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Alleviating Effects of Vitamin C on the Gramoxone Toxicity in the Mucosubstances of Rat Duodenum

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Abstract

The effects of vitamin C on the gramoxone toxicity in the duodenal goblet cells of rats were investigated using histochemical methods. Rats in control, gramoxone and gramoxone + vitamin C (Vt. C) group, aged 6 to 7 weeks, were fed 18% casein diet. In the gramoxone group, neutral and acid mucins of the goblet cells in villi and crypts of duodenum tended to decrease as compared with the control group. And the goblet cells secreting nonsulphated mucins tended to increase in number, being usually accompanied by a decrease of the goblet cells secreting sulphated mucins which are prominent in the duodenal mucosa of control group. However, the goblet cells secreting nonsulphated mucins tended to increase in the gramoxone + Vt. C group. Morphological changes of the goblet cells in the gramoxone group were noted vacuolation and demolition of goblet cells, while those changes were not significant in the gramoxone + Vt. C group. It seems to be that Vt. C has alleviating effects on the gramoxone toxicity in secretion and production of the duodenal goblet cells.

Key words : gramoxone toxicity, Vt. C, goblet cells

INTRODUCTION

The production and use of herbicides for destruction of noxious weeds has increased markedly. Of the most commonly used, herbicides gramoxone (paraquat ; 1,1,'-dimethyl-4,4'-bipyridium dichloride) has been reported to cause necrotic effects in animal lung, liver, and kidney, the suppressed activities of alkaline and acid phosphatases, and the alterations in the nature of the mucosubstances in the rat intestine[1~4]. Gramoxone has been reported to have rigorous effects on lipid contents, glycogen metabolism of liver, activities of sGOT, sGPT, cholinesterase, and alkaline and acid phosphatases[5]. Suggested mechanism of gramoxone toxicity is related to the formation of superoxide, hydrogen peroxides and NADPH dependent lipid peroxides, the damage to hemoglobin by free radical, and the catabolism of protein and hemolysis by lipid peroxides in cell membrane[6,7].

Vt. C (L-ascorbic acid) deficiency results in the condition known as scurvy, which is characterized by an inability of tissues of mesenchymal origin to produce and maintain osteocollagenous fibers and ground substances[8]. Also, Vt. C plays an important role in numerous biological mechanisms including collagen synthesis, the healing of wounds, the union of bone fractures, the regeneration of nerve cells, the metabolism of folic acid, the absorption of iron, carnitine synthesis, norepinephrine synthesis, degradation of cholesterol, and the metabolism of tyrosine[9~12]. Vt. C acts as an antioxidant, and converts active oxygen such as superoxide radical into less toxic or non-toxic to the cell[12]. Rats given daily doses of 6.5g of Vt. C/kg body weight were not showed any abnormal toxicities[11]. Vt. C increased the mobility of leukocytes, serum levels of immunoglobulins, and antibody formation[12].

According to previous report[13], it seemed to be that Vt. C has alleviating effects on the gramoxone toxicity in rats with regard to the growth gain, feed efficiency ratio, lipid contents of liver, and TBA value. Moreover, the changes of liver protein patterns, such as the decrease of high molecular weight protein and the increase of low molecular weight protein were observed in the gramoxone+Vt. C group. This study was

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performed to examine the effect of dietary supplementation of Vt. C on the gramoxone toxicity in the mucin secretion and morphological changes of the goblet cells in the duodenum of rat.

MATERIALS AND METHODS

In order to determine the effects of dietary supplementation of Vt. C on the gramoxone toxicity, 32 Wistar-strained male rats, aged 6 to 7 weeks, were divided into a control group (12) and an experimental group (20). The experimental group was divided into gramoxone-treated group (toxic group) and gramoxone+Vt. C-treated group (alleviating group). Rats in the control and gramoxone-treated groups were fed 18% casein diet and 18% casein+0.04% gramoxone diet for 4 weeks, respectively. In the case of the gramoxone+Vt. C-treated group, rats were fed 18% casein+0.04% gramoxone+Vt. C diet for 2 weeks after feeding 18% casein+0.04% gramoxone diet for 2 weeks. Experimental diets were prepared according to the composition shown in Table 1.

