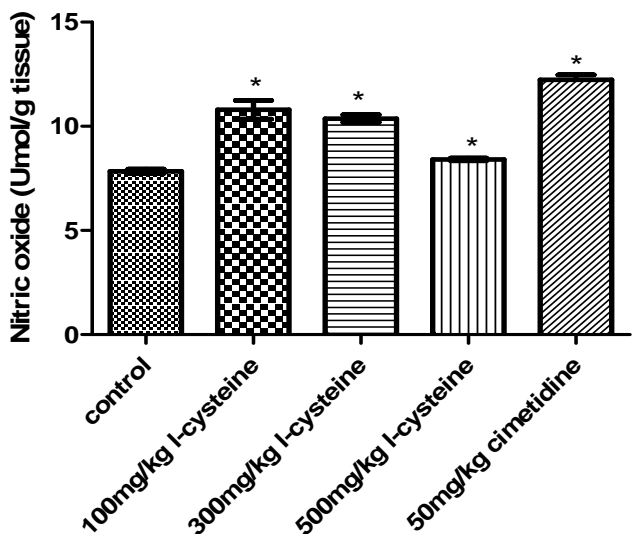


Figure 4: Effect of L-cysteine on Nitric Oxide activity in Indomethacin induced ulceration

\* $p < 0.05$  when compared with ulcer control.

### 3.4 Effect of L-cysteine Pre-treatment on Gastric Blood Flow in Indomethacin induced Ulceration in Rats

The gastric blood flow was significantly increased in all the treated groups compare to the ulcer control group as shown in Figure ( 5).

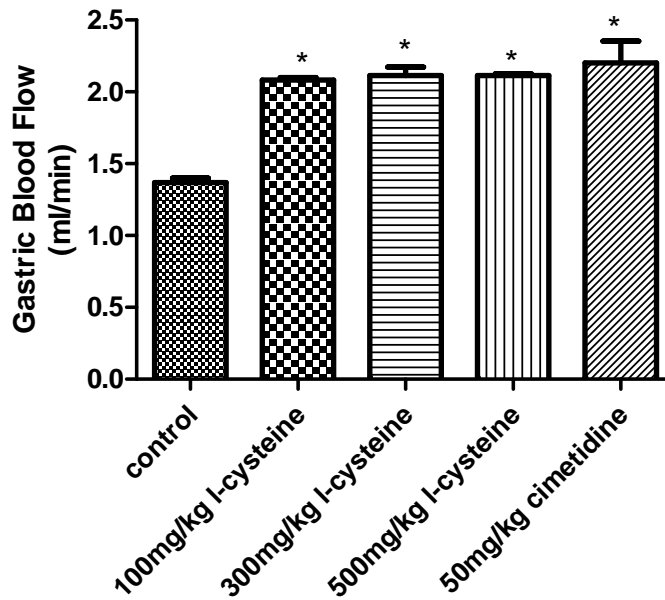


Figure 5: Effect of Cysteine on Gastric blood flow in indomethacin-induced ulceration.

\*p<0.05when compared with ulcer control.

### 3.5 Effect of L-cysteine Pre-treatment on Mean Ulcer Score

The mean ulcer score recorded in this study is presented in Table (1). The ulcer control group had a mean ulcer score of  $39.5 \pm 7.90 \text{ mm}^2$ , which was significantly reduced in all the L-cysteine treated groups in a dose-dependent manner.

Table 1: Effect of L-cysteine pretreatment on mean ulcer score

groups	Mean ulcer score ( $\text{mm}^2$ )
Control	$39.5 \pm 7.9$
L-cysteine (100 mg/kg)	$9.5 \pm 1.9^*$
L-cysteine (300 mg/kg)	$7.5 \pm 1.5^*$
L-cysteine (500 mg/kg)	$4.5 \pm 0.9^{**}$
Cimetidine	$7.0 \pm 1.4^*$

\*p<0.05 when compared with ulcer control.

#### 4. DISCUSSION

Nonsteroidal anti-inflammatory drugs (NSAIDs) are widely used to treat musculoskeletal disorders, and are used almost routinely long term by patients with rheumatoid arthritis but has been associated with development of gastric ulcers [19]. It has been demonstrated that NSAIDs (e.g. indomethacin) cause peptic ulceration by a combination of direct effects in the mucous barrier and by local and systemic inhibition of the prostaglandin system. The inhibition of endogenous prostaglandins (PGs) and related compounds, decreases gastric mucosal blood flow, and carbonate synthesis as well as increasing susceptibility to mucosal injury and gastric ulceration [20, 21]. In addition, sequel to the acidic nature of indomethacin [22], it enhances lipid peroxidation and generation of free radicals in the gastric mucosa [23] thereby leading to oxidative damage [24]. Thus, NSAIDs given orally or systemically will cause damage to gastric protective mechanisms, allowing gastric acid to penetrate to submucous structures and thus cause ulceration. Therefore, strategies to protect the gastric mucosa from this offensive agent has been of immense interest to various scientists.