At the end of the desired experimental days, rats were fasted for 18 hours and sacrificed immediately under ether anesthesia. The duodenal mucosa was removed immediately and then fixed for 24 hours in a solution of 10% neutral buffered formalin, dehydrated, and embedded in paraffin according to routine methods.

Sections were cut at 5 to 6μm in thickness, deparaffinized and the subjected to histological and histochemical staining procedures were as follows :

1. Hematoxylin and eosin (H-E) staining for the general observation of histological structure.
2. Periodic acid-Schiff (PAS) reaction for studying neutral mucins[14].
3. Alcin blue (AB) pH 2.5 staining for the demonstration of acid mucins[15,16].
4. AB pH 1.0 staining for the selective characterization of sulphated mucins[17].
5. AB pH 2.5-PAS staining sequence distinguishes PAS positive (red) neutral from AB positive (blue) acid mucins[18,19].
6. AB pH 1.0-PAS staining sequence distinguishes PAS positive (red) neutral from AB positive (blue) sulphated mucins[18,19].
7. Aldehyde fuchsin (AF) pH 1.7-AB pH 2.5 staining sequence distinguished AF positive (purple) sulphated from AB positive (blue) nonsulphated mucins[20].

With AB pH 2.5-PAS sequence, cells containing both acid and neutral mucins usually showed purple, bluish purple, or reddish purple staining. With AB pH 1.0-PAS sequence, cells containing both sulphated and neutral mucins usually showed purple, bluish purple, or reddish purple staining. In the AF pH 1.7-AB pH 2.5 sequence, cells staining bluish purple containing both sulphated and nonsulphated mucins.

Table 1. Composition of the experimental diets

Constituents (%)	CG	GG	GVG
Corn starch	72	72	69
Casein	18	18	18
Corn oil	5	5	5
Salt mixture[1)]	4	4	4
Vitamin mixture[2)]	1	1	1
L-ascorbic acid	–	–	3
Gramoxone	–	0.04	0.04

Abbreviations : CG, 18% casein diet (control group) ; GG, 18% casein+0.04% gramoxone diet(gramoxone group) ; GVG, 18% casein+0.04% gramoxone+3% L-ascorbic acid diet (gramoxone-vitamin C group)

[1)] Salt mixture : Purchased from Nutritional Biochemicals Corp., Cleveland, Ohio, U.S.A.

[2)] Vitamin mixture : Vitamin diet fortification mixture ; purchased from Nutritional Biochemicals Corp., Cleveland, Ohio, U.S.A.

RESULTS AND DISCUSSION

Examination of H-E stained sections of duodenal mucosa of the control group revealed no significant histological abnormalities. The histochemical staining patterns of mucins observed the goblet cells of both villi and crypts of the duodenum in the control, gramoxone-treated and gramoxone+Vt. C-treated groups are outlined in Tables 2~7.

The duodenal goblet cells of the control group containing both acid and neutral mucins, although the differences existed in amounts of mucins, tended to increase amounts of acid mucins with the duration of feeding time.

Judging from the compositions of the acid mucins in the duodenal goblet cells of the control group, the goblet cells containing sulphated and neutral mucins

Table 2. PAS staining properties of mucosubstances of goblet cells in the duodenum of rats fed the experimental diets

Cells	CG			GG			GVG*	
	2wks	3wks	4wks	2wks	3wks	4wks	3wks	4wks
UVGC	3-4R>1-2R,±R	3R>1R±R	3-4R>1-2R,±R	3R>0,±R	2-3R,±R,0	±-1R,0>2R	3-4R,±-1R>0	3-4R,±-1R>0
LVGC	3-4R>1-2R	3R>1-2R,±R	3-4R>1-2R	3R>±-1R	2-3R>±R,0	±-1R>2-3R,0	3-4R>1R,±R	3-4R>1-2R±R
UCGC	3-4R>1-2R	3-4R>1-2R	3R>1-2R	2-3R>±1R, 0	2-3R>±R,0	±-1R>2R,0	3R>1-2R,±R,0	1-3R>±R,0
LCGC	1-2R>±R, 3R	2R>1R,±R	1-2R>3R, ±R	0,±-2R	0,±R>1-2R	1-2R,±R>0	1-3R>±R,0	1-3R>±R

Numbers indicate the relative intensity of the staining : 4, very intense ; 3, intense ; 2, moderate ; 1, weak ; ±, trace ; 0, absent
Abbreviation : CG, 18% casein diet (control group) ; GG, 18% casein + 0.04% gramoxone diet (gramoxone group) ; GVG, 18% casein + 0.04% gramoxone + 3% L-ascorbic acid diet (gramoxone-vitamin C group) ; UVGC, goblet cells of upper portion of intestinal villi ; LVGC, goblet cells of lower villi ; UCGC, goblet cells of upper portion of intestinal crypts ; LCGC, goblet cells of lower portion of intestinal crypts ; R, red ; >, most marked
Others are the same as those in Table 1

Table 3. Alcian blue pH 2.5 staining properties of mucosubstances of goblet cells in the duodenum of rats fed the experimental diets

Cells	CG			GG			GVG*	
	2wks	3wks	4wks	2wks	3wks	4wks	3wks	4wks
LVGC	2-3B>1B	3-4B>±B,1B	3-4B>1B,	±B,0>1-3B	1-4B,±B,0	±-1B0>2B	±-1B>02-3B	2-3B±-1B>0
LVGC	3B>±-2B	3-4B>1B	3-4B>1-2B	2-3B>±B,0	3B>±-1B	±-1B,0>2B	3-4B>±-2B	3-4B>±-2B
UCGC	2-3B	3B>4B,±-1B	3-4B>1-2B	1-2B>±B,0	1-2B,±B,0	±-1B>2B,0	±-1B,>0 2-3B	2-3B,±-1B
LCGC	2-3B>±-1B	2-3B>±-1B	2-3B>±-1B	±B,0>1B	±B,0>1B	±-1B>2B	±B>1-2B,0	±-2B>0

Abbreviation : B, blue. Others are the same as those in Table 1 and 2

were seen mixed with those showing nonsulphated and neutral mucins, and the amounts of mucins in the goblet cells were most prominent in the villi than in the crypts (Fig. 1A, 2A, 3A, and 4A).

These observations are consistent with previous results[3,4,20~24]. In the gramoxone-treated group, neutral and acid mucins tended to decrease as compared with the control group, and this tendency was found to be significant in the goblet cells of 4 week-feeding group. In the villi and crypts of duodenum, both staining properties of the goblet cells containing sulphated mucins and the goblet cells containing nonsulphated mucins appeared to decrease, and staining properties of the former were severely affected rather than the latter. And the goblet cells containing nonsulphated mucins tended to increase in number, while the goblet cells containing strong sulphated mucins tended to decrease comparatively (Fig. 1B, 2B, 3B, and 4B).

Amounts of the neutral and acid mucins of the goblet cells appeared to increase all over again in the gramoxone+Vt. C-treated group as compared with the gramoxone-treated group. And the goblet cells secreting nonsulphated mucins tended to decrease in number, while the goblet cells secreting strong sulphated mucins tended to increase (Fig. 1C, 2C, 3C, and 4C).

In the gramoxone-treated group, the upper villi and the crypts of duodenal mucosa showed changes in the histological structures of goblet cells. Among the goblet cells of the upper villi and crypts were presented a large number of the goblet cells with vacuolation, demolition and indistinctness of cell membrane (Fig. 1B, 2B, 3B, and 4B). Especially, the lower crypts were lined by a large number of immature goblet cells.