The importance of increased mucus strength and quantity in protecting the regenerating gastric epithelium has been established [25, 26]. Gastric mucus is the first protective barrier in the gastric epithelium that prevents the actions of free radical on the stomach mucosal [27] which could lead to the formation of ulcers [28]. Hydrophobicity play a significant role in protecting the gastric membrane against noxious agents in the lumen [29] as the protective property of the mucus barrier depends not only on the gel structure but also on the amount or thickness of the layer covering the mucosal surface [30]. In this present study, there was an increase in the gastric mucus secretion in the group of animal pre-treated with L-cysteine, which implies that L-cysteine has a promising potential in ameliorating indomethacin- induce peptic ulcer. This report is in agreement with the earlier work carried out by [31], where it was reported that gastric mucus secretion increased in the gastric mucosa of animals treated

206 with aqueous extract of *Eremomastax speciose* against indomethacin-induced ulceration.  
207 Allen and Flemstrom reported that an increase in the gastric mucus secretion in stomach  
208 confers double protection on the gastric mucosal as it prevents physical damage by acting as  
209 a lubricant and chemical damage by sequestering bicarbonate and forming a pH gradient  
210 against the proteolytic and acid nature of gastric juice [32].

211 It has been reported that biochemical with antioxidant properties exerts gastroprotective  
212 function [33]. Studies have demonstrated that these compounds can scavenge free radicals  
213 and are also involve in inhibition of lipid peroxidation, mucus production, decrease of  
214 histamine levels and inhibition of gastric acid secretion [34, 35]. Studies have demonstrated  
215 that L-cysteine supplementation in rats reduces reactive oxygen species (ROS) thereby  
216 demonstrating its antioxidant property [36, 37] and also contains sulfhydryl group which is a  
217 precursors of hydrogen sulfide [38] that mediates various biological functions.

218 In this study, the antioxidant activity of L-cysteine against indomethacin-induced ulcer in rats  
219 was observed to determine the possible mechanism of action of this amino acid. L-cysteine  
220 mediates its protective role against indomethacin-induced ulcer by reducing the level of  
221 malondialdehyde (marker for oxidative stress) and also enhancing the superoxide dismutase  
222 activity (antioxidant enzyme). Antioxidant compounds are able to protect the gastric mucosa  
223 by binding to acetylcholine muscarinic receptors inhibiting acid secretion [39] and  
224 attenuating blood flow, thereby diminishing the hemorrhagic lesions [40].

225 In this study, it was confirmed that the standard drug cimetidine caused a significant increase  
226 in nitric oxide. Similar result was recorded when the animals were pre-treated with L-cysteine  
227 compared with the control group. Nitric oxide is one of the most important defensive  
228 endogenous agents in the gastric mucosa [41]. It is essentially important in the regulation of  
229 gastric blood flow and also increases mucus secretion in the gastric mucosa [42]. It inhibits

the activation of leukocytes within the microcirculation, and inhibits the inherent release of reactive oxygen metabolites and proteases [43]. On the other hand, suppression of NO production has been reported to delay healing process and this effect was accompanied by a decrease in the gastric blood flow, mucosal growth parameters and attenuated angiogenic response [44]. Also, data obtained from in vitro and in vivo studies suggested that nitric oxide exerts an anti-apoptotic effect on rat gastrointestinal mucosal cells [45]. In addition, L-cysteine contains sulfhydryl group (SH) and serves as a precursor of hydrogen sulphide. Hydrogen sulphide is a potent mediator of vascular smooth muscle relaxation, exhibiting anti-inflammatory activities and contributing to gastric mucosal defense [46]. The SH groups are also responsible for increasing the production of and maintaining mucus stability, through the disulfide bridges, and are involved in maintaining gastric integrity, thereby limiting the production of free radicals involved in tissue damage [47]. The relatively high concentrations of SH have been implicated as in gastroprotection [48].

In this study, pre-treatment with L-cysteine caused a significant reduction in the mean ulcer score. The percentage ulcer inhibition in animal pre-treated with L-cysteine were comparable to the standard drug cimetidine and appears to be dose-dependent. Cimetidine is a histamine H<sub>2</sub> receptor antagonist which markedly inhibits gastric acid secretion [49, 50]. This supports the earlier study that cimetidine significantly reduces the effect of NSAIDs-induced peptic ulcer [51]. Thus, L-cysteine could also exert its anti-ulcerogenic effect via the inhibition of H<sub>2</sub> receptors in the gastric epithelia cells.

Despite the potent therapeutic effect of non-steroidal anti-inflammatory drugs (NSAIDs), it has been classically established that NSAIDs, such as indomethacin, significantly reduces prostaglandin levels and blood flow to gastric mucosa and thus are considered ulcerogenic agents in long-term use [52]. Therefore, it is important to assess the gastroprotective effects

of different doses of L- cysteine against indomethacin-induced gastric ulcer. The increase in gastric blood flow facilitated by L-cysteine contributes to protection by supplying the mucosa with oxygen and  $\text{HCO}_3^-$ , and by removing  $\text{H}^+$  and toxic agents diffusing from the lumen into the mucosa. Thus, the results showed that L-cysteine has anti-ulcer potential against different ulcerogenic agents which may be due to the high sulfhydryl content of this amino acid.

## 5. CONCLUSION

The result from this study shows that L-cysteine possess antiulcer activities which can be attributed to its antioxidant properties, its ability to enhance gastric mucus secretion as well as its sulfhydryl content. L-cysteine which is usually taken as a supplement might be beneficial to people with peptic ulcer disease.

## Ethical Disclaimer:

As per international standard or university standard written ethical permission has been collected and preserved by the authors.

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