In the gramoxone+Vt. C-treated group, the vacuolation and demolition of the goblet cells were not significant as compared with the gramoxone-treated group (Fig. 1C, 2C, 3C, and 4C), while immature and middle mature goblet cells were plentifully observed in the lower crypts of the former group. The results obtained in the gramoxone-treated group were similar to the results of previous studies of DDVP, malathion, dipterex and EPN[24], bassa[3], thiodan[25], and gramoxone[4] though some differences of morphological changes and life span of goblet cells existed.

It has been found that the mucins of tissue play an important role in the initiation and control of cell division, and there is no active tissue proliferation in the

Table 4. Alcian blue pH 2.5-PAS staining properties of mucosubstances of goblet cells in the duodenum of rats fed the experimental diets

Cells	CG			GG			GVG*	
	2wks	3wks	4wks	2wks	3wks	4wks	3wks	4wks
UVGC	3-4P>1-2P±P	3-4P>3BP,3RP,1BP	3-4P>3BP,2-3RP	3RP,3P>±RP,0	2-3P,2BP,±P	±-1P,0>3P	3-4P,3BP,±-1P>0	3P,3BP,±-1P>0
LVGC	3-4P>1-2P,±P	3-4P>1-2P,2BP,2RP	3-4P>2P,2BP,1-2RP	3BP,3P>±BP,0	3P,3BP>1P,±BP	±-1P,0>3-4P	3-4P,3BP>±-2P	3-4P,3BP>±-2P
UCGC	3-4P>1-2P,±P	3P>2BP,1-2RP,±P	3-4P>2-3BP,1-2RP,±P	2-3RP,2-3P>0,±BP	2-3P,2BP>±BP,1P,0	±-1P>2-3P,2BP,0	3RP,1-3P>0	1-3P,1-3BP>±BP,3RP
LCGC	3P>±BP,1P,2BP	2-3BP,2-3P>1BP,±P	2-3BP>2-3P,±P	0,±BP>2P,2BP	±BP,±P>1P,0	±P,±BP>1-2P,1-2BP,0	1-3RP>1-2P	1-3P,1-3BP>±BP,3RP

Abbreviation : P, purple ; BP, bluish purple ; RP, reddish purple. Others are the same as those in Table 1 and 2

Table 5. Alcian blue pH 1.0 staining properties of mucosubstances of goblet cells in the duodenum of rats fed the experimental diets

Cells	CG			GG			GVG*	
	2wks	3wks	4wks	2wks	3wks	4wks	3wks	4wks
UVGC	2B,±B,0	2-3B>±B	2-3B>±B	1B>0,2B	2-3B,±B,1B,0	±-1B,0>2B	±-1B>0,2-3B	2-3B,>0±-1B
LVGC	2B,±B,0	2-3B>±B	2-3B>±B	±-1B,>2B0	2-3B>-1B,0	±-1B,0>2B	3-4B>±-2B	3-4B>±-2B
UCGC	2B,±B,0	1-2B>3B,±B	2B>3B,±B	1-2B,±B	1-2B>±B,0	±-1B>2B,0	±-1B,>02-3B	2-3B,±-1B
LCGC	1B,±B,0	1B>2B,±B	1B>2B,±B	±B,0>1B	±B,0>1B	1-2B,±B>0	0,±B>1-2B	±-2B>0

Degree of staining and abbreviation are the same as those in Table 1, 2, and 3

Table 6. Alcian blue pH 1.0-PAS staining properties of mucosubstances of goblet cells in the duodenum of rats fed the experimental diets

Cells	CG			GG			GVG*	
	2wks	3wks	4wks	2wks	3wks	4wks	3wks	4wks
UVGC	3-4RP>3R,3P±RP	3-4P>2-3RP>3R,±RP	3-4P3R,>2-3RP>±RP	3RP,2-3R>±RP,±P	3-4P,2-3RP,±P	±-1P,0>3P,3RP	3-4P,3BP,±-1P>0	3P,3RP,±-1P
LVGC	3-4RP>3P,2R,±BP	3-4P>2-3RP,±P,±RP	3-4P>2-3RP,±P,±RP	2R,3RP>2-3P,±P	3-4P,2-3RP,±RP	±-1P,0>3-4P,3RP	3-4P,3BP>±-2P	3-4P,3RP>±-1P
UCGC	3-4RP>2R,3P,2BP	3P>2-3RP,2R	3P>2-3RP,2R	2-3R,3RP>±,P,2-3P,±RP	2-3P,2-3RP>±RP,±P	±-1P>2-3P,2RP,0	3RP,1-3P>0	1-3P>1-3RP>±P
LCGC	1-2RP>2R,2P,2BP,±RP	2BP,2P>1-2RP	2BP,2P>1-2RP,±P	1R,1RP,0±P,	±-1P,1RP,0	±P>1-2P,1RP,0	1-3RP>1-2P	1-3P,1-3RP,±P

Degree of staining and abbreviation are the same as those in Table 1, 2, and 4

Table 7. Aldehyde fuchsin pH 1.7-alcian blue pH 2.5 staining properties of mucosubstances of goblet cells in the duodenum of rats fed the experimental diets

Cells	CG			GG			GVG*	
	2wks	3wks	4wks	2wks	3wks	4wks	3wks	4wks
UVGC	2P,2BP,2B>±BP,±P	3P,3B>±BP±P	3P,3B>±BP,±P	±BP,0>1-2P,1B	2P,2-3B,±B±BP,±P	±-1P,0,1B	2-3P,2B,±BP	2-3P,1-2B±BP,
LVGC	2P,2B,2BP±BP	3P,3B>±BP,±P	3P,3B>±BP±P	2B>1-2P>±P,2BP	2P,2-3B>±BP,±P	1-2B,2P±-±BP>0	2-3P,2-3B>±-1BP	2-3P,2-3B>2-1BP
UCGC	2P,2BP,2B	2-3P,2-3B>±BP,±P	2-3P,2-3B±BP,±P	2B,2P,1-2BP>±P	2-3B>2P,2BP>±BP,±P	±-1P,±-1B,2P,2B>0	±-1B,>0±-1P	1-3P,±-1B,>1-2BP,0
LCGC	1-2P,1B±B,	1-2P,1B>±B	1-2P,1B>±B	±-1B,±BP,0±-1P,	±-1B,±-1P>0	±-1P,±-1BP,1-2B>0	±-1P,±-1B>0	1-3P,2B±-1B>0

Degree of staining and abbreviation are the same as those in Table 1~4

Fig. 1. Duodenum of rat showing goblet cells of villi in the control (1A), gramoxone (1B) and gramoxone + Vt. C groups (1C) fed for 3 weeks.
PAS stain.×400. In control group, PAS stainability of goblet cells appeared intense or very intense red coloring. But in the gramoxone group, the stainability of goblet cells become diminished markedly as compared with those of control group. And disordered epithelial lining in the luminal surface of upper villi is seen. The demolition and vacuolation of goblet cells in upper villi are also prominent features. No significant differences existed between control and gramoxone–vitamin C groups.

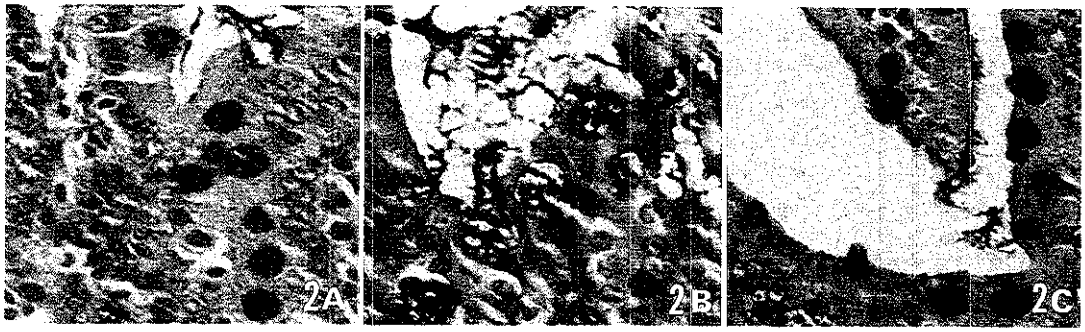

Fig. 2. Duodenum of rat showing goblet cells of crypts and villi in the control (2A), gramoxone (2B), and gramoxone + Vt. C (2C) group fed for 3, 4, and 3 weeks, respectively.
Alcian blue pH 2.5 stain.×400. In the control group, the alcianophilia in the goblet cell of upper crypt appeared intense or very intense blue coloring. But in the gramoxone group, the alcianophilia in goblet cells of upper crypt was markedly diminished than those of control group and the demolition and vacuolation of goblet cells are also prominent features. The alcianophilia of goblet cells of lower villi in gramoxone–Vt. C group are markedly increased than those of gramoxone group.

Fig. 3. Duodenum of rat showing goblet cells of villi and crypt in the control (3A), gramoxone (3B) and gramoxone + Vt. C group (3C) fed for 4, 3, and 4 weeks, respectively.
Alcian blue pH 1.0-PAS stain.×400. In the control group, most of goblet cells in lower villi appeared intense to very intense purple coloring. In the lower crypts of gramoxone group, the stainability of goblet cells decreased severely as compared with those of control group. In the upper crypts of the gramoxone–Vt. C group, no significant differences existed between control and gramoxone–vitamin C group.

Fig. 4. Duodenum of rat showing goblet cells of lower villi in the control (4A), gramoxone (4B) and gramoxone-Vt. C group (4C) fed for 3 weeks.
Aldehyde fuchsin pH 1.7-alcian blue pH 2.5 stain. × 400. Most of goblet cells of control group appeared intense purple or blue coloring. In the gramoxone group, the stainability of goblet cells decreased severely as compared with those of control group. However, the stainability in the goblet cells of gramoxone-Vt. C group increased obviously as compared with those of gramoxone group.

abscence of mucins[26]. Additionally, it proved that unstable mucopolysaccharide-calcium complexes in tissue resulted from the radiation of X-ray, the presence of viruses, external wounds, changes in the secretion of hormones, changes in the metabolism of calcium ion, and also from a lack in the supply of mucins. Those conditions cause abnormal cell division[26,27]. Mucins secreted from mucous cells in the digestive tracts play an important physical role as a lubricant on the surface of the mucosa in the digestive tract. They protect the mucosa of the digestive tracts from various chemicals, toxins of disease, mechanical stimulation, and various kinds of digestive enzyme[28-32].

The cell surface sialoglycopeptides appear to play a role in cellular recognition phenomena[33] and the sulphated mucins may be related to cellular proliferation[23,26]. Changes in the mucous protective barrier has been suggested as a basis for chronic gastric ulcer and acute ulceration of the stomach or duodenum. An alteration in this barrier might result from decreased mucin production, thereby rendering that the gastric mucous membrane is more susceptible to damage. Also, acute and chronic ulcer diseases induced histochemical changes in the preformed mucins and a decrease in production of mucins[34].

It was suggested that carcinoma cells of stomach may be arised from immature mucous cells of regeneration and proliferation or metaplastic mucous cells[35,36]. Also, those metaplastic cells may be change to malignant type through stages of hyperplasia, dysplasia, and anaplasia and chronic gastritis and carcinoma of the stomach induced changes in the compositions and contents of the mucins in the gastric mucosa[37]. As in humans, histological normal mucosa adjacent to carcinomas of the large intestine showed that there is an increase of nonsulphated mucins(sialomucins) accompanied usually by a decrease or abscence of the sulphated mucins (sulphomucins), in contrast with normal mucosa in which sulphated mucins predominate.

The rectal mucosa with ulcerative colitis and Crohn's disease of human showed that there was an increase of nonsulphated mucins accompanied usually by a decrease of sulphated mucins which were predominate in the normal mucosa[38]. The part played by sialic acids is not yet known. It suggests that tumor cells are coated with neuraminidase-sensitive sialic acids which may not only hide their antigens from the host, but also shield them from his immunocompetent cells[39].

Increased amounts of sulphated mucins in intestinal mucosa have been considered to be related to the decreased solubility of such mucus in patients with cystic fibrosis[40].

Decreased amounts of galactosamine in granulation tissue and costal cartilage of guinea pig with scurvy have been considered to be related to an injury in the metabolism of mucins. Moreover, the production of galactosaminoglycan containing galactosamine was infringed by the lower sulphate (^{35}S) absorpt-

ion and lower content of galactosamine. Furthermore, changes in the mucins content resulted from strikingly decreased content of Vt. C in adrenal gland, and occurred when the decreases of body weight started[41].

Gramoxone+Vt. C-treated group has been observed in an increase of amounts of acid and neutral mucins as compared with gramoxone-treated group. And, restored histochemical properties of mucins and, morphological changes of goblet cells in the villi and crypts of duodenum were usually accompanied by an increase of immature and middle mature goblet cells in the lower crypts.

Consequently, our results suggest that ascorbic acid alleviates not only the toxicity of the morphological changes of goblet cells by gramoxone, but also the toxicity of the metabolism of mucins.

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흰쥐 십이지장 점액질에 미치는 Gramoxone 독성에 대한 비타민 C의 완화 효과

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요 약

식이속의 비타민 C가 피리딘계 제초제인 gramoxone의 독성발현에 어떤 영향을 미치는 가를 알기위해 6~7주령의 Wistar계 흰쥐 숫놈 32마리를 정상대조군과 실험군으로 나누어 자유급식법으로 4주간 사육하였다. 정상대조군은 2, 3 및 4주 사육군으로 나누고 18% casein식이로 사육하였고 실험군 중 gramoxone처리군도 2, 3 및 4주 사육군으로 나누고 18% casein식이에 0.04% gramoxone을 첨가하여 사육하였으며, gramoxone-비타민 C처리군은 2주 사육군의 gramoxone처리군의 흰쥐에다 18% casein식이에 0.04% gramoxone과 3% 비타민 C를 첨가하여 1주 및 2주 사육하여 3 및 4주 사육군으로 하였다. 십이지장의 조직학적 구조 및 배상세포의 형태변화는 hematoxylin-eosin염색으로, 배상세포내 점액질양과 성상변화는 PAS, alcian blue pH 2.5 및 1.0, alcian blue pH 2.5-PAS염색, alcian blue pH 1.0-PAS염색 및 alden blue pH 1.0-PAS염색 및 aldehyde fuchsin pH 1.7-alcian blue pH 2.5 염색으로 관찰하였다. 정상대조군의 십이지장 융모 및 은와에는 강 sulfomucin과 중성점액질을 분비하는 배상세포와 nonsulfomucin과 중성점액질의 분비하는 배상세포가 섞여 있었으며 융모 배상세포내 점액질양이 은와 배상세포내 점액질양보다 많았으며 사육기간이 증가함에 따라 점액질양이 다소 증가하는 경향을 나타내었다. Gramoxone처리군의 경우 십이지장의 산성점액질 및 중성점액질양이 다같이 감소되며 사육기간이 증가함에 따라 강 sulfomucin과 중성점액질을 분비하는 배상세포수는 감소하는 반면에 nonsulfomucin과 중성점액질을 분비하는 배상세포는 다소 증가하는 경향을 나타내었으나 gramoxone-비타민 C처리군의 경우 감소된 산성점액질과 중성점액질양이 다시 증가하고 감소 되었던 강 sulfomucin과 중성점액질을 분비하는 배상세포가 다시 증가하였다. 십이지장 배상세포의 형태변화는 gramoxone처리군의 경우 커진 세포, 공포변성된 세포, 세포막이 파괴된 세포 및 미성숙세포가 많이 관찰되었으나 gramoxone-비타민 C처리군의 경우 그 수가 감소되었다. 위의 사실로 보아 비타민 C는 흰쥐 십이지장의 배상세포형태 및 점액질에 미치는 gramoxone의 독성을 완화시키는 효과가 있음을 알 수 있었다.